GOVERNMENT COLLEGE OF TECHNOLOGY

(An Autonomous Institution Affiliated to Anna University)

Coimbatore - 641 013

Curriculum For

B. E. MECHANICAL ENGINEERING

(Full Time)

2022

Regulations

OFFICE OF THE CONTROLLER OF EXAMINATIONS
GOVERNMENT COLLEGE OF TECHNOLOGY

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GOVERNMENT COLLEGE OF TECHNOLOGY, COIMBATORE – 641 013
B.E.MECHANICAL ENGINEERING (FULL TIME)
FIFTH SEMESTER

Sl. No	Course Code	Course Title	Category	CA Marks	End sem Marks	Total Marks	Hours/Week			
							L	T	P	C
THEORY										
1	22MPC512	HEAT AND MASS TRANSFER	PC	40	60	100	3	0	0	3
2	22MPC513	DESIGN OF MACHINE ELEMENTS	PC	40	60	100	3	0	0	3
3	22MPC514	DYNAMICS OF MACHINES	PC	40	60	100	3	0	0	3
4	22MPC515	THEORY OF ELASTICITY	PC	40	60	100	3	0	0	3
5	22MPE$XX	PROFESSIONAL ELECTIVE I	PE	40	60	100	3	0	0	3
6	22MMC5Z2	CONSTITUTION OF INDIA (Common to all branches)	MC	40	60	100	3	0	0	0
PRACTICAL										
7	22MPC516	CAD LABORATORY	PC	60	40	100	0	0	3	1.5
8	22MPC517	THERMAL ENGINEERING LABORATORY II	PC	60	40	100	0	0	3	1.5
9	22MES512	DESIGN THINKING FOR MECHANICAL ENGINEERING	ES	100	0	100	0	0	3	1.5
TOTAL				**460**	**440**	**900**	**18**	**0**	**9**	**19.5**

SIXTH SEMESTER

Sl. No	Course Code	Course Title	Category	CA Marks	End sem Marks	Total Marks	Hours/Week			
							L	T	P	C
THEORY										
1	22MPC618	METROLOGY AND QUALITY CONTROL	PC	40	60	100	3	0	0	3
2	22MPC619	FINITE ELEMENT ANALYSIS	PC	40	60	100	3	0	0	3
3	22MPC620	DESIGN OF TRANSMISSION SYSTEMS	PC	40	60	100	3	0	0	3
4	22MPC621	MECHATRONICS	PC	40	60	100	3	0	0	3
5	22MPE$XX	PROFESSIONAL ELECTIVE II	PE	40	60	100	3	0	0	3
6	22#OE$XX/ 22MPE$XX	OPEN ELECTIVE I/ PROFESSIONAL ELECTIVE VII	OE/ PE	40	60	100	3	0	0	3
PRACTICAL										
7	22MEE602	SKILL DEVELOPMENT ON TECHNICAL AND INDUSTRIAL PRACTICES	EEC	60	40	100	0	0	3	1.5
8	22MEE603	MODELING AND SIMULATION LABORATORY	EEC	60	40	100	0	0	4	2
TOTAL				**360**	**440**	**800**	**18**	**0**	**7**	**21.5**

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GOVERNMENT COLLEGE OF TECHNOLOGY, COIMBATORE – 641 013
B.E.MECHANICAL ENGINEERING (FULL TIME)

SEVENTH SEMESTER

Sl. No	Course Code	Course Title	Category	CA Marks	End sem Marks	Total Marks	Hours/Week			
							L	T	P	C
THEORY										
1	22MHS706	OPERATIONS RESEARCH	HS	40	60	100	3	0	0	3
2	22MPC722	REFRIGERATION AND AIR CONDITIONING	PC	40	60	100	3	0	0	3
3	22MPC723	COMPUTER AIDED DESIGN AND MANUFACTURING	PC	40	60	100	3	0	0	3
4	22MPE$XX	PROFESSIONAL ELECTIVE III	PE	40	60	100	3	0	0	3
5	22MPE$XX	PROFESSIONAL ELECTIVE IV	PE	40	60	100	3	0	0	3
6	22#OE$XX/ 22MPE$XX	OPEN ELECTIVE II/ PROFESSIONAL ELECTIVE VIII	OE/ PE	40	60	100	3	0	0	3
PRACTICAL										
7	22MPC724	AUTOMATION LABORATORY	PC	60	40	100	0	0	3	1.5
8	22MEE704	ENGINEERING PROJECTS IN COMMUNITY SERVICE	EEC	60	40	100	0	0	4	2
9	22MEE705	INTERNSHIP	EEC	100		100				4
TOTAL				**460**	**440**	**900**	**18**	**0**	**7**	**25.5**

EIGHTH SEMESTER

Sl. No	Course Code	Course Title	Category	CA Marks	End sem Marks	Total Marks	Hours/Week			
							L	T	P	C
THEORY										
1	22MPE$XX	PROFESSIONAL ELECTIVE V	PE	40	60	100	3	0	0	3
2	22MPE$XX	PROFESSIONAL ELECTIVE VI	PE	40	60	100	3	0	0	3
PRACTICAL										
3	22MEE806	CAPSTONE PROJECT	EEC	60	40	100	0	0	16	8
TOTAL				**140**	**160**	**300**	**6**	**0**	**16**	**14**

Note:
Internship of four consecutive weeks or two 2 consecutive weeks which are completed during summer vacation of fourth and sixth semester and/or winter vacation of fifth semester shall be considered here.

Total credits from courses: 165
Internship/ Industrial Training: 4
Total Credits: 169

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CATEGORY-WISE CREDIT DISTRIBUTION

HUMANITIES AND SOCIAL SCIENCES INCLUDING MANAGEMENT (HS)

Sl. No.	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	22MHS1Z1	HERITAGE OF TAMILS	HS	40	60	100	1	0	0	1
2	22MHS1Z2	VALUES AND ETHICS	HS	40	60	100	3	0	0	3
3	22MHS1Z3	CAMBRIDGE ENGLISH	HS	60	40	100	0	0	2	1
4	22MHS2Z4	TAMILS AND TECHNOLOGY	HS	40	60	100	1	0	0	1
5	22MHS2Z5	PROFESSIONAL ENGLISH	HS	40	60	100	2	1	0	3
6	22MHS706	OPERATIONS RESEARCH	HS	40	60	100	3	0	0	3

BASIC SCIENCES (BS)

Sl. No.	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	22MBS1Z1	LINEAR ALGEBRA AND CALCULUS	BS	40	60	100	3	1	0	4
2	22MBS1Z2	ENGINEERING PHYSICS	BS	40	60	100	3	0	0	3
3	22MBS103	ENGINEERING CHEMISTRY	BS	40	60	100	3	0	0	3
4	22MBS1Z4	CHEMISTRY LABORATORY	BS	60	40	100	0	0	3	1.5
5	22MBS205	DIFFERENTIAL EQUATIONS AND NUMERICAL METHODS	BS	40	60	100	3	1	0	4
6	22MBS206	MATERIALS SCIENCE	BS	40	60	100	3	0	0	3
7	22MBS2Z7	PHYSICS LABORATORY	BS	60	40	100	0	0	3	1.5
8	22MBS408	APPLIED PROBABILITY AND STATISTICS	BS	40	60	100	3	1	0	4

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ENGINEERING SCIENCES (ES)

Sl. No.	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	22MES101	BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING	ES	40	60	100	3	0	0	3
2	22MES1Z2	ENGINEERING GRAPHICS	ES	60	40	100	1	0	4	3
3	22MES203	PYTHON PROGRAMMING	ES	40	60	100	3	0	0	3
4	22MES2Z4	WORKSHOP PRACTICE	ES	60	40	100	0	0	3	1.5
5	22MES205	PYTHON PROGRAMMING LABORATORY	ES	60	40	100	0	0	3	1.5
6	22MES306	APPLIED ENGINEERING MECHANICS	ES	40	60	100	2	1	0	3
7	22MES307	SOLID MECHANICS	ES	40	60	100	3	0	0	3
8	22MES308	FLUID MECHANICS AND MACHINERY (COMMON TO MECH & PROD)	ES	40	60	100	3	0	0	3
9	22MES309	ELECTRICAL AND ELECTRONICS ENGINEERING LABORATORY	ES	60	40	100	0	0	3	1.5
10	22MES310	MATERIAL TESTING AND FLUID MACHINES LABORATORY (COMMON TO MECH & PROD)	ES	60	40	100	0	0	3	1.5
11	22MES411	ENGINEERING EXPLORATION FOR MECHANICAL ENGINEERING	ES	100	-	100	0	0	3	1.5
12	22MES512	DESIGN THINKING FOR MECHANICAL ENGINEERING	ES	100	0	100	0	0	3	1.5

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PROFESSIONAL CORE (PC)

Sl. No.	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	22MPC301	MANUFACTURING TECHNOLOGY I	PC	40	60	100	3	0	0	3
2	22MPC302	MATERIALS ENGINEERING AND METALLURGY	PC	40	60	100	3	0	0	3
3	22MPC303	THERMODYNAMICS	PC	40	60	100	3	0	0	3
4	22MPC304	MACHINE DRAWING	PC	60	40	100	0	0	6	3
5	22MPC405	HYDRAULIC AND PNEUMATIC CONTROLS	PC	40	60	100	3	0	0	3
6	22MPC406	KINEMATICS OF MACHINES	PC	40	60	100	3	0	0	3
7	22MPC407	THERMAL ENGINEERING	PC	40	60	100	3	0	0	3
8	22MPC408	MANUFACTURING TECHNOLOGY II	PC	40	60	100	3	0	0	3
9	22MPC409	MECHANICAL MEASUREMENTS AND CONTROL	PC	40	60	100	3	0	0	3
10	22MPC410	MANUFACTURING TECHNOLOGY LABORATORY	PC	60	40	100	0	0	3	1.5
11	22MPC411	THERMAL ENGINEERING LABORATORY I	PC	60	40	100	0	0	3	1.5
12	22MPC512	HEAT AND MASS TRANSFER	PC	40	60	100	3	0	0	3
13	22MPC513	DESIGN OF MACHINE ELEMENTS	PC	40	60	100	3	0	0	3
14	22MPC514	DYNAMICS OF MACHINES	PC	40	60	100	3	0	0	3
15	22MPC515	THEORY OF ELASTICITY	PC	40	60	100	3	0	0	3
16	22MPC516	CAD LABORATORY	PC	60	40	100	0	0	3	1.5
17	22MPC517	THERMAL ENGINEERING LABORATORY II	PC	60	40	100	0	0	3	1.5
18	22MPC618	METROLOGY AND QUALITY CONTROL	PC	40	60	100	3	0	0	3
19	22MPC619	FINITE ELEMENT ANALYSIS	PC	40	60	100	3	0	0	3
20	22MPC620	DESIGN OF TRANSMISSION SYSTEMS	PC	40	60	100	3	0	0	3
21	22MPC621	MECHATRONICS	PC	40	60	100	3	0	0	3
22	22MPC722	REFRIGERATION AND AIR CONDITIONING	PC	40	60	100	3	0	0	3
23	22MPC723	COMPUTER AIDED DESIGN AND MANUFACTURING	PC	40	60	100	3	0	0	3
24	22MPC724	AUTOMATION LABORATORY	PC	60	40	100	0	0	3	1.5

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PROFESSIONAL ELECTIVE (PE)
Verticals/Minor

Modern Mobility Systems	**Product and Process Development**	**Robotics and Automation (Minor)**	**Digital and Green Manufacturing**	**Processes Equipment and Piping Design**	**Computational Engineering**	**Professional Elective (Not for Specialization and Honors)**
Group-1	**Group-2**	**Group-3**	**Group-4**	**Group-5**	**Group-6**	**Group-7**
Automotive materials, components, design and testing	Value Engineering	Principles of Robotics	Automation in Manufacturing	Design of Pressure Vessels	Computational Solid Mechanics	Total Quality Management
Conventiona l and futuristic vehicle technology	Additive Manufacturing Techniques	Robotic Drives and Control techniques	Lean Manufacturing (Common to Mech & Prod)	Failure Analysis and NDT Techniques	Computational Fluid Dynamics	Gas Dynamics and Jet Propulsion
Renewable Powered Vehicles and Emission Control	Computer Integrated Manufacturing	Kinematics and Dynamics of Robotics	Green manufacturing design and Practices	Material processing and Solid processing equipments	Theory on Computation and Visualisation	Welding Technology
Vehicle Health Monitoring	Design for Manufacture	Advanced Materials for Robotics	Environment Sustainability and Impact assessment	Rotating Machinery Design	Computational Bio-Mechanics	Entrepreneurial Development
CAE and CFD approach in future Mobility	Ergonomics in design	Robots Applications and Maintenance	Energy Saving Machinery and Components	Thermal and Fired equipment design	CAD and CAE	
Hybrid and Electric Vehicle Technology	Process Planning and Cost Estimation (Common to Mech & Prod)	Drone Technology	Green Supply Chain Management	Industrial Engineering	Machine Learning for Intelligent systems	

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PROFESSIONAL ELECTIVE (PE)

VERTICAL I: MODERN MOBILITY SYSTEMS

Sl. No	Course Code	Course Title	Category	CA Marks	End sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	22MPE$01	AUTOMOTIVE MATERIALS, COMPONENTS, DESIGN AND TESTING	PE	40	60	100	3	0	0	3
2	22MPE$02	CONVENTIONAL AND FUTURISTIC VEHICLE TECHNOLOGY	PE	40	60	100	3	0	0	3
3	22MPE$03	RENEWABLE POWERED VEHICLES AND EMISSION CONTROL	PE	40	60	100	3	0	0	3
4	22MPE$04	VEHICLE HEALTH MONITORING	PE	40	60	100	3	0	0	3
5	22MPE$05	CAE AND CFD APPROACH IN FUTURE MOBILITY	PE	40	60	100	3	0	0	3
6	22MPE$06	HYBRID AND ELECTRIC VEHICLE TECHNOLOGY	PE	40	60	100	3	0	0	3

VERTICAL II: PRODUCT AND PROCESS DEVELOPMENT

Sl. No	Course Code	Course Title	Category	CA Marks	End sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	22MPE$07	VALUE ENGINEERING	PE	40	60	100	3	0	0	3
2	22MPE$08	ADDITIVE MANUFACTURING TECHNIQUES	PE	40	60	100	3	0	0	3
3	22MPE$09	COMPUTER INTEGRATED MANUFACTURING	PE	40	60	100	3	0	0	3
4	22MPE$10	DESIGN FOR MANUFACTURE	PE	40	60	100	3	0	0	3
5	22MPE$11	ERGONOMICS IN DESIGN	PE	40	60	100	3	0	0	3
6	22MPE$12	PROCESS PLANNING AND COST ESTIMATION (COMMON TO MECH & PROD)	PE	40	60	100	3	0	0	3

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VERTICAL III: ROBOTICS AND AUTOMATION / (MINOR)

Sl. No	Course Code	Course Title	Category	CA Marks	End sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	22MPE$13	PRINCIPLES OF ROBOTICS	PE	40	60	100	3	0	0	3
2	22MPE$14	ROBOTIC DRIVES AND CONTROL TECHNIQUES	PE	40	60	100	3	0	0	3
3	22MPE$15	KINEMATICS AND DYNAMICS OF ROBOTICS	PE	40	60	100	3	0	0	3
4	22MPE$16	ADVANCED MATERIALS FOR ROBOTICS	PE	40	60	100	3	0	0	3
5	22MPE$17	ROBOTS APPLICATIONS AND MAINTENANCE	PE	40	60	100	3	0	0	3
6	22MPE$18	DRONE TECHNOLOGY	PE	40	60	100	3	0	0	3

VERTICAL IV: DIGITAL AND GREEN MANUFACTURING

Sl. No	Course Code	Course Title	Category	CA Marks	End sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	22MPE$19	AUTOMATION IN MANUFACTURING	PE	40	60	100	3	0	0	3
2	22MPE$20	LEAN MANUFACTURING (COMMON TO MECH & PROD)	PE	40	60	100	3	0	0	3
3	22MPE$21	GREEN MANUFACTURING DESIGN AND PRACTICES	PE	40	60	100	3	0	0	3
4	22MPE$22	ENVIRONMENT SUSTAINABILITY AND IMPACT ASSESSMENT	PE	40	60	100	3	0	0	3
5	22MPE$23	ENERGY SAVING MACHINERY AND COMPONENTS	PE	40	60	100	3	0	0	3
6	22MPE$24	GREEN SUPPLY CHAIN MANAGEMENT	PE	40	60	100	3	0	0	3

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VERTICAL V: PROCESSES EQUIPMENT AND PIPING DESIGN

Sl. No	Course Code	Course Title	Category	CA Marks	End sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	22MPE$25	DESIGN OF PRESSURE VESSELS	PE	40	60	100	3	0	0	3
2	22MPE$26	FAILURE ANALYSIS AND NDT TECHNIQUES	PE	40	60	100	3	0	0	3
3	22MPE$27	MATERIAL PROCESSING AND SOLID PROCESSING EQUIPMENTS	PE	40	60	100	3	0	0	3
4	22MPE$28	ROTATING MACHINERY DESIGN	PE	40	60	100	3	0	0	3
5	22MPE$29	THERMAL AND FIRED EQUIPMENT DESIGN	PE	40	60	100	3	0	0	3
6	22MPE$30	INDUSTRIAL ENGINEERING	PE	40	60	100	3	0	0	3

VERTICAL VI: COMPUTATIONAL ENGINEERING

Sl. No	Course Code	Course Title	Category	CA Marks	End sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	22MPE$31	COMPUTATIONAL SOLID MECHANICS	PE	40	60	100	3	0	0	3
2	22MPE$32	COMPUTATIONAL FLUID DYNAMICS	PE	40	60	100	3	0	0	3
3	22MPE$33	THEORY ON COMPUTATION AND VISUALISATION	PE	40	60	100	3	0	0	3
4	22MPE$34	COMPUTATIONAL BIO-MECHANICS	PE	40	60	100	3	0	0	3
5	22MPE$35	CAD AND CAE	PE	40	60	100	3	0	0	3
6	22MPE$36	MACHINE LEARNING FOR INTELLIGENT SYSTEMS	PE	40	60	100	3	0	0	3

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VERTICAL VII: PROFESSIONAL ELECTIVE (NOT FOR SPECIALIZATION AND HONORS)

Sl. No	Course Code	Course Title	Category	CA Marks	End sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	22MPE$37	TOTAL QUALITY MANAGEMENT	PE	40	60	100	3	0	0	3
2	22MPE$38	GAS DYNAMICS AND JET PROPULSION	PE	40	60	100	3	0	0	3
3	22MPE$39	WELDING TECHNOLOGY	PE	40	60	100	3	0	0	3
4	22MPE$40	ENTREPRENEURIAL DEVELOPMENT	PE	40	60	100	3	0	0	3

FIXING OF VERTICALS FOR B.E. / B.TECH. MINOR DEGREE

VERTICAL I
INDUSTRIAL ROBOTICS AND AUTOMATION
PRINCIPLES OF ROBOTICS
ROBOTIC DRIVES AND CONTROL TECHNIQUES
KINEMATICS AND DYNAMICS OF ROBOTICS
ADVANCED MATERIALS FOR ROBOTICS
ROBOTS APPLICATIONS AND MAINTENANCE
DRONE TECHNOLOGY

VERTICAL I: ROBOTICS AND AUTOMATION / GROUP - 3

Sl. No	Course Code	Course Title	Category	CA Marks	End sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	22MPE$13	PRINCIPLES OF ROBOTICS	PE	40	60	100	3	0	0	3
2	22MPE$14	ROBOTIC DRIVES AND CONTROL TECHNIQUES	PE	40	60	100	3	0	0	3
3	22MPE$15	KINEMATICS AND DYNAMICS OF ROBOTICS	PE	40	60	100	3	0	0	3
4	22MPE$16	ADVANCED MATERIALS FOR ROBOTICS	PE	40	60	100	3	0	0	3
5	22MPE$17	ROBOTS APPLICATIONS AND MAINTENANCE	PE	40	60	100	3	0	0	3
6	22MPE$18	DRONE TECHNOLOGY	PE	40	60	100	3	0	0	3

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OPEN ELECTIVE (OE)

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1.	22COE$01	DISASTER MANAGEMENT AND MITIGATION	OE	40	60	100	3	0	0	3
2.	22COE$02	WATER SANITATION AND HEALTH	OE	40	60	100	3	0	0	3
3.	22MOE$03	NANOTECHNOLOGY AND SURFACE ENGINEERING	OE	40	60	100	3	0	0	3
4.	22MOE$04	INDUSTRIAL SAFETY MANAGEMENT	OE	40	60	100	3	0	0	3
5.	22EOE$05	RENEWABLE POWER GENERATION SYSTEMS	OE	40	60	100	3	0	0	3
6.	22EOE$06	SMART GRID TECHNOLOGY	OE	40	60	100	3	0	0	3
7.	22LOE$07	CMOS VLSI DESIGN	OE	40	60	100	3	0	0	3
8.	22LOE$08	MOBILE COMMUNICATION	OE	40	60	100	3	0	0	3
9.	22POE$09	RAPID PROTOTYPING	OE	40	60	100	3	0	0	3
10	22POE$10	MANAGERIAL ECONOMICS	OE	40	60	100	3	0	0	3
11.	22NOE$11	MEASUREMENT AND CONTROL	OE	40	60	100	3	0	0	3
12.	22NOE$12	INDUSTRIAL AUTOMATION	OE	40	60	100	3	0	0	3
13.	22SOE$13	PROGRAMMING IN JAVA	OE	40	60	100	3	0	0	3
14.	22SOE$14	NETWORK ESSENTIAL	OE	40	60	100	3	0	0	3
15.	22I0E$15	VIDEO CREATION AND EDITING	OE	40	60	100	3	0	0	3
16.	22IOE$16	DIGITAL MARKETING	OE	40	60	100	3	0	0	3
17.	22BOE$17	PRINCIPLES OF FOOD TECHNOLOGY	OE	40	60	100	3	0	0	3
18.	22BOE$18	BIOLOGY FOR ENGINEERS	OE	40	60	100	3	0	0	3

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EMPLOYABILITY ENHANCEMENT COURSE (EEC) – PRACTICAL COURSE AND PROJECT WORK

Sl. No.	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	22MEE602	SKILL DEVELOPMENT ON TECHNICAL AND INDUSTRIAL PRACTICES	EEC	60	40	100	0	0	3	1.5
2	22MEE603	MODELING AND SIMULATION LABORATORY	EEC	60	40	100	0	0	4	2
3	22MEE704	ENGINEERING PROJECTS IN COMMUNITY SERVICE	EEC	60	40	100	0	0	4	2
4	22MEE705	INTERNSHIP	EEC	100	-	100				4
5	22MEE806	CAPSTONE PROJECT	EEC	60	40	100	0	0	11	9.5

MANDATORY COURSE (MC)

Sl. No.	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	22MMC1Z0	INDUCTION PROGRAMME	MC	-	-	-	-	-	-	0
2	22MMC2Z1	ENVIRONMENTAL SCIENCES AND ENGINEERING	MC	40	60	100	3	0	0	0
3	22MMC5Z2	CONSTITUTION OF INDIA (COMMON TO ALL)	MC	40	60	100	3	0	0	0

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VALUE ADDED COURSE

Sl. No	Course Code	Course Title	Category	CA Marks	End sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	22MVA$07	YOGA AND ART OF LIVING	EE	100	-	100	1	0	0	1
2	22MVA$08	GEOMETRIC DIMENSIONING AND TOLERANCING	EE	100	-	100	1	0	0	1
3	22MVA$09	CONCEPTS OF METALLOGRAPHY	EE	100	-	100	1	0	0	1
4	22MVA$10	MICROMACHINING	EE	100	-	100	1	0	0	1
5	22MVA$11	WIND ENERGY MANAGEMENT	EE	100	-	100	1	0	0	1
6	22MVA$12	APPLICATIONS OF MATLAB IN MECHANICAL ENGINEERING	EE	100	-	100	1	0	0	1
7	22MVA$13	DESIGN OF E -VEHICLE	EE	100	-	100	1	0	0	1
8	22MVA$14	DESIGN OF PUMPS	EE	100	-	100	1	0	0	1
9	22MVA$15	DESIGN OF EXPERIMENTS	EE	100	-	100	1	0	0	1
10	22MVA$16	INDUSTRY 4.0	EE	100	-	100	1	0	0	1
11	22MVA$17	NON DESTRUCTIVE TESTING	EE	100	-	100	1	0	0	1
12	22MEE$18	ENTERPRISE RESOURCE PLANNING	EE	100	-	100	1	0	0	1

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SUMMARY OF CREDIT DISTRIBUTION

Sl. No	Category	Credits Per Semester								Total Credits	Total Credits in %	Credits as per AICTE model curriculum
		I	II	III	IV	V	VI	VII	VIII			
1	HS/HSMC	5	4					3		12	7.10	12
2	BS	11.5	8.5		4					24	14.20	25
3	ES	6	6	12	1.5					25.5	15.09	24
4	PC			12	18	15	12	7.5		64.5	38.17	48
5	PE					3	3	6	6	18	10.65	18
6	OE						3	3		6	3.55	18
7	EEC					1.5	3.5	6	8	19	11.24	15
8	MC	0	0			0						0
Total		22.5	18.5	24	23.5	19.5	21.5	25.5	14	169	100	160

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22MPC512	**HEAT AND MASS TRANSFER** *(Use of Approved Heat and Mass Transfer Data Book is permitted)*	**SEMESTER V**

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To familiarize and appreciate different modes of heat and mass transfer and its applications by imparting knowledge on bioprocess industries, design of heat and mass transfer equipment's and bio-reactors.	
UNIT – I	**MODES OF HEAT TRANSFER**	**(9 Periods)**
Modes of heat transfer; Fourier's law, thermal conductivity, steady state conduction in plane wall and composite walls; Heat flow in cylinder and spheres, countercurrent and parallel current flows; Energy balances, rate of heat transfer, overall heat transfer coefficient, logarithmic mean temperature difference, individual heat transfer coefficients, and fouling factors.		
UNIT – II	**HEAT TRANSFER TO FLUIDS WITHOUT PHASE CHANGE AND WITH PHASE CHANGE**	**(9 Periods)**
Thermal boundary layer, heat transfer by forced convection in laminar flow and turbulent flow; Natural convection to air from vertical and horizontal planes, heat transfer from condensing vapors and heat transfer to boiling liquids.		
UNIT – III	**DESIGN OF HEAT TRANSFER EQUIPMENTS**	**(9 Periods)**
General design of heat exchange equipment, heat exchangers, condensers, boilers and calandrias; Liquid characteristics, types of evaporators, performance of tubular evaporators, enthalpy balances for single effect evaporator.		
UNIT – IV	**DIFFUSION AND MASS TRANSFER**	**(9 Periods)**
Mass transfer operations, molecular diffusion in fluids, binary solutions, Fick's law of diffusion, equation of continuity, steady state equimolar counter current diffusion, Stefan's estimation of diffusivity in gases and liquids, application of molecular diffusion, theories of mass transfer.		
UNIT – V	**MASS TRANSFER OPERATIONS**	**(9 Periods)**
Introduction, counter and cocurrent isothermal absorption and stripping of single component, operating lines, minimum flow rate, determination of number of transfer units and height of continuous absorber, determination of number of plates; Steam distillation, flash vaporization and differential distillation for binary and multi component mixtures.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Yunus A. Cengel and Afshin J.Ghajar, **"Heat and Mass Transfer"**, McGraw Hill Company, 2020*
2	*Frank P Incropera and David P. Dewitt, **"Fundamentals of Engineering Heat and Mass Transfer"**, John Wiley and Sons, 2010.*

REFERENCES:

1	*C. J. King, **"Separation Processes"**, 2nd edition, McGraw Hill, 2014.*
2	*P.M. Doran, **"Bioprocess Engineering Principles"**, 2nd edition, Academic Press, 2012.*
3	*R.E.Treybal, **"Mass Transfer Operations"**, 3rd edition, Mc-Graw Hill, 2017.*
4	*Ozisik M.N., **"Heat Transfer",** McGraw Hill Book Co., 2005*
5	*Yadav R., **"Heat and Mass Transfer"**, Central Publishing House, Allahabad, 2018*

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COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand the basic modes of heat and mass transfer.	K1
CO2	Apply principles of heat and mass transfer to predict transfer coefficients	K1
CO3	Analyze working of various heat transfer equipment	K2
CO4	Design heat and mass transfer equipment.	K2
CO5	Evaluate number of stages required for given mass transfer problem.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping														
COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	2	3	1	2	1	2	2	1	1	1	1	1	2	
CO2	1	2	2	2	1	2	1	1	1	1	1	1	1	3	
CO3	1	3	3	2	2	2	1	1	1	1	1	1	1	2	
CO4	1	3	2	1	1	1	2	2	1	1	1	1	1	3	
CO5	1	3	3	2	2	1	1	1	1	1	1	1	1	2	
22MPC512	1	3	3	2	2	1	1	1	1	1	1	1	1	2	
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.2.1, 2.1.1, 3.1.1, 4.1.4, 10.3.1, 12.1.2														
CO2	1.3.1, 2.1.3, 4.1.1, 12.3.2														
CO3	1.4.1, 2.2.4, 3.1.6, 4.1.4, 4.3.2, 7.2.1														
CO4	1.3.1, 2.2.4, 2.4.2, 3.1.6, 4.2.1, 5.1.1, 7.1.2, 11.2.1, 12.1.2, 12.3.2														
CO5	1.1.2, 2.2.4, 3.4.1, 4.2.1, 7.1.1														

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	30	10	10	10	10	100
CAT2	10	10	20	20	20	20	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	30	30	10	10	10	10	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	10	10	20	20	20	20	100
ESE	25	20	15	15	15	10	100

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22MPC513	DESIGN OF MACHINE ELEMENTS *(Use of Approved Design Data Book is permitted)*	SEMESTER V

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To study proper procedure and standards to design the different machine elements depending on their physical and mechanical properties along with the theories of failures.	
UNIT – I	**BASICS OF DESIGN**	**(9 Periods)**
Basic concept of design, classification of design, design procedure – factors influencing machine design, Engineering parameters - Stress-strain diagrams - Mechanical properties of engineering materials – preferred numbers, fits and tolerances – Modes of failure – Stresses acting on machine elements - Stress due to bending and eccentric axial loading - Principal stresses - Theories of elastic failure - Selection and application of failure theories.		
UNIT – II	**FLUCTUATING STRESSES AND DESIGN OF SHAFT**	**(9 Periods)**
Fluctuating Stresses - Stress concentration - Fatigue failure - Endurance limit-low and high cycle fatigue – Notch Sensitivity - Reversed stresses - Soderberg, Goodman and Gerber relations - Design of shaft under static loading – Problems under single plane and two plane load acting shafts- Design of shaft under fatigue loading - Case studies.		
UNIT – III	**DESIGN OF ENERGY STORING ELEMENTS**	**(9 Periods)**
Design of helical spring -, Design of torsional spring - Design of leaf springs - Design of flywheels considering stresses in rims and arms for engines and punching machines. Case studies - springs and flywheel.		
UNIT – IV	**DESIGN OF TEMPORARY AND PERMANENT JOINTS**	**(9 Periods)**
Introduction about temporary joints – Types of temporary joints- Design of bolted joints (sleeve and cotter joint, Knuckle joint) - Design of joints with variable loading, adhesive joints – Types of permanent joints - Design of riveted joints - Design of welded joints in plates and pressure vessels - Design of eccentrically loaded riveted and welded joints. Case studies - joint applications.		
UNIT – V	**MISCELLANEOUS ELEMENTS**	**(9 Periods)**
Design of rigid coupling - Design of flexible coupling –Design of connecting rods - Design of crank shafts – Design and selection of rolling and sliding contact bearing.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*V.B. Bhandari, **"Design of Machine Elements"**, McGraw Hill Publication, 5th Edition, October 2020.*
2	*T.V. Sundarajamoorthy and N. Shanmugam, **"Machine Design"**, Anuradha Agencies Publishers, November 2017.*

REFERENCES:

1	*Shigley, J.E. and Mischke, C.R., **"Mechanical Engineering Design"**, Tenth Edition, McGraw Hill International, 2014.*
2	*R.S. Khurmi, Gupta J.K, **A text book of Machine Design**, S. Chand & Co, May 2020.*
3	*N.C.Pandya, C.S.Shah, **"Machine Design"**, 20th Edition, 2015.*
4	*Gitin M. Maitra, L.V.Prasad, **"Hand Book of Mechanical Design"**, 2nd Edition, 2004.*
5	*Robert L Mott, **"Machine Elements in Mechanical Design"**, Pearson, 2020.*
6	***"Design Data"** – P.S.G. College of Technology, Coimbatore.*

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	COURSE OUTCOMES: Upon completion of the course, the students will be able to:	**Bloom's Taxonomy Mapped**
CO1	Understand the different types of designs, stresses, material properties and their significance in machine elements design	K4
CO2	Design the shafts by considering failure theories for reliability	K5
CO3	Design the energy storing elements for various applications according to the prescribed standards	K5
CO4	Design the temporary and permanent joints for fabrication of different machine components and boilers as per the standards	K5
CO5	Design the connecting rod, crank shaft and selection of couplings and bearings for industrial applications	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	2	1	3	2	1	0	1	0	2	1	1	1
CO2	3	3	3	3	3	3	3	3	2	2	3	3	2	2	2
CO3	2	2	3	3	2	3	2	2	1	2	2	1	2	2	3
CO4	2	2	3	3	2	3	2	2	1	2	2	1	3	3	3
CO5	2	2	3	3	2	3	2	2	1	2	2	1	3	3	3
22MPC513	2	2	3	3	2	3	2	2	1	2	2	2	2	2	2
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.1.1, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2. 2.1.3, 2.2.3, 2.3.2, 2.4.1, 2.4.2, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.6, 3.3.1, 3.3.2, 3.4.2, 4.1.4, 4.2.1, 4.3.1, 4.3.3, 4.3.4, 5.2.1, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 8.2.2, 10.1.1, 12.1.1, 12.2.1, 12.2.2, 12.3.1														
CO2	1.1.1, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2,5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.1, 8.2.2, 9.1.2, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.3.1, 11.1.1, 11.1.2, 11.2.1, 11.3.1, 11.3.2, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2														
CO3	1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.3.2, 2.4.1, 2.4.2, 2.4.4, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.3.1, 3.3.2, 3.4.2, 4.1.1, 4.1.2, 4.1.4, 4.2.1, 4.3.1, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.2.2, 8.2.1, 8.2.2, 9.1.2, 9.3.1, 10.1.2, 10.1.3, 10.3.1, 11.1.1, 11.3.1, 11.3.2, 12.2.1, 12.3.1														
CO4	1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.4, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.3.1, 3.3.2, 3.4.2, 4.1.1, 4.1.2, 4.1.4, 4.2.1, 4.3.1, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.2.2, 8.2.1, 8.2.2, 9.1.2, 9.3.1, 10.1.2, 10.1.3, 10.3.1, 11.1.1, 11.3.1, 11.3.2, 12.2.1, 12.3.1														
CO5	1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.4, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.3.1, 3.3.2, 3.4.2, 4.1.1, 4.1.2, 4.1.4, 4.2.1, 4.3.1, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.2.2, 8.2.1, 8.2.2, 9.1.2, 9.3.1, 10.1.2, 10.1.3, 10.3.1, 11.1.1, 11.3.1, 11.3.2, 12.2.1, 12.3.1														

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ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	30	40	20	-	-	100
CAT2	10	30	40	20	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	10	30	40	20	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	10	30	40	20	-	-	100
ESE	10	30	40	20	-	-	100

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22MPC514	DYNAMICS OF MACHINES	SEMESTER V

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To learn the techniques of Force analysis, Flywheel, Governors, Gyroscope, Balancing and vibration to solve engineering problems.	
UNIT – I	**FORCE ANALYSIS**	**(9 Periods)**
Static equilibrium of two/three force members – Static equilibrium of member with two forces and torque – Static force analysis of linkages – D'Alembert's principle – Equivalent offset inertia force – Dynamic force analysis of four link mechanism and slider crank mechanism – Dynamically equivalent system Engine force analysis – Piston and crank effort – Turning moment on crankshaft – Turning moment diagrams – single cylinder double acting steam engine – four stroke IC engine and multi-cylinder steam engine – Fluctuation of energy – Flywheel and its design		
UNIT – II	**GOVERNORS AND GYROSCOPE**	**(9 Periods)**
Governors Terminology - Centrifugal governors -Watt governor - Dead weight governors - Porter & Proell governor - Spring controlled governor- Hartnell governor - Sensitivity, Stability – Hunting – Isochronism - Effort and Power of governor - Gyroscopic Motion Principles - Gyroscopic torque - Effect of gyroscopic couple on the stability of aeroplanes, ships& automobiles.		
UNIT – III	**BALANCING OF MACHINES**	**(9 Periods)**
Static and dynamic balancing - Balancing of several masses rotating in the same plane and different planes - Balancing of primary and secondary forces in reciprocating engine - Partial balancing of two - cylinder locomotives - Variation of tractive force - swaying couple - hammer blow - Balancing of two cylinder in-line engines		
UNIT – IV	**FREE VIBRATION**	**(9 Periods)**
Basic elements of vibrating system - Types of free vibrations - Longitudinal vibrations - Equilibrium method - D'Alembert's principle - Energy method - Rayleigh's method - Determination of natural frequency of single degree freedom systems - Effect of spring mass - Damped free vibrations - Under damped - over damped and critically damped systems - Logarithmic decrement.		
UNIT – V	**FORCED VIBRATION**	**(9 Periods)**
Undamped forced vibration of spring mass system – Torsional vibration - Damped forced vibrations - Rotating unbalance - Reciprocating unbalance - Vibration isolation - Support motion (absolute and relative motion) - Transverse vibration of shaft with single concentrated load, several loads, and uniformly distributed load - Critical speed. Introduction to Noise, Vibration and Harshness (NVH)		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Sadhu Singh, **"Theory of Machines: Kinematics and Dynamics"**, Pearson Third edition 2019.*
2	*G. Ambekar, **"Mechanism and Machine Theory"**, PHI 2009.*

REFERENCES:

1	*Rattan S.S., **"Theory of Machines"**, Tata McGraw-Hill Publishing Company 2019.*
2	*Michael M, **"Mechanisms and Machines- Kinematics, Dynamics and Synthesis"**, Stanisic Cengage Learning 2016.*
3	*J. J. Uicker (Jr), G. R. Pennock, and J. E. Shigley, **"Theory of Machines and Mechanisms"**, 3rd Ed., Oxford International Student Edition, 2014.*

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4	*Robert L. Norton*, "***Kinematics and Dynamics of Machinery"***, *2nd Edition, McGraw Hill, 2020.*
5	*J S Rao and R V Dukkipat*, "***Mechanism and Machine Theory"***, *2nd Ed., New Age Intl., 2008*
6	*Kenneth J. Waldron, Gary L. Kinzel, Sunil K. Agarwal*, "***Kinematics, Dynamics, and Design of Machinery"***, *3rd Edition, John Wiley & Sons, Ltd., 2016.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Able to solve force analysis and turning moment problems.	K1
CO2	Frame and solve Governor and Gyroscopic problems.	K2
CO3	Follow systematic procedure to do balancing of rotary and reciprocating masses.	K2
CO4	Derive equations for vibration problems and to solve free vibration problems.	K3
CO5	Derive equations for vibration problems and to solve forced vibration problems.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	0	1	3	0	0	0	0	0	0	0	3	1	2
CO2	3	3	0	1	2	0	0	0	0	0	0	0	3	2	2
CO3	3	3	0	0	3	0	0	0	0	0	0	0	3	1	2
CO4	3	3	0	0	3	0	0	0	0	0	0	0	3	2	2
CO5	3	3	0	0	3	0	0	0	0	0	0	0	3	2	2
22MPC514	3	2	0	1	3	0	0	0	0	0	0	0	3	1	2
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.3, 2.2.1, 2.2.3, 2.2.4, 2.4.4, 4.3.4, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2														
CO2	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 4.1.4, 5.1.2, 5.2.1, 5.3.1, 5.3.2														
CO3	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2														
CO4	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2														
CO5	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2														

ASSESSMENT PATTERN							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	70	20	10				100
CAT2	50	30	20				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	60	40					100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	50	30	20				100
ESE	50	30	20				100

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22MPC515	THEORY OF ELASTICITY	SEMESTER V

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To impart the knowledge of the fundamentals of Theory of Elasticity for 2D problems on torsion and bending using Generalized Hook's law based equilibrium equation in Cartesian and polar coordinate systems.	
UNIT – I	**BASICS OF ELASTICITY**	**(9 Periods)**
Stress-strain relations for linearly elastic solids, Generalized Hooke's law. Analysis of three dimensional stresses and strains. Tensor character of stress. Strain-displacement relations, equilibrium equations, Compatibility Equations Strain displacement relationship.		
UNIT – II	**PLANE STRESS AND PLANE STRESS TWO DIMENSIONAL PROBLEMS IN CARTESIAN COORDINATES**	**(9 Periods)**
Plane stress- Stress at a point, Plane stress problems- equilibrium equations, Compatibility Equations Plane strain- Strain at a points, Plane strain problems- equilibrium equations, Compatibility Equations. Solution by polynomials, Saint-Venant's Principle, Bending of a cantilever beam loaded at the End.		
UNIT – III	**TWO DIMENSIONAL PROBLEMS IN POLAR COORDINATES AND TORSION**	**(9 Periods)**
General Equations in Polar coordinates, Strain displacement relationship in polar coordinates system, Airy's stress function, Thick cylinder under uniform pressure. Torsion- Saint-Venant's approach, torsion of circular cross sectional, Membrane analogy-Torsion of Thin Walled-Open and Closed sections.		
UNIT – IV	**SHEAR CENTER AND UNSYMMETRICAL BENDING**	**(9 Periods)**
Location of shear center for various thin sections - shear flows. Stresses and Deflections in beams subjected to unsymmetrical loading-kern of a section.		
UNIT – V	**ENERGY THEOREMS**	**(9 Periods)**
Strain energy for 2D and 3D- principle of complementary energy- Principle of virtual work – Reciprocal theorem – Raleigh Ritz method.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total:45 Periods**		

TEXT BOOKS:

1	*PN Chandramouli, "* ***Theory of Elasticity****", Yes Dee Publishing Pvt. Limited, 2017*
2	Helena, H. Jane, "***Theory of Elasticity and Plasticity***", PHI Learning; 1st edition, 2017

REFERENCES:

1	*Timeshenko.S.P and Goodier.J.N, "****Theory of Elasticity****", McGraw hill international edition, 2017.*
2	*Sadhu Singh, "****Theory of Elasticity and metal forming processes****", Khanna publishers, 2016.*
3	*L D Landau, L. P. Pitaevskii, A. M. Kosevich, E.M. Lifshitz," **Theory of Elasticity",** Elsevier, 2012.*
4	*A.I. Lurie," **Theory of Elasticity",** Springer Science & Business Media, 2010.*

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COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	To learn the concepts of theory of elasticity in three-dimensional stress system.	K3
CO2	To Illustrate the equilibrium and compatibility conditions in Cartesian coordinate systems for plane stress and strain problems	K5
CO3	To Investigate the 2D stress system using Airy's stress function in Polar Coordinates and Torsion problems	K5
CO4	To Determine the shear center of various cross-sections and deflections in beams subjected to unsymmetrical bending	K5
CO5	To solve elastic problems using energy principles	K5

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	0	0	1	0	2	1	3	1	2	1
CO2	3	3	2	1	1	0	0	1	0	2	1	3	1	2	1
CO3	3	3	2	1	1	0	0	1	0	2	1	3	1	2	1
CO4	3	3	2	1	1	0	0	1	0	2	1	3	1	2	1
CO5	3	3	2	1	1	0	0	1	0	2	1	3	1	2	1
22MPC515	3	3	2	1	1	0	0	1	0	2	1	3	1	2	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.4.2,2.4.3,2.4.4,3.1.1,3.1.6,3.2.1,3.3.2,3.4.1,4.1.1,5.2.2,5.3.2, 8.2.1,10.1.1,10.1.2,10.3.1,11.3.1,12.1.1,12.2.1,12.2.2,12.3.1,12.3.2
CO2	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.1,2.3.1,2.3.2,2.4.1,2.4.2,2.4.3,2.4.4,3.1.1,3.1.2,3.1.3,3.1.6, 3.2.1,3.3.2,3.4.1,4.1.1,5.2.2,5.3.2,8.2.1,10.1.1,10.1.2,10.3.1,11.3.1,12.1.1,12.2.1,12.2.2,12.3.1,12.3.2
CO3	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.1,2.3.1,2.3.2,2.4.1,2.4.2,2.4.3,2.4.4,3.1.1,3.1.2,3.1.3,3.1.6, 3.2.1,3.3.2,3.4.1,4.1.1,5.2.2,5.3.2,8.2.1,10.1.1,10.1.2,10.3.1,11.3.1,12.1.1,12.2.1,12.2.2,12.3.1,12.3.2
CO4	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.1,2.3.1,2.3.2,2.4.1,2.4.2,2.4.3,2.4.4,3.1.1,3.1.2,3.1.3,3.1.6, 3.2.1,3.3.2,3.4.1,4.1.1,5.2.2,5.3.2,8.2.1,10.1.1,10.1.2,10.3.1,11.3.1,12.1.1,12.2.1,12.2.2,12.3.1,12.3.2
CO5	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.1,2.3.1,2.3.2,2.4.1,2.4.2,2.4.3,2.4.4,3.1.1,3.1.2,3.1.3,3.1.6, 3.2.1,3.3.2,3.4.1,4.1.1,5.2.2,5.3.2,8.2.1,10.1.1,10.1.2,10.3.1,11.3.1,12.1.1,12.2.1,12.2.2,12.3.1,12.3.2

ASSSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	5	10	45	20	20		100
CAT2	5	10	45	20	20		100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	5	10	45	20	20		100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	5	10	45	20	20		100
ESE	5	10	45	20	20		100

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22MMC5Z2	CONSTITUTION OF INDIA *(Common to all branches)*	SEMESTER V

PREREQUISITES	CATEGORY	L	T	P	C
NIL	MC	3	0	0	0

Course Objectives	The objective of the course is to familiarize the students on the role, powers and functions of Indian government. Also understand the recent acts in India.	
UNIT – I	**INTRODUCTION AND EMERGENCY PROVISIONS**	**(9 Periods)**
Historical Background: The Company rule, The Crown rule - Constituent Assembly: Composition, Objectives - Preamble and Salient features of the Indian Constitution - Fundamental Rights, Fundamental Duties, Directive Principles of state policy, Emergency Provisions - National Emergency, President Rule, Financial Emergency.		
UNIT – II	**SYSTEM OF GOVERNMENT**	**(9 Periods)**
Parliamentary system: merits, demerits, reasons for adopting parliamentary system – Federal system: Evaluation of federal features – Centre-State relations: Legislative, Administrative and Financial relations – Local Government: Panchayat Raj and urban local government.		
UNIT – III	**UNION AND STATE GOVERNMENT**	**(9 Periods)**
President of India: Election, Powers and functions - Prime Minister and Cabinet: Structure and functions – Governor: Powers and functions - Chief Minister and Council of Ministers: Functions.		
UNIT – IV	**ORGANS OF GOVERNANCE AND RECENT ACTS**	**(9 Periods)**
Parliament: Lok Sabha and Rajya Sabha, Composition and powers - State Legislative Assembly and Legislative Council: Composition and powers - Judicial System in India: Structure and features - Supreme Court and High Court: Composition, Jurisdiction, Recent acts in significance- RTI, Citizenship act, POCSO act.		
UNIT – V	**POLITICAL DYNAMICS**	**(9 Periods)**
Political parties: Party system, Recognition of National and State parties – Elections: Electoral system and reforms – Pressure groups – National Integration: Obstacles, National Integration Council – Foreign Policy: Principles and Objectives.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*National portal of India, "**The Constitution of India**" (Full Text), https://legislative.gov.in/constitution-of-india*
2	*Dr.B.R.Ambedkar, "**The Constitution of India**", SudhirPrakashan, 2020*

REFERENCES:

1	*Durga Das Basu, "**Introduction to the Constitution of India**, LexisNexis, 2022*
2	*P.M.Bakshi, "**The Constitution of India**", LexisNexis, 2020*
3	*Subash C Kashyap, "**Our Parliament**", National Book Trust, 2021*
4	*Subash C Kashyap, "**Our Political System**", National Book Trust, 2011*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Know the evolution of Indian Constitution and its basic premises.	K1
CO2	Explain the system of governance in India.	K2
CO3	Describe the structure of Union and State Governments	K2
CO4	Obtain the knowledge of functions of Legislature and Judiciary	K1
CO5	Know the political system of India	K1

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COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	1	-	1	1	-	-	-	-	-	-
CO3	-	-	-	-	-	2	-	1	1	-	-	-	-	-	-
CO4	-	-	-	-	-	1	-	1	2	-	-	-	-	-	-
CO5	-	-	-	-	-	2	-	2	1	-	-	-	-	-	-
22MMC5Z2	-	-	-	-	-	**2**	-	**1**	**1**	-	-	-	-	-	-
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	6.1.1, 6.2.1, 8.1.1, 8.2.1, 8.2.2, 9.1.2
CO2	6.1.1, 6.2.1, 8.1.1, 8.2.1, 8.2.2, 9.1.2
CO3	6.1.1, 6.2.1, 8.1.1, 8.2.1, 8.2.2
CO4	6.1.1, 6.2.2, 9.1.2, 9.2.1
CO5	6.2.2, 8.1.1,8.2.2, 9.1.2, 9.2.1

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	50	50					100
CAT2	50	50					100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50					100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	50	50					100
ESE	50	50					100

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22MPC516	CAD LABORATORY	SEMESTER V

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	0	0	3	1.5

Course Objectives	Understand the usage of CAD software packages for mechanical parts and assembly.

LIST OF EXPERIMENTS

1. CAD – 2D - Sketching - Create, Edit, Layers, Construction, Dimension, Sketch, constraints, Datum planes, Construction aids – 2D Drawing.

2. 3D Part Modeling – Protrusion, Cut, Sweep, Draft, Loft, Blend, Rib – Simple Mechanical Component

3. Assembly of 3D Parts – Mechanical and Automobile Components

4. Conversion of 3D solid model to 2D drawing - orthographic views, sectional views and dimensioning with GD and T.

5. Surface Modeling – Mechanical and Automobile Components

6. Introduction to HVAC, Duct drawing in a Buildings.

7. Introduction to File Import, Export – DXF, IGES, STL, STEP formats.

Contact periods:
Lecture: 0 Period Tutorial: 0 Period Practical: 45 Periods Total: 45 Periods

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Develop and create models of different mechanical system using CAD packages and its tools.	K3
CO2	Apply the different surface modeling tools.	K3
CO3	Assemble the mechanical parts as per the industrial drawings.	K3
CO4	Import and export files in different formats.	K3
CO5	Evaluate the Industrial drawings.	K3

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COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	3	2	3						2	1	2	3	2
CO2	2	2	3	2	3						2	1	2	3	2
CO3	2	2	3	2	3						2	1	2	3	2
CO4	2	2	3	2	3						2	1	2	3	2
CO5	2	2	3	2	3						2	1	2	3	2
22MPC516	2	2	3	2	3						2	1	2	3	2
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.2.1,1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.2.1,4.2.2, 4.3.1, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 11.1.1, 11.2.1, 11.3.2, 12.2.2, 12.3.2
CO2	1.2.1,1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.2.1,4.2.2, 4.3.1, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 11.1.1, 11.2.1, 11.3.2, 12.2.2, 12.3.2
CO3	1.2.1,1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.2.1,4.2.2, 4.3.1, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 11.1.1, 11.2.1, 11.3.2, 12.2.2, 12.3.2
CO4	1.2.1,1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.2.1,4.2.2, 4.3.1, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 11.1.1, 11.2.1, 11.3.2, 12.2.2, 12.3.2
CO5	1.2.1,1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.2.1,4.2.2, 4.3.1, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 11.1.1, 11.2.1, 11.3.2, 12.2.2, 12.3.2

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22MPC517	THERMAL ENGINEERING LABORATORY II	SEMESTER V

PREREQUISITES	CATEGORY	L	T	P	C
1. 22MPC407 THERMAL ENGINEERING	PC	0	0	3	1.5

Course Objectives	To provide exposure to the students on studying the performance of heat transfer equipment's

LIST OF EXPERIMENTS

1. Test on pin fin apparatus.
2. Test on counter flow heat-exchanger.
3. Determination of convection heat transfer coefficient.
4. Determination of thermal resistance and conductivity.
5. Determination of emissivity of non-black surfaces.
6. Determination of transient temperature distribution.
7. Performance test on cooling tower.
8. Determination of COP of a heat pump.
9. Determination of COP of a refrigeration system.
10. Determination of COP of an air-conditioning system.
11. Study of Boiler, Steam turbines and Steam Engines.

Contact periods:
Lecture: 0 Period Tutorial: 0 Period Practical: 45 Periods Total: 45 Periods

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Conduct of experiments on heat transfer.	K4
CO2	Estimate COP of refrigerator, heat pump and air-conditioning system.	K4
CO3	Illustrate the working of boiler, steam turbines and steam engines.	K4

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COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	3	2	3	3	2	2	1	1	1	1	2	1	1	2
CO2	2	2	2	3	3	3	3	1	1	1	1	2	2	2	2
CO3	2	2	2	2	1	2	2	-	-	1	1	1	1	1	2
22MPC517	2	2	2	3	2	2	2	1	1	1	1	2	1	1	2
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.1, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.6, 3.2.1, 3.3.1, 3.4.1, 3.4.2, 4.1.2, 4.2.1, 4.3.1, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 7.2.2, 8.2.1, 10.1.2, 10.1.3, 10.3.1, 11.1.2, 11.2.1, 12.1.1, 12.2.2, 12.3.2.
CO2	1.1.2, 2.2.2, 2.4.4, 3.1.4, 3.1.5, 3.1.6, 3.2.2, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.4, 4.2.1, 4.2.2, 4.3.2,4.3.3, 4.3.4, 5.1.2, 5.2.2, 7.1.1, 7.1.2, 7.2.1, 8.1.1, 9.2.1, 10.1.1, 10.1.2, 10.2.2, 12.1.1, 12.3.2.
CO3	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.4.1, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.5, 3.1.6, 3.2.1, 3.2.3, 3.3.1, 4.1.1, 4.1.2, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.3, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.2.1, 8.1.1, 9.1.1, 9.2.4, 10.1.3, 10.3.1, 11.1.2, 11.2.1, 11.3.1, 12.1.2, 12.2.1.

22MES501	DESIGN THINKING FOR MECHANICAL ENGINEERING	SEMESTER V

PREREQUISITES	CATEGORY	L	T	P	C
NIL	ES	0	0	3	1.5

Course Objectives	To Conceive, conceptualize, design and demonstrate innovative ideas using prototypes.	
UNIT – I	**INTRODUCTION**	**(9 Periods)**
Design process: Traditional design, Design thinking, Existing sample design projects, Study on designs around us, Compositions/structure of a design – day to day examples and case studies. Design team-Team formation, Selection of problem statement.		
UNIT – II	**INNOVATIVE DESIGN**	**(9 Periods)**
Innovative design: Breaking of patterns, Reframe existing design problems with suitable examples, Principles of creativity, Empathy: Customer Needs, Insight-leaving from the lives of others/standing on the shoes of others, Observation.		
UNIT – III	**CONCEPTUALIZATION**	**(9 Periods)**
Conceptualization: Visual thinking, Drawing/sketching, New concept thinking, Patents and Intellectual Property, Concept Generation Methodologies, Concept Selection, Concept Testing, Opportunity identification		
UNIT – IV	**PROTOTYPING**	**(9 Periods)**
Prototyping: Principles of prototyping, Prototyping technologies, Prototype using simple things, Wooden model, Clay model, 3D printing; Experimenting/testing.		
UNIT – V	**DESIGN PROJECT**	**(9 Periods)**
Sustainable product design, Ergonomics, Semantics, Entrepreneurship/business ideas, Product Data Specification, Establishing target specifications, Setting the final specifications. Design projects for teams.		
Contact Periods: **Lecture: 0 Periods Tutorial: 0 Periods Practical: 45 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Tim Brown, "**Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation**", HarperCollins Publishers Ltd*
2	*Idris Mootee, "**Design Thinking for Strategic Innovation**",2013, John Wiley & Sons Inc*

REFERENCES:

1	*Brenda Laurel, "**Design Research Methods and Perspectives**", MIT press 2003*
2	*Terwiesch, C. & Ulrich, K.T., 2009. "**Innovation Tournaments: Creating and Identifying Exceptional Opportunities**", Harvard business press.*
3	*Ulrich &Eppinger, "**Product Design and Development**", 3rd Edition, McGraw Hill, 2004*
4	*Kevin Henry, "**Drawing for Product Designers**", 2012, Laurence King Publishing Ltd*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand the differences between traditional and design thinking process	K2
CO2	Demonstrate the critical theories of design, systems thinking, and design methodologies.	K3
CO3	Produce great designs, be a more effective engineer, and communicate with high emotional and intellectual impact	K3
CO4	Understand the diverse methods employed in design thinking and establish a workable design thinking framework to use in their practices	K4
CO5	Conceive, organize, lead and implement projects in interdisciplinary domain and address social concerns with innovative approaches	K6

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

Cos/Pos	PO 1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO1	3	2									1	2	1		
CO2	3	2	3	2	1	1					1	1	1		
CO3	3	2	3	2	1	1	1		2		2	1	1		
CO4	2	2	2	2	1	1			2		1	1	1		
CO5	3	2	3	2	1	1	2		2		2	1	1		
22MES501	3	2	2	2	1	1	1		1		1	1	1		
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 2.1.2, 11.1.1, 12.1.1.
CO2	1.2.1, 1.4.4, 2.1.2, 2.2.3, 3.1.1, 4.1.1, 4.1.2, 5.1.1, 6.1.1, 7.1.2, 9.1.1, 11.1.1, 12.1.1.
CO3	1.2.1, 1.4.4, 2.1.2, 2.2.3, 3.1.1, 4.1.1, 4.1.2, 5.1.1, 6.1.1,7.1.1, 9.1.1, 11.1.1, 12.1.1.
CO4	1.2.1, 1.4.4, 2.1.2, 2.2.3, 3.1.1, 4.1.1, 4.1.2, 5.1.1, 6.1.1, 9.1.1, 11.1.1, 12.1.1.
CO5	1.2.1, 1.4.4, 2.1.2, 2.2.3, 3.1.1, 4.1.1, 4.1.2, 5.1.1, 6.1.1, 7.1.2, 9.1.1, 11.1.1, 12.1.1.

ASSESSMENT PATTERN – THEORY

The students will be divided into teams and a problem statement will be assigned to each at starting of the semester. Each team will follow the design thinking approach for fabricating the product which will be assessed periodically by the course instructor.

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	50	30	20				100
CAT2	50	30	20				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1		10	40	10	10	30	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2		10	40	10	10	30	100
ESE		10	30	10	10	40	100

22MPC618	METROLOGY AND QUALITY CONTROL	SEMESTER VI

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To Learn the concept of Linear and Angular measuring instruments and the working principles of advanced devices used in metrology and to gain knowledge about the Statistical Quality Control process, Reliability and Acceptance of sampling.	
UNIT – I	**LINEAR AND ANGULAR MEASUREMENTS**	**(9 Periods)**
Length Standards - Length Measuring instruments - Vernier instruments - micrometer, height gauge, dial indicators, Bore gauges, Slip gauges, Comparators - Mechanical, Electrical, Optical and Pneumatic, Optical Projector. Angle measuring instruments - Bevel protractor, Spirit level, Sine bar, Autocollimator, Angle Decker.		
UNIT – II	**MAGNIFICATION AND FORM MEASUREMENT**	**(9 Periods)**
Mechanical, Optical, electrical, Pneumatic method of magnification. Gear tooth terminology- Methods of measurements of run out, pitch, profile, lead, backlash, tooth thickness Screw thread terminology- Measurement of effective diameter by two wire and three wire methods -errors in threads- Measurement of pitch, profile errors and total composite errors, composite method of inspection - Parkinson gear tester - Measurement of surface finish - Stylus probe instruments - Tomlinson and Talysurf instrument-Straightness, Flatness and Roundness measurement.		
UNIT – III	**RECENT TRENDS IN METROLOGY**	**(9 Periods)**
Precision instruments based on Laser- laser interferometer – Universal Measuring Machine- Toolmaker's microscope - Coordinate Measuring Machine (CMM): need, construction, types, Applications- Computer Aided Inspection, Machine Vision - Introduction to Nano metrology. Six sigma concepts – Poka Yoke – Computer controlled systems used in inspection		
UNIT – IV	**STATISTICAL QUALITY CONTROL**	**(9 Periods)**
Concept of Quality and quality control, Quality of design and conformance, balance between cost and quality and value of quality. Specification of quality, planning through trial lots and for essential information - significance of SQC - benefits and limitations of SQC – Quality assurance - Quality cost - quality engineering tools and techniques – Computer aided Quality Control. Process capability – process capability studies – Construction and uses of control charts.		
UNIT – V	**RELIABILITY AND SAMPLING METHODS**	**(9 Periods)**
Reliability: Definition, relationship of reliability with maintainability and availability, failure data analysis- bath tub curve, system reliability, reliability improvement. Sampling inspection and percentage inspection, basic concept of sampling inspection, Lot by lot sampling - probability of acceptance in single, double, multiple sampling techniques – OC curves – producers' risk and consumers' risk. Acceptable quality level, Lot Tolerance Percent Defective, Average Outgoing Quality Level concepts-standard sampling plans for AQL and LTPD.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS

1	*Jain R.K., **"Engineering Metrology",** Khanna Publishers, 2022.*
2	*Beckwith, Marangoni, Lienhard, **"Mechanical Measurements"**, Pearson Education, 2020.*

REFERENCES:

1	*Gupta S.C,* ***"Engineering Metrology"****, Dhanpat rai Publications, 2018*
2	*Douglas C. Montgomery,* ***"Introduction to Statistical Quality Control"****, John wiley & sons, 2010.*
3	*Shotbolt, C.S. and Galyer. J.* ***"Metrology for Engineers"****, Cassell Publications., Fifth Edition, 1990*.
4	*Anthony, D.M.* ***"Engineering Metrology"****, Pergamon Press, First Edition, 1986.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Apply the Knowledge to operate linear and angular measurement devices.	K3
CO2	Gain knowledge about the Magnification, comparators, and form measurements with effective communication.	K2
CO3	Understand the principles of advanced instruments used in Industries.	K4
CO4	Learn about the concept of quality control and various control charts for the variables and attributes.	K4
CO5	Apply the concept of reliability and various sampling methods for suitable applications.	K4

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	2	3	3	1	1	1	2	2	2	3	1	2
CO2	2	2	2	2	2	2	2	1	1	1	3	2	1	2	1
CO3	3	2	2	2	2	2	2	1	1	2	2	1	1	1	1
CO4	2	3	2	2	2	3	2	1	2	1	2	2	1	1	1
CO5	3	2	2	3	1	3	3	2	-	2	3	2	2	3	3
22MPC618	3	2	2	2	2	3	2	1	1	2	2	2	1	2	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2,2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1,4.1.2, 4.1.3,4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1,6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4,9.3.1, 10.1.1,10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.1, 11.1.2, 11.2.1, 11.3.1,11.3.2, 12.1.1, 12.1.2,12.2.1, 12.2.2, 12.3.1, 12.3.2.
CO2	1.1.2, 1.4.1, 2.1.1, 2.1.2, 2.2.1, 2.2.3, 2.3.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.3, 3.2.1, 3.3.1, 3.3.2, 3.4.2,4.1.3, 4.3.1, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.3.2, 6.2.1, 7.1.2, 7.2.2, 8.2.2, 9.1.1, 9.3.1, 10.1.1, 1.1.2,11.2.1, 11.3.1, 11.3.2, 12.1.2, 12.2.2, 12.3.2
CO3	1.1.1, 1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.2, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 2.4.4, 3.1.1, 3.1.4, 3.1.5,3.2.1, 3.2.2, 3.2.3, 3.4.2, 4.1.1, 4.1.2, 4.2.1, 4.3.2, 5.1.1, 5.2.1, 5.3.1, 5.3.2, 6.1.1, 7.1.2, 7.2.1, 8.1.1,9.1.1, 9.2.1, 10.1.3, 10.3.1, 10.3.2, 11.1.1, 11.3.1, 12.1.1, 12.2.1.
CO4	1.1.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.3, 3.1.1, 3.1.4, 3.2.1,3.2.2, 3.3.1, 3.4.2, 4.1.3, 4.2.1, 4.3.3, 4.3.4, 5.1.1, 5.2.1, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.2.2, 8.2.2,9.1.2, 9.2.2, 9.2.4, 10.1.1, 11.1.1, 11.1.2, 11.2.1, 12.2.1, 12.2.2, 12.3.1.
CO5	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.2.1, 2.2.2, 2.2.4, 2.3.1, 2.4.1, 2.4.2, 2.4.4, 3.1.2, 3.1.3, 3.1.5,3.1.6, 3.2.1, 3.2.3, 3.3.2, 3.4.1, 4.1.2, 4.1.3, 4.1.4, 4.2.2, 4.3.2, 4.3.3, 5.1.2, 5.2.2, 6.1.1, 6.2.1, 7.1.1,7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.1, 10.1.1, 10.1.2, 10.3.1, 10.3.2, 11.1.1, 11.1.2, 11.3.1, 11.3.2, 12.1.1,12.2.1, 12.3.2.

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Rememberin g (K1) %**	**Understandin g (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	40	20				100
CAT2	40	40	10	10			100
Individual Assessmen t 1 /Case Study 1/ Seminar 1 / Project1	40	40	20				100
Individual Assessmen t 2 /Case Study 2/ Seminar 2 / Project 2	40	40	10	10			100
ESE	40	40	10	10			100

22MPC619	FINITE ELEMENT ANALYSIS	SEMESTER VI

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To learn the techniques of finite element analysis to model and solve structural, thermal, dynamic problems in engineering.	
UNIT – I	**RELEVANCE OF FEM**	**(9 Periods)**
Historical background - basic concept of FEM – discretization of 1D, 2D and 3D Domains, mesh refinement and their types - convergence requirements – error estimates – Super convergent patch recovery (SPR), Recovery by equilibrium of patches (REP) -Introduction to gradient and divergence theorems - boundary and initial value problems.		
UNIT – II	**CHARACTERISTIC MATRICES AND LOAD VECTORS**	**(9 Periods)**
One dimensional governing equation - structural and heat transfer problems - variational method - variation calculus – weighted residual methods – Galerkin method - Ritz method - generalized coordinate's approach - principle of minimization of potential energy.		
UNIT – III	**ONE DIMENSIONAL PROBLEMS**	**(9 Periods)**
Derivation of shape functions, Stiffness matrices and force vectors -Assembly of Matrices - shape function characteristics - problems in axial load members, trusses, and heat transfer through composite walls and fins –Buckling of columns.		
UNIT – IV	**TWO DIMENSIONAL PROBLEMS**	**(9 Periods)**
Derivation of shape functions for CST and LST triangular and rectangular elements, Stiffness matrices and force vectors - Pascal's triangle- concept of plane stress and plain strain and axi-symmetry - Structural and heat transfer application - introduction to coupled field analysis.		
UNIT – V	**HIGHER ORDER ELEMENTS**	**(9 Periods)**
Natural co-ordinate systems – Isoparametric elements – Shape functions for isoparametric elements – One and two dimensions – Jacobian transformation - Serendipity and Lagrangian elements – Numerical integration - Matrix solution techniques.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Larry J. Segerlind*, ***"Applied Finite element Analysis"****, John Wiley & Sons , 2010*
2	*Logan D L*, ***"A First Course in the Finite Element Method"****, Fifth Edition, Thomson Learning, 2016.*

REFERENCES:

1	*Singiresu.S.Rao,* ***"The Finite Element Method in Engineering"****, ButterWorthHeinemann, Fifth Edition, 2017.*
2	*J.N Reddy,* ***"An Introduction to Finite Element Method"****, McGraw Hill, Intl, Fourth Edition 2020.*
3	*Tirupathi R. Chandrupatla and Ashok D. Belegundu*,***"Introduction to Finite Element in Engineering"****, Pearson Education Fourth Edition ,2021*
4	*David V.Hutton,****"Fundamentals of finite element Analysis",*** *McGraw Hill Inc, Newyork, 2011.*
5	*J Seshu. P,****"Textbook of Finite Element Analysis",*** *Prentice Hall of India, 2012.*
6	***Olek C Zienkiewicz, "The Finite Element Method: Its Basis and Fundamentals",*** *Butterworth-Heinemann Ltd, SeventhEdition, 2013.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Select appropriate mathematical techniques for solving Finite Element problems.	K1
CO2	Frame and solve strong and weak form equations for structural and non-structural problems.	K2
CO3	Follow systematic procedure to solve one dimensional problem.	K2
CO4	Derive equations for complex 2D problems and to solve simple 2D problems.	K3
CO5	Formulate necessary matrices for 3D elements.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2		1	3								3	1	2
CO2	3	3		1	2								3	2	2
CO3	3	3			3								3	1	2
CO4	3	3			3								3	2	2
CO5	3	3			3								3	2	2
22MPC619	3	2		1	3								3	1	2
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.3, 2.2.1, 2.2.3, 2.2.4, 2.4.4, 4.3.4, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2.														
CO2	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 4.1.4, 5.1.2, 5.2.1, 5.3.1, 5.3.2.														
CO3	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2.														
CO4	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2.														
CO5	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2.														

ASSESSMENT PATTERN							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	70	20	10				100
CAT2	50	30	20				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	60	40					100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	50	30	20				100
ESE	50	30	20				100

22MPC620	DESIGN OF TRANSMISSION SYSTEMS *(Use of Approved Design Data Book is permitted)*	SEMESTER VI

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To learn the techniques of finite element analysis to model and solve structural, thermal, dynamic problems in engineering.	
UNIT – I	**DESIGN OF POWER TRANSMISSION ELEMENTS**	**(9 Periods)**
Selection of ropes, Flat belt – V belt – ribbed V belt – selection of chains and sprockets – Ratchet and pawl mechanism.		
UNIT – II	**SPUR AND HELICAL GEARS**	**(9 Periods)**
Kinematics – force analysis in gears – stress analysis – dynamic effects – gear blank design - estimating gear size, module and face width - power rating calculations based on strength and wear considerations, crossed helical gear terminology - estimating the size of the pair of crossed-helical gears.		
UNIT – III	**BEVEL AND WORM GEAR**	**(9 Periods)**
Straight bevel gear: Tooth terminology, tooth forces and stresses, equivalent number of teeth, estimating the dimensions of pair of straight bevel gears. Worm Gear: Merits and demerits – Terminology. Thermal Capacity, Materials-forces and stresses, efficiency, estimating the size of the worm gear pair.		
UNIT – IV	**DESIGN OF GEAR BOX**	**(9 Periods)**
Geometric progression - standard step ratio - ray diagram, kinematic layout - design of sliding mesh and constant mesh gear box - introduction to planetary gear box. Introduction to fluid couplings.		
UNIT – V	**CAMS, CLUTCHES AND BRAKES**	**(9 Periods)**
Cam Design: Types-pressure angle and under cutting base circle determination-forces and surface stresses. Design of plate clutches-axial clutches-cone clutches- introduction to Hydraulic clutch and electromagnetic clutches. Band and block brakes-external shoe brakes-Internal expanding shoe brake.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*V.B. Bhandari, "**Design of Machine Elements**", McGraw Hill Publication Co., 2020.*
2	***Design Data** – P.S.G. College of Technology, Coimbatore.*

REFERENCES:

1	*Juvinal R.C. "**Fundamentals of Machine Components Design**"John Wiely and Sons. 2016.*
2	*Merhyle F.Spotts,Terry E.Shoup and Lee E.Hornberger "**Design of Machine elements**", Prentice Hall, India International ed,2019.*
3	*Robert L Mott, "**Machine Elements in Mechanical Design**", Pearson, 2020.*
4	*Joseph Edward Shigley and Charles, R. Mischke, "**Mechanical Engineering Design**", McGraw Hill International ,2014.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Select appropriate flexible transmission elements for machinery and equipments.	K1
CO2	Perform engineering analysis and estimate the required size and type of spur and helical gears.	K2
CO3	Perform engineering analysis and estimate the required size and type of bevel and worm gears.	K2
CO4	Design and develop gear box for various machinery and equipments.	K3
CO5	Design Cams, friction clutches and brake components	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO 1**	**PO 2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	0	2	2	2							1		1	2	1
CO2	2	2	2	1							2		1	2	1
CO3	2	2	2	1							2		1	2	1
CO4	2	2	2	1							2		1	2	1
CO5	2	2	2	1							2		1	2	1
22MPC620	2	2	2	1							2		1	2	1
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping (Times New Roman, Size 11)															
CO1	2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 3.1.1, 3.1.2, 3.1.3, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 4.1.1, 4.1.2, 4.2.1, 11.2.1.														
CO2	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.3, 2.2.4, 2.4.1, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 4.1.1, 4.2.1, 11.2.1, 11.3.1 .														
CO3	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.3, 2.2.4, 2.4.1, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 4.1.1, 4.2.1, 11.2.1, 11.3.1.														
CO4	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.3, 2.2.4, 2.4.1, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 4.1.1, 4.2.1, 11.2.1, 11.3.1.														
CO5	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.3, 2.2.4, 2.4.1, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 4.1.1, 4.2.1, 11.2.1, 11.3.1.														

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	70	20	10				100
CAT2	50	30	20				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	60	40					100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	50	30	20				100
ESE	50	30	20				100

22MPC621	MECHATRONICS	SEMESTER VI

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To study the mechatronics system and understanding the concepts of integration and design of mechatronics system.	
UNIT – I	**INTRODUCTION TO MECHTRONICS**	**(9 Periods)**
Introduction – definition- mechatronic approach, integrated product design- application areas. Open and closed loop control system - embedded systems - components overview- actuators-hydraulic and pneumatic actuators -electrical Actuators - servo motor and stepper motor-mechanical actuation systems-selection of actuators		
UNIT – II	**SENSORS AND SIGNAL CONDITIONING**	**(9 Periods)**
Sensors-types- position-proximity-force-velocity-pressure -temperature -fluid flow -optical - Image sensors-working principle-specification -application -selection of sensors. Signal conditioning- types of operational amplifiers -protection and filtering- Wheatstone bridge- analogue-to-digital and digital-to-analogue converters.		
UNIT – III	**SYSTEM MODELLING AND CONTROL SYSTEMS**	**(9 Periods)**
Mathematical models-Building blocks of mechanical, electrical, fluid and thermal system-rotational translational systems, electro mechanical systems-linearity-hydraulic mechanical systems. Continuous and discrete control process-two step mode, PI, PD, PID controllers, micro controllers-digital controllers, PLC programming		
UNIT – IV	**MEMS AND SMART MATERIALS**	**(9 Periods)**
MEMS-Introduction-economy of MEMS manufacturing-MEMS design-micro sensors, micro actuators - micro-fabrication techniques – LIGA Process- lithography, etching, micro-joining. Introduction to smart materials - Shape Memory Alloy- properties- working principle of piezoelectric and magneto strictive actuators		
UNIT – V	**APPLICATIONS AND CASE STUDIES**	**(9 Periods)**
Mechatronic systems from robotics manufacturing- consumer mechatronics products- surgical equipment - Introduction to artificial intelligence Case studies—automated glue dispensing system —mechatronic design of a coin counter — mechatronic design of a robotic walking machine- automated mining shovel-automated air conditioner		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*W.Bolton, **"Mechatronics"**, Longman, 2nd Edition, 2023.*
2	*Michael B. Histand and David G.Alciatore, **"Introduction to Mechatronics and Measurement Systems"**, Tata McGraw Hill, 2nd Edition, 2006.*

REFERENCES:

1	*D.A.Bradley, D.Dawson, N.C.Buru and A.J.Loader**, "Mechatronics"** Chapman and Hall,1993*
2	*Dan S Necsulescu, **"Mechatronics"**, Pearson Education Asia,2016*
3	*Devdas Shetty, Richard A. Kolk, **"Mechatronics System Design"**, Thomson, PWS publishing, 2007.*
4	*Smaili.A and Mrad.F, "**Mechatronics: Integrated Technologies for Intelligent Machines**", Oxford, 2008.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Identify the key elements of mechatronics system and models	K1
CO2	Select appropriate sensors and transducers for industrial application.	K2
CO3	Integrate mechanical, electrical, electronics, control systems in the mechatronics system design	K3
CO4	Select the proper smart material for mechatronics system.	K3
CO5	Apply the principles of mechatronics in industrial needs	K4

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO 1**	**PO 2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	0	1	3	0	0	0	0	0	0	0	3	1	1
CO2	3	3	2	2	3	1	0	0	0	0	0	0	3	2	2
CO3	3	2	2	1	3	0	0	0	0	0	0	0	3	1	2
CO4	3	3	1	0	3	0	0	0	0	0	0	1	3	2	2
CO5	3	3	3	2	3	0	1	1	0	1	1	1	3	2	3
22MPC621	3	3	2	2	3	1	1	1	0	1	1	1	3	2	2
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.3, 2.2.1, 2.2.3, 2.2.4, 2.4.4, 4.3.4, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2														
CO2	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 4.1.4, 5.1.2, 5.2.1, 5.3.1, 5.3.2														
CO3	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2														
CO4	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2														
CO5	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2														

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	50	20	20	10			100
CAT2	20	30	20	30			100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	40	40	20				100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	30	20	20			100
ESE	50	30	20				100

22MEE602	SKILL DEVELOPMENT ON TECHNICAL AND INDUSTRIAL PRACTICES	SEMSTER VI

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EEC	0	0	3	1.5

Course Objectives	To educate the skill of technical report writing and technical surveying.

LIST OF EXPERIMENTS

1. Conduct literature survey on selected technical domain. (Minimum 30 literatures to be reviewed) and prepare a review article.
2. Visit any one industry and prepare a technical report describing the work flow and processes involved in the industry.
3. Identify areas where energy can be saved in an industry, make a report on the quantum of energy wasted and possible ways of recovering energy.
4. Identify areas where productivity can be improved by slight modification like addition of material handling equipment / change of process flow would improve productivity without changing existing machinery.
5. Discuss with the any two technical staff and record the challenge or failure they faced as well as the success they faced in their career in that particular industry..
6. Conduct market survey and prepare report on any selected product by meeting the customers / retailers using any methods. (Questionnaire, Audio / Video recording etc.)
7. Assess the risk involved in any industries. (Existing risk or upcoming risk in the market).
8. Identify a feature that would add value to an existing product or mechanism and prepare a conceptual design for the same.

Contact Periods:
Lecture: 0 Periods Tutorial: 0 Periods Practical: 45 Periods Total: 45 Periods

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Write a review article about a technical domain.	K1
CO2	Write technical report about any industrial activity.	K3
CO3	Prepare a survey report from market survey.	K3
CO4	Identify present risk and forecast possible future risk in an industry.	K3
CO5	Conceptualize and design a value addition to an existing product or mechanism.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO 1**	**PO 2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	0	2	2	2	2	0	1	1	0	2	2	3	2	1	1
CO2	0	1	1	1	1	2	0	2	1	3	1	3	1	1	2
CO3	0	1	2	3	1	0	1	0	1	3	2	1	2	1	2
CO4	0	0	1	2	2	0	3	0	0	2	2	3	2	2	2
CO5	0	2	3	3	3	2	3	0	3	3	3	3	3	3	2
22MEE602	0	1	2	2	2	1	1	2	1	2	2	2	2	2	2
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.6, 3.3.2, 4.1.1, 4.1.2, 4.3.2, 4.3.3, 4.3.4, 5.1.2, 5.2.1, 5.3.1, 5.3.2, 7.1.1, 8.2.2, 10.1.1, 10.1.2, 10.1.3, 10.3.1, 11.2.1, 11.3.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO2	2.2.2, 3.1.2, 3.1.3, 4.3.3, 5.3.1, 6.1.1, 8.1.1, 8.2.1, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.3.1, 11.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO3	2.2.1, 2.2.2, 2.2.3, 2.2.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 4.1.1, 4.1.2, 4.1.4, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.2.1, 5.3.2, 7.1.2, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.3.1, 11.1.1, 11.2.1, 12.3.2
CO4	3.1.1, 3.1.2, 3.1.3, 3.1.5, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.2.1, 5.3.1, 5.3.2, 7.1.1, 7.1.2, 7.2.1, 10.1.2, 10.1.3, 10.2.1, 11.1.1, 11.2.1, 11.3.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO5	2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 6.1.1, 7.1.1, 7.1.2, 7.2.2, 9.1.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.3.2, 11.1.1, 11.1.2, 11.2.1, 11.3.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2

22MEE603	MODELING AND SIMULATION LABORATORY	SEMESTER VI

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EEC	0	0	4	2

Course Objectives	Understand the usage of model and simulation software packages for mechanical parts and assembly.

LIST OF EXPERIMENTS
1. Introduction to simulation 2. Modeling and Meshing 3. Structural analysis of steel bracket, Truss, Beams, Spanner. 4. Thermal analysis of 1D, 2D and 3D – Steady and Transient problems 5. Coupled field analysis. Using any of the Simulation Software's like Ansys.
Contact Periods: **Lecture: 0 Periods Tutorial: 0 Periods Practical: 60 Periods Total: 60 Periods**

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Develop and analysis models of different mechanical system using Simulation and its tools.	K3
CO2	Apply the modelling and meshing tools.	K3
CO3	Interpret complex engineering structural analysis of the mechanical parts.	K3
CO4	Conduct thermal analysis on the mechanical component	K3
CO5	Perform the Coupled field analysis.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
Cos /POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	3	2	3						2	1	2	3	2
CO2	2	2	3	2	3						2	1	2	3	2
CO3	2	2	3	2	3						2	1	2	3	2
CO4	2	2	3	2	3						2	1	2	3	2
CO5	2	2	3	2	3						2	1	2	3	2
22MEE603	2	2	3	2	3						2	1	2	3	2
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.2.1,1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.2.1,4.2.2, 4.3.1, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 11.1.1, 11.2.1, 11.3.2, 12.2.2, 12.3.2
CO2	1.2.1,1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.2.1,4.2.2, 4.3.1, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 11.1.1, 11.2.1, 11.3.2, 12.2.2, 12.3.2
CO3	1.2.1,1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.2.1,4.2.2, 4.3.1, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 11.1.1, 11.2.1, 11.3.2, 12.2.2, 12.3.2
CO4	1.2.1,1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.2.1,4.2.2, 4.3.1, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 11.1.1, 11.2.1, 11.3.2, 12.2.2, 12.3.2
CO5	1.2.1,1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.2.1,4.2.2, 4.3.1, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 11.1.1, 11.2.1, 11.3.2, 12.2.2, 12.3.2

22MHS706	OPERATIONS RESEARCH	SEMESTER VI

PREREQUISITES	CATEGORY	L	T	P	C
NIL	HS	3	0	0	3

Course Objectives	To enrich the students with the knowledge on different industrial problems involving limited resources and strengthen the ability to choose an appropriate solution technique for solving the problems.	
UNIT – I	**LINEAR MODELS**	**(9 Periods)**
Development of Operations Research – Characteristics and phases of Operation Research – Types of models – Linear Programming Problem – Formulation – Graphical method – Simplex algorithm – Big M method – Two phase method – Duality formulation – Dual simplex method – Solution by Excel solver.		
UNIT – II	**TRANSPORTATION AND ASSIGNMENT MODELS**	**(9 Periods)**
Transportation models – Optimal solution by North West Corner method – Least Cost Method – Vogel's Approximation Method – Optimality test – MODI method – Assignment problem formulation – Hungarian method – Unbalanced and maximization type of assignment problems – Travelling salesman problem.		
UNIT – III	**NETWORK MODELS AND SEQUENCING PROBLEMS**	**(9 Periods)**
Construction of project networks – Network optimization algorithms – Shortest route models – Minimal spanning tree models – Maximum flow models – CPM and PERT networks – Critical path scheduling – Sequencing problems – *n* jobs through *two* machines – *n* jobs through *m* machines – *Two* jobs through *m* machines.		
UNIT – IV	**INVENTORY MODELS AND QUEUE THEORY**	**(9 Periods)**
Inventory – Economic order quantity models – Quantity discount models – Probabilistic models – Safety stock and reorder point calculation – Queuing systems and structures – Notations and parameters – Queuing models – Random number generation - Application of simulation for queuing and maintenance.		
UNIT – V	**DECISION AND REPLACEMENT MODELS**	**(9 Periods)**
Decision models – Game theory – Two person zero sum games – Graphical solution – Replacement models – Economic life – Replacement of items that deteriorate with time – Value of money change with time, not change with time – Optimum replacement policy - Individual and group replacement.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Taha H.A., "**Operation Research**", 10th Edition, Pearson Education*, 2017.
2	*Hira and Gupta, "**Problems in Operations Research**", S.Chand and Co.2021.*

REFERENCES:

1	*Sharma J.K, **"Operations Research"**, 6th Edition, Macmillan, 2017.*
2	*Philip and Ravindran, **"Operational Research"**, 2nd Edition, John Wiley, 2007.*
3	*Wagner, **"Operations Research"**, Prentice Hall of India, 2000.*
4	*Hillier F S, Lieberman G J, Nag B and Basu P, **"Operations Research"**, 11th Edition, McGraw Hill, 2021.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Apply linear programming models to domain specific situations and solve by appropriate solution techniques.	K3
CO2	Analyze the various methods under transportation model and apply the model for testing the closeness of their results to optimal results	K4
CO3	Apply the concepts of PERT and CPM networks and sequencing models for decision making and optimally managing projects	K3
CO4	Analyze and apply appropriate inventory and queue theory techniques in domain specific situations.	K4
CO5	Make strategic decisions using decision and replacement models.	K6

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/ POs	PO 1	PO2	PO3	PO 4	PO 5	PO 6	PO7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	1		1								2		
CO2	2	2	1		1								2		
CO3	2	2	1		1						2		2		
CO4	2	2	1		1								2		
CO5	2	2	1		1								2		
22MHS706	3	3	3		3						1		3		

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.1, 1.1.2, 1.3.1,2.1.1,2.1.2,2.1.3,2.2.3, 2.2.4,3.1.6,3.2.1,3.2.2,3.2.3,5.1.2
CO2	1.1.1, 1.1.2, 1.3.1,2.1.1,2.1.2,2.1.3,2.2.3, 2.2.4,3.1.6,3.2.1,3.2.2,3.2.3,5.1.2
CO3	1.1.1, 1.1.2, 1.3.1,2.1.1,2.1.2,2.1.3,2.2.3, 2.2.4,3.1.6,3.2.1,3.2.2,3.2.3,5.1.2,11.2.1,11.3.2
CO4	1.1.1, 1.1.2, 1.3.1,2.1.1,2.1.2,2.1.3,2.2.3, 2.2.4,3.1.6,3.2.1,3.2.2,3.2.3,5.1.2
CO5	1.1.1, 1.1.2, 1.3.1,2.1.1,2.1.2,2.1.3,2.2.3, 2.2.4,3.1.6,3.2.1,3.2.2,3.2.3,5.1.2

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	5	5	30	30	20	10	100
CAT2	5	5	30	30	20	10	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	5	5	30	30	20	10	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	5	5	30	30	20	10	100
ESE	5	5	30	30	20	10	100

22MPC722	**REFRIGERATION AND AIR CONDITIONING** *(Use of Approved Refrigeration And Air Conditioning Data Book is permitted)*	**SEMESTER VII**

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To analyze various refrigeration system and to design the air conditioning system based on the heating and cooling load.	
UNIT – I	**REFRIGERATION CYCLES**	**(9 Periods)**
Air refrigeration cycles – Reversed Carnot Cycle, Bell Coleman cycle, Simple Vapour Compression Refrigeration Cycle, Compound Compression Refrigeration Cycles, and Cascade Refrigeration Cycles.		
UNIT – II	**VAPOUR ABSORPTION SYSTEM AND REFRIGERANTS**	**(9 Periods)**
Ammonia – Water System, Lithium Bromide – Water System - Electrolux Refrigeration System, Steam Jet Refrigeration and Solar Refrigeration Systems. Refrigerants – Properties and Classification– Eco-Friendly Refrigerants		
UNIT – III	**SYSTEM COMPONENTS**	**(9 Periods)**
Compressors – Reciprocating, Rotary and Centrifugal Compressors, Evaporators- Flooded, Dry Expansion, Shell and Tube and Double Pipe Evaporators, Condensers – Air cooled, Water cooled and Evaporative Condensers, Expansion Devices – Automatic, Capillary tube and Thermostatic Expansion Valve.		
UNIT – IV	**DUCT DESIGN AND DISTRIBUTION**	**(9 Periods)**
Air distribution systems – study of different types of duct systems, methods of duct design, duct insulation, air purity – air cleaning methods.		
UNIT – V	**AIR CONDITIONING AND COOLING LOAD**	**(9 Periods)**
Psychrometry, Psychrometer, Psychometric processes, Moist Air behaviour, Effective Temperatures, Sensible Heat Factor ratio and Cooling Load Estimation for an Air-Conditioned Space.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Arora S C and Domkundwar S.,* ***"Refrigeration and Airconditioning",*** *DhanpatRai& Sons 8th Edition, New Delhi, 2021.*
2	*Roy J Dossat,* ***"Principle of Refrigeration",*** *Wiley Eastern Limited, Fifth Edition 2002.*

REFERENCES

1	*Stocker,* ***"Refrigeration and Air Conditioning"****, Tata McGraw Hill Publishing Company Limited, New Delhi, 2014.*
2	*Manohar Prasad,* ***"Refrigeration and Air Conditioning"****, Wiley Eastern Limited, 2021.*
3	*Jordan and Prister,* ***"Refrigeration and Air Conditioning",*** *Prentice Hall of India Limited, NewDelhi, 1985.*
4	*Arora C.P,* ***"Refrigeration and Air Conditioning",*** *Tata McGraw Hill Publishing Company Limited, 3rd Edition, NewDelhi, 2009.*
5	*P.N. Ananthanarayanan* ***"Basic Refrigeration and Air Conditioning",*** *Tata McGraw Hill Publishing Company Limited, 4th Edition, 2013.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Solve the problems on Refrigeration Cycle.	K1
CO2	Analyze the Vapor Absorption Refrigeration System.	K1
CO3	Define the Refrigeration System Components.	K2
CO4	Design the Duct Geometry	K2
CO5	Do the Cooling Load Estimation.	K2

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1		1	2	1	1								2	2	3
CO2		1	2	1	1								2	2	3
CO3		1	2	1	1								2	2	3
CO4		2	2	1	1						1		2	3	3
CO5		1	2	1	1						1		3	2	3
22MPC722		1	2	1	1						1		2	2	3
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	2.2.2, 2.2.3, 2.2.4, 2.3.1, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 4.1.1, 4.3.4, 5.1.2														
CO2	2.2.2, 2.2.3, 2.2.4, 2.3.1, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 4.1.1, 4.3.4, 5.1.2														
CO3	2.2.2, 2.2.3, 2.2.4, 2.3.1, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 4.1.1, 4.3.4, 5.1.2														
CO4	2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 4.1.1, 4.3.4, 5.1.2, 5.3.1, 11.3.1														
CO5	2.2.2, 2.2.3, 2.2.4, 2.3.1, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 4.1.1, 4.3.4, 5.1.2, 5.3.1, 11.3.1														

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	40	10	20			100
CAT2	30	40	10	20			100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50					100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	50	50					100
ESE	40	60					100

22MPC723	COMPUTER AIDED DESIGN AND MANUFACTURING	SEMESTER VII

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To provide an exposure to CAD, CAM and understand the role of computers in modeling and manufacturing.	
UNIT – I	**INTRODUCTION**	**(9 Periods)**
Fundamentals of CAD/CAM - Product cycle - Design process- sequential and concurrent engineering – Computer graphics – co-ordinate-systems - 2D and 3D transformations-translation, rotation, scaling, homogeneous coordinates - Line drawing algorithm –Clipping-point, line		
UNIT – II	**GEOMETRIC MODELING**	**(9 Periods)**
Representation of curves- Hermite curve- Bezier curve- B-Spline curves-rational curves- Surface modeling – surface patch- Coons and bicubic patches- Bezier and B-spline surfaces. Solid Modeling techniques- CSG and B-rep.		
UNIT – III	**VISUAL REALISM AND CAD STANDARDS**	**(9 Periods)**
Model cleanup – visibility technique-sorting-coherence-hidden line removal algorithms Standards for computer graphics- Data exchange standards - IGES, STEP, and CALS.		
UNIT – IV	**GROUP TECHNOLOGY AND FMS**	**(9 Periods)**
Group Technology(GT) - Part Families – Parts Classification and coding system – Production flow Analysis – Cellular Manufacturing - Computer Aided Process Planning – Variant and Generative Process Planning Methods – Types of FMS - Flexibility – FMS Components – FMS Application – Benefits.		
UNIT – V	**PRODUCTION PLANNING AND CONROL**	**(9 Periods)**
Aggregate Production Planning and Master Production Schedule – Material Requirement Planning (MRP I)– Capacity Planning – Shop Floor Control – Inventory Control – EOQ, Introduction to Manufacturing Resource Planning (MRP II) & Enterprise Resource Planning (ERP), Lean Production		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Mikell P. Groover, "**Automation, Production Systems and Computer-Integrated Manufacturing**", Pearson Education, New Delhi, 2016.*
2	*P. Radhakrishnan and S. Subramanyan "**CAD/CAM/CIM**" New Age International(P) Ltd, New Delhi , 2023*

REFERENCES:

1	*Donald Hearn and M.Pauline Baker, **"Computer Graphics"** Prentice Hall Inc., 2013.*
2	*David Bedworth, **"Computer Integrated Design and Manufacturing"**, TMH, New Delhi, 1998*
3	*Zeid Ibrahim, **"CAD/CAM Theory and Practices",** McGraw Hill International Edition, 2013.*
4	*Ulrich Sendler, **"The Internet of Things: Industrie 4.0 Unleashed",** 1st Edition, Springer, New York, 2019.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Compute line, 2D and 3D transformation models	K3
CO2	Generate mathematical representation of curves, surfaces and solids	K3
CO3	Familiarize the visual realism and product data exchange techniques	K3
CO4	Apply knowledge on Group Technology and FMS in shop floor.	K3
CO5	Get a comprehensive picture of Production Planning and control	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/ POs	PO 1	PO2	PO3	PO 4	PO 5	PO 6	PO7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	2	1	3						1	2	2		
CO2	2	2	2	1	3						1	2	2		
CO3	1	2	2	1	3						1	2	2		
CO4	1	2	2	1	2						2	2	2		2
CO5	1	2	2	2	2						2	2	2		2
22MPC722	1	2	2	1	3						2	2	2		2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.2,1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 11.1.1, 11.3.1, 11.3.2, 12.2.2, 12.3.1, 12.3.2
CO2	1.1.2,1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 11.1.1, 11.3.1, 11.3.2, 12.2.2, 12.3.1, 12.3.2
CO3	1.1.2,1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 11.1.1, 11.3.1, 11.3.2, 12.2.2, 12.3.1, 12.3.2
CO4	1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.3, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 11.1.1, 11.3.1, 11.3.2, 12.3.1, 12.3.2
CO5	1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 11.1.1, 11.3.1, 11.3.2, 12.2.2, 12.3.1, 12.3.2

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	30	30	40				100
CAT2	20	40	40				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	30	30	40				100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	10	40	50				100
ESE	20	40	40				100

22MPC724	AUTOMATION LABORATORY	SEMESTER VII

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	0	0	3	1.5

Course Objectives	To understand and practice the real time industrial applications of automation experiments related to Industry 4.0

LIST OF EXPERIMENTS

1. Design of simple pneumatic circuit for direction control.
2. Design of electro pneumatic circuit for direction control.
3. Design of meter-in and meter-out circuit using electro pneumatics.
4. Design of sequential circuit using electro pneumatics.
5. Design of cascading circuit using electro pneumatics.
6. Training on advanced 4 axis robotic arm for industrial operations.
7. Study on the components and working of IoT system.
8. Programming of LoRAWAN IoT trainer for different industrial operations.
9. Study on the components and working of machine vision system.
10. Colour sorting applications using machine vision system.

Contact periods:
Lecture: 0 Period Tutorial: 0 Period Practical: 45 Periods Total: 45 Periods

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand the basic concepts of process automation through practical experiments on pneumatic systems.	K3
CO2	Analyze and construct the automation circuits using electro pneumatics	K4
CO3	Construct the robotic systems for basic automation experiments.	K3
CO4	Understand the components and working of industrial IoT system.	K3
CO5	Operate the machine vision for industrial application	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO 6**	**PO7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	2	2	2	3	3	3	1	2	1	2	3	1		
CO2	2	2	2	3	3	3	3	2	2	1	3	3	1		
CO3	2	3	2	3	3	3	3	2	2	1	3	3	1		
CO4	2	3	3	3	3	3	3	2	2	1	3	3	1		
CO5	2	3	3	3	3	3	3	2	2	1	2	3	1		
22MPC724	2	3	2	3	3	3	3	2	2	1	3	3	1		
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.2.1, 1.4.4,2.1.1, 3.1.1,4.1.2,5.1.2, 8.2.1, 9.3.1, 12.1.1.
CO2	1.2.1, 1.3.1,2.1.1,2.4.1, 3.1.1,4.1.2,5.1.2, 8.2.1, 9.3.1, 12.1.1.
CO3	1.2.1, 1.4.4,2.1.1, 3.1.1,4.1.2,5.1.2, 8.2.1, 9.3.1, 12.1.1.
CO4	1.2.1, 1.3.1,2.1.1, 2.2.1, 3.1.3,4.1.2,5.1.2, 8.2.1, 9.3.1, 12.1.1.
CO5	1.2.1, 1.3.1,2.1.1, 2.2.1, 3.1.3,4.1.2,5.1.2, 8.2.1, 9.3.1, 12.1.1.

22MEE704	ENGINEERING PROJECTS IN COMMUNITY SERVICE	SEMESTER VII

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EEC	0	0	4	2

Course Objectives	To provide an environment where teams of students can exercise their engineering skills by being exposed to realistic systems and customers and at the same time helping their community.

Problem identification – Identifying the issues within the community -Preliminary survey - Preparing a questionnaire, formats and survey forms. - A preliminary survey including the socio-economic conditions of the allotted habitation - Different types of surveys, tools and techniques for collecting the information. - Analysis of collected data and mapping of issues with the solutions available. - Based on the survey and the specific requirements of the habitation, Community Awareness Campaigns – Identifying the factors – Normalization of factors and finding the path way for problem solution – Selection of problem from the community and mapping of issues - Planning for working: Aim, objective and scope, time line - Application of engineering knowledge and tools for solutions

Validation of the solution by supervising the execution of solution - Measuring the attainment of the solution: Feedback from community

Contact periods:
Lecture: 0 Period Tutorial: 0 Period Practical: 60 Periods Total: 60 Periods

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Identify engineering related problems in the community.	K2
CO2	Analyze and Design different solutions to solve the problems of community.	K4
CO3	Apply economical solution to those problems in the field.	K4
CO4	To understand complexity and ambiguity	K1
CO5	Connections with professionals and community members for learning and career opportunities	K2

COURSE ARTICULATION MATRIX:

CO and PO Mapping															
COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO2**	**PSO3**
CO1		2	2		1	2	1		2		1		1	1	1
CO2		2	2		1	2	1		2		1		1	1	1
CO3		2	2		1	2	1		2		1		1	1	1
CO4		2	2		1	2	1		2	2	1		1	1	1
CO5		2	2		1	2	1		2	2	1		1	1	1
22MEE704		2	2		1	2	1		2		1		1	1	1
1 – Slight, 2 – Moderate, 3 – Substantial															

22MEE806	CAPSTONE PROJECT	SEMESTER VIII

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EEC	0	0	16	8

Course Objectives	To create an opportunity for a small team environment in applying the knowledge learned throughout the program by undertaking problem identification, formulation and solution to a small industrial problem.
The students may be grouped into groups of about four members per group and work under a project supervisor. The device / system / component(s) to be fabricated / investigated / analyzed may be decided in consultation with the supervisor. An industrial expert may be included as an external supervisor. A project report to be submitted by the group and the fabricated model / investigation / analysis to be reviewed and evaluated continuously by a committee constituted by the Head of the Department / Program Coordinator.	
Contact Periods: **Lecture: 0 Periods Tutorial: 0 Periods Practical: 240 Periods Total: 240 Periods**	

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Model or simulate solutions to small engineering problems considering environmental issues	K4
CO2	Apply the principles of mechanical engineering to solve engineering problems	K3
CO3	Perform feasibility study and manage activities to complete task in specified duration.	K2
CO4	Assign and undertake tasks in a team as per team discussion.	K1
CO5	Do presentation and write technical reports for effective communication within and outside the team.	K1

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	3	2	3	3	1	3	-	2	-	3	2	
CO2	3	3	3	3	2	3	3	-	3	-	1	-	3	3	
CO3	2	2	2	2	2	2	1	1	3	1	1	3	3	2	
CO4	3	2	2	1	1	1	2	3	3	3	-	3	3	2	
CO5	-	-	-	-	2	2	-	1	3	3	-	2	3	-	
22MEE806	2	2	2	2	2	2	2	1	3	1	1	2	3	2	
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.1.2, 1.2.1, 1.3.1, 2.1.1, 2.2.3, 2.2.4, 2.3.1, 2.4.1, 3.1.3, 3.2.2, 3.4.1, 4.1.1, 4.2.1, 4.3.1, 5.1.2, 7.1.1, 7.2.1, 7.2.2, 9.2.2, 9.2.3, 9.3.1														
CO2	1.1.2, 1.2.1, 2.2.3, 3.1.3, 4.3.1, 7.1.1, 9.2.2, 9.2.3, 9.3.1														
CO3	9.2.2, 9.2.3, 9.3.1														
CO4	1.1.2, 1.2.1, 1.3.1, 2.1.1, 2.2.3, 3.1.3, 3.4.1, 7.1.1, 7.2.1, 7.2.2, 9.2.2, 9.2.3, 9.3.1														
CO5	9.1.2, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.2, 10.3.1, 10.3.2														

22MPE$01	AUTOMOTIVE MATERIALS, COMPONENTS, DESIGN AND TESTING

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objective	To identify the components, understand the cause of problem, provide a solution to the problem and also to design and perform testing on the component.	
UNIT – I	**INTRODUCTION TO AUTOMOTIVE COMPONENTS**	**(9 Periods)**
Automotive components categories - materials - functionality considerations - factors influencing selection of materials - strengthening mechanisms and their need in automotive environment - ferrous and nonferrous metals for automotive applications - non-metallic materials for automotive components - advantages and limitations.		
UNIT – II	**SUSPENSION SYSTEM**	**(9 Periods)**
Function – types, conventional and independent - spring - types, coil, leaf, elliptical, semi elliptical helper springs, transverse springs - spring camber - spring material, torsion bar and stabilizer bar, telescopic shock absorbers, nitro gas shock absorber suspension – testing suspension systems.		
UNIT – III	**STEERING SYSTEM AND FRONT AXLE**	**(9 Periods)**
Principle - Ackermann and Davis, function, requirements - steering gear box - types, construction and working – steering - types, construction and working - types of axles - front axle, rear axle and stub axle - wheel alignment, castor angle, camber angle - toe-in and toe-out - effects, measurement, advantages and disadvantages – testing of steering system and front axle.		
UNIT – IV	**BRAKING SYSTEM**	**(9 Periods)**
Braking terms - types of braking systems - constructional details and working - braking efficiency - determination of braking torque - effect of braking on steering - master cylinder, tandem master cylinder, wheel cylinder, brake lining, brake disc and brake fluid - brake defects, their causes and remedies - antilock braking system - electronic brake distribution - testing of braking system.		
UNIT – V	**FINAL DRIVE**	**(9 Periods)**
Torque tube drive, Hotchkiss drive, universal joints, constant velocity joints, slip joints - propeller shaft – differential – types, construction and working - final drive ratio - rear axles - full floating, semi floating and three-quarter floating axle – testing of final drive and rear axle.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total:45 Periods**		

TEXT BOOKS:

1	*Karoly Jarmai, **"Vehicle and Automotive Engineering"**, Springer International Publishing, 1st Edition, 2017.*
2	*R.K. Rajput, **"A Textbook of Automobile Engineering"**, Laxmi Publications, 2nd Edition, 2007.*

REFERENCES:

1	*Clemens guhmann, **"Simulation and Testing for Vehicle Technology"**, Springer International Publishing, 1st Edition, 2017.*
2	*D.H. Wright, **"Testing Automotive Materials and Components"**, Society of Automotive Engineers, 1993.*
3	*Thomas D. Gillespie, **"Fundamentals of Vehicle Dynamics"**, SAE International, 1992.*
4	*Markus Maurer, **"Automotive Systems Engineering"**, Springer, 2013.*
5	*G. Marquis and J. Solin, **"Fatigue design of components"**, Elsevier Science, 1997.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Identify the different components and materials employed to manufacture them.	K2
CO2	Able to design and test the specific suspension system based on the requirements and conditions.	K4
CO3	Explain the working principle of steering systems and their working on different environments and their reason for failures.	K4
CO4	Explain the working of different kind of braking system and also able to identify the causes for the occurring problem.	K4
CO5	Able to design and check the required differentials.	K4

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	1	2	2	2	2	1	1	-	-	2	2	1	2	2
CO2	2	2	1	3	3	-	1	-	1	1	1	2	1	2	2
CO3	2	2	2	2	2	2	2	1	1	-	2	2	1	2	2
CO4	2	2	2	2	2	2	1	-	1	-	2	2	1	2	2
CO5	2	1	1	1	2	-	-	-	-	1	1	2	1	2	2
22MPE$01	2	2	2	2	2	2	1	1	1	1	2	2	1	2	2
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.2.1, 1.4.1, 2.2.3, 2.3.1, 2.4.3, 3.1.4, 3.1.5, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.2, 4.1.3,4.2.1, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.3.1, 6.1.1, 7.1.1, 8.2.1, 11.1.2, 11.3.1, 12.1.2, 12.2.2, 12.3.2.														
CO2	1.1.1, 1.1.2, 1.2.1, 2.1.2, 2.1.3, 2.2.4, 2.3.1, 2.4.2, 2.4.3, 3.1.4, 3.4.2, 4.1.2, 4.1.3, 4.2.2, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2, 7.1.2, 9.1.2, 10.1.3, 10.3.2, 11.2.1, 12.2.1, 12.2.2, 12.3.1, 12.3.2.														
CO3	1.1.1, 1.1.2, 1.4.1, 2.1.2, 2.1.3, 2.2.1, 2.3.1, 2.3.2, 2.4.2, 3.1.2, 3.1.3, 3.1.6, 3.2.2, 3.2.3, 3.4.1, 3.4.2, 4.1.2, 4.2.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.2.1, 5.3.1, 6.2.1, 7.1.1, 7.2.1, 8.2.2, 9.2.1, 11.1.1, 11.3.1, 12.1.2, 12.3.1, 12.3.2.														
CO4	1.1.1, 1.1.2, ,2.1.2, 2.2.1, 2.2.2, 2.2.3, 2.4.2, 3.1.2, 3.1.4, 3.1.6, 3.2.1, 3.2.2, 3.3.1, 3.4.1, 3.4.2, 4.1.2, 4.1.3, 4.2.1, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.3.1, 6.1.1, 7.1.1, 9.3.1, 11.1.2, 11.2.1, 12.2.1, 12.2.2, 12.3.2.														
CO5	1.2.1, 1.3.1, 1.4.1, 2.1.3, 2.2.1, 3.1.6, 3.2.2, 3.2.3, 3.4.2, 4.1.4, 4.3.2, 5.1.1, 5.2.1, 5.3.2, 10.2.1, 11.1.1, 12.1.1, 12.1.2, 12.3.2.														

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	30	20	10	5	5	100
CAT2	25	25	20	20	5	5	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	30	30	20	10	5	5	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	30	20	10	5	5	100
ESE	30	30	20	10	5	5	100

22MPE$02	CONVENTIONAL AND FUTURISTIC VEHICLE TECHNOLOGY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	Learners will understand the need for advancements in existing automotive components	
UNIT – I	**EVOLUTION OF VEHICLE SYSYTEMS**	**(9 Periods)**
Innovations and inventions in Vehicles, Mass production, Streamlining, Development of the world motor industry, Commercial vehicles, Engine developments, Transmission system development, Steering, Suspension, Tires, Braking Systems		
UNIT – II	**CONVENTIONAL VEHICLE TECHNOLOGY**	**(9 Periods)**
Energy Conversion, The Working Principle of Engines, Classification of IC Engines, Application of IC Engines – Two Stroke Engines – Four Stroke Engines, Air-Standard Cycles and Their Analysis - Otto Cycle - Diesel Cycle - Dual Cycle, Compression Ratio, Peak Pressure, Peak Temperature, Heat Rejection and Heat Rejection.		
UNIT – III	**COMPONENTS OF CONVENTIONAL VEHICLES**	**(9 Periods)**
Fuel–Air Cycles and their Analysis, Conventional Fuels, Carburetion, Mechanical Injection Systems, Electronic Injection Systems, Combustion and Combustion Chambers, Engine Friction and Lubrication, Heat Rejection and Cooling, Measurements and Testing.		
UNIT – IV	**ELECTRICAL VEHICLE SYSTEMS**	**(9 Periods)**
Battery Electric Vehicles, Batteries, Flywheels, Super capacitors, Electricity Supply, Electric Vehicle Modelling, Design Considerations, Heating and Cooling Systems, Design of the Controls, Electric Vehicle Recharging and Refueling Systems.		
UNIT – V	**FUTURE OF VEHICLE SYSTEMS**	**(9 Periods)**
Hydrogen Engines, Dual Fuel and Multi-Fuel Engine, Computer-based combustion analysis Advanced test systems, Plug-in hybrid electric vehicles, Charging Stations for EVs, Electric Road–Rail Systems.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total:45 Periods**		

TEXT BOOKS:

1	*R.K. Rajput – **"Textbook of automobile engineering"** - 2017*
2	*Julian Happian-Smith – "**An Introduction to Modern Vehicle Design**" - 2002*
3	*James Larminie , John Lowry - "**Electric Vehicle Technology Explained**" - 2012*

REFERENCES:

1	*R.K. Rajput – "**Textbook of automobile engineering"** - 2007*
2	*Julian Happian-Smith – "**An Introduction to Modern Vehicle Design**" - 2002*
3	*James Larminie , John Lowry - "**Electric Vehicle Technology Explained**" - 2012*
4	*R.K. Rajput – "**Thermal Engineering**" - 2002*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Know about the upgrades and revolution happened in vehicles and its parts.	K2
CO2	Understand the working of conventional systems	K3
CO3	Know about systems and components used in conventional vehicles	K2
CO4	To understand the need of electric and electronic components and its performance.	K4
CO5	Gain knowledge of ongoing as well as upcoming revolution and up gradation about to happen in vehicle systems	K4

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	2	3	2	3	2	2	1	1	2	2	2	2	1
CO2	3	2	3	3	2	2	2	2	1	1	3	1	2	2	1
CO3	2	2	2	2	2	2	2	-	1	1	2	1	2	2	1
CO4	2	2	2	3	1	-	2	1	1	2	1	1	2	2	1
CO5	2	2	2	3	2	2	1	2	3	1	1	3	2	2	1
22MPE$02	2	2	2	3	2	2	2	2	1	1	2	2	2	2	1
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.1.2, 1.2.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.2, 2.2.3, 2.3.2, 2.4.1, 2.4.3, 2.4.4, 3.1.1, 3.1.4, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 4.1.1, 4.1.2, 4.1.3, 4.2.1, 4.2.2, 4.3.1, 4.3.4, 5.1.2, 5.2.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 8.2.1, 8.2.2, 9.2.1, 10.1.1, 10.3.1, 11.1.1, 11.2.1, 12.1.1, 12.2.1, 12.2.2, 12.3.1.														
CO2	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.2.2, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 3.1.1, 3.1.3, 3.1.4, 3.1.5, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.2, 4.3.2, 4.3.3, 5.1.1, 5.1.2, 5.3.1, 5.3.2, 6.1.1, 7.1.1, 7.2.2, 8.1.1, 8.2.1, 9.1.1, 10.1.3, 10.3.1, 11.1.1, 11.1.2, 11.2.1, 11.3.1, 11.3.2,12.3.1, 12.3.2.														
CO3	1.1.1, 1.2.1, 1.4.1, 2.1.2, 2.2.1, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 2.4.4, 3.1.2, 3.1.3, 3.1.6, 3.2.2, 3.3.2, 3.4.1, 4.1.2, 4.2.1, 4.3.2, 5.1.2, 5.2.1, 5.2.2, 6.1.1, 7.1.2, 7.2.1, 9.1.2, 10.2.1, 11.2.1, 11.3.1, 11.3.2, 12.1.2, 12.3.1.														
CO4	1.1.1, 1.1.2, 2.1.1, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 3.1.1, 3.1.4, 3.1.6, 3.2.1, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.3.3, 5.1.1, 5.3.1, 7.1.1, 7.2.2, 8.2.1, 9.1.1, 9.2.1, 10.1.1, 10.1.3, 10.3.2, 11.1.1, 12.3.2.														
CO5	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.4, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.5, 3.1.6, 3.2.2, 3.3.2, 3.4.2, 4.1.1, 4.1.4, 4.2.2, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.2.1, 5.2.2, 5.3.2, 6.2.1, 7.1.2, 8.1.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 10.3.1, 11.1.2, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2.														

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	35	35	20	10			100
CAT2	35	35	15	15			100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	40	40	20				100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	40	15	15			100
ESE	30	40	15	15			100

22MPE$03	RENEWABLE POWERED VEHICLES AND EMISSION CONTROL

PRE-REQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To study suitability of the low and zero carbon fuels, green energy and fuel cells in off-road vehicles and to illustrate the emission control and existing after-treatment technologies in such applications.	
UNIT – I	**LOW AND ZERO CARBON FUELS POWERED OFF-HIGHWAY VEHICLES**	**(9 Periods)**
Ethanol, Methanol, Butanol, Biodiesel, CNG, LNG, DME, Polyoxymethylene Dimethyl Ether (PODE), Ammonia and Hydrogen Fuels suitability, methods, and technologies for powering off-road vehicles.		
UNIT – II	**GREEN ENERGY POWERED OFF-HIGHWAY VEHICLES**	**(9 Periods)**
Solar Technology for Green Electricity, Green Electricity for Hydrogen Production, Hydrogen Smart Grid Technologies, Hydrogen to ICE powered vehicles, Hydrogen to Fuel Cell Powered Vehicles.		
UNIT –III	**FUEL CELL POWERED OFF-HIGHWAY VEHICLES**	**(9 Periods)**
Fuel Cell, Types, Applications, Fuel Cell Requirement, Sizing and Design for Off-Highway applications, Merits and Demerits, Pathway to overcome the limitations. Scope of the fuel cell research on Off-road vehicle applications.		
UNIT – IV	**IN-CYLINDER TREATMENT TECHNOLOGIES**	**(9 Periods)**
Low temperature Combustion Modes - Homogeneous Charge Compression Ignition, Premixed Charge Compression Ignition, Reactivity Controlled Compression Ignition, Gasoline Direct Injection Compression Ignition, Water Injection Technologies.		
UNIT – V	**AFTER TREATMENT TECHNOLOGIES**	**(9 Periods)**
Diesel Oxidation Catalyst, Diesel Particulate Filter, Selective Catalytic Reduction, Ammonia slip / clean up catalyst. CO2 absorption techniques, Waste Heat Recovery and Organic Rankine Cycle.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*John Twidell, and Tony Weir.* ***"Renewable Energy Sources"****,Taylor and Francis Group, 3rd Edition, 2015.*
2	*Rakesh Kumar Maurya,* ***"Characteristics and Control of Low Temperature Combustion Engines"****, Springer International Publishing, 2018.*

REFERENCES:

1	*Daniel J Holt.* ***"Fuel Cell Powered Vehicles: Automotive Technology of the Future"****, Society of Automotive Engineers, 2001 - Technology & Engineering.*
2	*W. Addy Majewski, Magdi K. Khair.* ***"Diesel Emissions and Their Control"****, SAE International, 2006.*
3	*Adrian Smith and Gordon Gill,* ***"Toward Zero Carbon: The Chicago Central Area DeCarbonization Plan"****, Images Publishing Group Pty Ltd, 2011.*
4	*Kathryn G. Logan, Astley Hastings, et al.,* ***"Transportation in a Net Zero World: Transitioning Towards Low Carbon Public Transport (Green Energy and Technology)",*** *Springer International, 2022.*
5	*G. Amba Prasad Rao,* ***Engine Emission Control Technologies, Design Modifications and Pollution Mitigation Techniques****, Apple Academic Press, 2021.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand the availability, suitability, and its role in off-road vehicle categories in reducing the carbon footprint on the environment.	K2,K3
CO2	Gain knowledge on various green energy production methods and its impact on meeting energy demand of off-road vehicle applications.	K2,K3
CO3	Understand the working of fuel cell, various fuel cell types, and its design for off-road vehicle applications.	K2,K3
CO4	Gain knowledge on various in-cylinder low temperature combustion technologies and its key role in controlling the engine-out emissions.	K2
CO5	Understand the working of various existing after treatment systems in controlling the engine out emissions.	K2

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	2	3	-	-	3	3	-	-	2	2	2	3	2	2
CO2	3	2	3	-	-	3	3	-	-	2	2	2	2	3	2
CO3	3	3	2	-	-	3	3	-	-	3	1	1	3	2	2
CO4	2	2	3	-	-	3	3	-	-	3	1	1	2	3	1
CO5	2	3	3	-	-	3	3	-	-	2	2	2	2	3	1
22MPE$03	3	2	3	-	-	3	3	-	-	2	2	2	2	3	2
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.2.1,1.4.1,2.2.2,2.2.3,2.3.1,2.4.2,3.1.5,6.1.1,7.1.1,10.1.3,11.3.1,12.1.2
CO2	1.3.1,1.4.1,2.2.4,3.2.1,6.1.1,7.2.1,9.1.1,10.1.1,11.1.1,12.3.1
CO3	1.3.1,1.4.1,2.2.3,2.4.2,3.4.2,4.3.4,5.3.1,5.3.2,6.1.1,7.2.2,10.1.1,11.3.1,12.3.2
CO4	1.4.1,2.2.3,2.4.4,3.1.6,3.2.3,7.1.2,10.2.1,11.2.1,12.3.2
CO5	1.4.1,2.2.4,3.1.6,6.1.1,7.1.2,10.2.1,11.1.2,12.2.2,12.3.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1		50	50				100
CAT2		75	25				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1		50	50				100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2		75	25				100
ESE		60	40				100

22MPE$04	VEHICLE HEALTH MONITORING

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To provide insight on continuous monitoring to identify the anomaly if occurred and also about maintenance of the vehicle	
UNIT – I	**INTRODUCTION TO WEARS IN VEHICLE SYSYTEMS**	**(9 Periods)**
Wears- Engine and Its Components, Fuel, Ignition, Electrical, Exhaust, Drive Train and Transmission Systems – Suspension, Steering, Brakes, Frame and Body; Importance of maintenance, monitoring and safety systems.		
UNIT – II	**MONITORING SYSTEMS**	**(9 Periods)**
Database Design - Backup Systems - Command Lines, Requirement Specifications – Hardware – Software - Functional specification, Design Principles and Methodology, Context Diagram, Feasibility Analysis - Economic feasibility - Operational feasibility - Technical feasibility - Feasibility study of VTMS, Data Flow Diagrams, Screens - Master screens - Transaction screens – Reports, Testing - Testing phases - Testing methodologies - Test approach.		
UNIT – III	**MAINTENANCE SYSTEMS**	**(9 Periods)**
Need of Maintenance, Breakdown Maintenance – Preventive Maintenance – Predictive Maintenance - TPM, Service Stations Operations, Tools and Equipment, Measurement Instruments, Service and Repair of All Vehicle Systems.		
UNIT – IV	**SAFETY OF VEHICLE SYSTEMS**	**(9 Periods)**
Basic concepts of vehicle safety, Risk evaluation, Human error control, Risk communication, Universal design, Occupant injury prevention, Human simulation application, Crash testing, Accident reconstruction, Special design problems,		
UNIT – V	**FUTURE OF VEHICLE MAINTENANCE AND SAFETY**	**(9 Periods)**
Maintenance Planning, Fault Detection and Isolation (FDI), Predicting Maintenance - Present business solutions – FMS Systems, Methodology - Learning from historical data - Learning from real-time data streams, Future vehicle safety, Out-of-position occupants, Human interaction, Compensatory actions, The precautionary principle, Advanced features in future vehicles.		
Contact periods: **Lecture: 45 Periods Tutorial: 0 Period Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	George A. Peters and Barbara J. Peters ***"Automatic Vehicle Safety"*** - 2012
2	Clemens guhmann – "***Simulation And Testing For Vehicle Technology***" – 2016

REFERENCES:

1	*Jigar A. Doshi, Dhruv U. Panchal, Jayesh P. Maniar "**Vehicle maintenance and garage practice**" - 2014*
2	*P. Raghu Vamsi **"Vehicle Tracking Monitoring System"***
3	*Asad Safi **"Vehicle Remote Health Monitoring and Prognostic Maintenance System" - 2017***
4	*M.Jyothi kiran, S.Ravi teja **"Vehicle Health Monitoring System"- 2012***

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the causes of wears and their effects in vehicle performance	K2
CO2	Interpret the Monitoring System and debrief their importance	K2
CO3	Know about the maintenance system and their parameters	K2
CO4	Know about importance of vehicle safety and their advantages	K2
CO5	Design a newer and better safety systems as a replacement for conventional systems	K6

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	1	3	2	2	2	1	1	-	-	1	2	2	2	1
CO2	2	2	2	3	3	-	1	-	1	1	-	2	2	1	1
CO3	2	2	2	2	2	2	2	1	1	-	1	2	2	2	1
CO4	2	2	2	2	2	2	1	-	1	1	1	2	2	1	1
CO5	2	1	1	1	2	-	-	-	1	1	2	2	2	2	1
22MPE$04	2	2	2	2	2	2	1	1	1	1	1	2	2	2	1
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.2.1, 1.4.1, 2.2.3, 2.3.1, 2.4.3, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.2, 4.1.3, 4.2.1, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.3.1, 6.1.1, 7.1.1, 8.2.1, 11.2.1, 12.1.2, 12.2.2, 12.3.2.
CO2	1.1.1, 1.1.2, 1.2.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.3, 3.1.1, 3.1.4, 3.1.5, 3.3.2, 3.4.2, 4.1.2, 4.1.3, 4.2.2, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2, 7.1.2, 9.1.2, 10.2.1, 12.2.1, 12.2.2, 12.3.1, 12.3.2.
CO3	1.1.1, 1.1.2, 1.4.1, 2.1.2, 2.1.3, 2.2.1, 2.2.4, 2.3.1,.3.2, 2.4.2, 2.4.4, 3.1.2,3.1.3, 3.1.5, 3.1.6, 3.2.2, 3.2.3, 3.4.1, 3.4.2, 4.1.2, 4.2.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.2.1, 5.3.1, 6.2.1, 7.1.1, 7.2.1, 8.2.2, 9.2.1, 11.1.2, 12.1.2, 12.3.1, 12.3.2.
CO4	1.1.1, 1.1.2, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.4.2, 2.4.4, 3.1.2, 3.1.4, 3.1.6, 3.2.1, 3.2.2, 3.3.1, 3.4.1, 3.4.2, 4.1.2, 4.1.3, 4.2.1, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.3.1, 6.1.1, 7.1.1, 9.3.1, 10.2.2, 11.2.1, 12.2.1, 12.2.2, 12.3.2.
CO5	1.1.1, 1.1.2, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.4.2, 2.4.4, 3.1.2, 3.1.4, 3.1.6, 3.2.1, 3.2.2, 3.3.1, 3.4.1, 3.4.2, 4.1.2, 4.1.3, 4.2.1, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.3.1, 6.1.1, 7.1.1, 9.3.1, 10.2.2, 11.2.1, 12.2.1,12.2.2, 12.3.2.

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	50	50					100
CAT2	30	30		15	15	10	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50					100
Individual Assessment 2 /Case Study 2/ Seminar 2 /	30	30		15	15	10	100

Project 2							
ESE	30	30		15	15	10	100

22MPE$05	CAE AND CFD APPROACH IN FUTURE MOBILITY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To familiarize and appreciate different Application of CFD and CAE in mobility industry and to impart knowledge on industrial application of CAE and different modeling methods incorporated in CFD.	
UNIT – I	**INTRODUCTION TO CAE AND CFD**	**(9 Periods)**
Introduction -Basic Concepts of Finite Element Analysis-Introduction to Elasticity-Steps in Finite Element Analysis Classification, CFD- Initial and Boundary conditions, Initial and Boundary value problems. Finite difference method, Central, Forward, Backward difference, Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test		
UNIT – II	**CAE**	**(9 Periods)**
Introduction to solid modeling -Concepts of 3-D modeling-Model structure- Engineering drawing - Fundamentals of assembly and sub-assembly - Parametric modeling - Advanced feature-based design - Fundamentals of modeling for finite element analysis - Analysis methods - Design creativity- Design for manufacturability - Real-world problems: critiques, analysis, and improvements.		
UNIT – III	**APPLICATION OF CAE IN MOBILITY**	**(9 Periods)**
Finite element analysis (FEA)-Thermal analysis using FEA method-Kinematics and dynamics analysis in powertrain systems-Multi-physics analysis in mobility industry-Electromagnetic analysis-Structural analysis in frames and structures of automobiles-Moldflow analysis-Stamping analysis-Acoustic analysis-Crash testing-Product simulation-Durability analysis-Design visualization and animation		
UNIT – IV	**CFD**	**(9 Periods)**
Classification of Partial Differential Equations and Physical Behavior-Fundamentals of Discretization and Finite Difference Method-Finite Volume Method for steady diffusion problems and advection diffusion problem-Numerical Solutions of Navier-Stokes Equations-Numerical Grid Generation-Basics of Turbulence Modeling.		
UNIT – V	**APPLICATION OF CFD IN MOBILITY**	**(9 Periods)**
Electronic Cooling-Battery Thermal management-Powertrain Simulations-HVAC Analysis.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*S. V. Patankar, **"Numerical Heat Transfer and Fluid Flow"**, McGraw-Hill*
2	*Anderson J.D. (1995) **"Computational Fluid Dynamics: The Basics with Applications"**, McGraw-Hill Inc*

REFERENCES:

1	*Reddy. J.N., **"An Introduction to the Finite Element Method"**, 3rd Edition, Tata McGraw-Hill, 2005*
2	*Chitale A.K and Gupta R.C **" Product design and manufacturing"** PHI learning private limited, 6th Edition, 2015*
3	***"Refrigeration and Air Conditioning"** - C. P. Arora- Tata McGraw Hill Publication*
4	*Plett, Gregory L. **"Battery management systems"**, Volume I: Battery modeling. Artech House, 2015.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand the basic concept of FEA.	K2
CO2	Apply principles relevant to CFD and CAE for practicality.	K2
CO3	Analyze the working of physical problem using numerical approaches.	K3
CO4	Understand the basic concept of finite volume method and discretization.	K3
CO5	Evaluate the industrial view of CFD in mobility.	K2

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	2	3	1	2	1	2	2	1	1	1	1	1	3	
CO2	1	2	2	1	1	2	1	1	1	1	1	1	1	3	
CO3	1	3	3	2	2	2	1	2	1	1	1	1	1	2	
CO4	1	2	2	1	1	2	2	2	1	1	1	1	1	3	
CO5	1	3	2	1	2	1	1	1	1	1	1	1	1	3	
22MPE$05	1	2	2	1	2	2	1	2	1	1	1	1	1	3	

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.3.1, 2.1.3, 4.1.1, 5.1.1
CO2	1.4.1, 2.1.2, 4.1.4
CO3	1.2.1, 2.1.1, 3.1.1, 10.3.1, 12.1.2
CO4	1.2.1, 2.2.4, 3.4.1, 4.2.1, 7.1.1
CO5	1.3.1, 2.2.4, 2.4.2, 3.1.6, 4.2.1, 5.1.1, 7.1.2, 12.1.2, 12.3.2

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	30	30	15	15	5	5	100
CAT2	10	10	20	20	20	20	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	20	15	15	15	15	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	10	10	20	20	20	20	100
ESE	25	20	15	15	15	10	100

22MPE$06	HYBRID AND ELECTRIC VEHICLE TECHNOLOGY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objective	To provide knowledge on technologies used in Hybrid and Electric vehicles	
UNIT – I	**INTRODUCTION**	**(9 Periods)**
Introduction to electric and hybrid electric vehicles, History of hybrid and electric vehicles, Social and environmental importance of electric and hybrid electric vehicles Electrical basics, Motor and Generators		
UNIT – II	**ELECTRIC DRIVE COMPONENTS**	**(9 Periods)**
Introduction to electric drive components used in electric and hybrid vehicles, Electric motor requirements, Direct Current (DC) motors (Brushed and Brushless), Power converters, Drive Controllers		
UNIT – III	**DRIVETRAINS AND POWERFLOW**	**(9 Periods)**
Basic concept of electric and hybrid traction, Introduction to various electric and hybrid electric drive train topologies, Advantages and disadvantages, Power flow control in electric and hybrid electric drive train topologies		
UNIT – IV	**ENERGY STORAGE**	**(9 Periods)**
Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis. Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.		
UNIT – V	**REGENERATIVE BRAKING SYSTEM**	**(9 Periods)**
Introduction and need of Regenerative Braking System, Advantages and disadvantages of RBS Working of RBS, Concept of Regenerative Braking using Piezoelectric material, Using shock absorbers vibration as energy harvesters		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS

1	*Iqbal Hussain, **"Electric & Hybrid Vehicles – Design Fundamentals"**, Second Edition, CRC Press, 2021.*
2	*James Larminie, **"Electric Vehicle Technology Explained"**, 2nd edition John Wiley & Sons, 2012.*

REFERENCES

1	*Chris Mi – "**Hybrid Electric Vehicles"** - 2017.*
2	*Mehrdad Eshani – **"Modern Electric, hybrid electric and fuel cell vehicles"** - 2004.*
3	*Ronald Jurgen – **"Electric and Hybrid-Electric Vehicles"** - 2002.*
4	*Gianfranco – **"Electric and hybrid vehicles"** - 2010*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the importance of Electric and Hybrid vehicles	K2
CO2	Suggest and specify the suitable motor based on the requirements	K3
CO3	Understand the working as well as to predict the errors and failures in drivetrain	K4
CO4	Select and Design a particular and suitable energy storing device	K3
CO5	Store and utilize the energy harvested from braking system	K2

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	2	3	2	1	1	-	2	2	2	2	1	2
CO2	1	1	2	3	1	-	3	1	1	2	-	1	2	1	2
CO3	3	2	2	3	3	3	1	1	1	1	2	1	2	1	2
CO4	3	2	2	3	3	-	2	1	-	1	2	1	2	1	2
CO5	3	2	1	2	1	2	-	1	1	2	-	2	2	1	2
22MPE$06	3	2	2	3	2	1	1	1	1	2	1	1	2	1	2
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.1, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.6, 3.2.1, 3.3.1, 3.4.1, 3.4.2, 4.1.2, 4.2.1, 4.3.1, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1,5.3.2, 6.1.1, 7.2.2, 8.2.1, 10.1.2, 10.1.3, 10.3.1, 11.1.2, 11.2.1, 12.1.1, 12.2.2. 12.3.2.
CO2	1.1.2, 2.2.2, 2.4.4, 3.1.4, 3.1.5, 3.1.6, 3.2.2, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.4, 4.2.1, 4.2.2, 4.3.2, 4.3.3, 4.3.4, 5.1.2, 5.2.2, 7.1.1, 7.1.2, 7.2.1, 8.1.1, 9.2.1, 10.1.1, 10.1.2, 10.2.2, 12.1.1, 12.3.2.
CO3	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.4.1, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.5, 3.1.6, 3.2.1, 3.2.3, 3.3.1, 4.1.1, 4.1.2, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.3, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.2.1, 8.1.1, 9.1.1, 9.2.4, 10.1.3, 10.3.1, 11.1.2, 11.2.1, 11.3.1, 12.1.2, 12.2.1.
CO4	1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.2.1, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 3.1.1, 3.1.3, 3.2.1, ,3.2.2, 3.3.2, 3.4.1, 3.4.2, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 7.1.2, 7.2.2, 8.1.1, 10.2.2, 11.1.1, 11.3.2, 12.2.2, 12.3.1.
CO5	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.2.3, 2.4.1, 2.4.4, 3.1.6, 3.2.1, 4.1.1, 4.1.4, 4.2.1, 4.3.1, 4.3.4, 5.1.1, 5.3.2, 6.2.1, 8.2.1, 9.1.2, 10.1.2, 10.2.1, 10.3.1, 12.1.1, 12.1.2, 2.3.2.

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	35	35	20	10			100
CAT2	35	35	20	10			100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	35	35	20	10			100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	35	35	20	10			100
ESE	35	35	20	10			100

22MPE$07	VALUE ENGINEERING

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To apply the concepts of value engineering in the real time engineering industrial applications.	
UNIT – I	**INTRODUCTION**	**(9 Periods)**
Value engineering concepts, advantages, applications, problem recognition, and role in productivity, criteria for comparison, element of choice. Organization Level of value engineering in the organization, size and skill of VE staff, small plant, VE activity, unique and quantitative evaluation of ideas		
UNIT – II	**JOB PLAN AND ANALYSIS FUNCTION**	**(9 Periods)**
Introduction, orientation, information phase, speculation phase, analysis phase. Selection and Evaluation of value engineering Projects, Project selection, application of value engineering methodology. Use esteem and exchange values, basic vs. secondary vs. unnecessary functions. Approach of function, determining function, classifying function		
UNIT – III	**VALUE ENGINEERING TECHNIQUES**	**(9 Periods)**
Selecting products and operation for value engineering action, value engineering programmes, developing alternate means to required functions, decision making for optimum alternative, use of decision matrix, queuing theory and Monte Carlo method make or buy, measuring profits, reporting results, Use of advanced technique like Function Analysis System.		
UNIT – IV	**VERSATILITY OF VALUE ENGINEERING**	**(9 Periods)**
Value engineering operation in maintenance and repair activities, value engineering in non-hardware projects. Initiating a value engineering programme Introduction, training plan, career development for value engineering specialties.		
UNIT – V	**VALUE ENGINEERING LEVEL OF EFFORT**	**(9 Periods)**
Value engineering team, co-coordinator, designer, different services, definitions, construction management contracts, value engineering case studies.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Anil Kumar Mukhopadhyaya, **"Value Engineering: Concepts Techniques and applications"**, SAGE Publications 2010*
2	*Khanna, O.P., **"Industrial Engineering and Management"**, Dhanpat Rai & Sons, 1993*

REFERENCES:

1	*Alphonse Dell'Isola, **"Value Engineering: Practical Applications for Design, Construction, Maintenance & Operations"**, R S Means Co., 1997*
2	*Richard Park, "**Value Engineering: A Plan for Invention"**, St. Lucie Press, 1999*
3	*Del L. Younker, "**Value Engineering analysis and methodology**", Marcel Dekker Inc, New York, 2004*
4	*Miles, L.D., **"Techniques of Value Analysis and Engineering"**, McGraw Hill second Edition, 1989*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand the concepts of value engineering, identify the advantages, applications	K1
CO2	Analysis various phases of value engineering. Analyze the function, approach of function and evaluation of function. Determine the worth and value.	K1
CO3	Implement the concept of queuing theory	K2
CO4	Appraise the value engineering operation in maintenance and repair activities	K3
CO5	Create the value engineering team and discuss the value engineering case studies	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	2	3	2	3	2	2	1	1	2	2	1	2	1
CO2	3	2	3	3	2	2	2	2	1	1	3	1	2	2	2
CO3	2	2	2	2	2	2	2	1	1	1	2	1	2	2	2
CO4	2	2	2	3	1	0	2	1	1	2	1	1	1	1	2
CO5	2	2	2	3	2	2	1	2	3	1	1	3	2	3	2
22MPE$07	2	2	2	3	1	1	1	1	3	2	3	3	2	3	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1,2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.4, 4.2.1, 4.3.4, 5.2.1, 5.3.1, 5.3.2, 10.1.1, 10.1.2, 10.1.3, 11.2.1, 11.3.1
CO2	2.2.3, 2.2.4, 2.3.1, 3.1.1, 3.1.2, 3.1.3, 3.3.2, 5.3.1, 7.1.1, 10.1.1, 10.1.2, 10.1.3
CO3	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.1, 2.4.2, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 4.1.1, 4.2.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 7.1.1, 10.1.1, 10.1.2, 10.1.3, 11.2.1, 11.3.1
CO4	1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1,2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.4, 4.2.1, 4.3.4, 5.2.1, 5.3.1, 5.3.2, 10.1.1, 10.1.2, 10.1.3, 11.2.1, 11.3.1
CO5	2.2.3, 2.2.4, 2.3.1, 3.1.1, 3.1.2, 3.1.3, 3.3.2, 5.3.1, 7.1.1, 10.1.1, 10.1.2, 10.1.3

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	60	30	10				100
CAT2	50	30	20				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	60	40					100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	50	50					100
ESE	50	30	20				100

22MPE$08	ADDITIVE MANUFACTURING TECHNIQUES

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To educate the students with fundamental and advanced knowledge in the field of Additive Manufacturing technology and associated Aerospace, Architecture, Art, Medical and Industrial applications.	
UNIT- I	**INTRODUCTION**	**(9 Periods)**
General overview Introduction to reverse engineering Traditional manufacturing viz AM Computer aided design (CAD) and manufacturing (CAM) and AM Different AM processes and relevant process physics AM process chain Application level: Direct processes - Rapid Prototyping, Rapid Tooling. Rapid Manufacturing; Indirect Processes - Indirect Prototyping. Indirect Tooling, Indirect Manufacturing		
UNIT- II	**MATERIALS SCIENCE FOR AM**	**(9 Periods)**
Choosing Materials for Manufacturing -Multiple Materials -Metal AM Processes & Materials Composite Materials -Biomaterials, Hierarchical Materials & Biomimetics -Ceramics & Bio-ceramics -Shape-Memory Materials, 4D Printing & Bio-active materials Role of solidification rate Evolution of non-equilibrium structure, Structure property relationship Grain structure and microstructure		
UNIT- III	**SOFTWARE AND METHODS**	**(9 Periods)**
Designing for Additive Manufacturing (DfAM) - Software Tools vs. Requirements-Pre& Post-processing-3D Scanning & the Scanning Process-Sculpting & Repairing data AM File Formats-STEP file format-More detail on NURBS-Model Validation.		
UNIT- IV	**POWDER BASED ADDITIVE MANUFACTURING SYSTEMS**	**(9 Periods)**
Transport phenomena models: temperature, fluid flow AM and composition, buoyancy driven tension driven free surface flow pool. Case studies: Numerical modeling of AM process, Powder bed melting based process, Droplet based printing process Residual stress, part fabrication time, cost, optimal orientation and optimal Defect in AM and role of transport Simulations (choice of parameter, Mo de! validation for different		
UNIT- V	**APPLICATIONS AND THE BUSINESS OF AM**	**(9 Periods)**
Choosing the Right Manufacturing Process, Injection Molding, Casting, Mold-making. Direct Digital Manufacturing, Distributed Manufacturing, Mass Customization, Biomedical Applications, Aerospace & Automotive Applications Architectural Engineering Food & Consumer Applications Personalized surgery Art, Fashion, Jewellery, Toys & Other Applications Intellectual Property Trade-offs of Open Source vs Proprietary Systems, Gartner hype cycle viz 3D Printing. Total cost of ownership Business Considerations for Material Selection Commercialization Trends, Business Opportunities & Future Directions		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Chua Chee Kai and Leong Kah Fai, "**Rapid Prototyping: Principles and Applications in Manufacturing**", John Wiley AND Sons, 1997.*
2	*Paul F. Jacobs, "**Stereo-lithography and other RP & M Technologies**", from Rapid Prototyping to Rapid Tooling, SME/ASME,1996*

REFERENCES:

1	*Ian Gibson, David Rosen, Brent Stucker, Mahyar Khorasani* ***"Additive manufacturing technologies"****. 3rd edition Springer Cham, Switzerland, 2021.*
2	*Chua, C.K., Leong K.F. and Lim C.S.* ***"Rapid prototyping: Principles and applications"****, second edition, World Scientific Publishers, 2010.*
3	*Gebhardt, A.,* ***"Rapid prototyping"****, Hanser Gardener Publications, 2003.*
4	*Liou, L.W. and Liou, F.W* ***"Rapid Prototyping and Engineering applications: A tool box for prototype development"****, CRC Press, 2011.*
5	*Hilton, P.D. and Jacobs, P.F* ***"Rapid Prototyping and Engineering applications: A tool box for prototype development"****, CRC press, 2005.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Describe the need and fundamentals of Additive Manufacturing (AM) systems.	K3
CO2	Create and analyse 2D and 3D models using CAD modelling software, discuss the fundamentals of Reverse Engineering and integrating with manufacturing systems.	K3
CO3	Describe Various AM Technologies	K3
CO4	Apply knowledge of powder based additive manufacturing techniques in the field of manufacturing and other fields.	K3
CO5	To gain knowledge on application and the business of AM.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	2	0	2	0	3	0	3	3	3	3	1	1	0
CO2	2	2	3	3	3	0	3	0	3	3	1	2	0	2	1
CO3	2	2	3	2	3	0	3	0	3	3	1	2	2	1	0
CO4	2	2	3	2	3	0	3	0	3	3	1	2	2	3	1
CO5	2	2	3	2	3	3	3	0	3	3	1	3	1	3	0
22MPE$08	**2**	**2**	**3**	**2**	**3**	**1**	**3**	**0**	**3**	**3**	**2**	**3**	**2**	**2**	**1**

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.3, 5.2.2, 5.3.1, 5.3.2, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.1, 11.1.2, 11.2.1, 11.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.2, 12.3.1, 12.3.2.
CO2	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.2, 12.2.2, 12.3.1, 12.3.2.
CO3	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.2.1, 4.3.1, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.2, 12.2.2, 12.3.1, 12.3.2.
CO4	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.2.1, 4.3.1, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.2, 12.2.2, 12.3.1, 12.3.2.
CO5	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.2.1, 4.3.1, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.1, 12.1.2, 12.2.2, 12.3.1, 12.3.2.

ASSESSMENT PATTERN– THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	15	52	33	-	-	-	100
CAT2	15	68	17	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	-	50	25	25	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	-	-	100	-	-	-	100
ESE	9	75	16	-	-	-	100

22MPE$09	COMPUTER INTEGRATED MANUFACTURING

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To provide knowledge on the CNC programming, material handling, application of robot and automated factory to manage the competitive manufacturing environment.	
UNIT – I	**INTRODUCTION**	**(9 Periods)**
Introduction to Computer Integrated Manufacturing, computerized elements of a CIM system, Evolution of Computer Integrated Manufacturing, Nature and role of the elements of CIM System, Basic Elements of an Automated system – Advanced Automation Functions - Levels of Automation		
UNIT – II	**COMPUTER NUMERICAL CONTROL**	**(9 Periods)**
Fundamentals of NC Technology - Basic Components of an NC System - NC Coordinate Systems-Motion Control Systems -Computers and Numerical Control - CNC Machine Control Unit - CNC Software - Distributed Numerical Control - Applications of NC-Machine Tool - Advantages and Disadvantages of NC -Analysis of Positioning Systems - Open-Loop Positioning Systems - Closed-Loop Positioning Systems - Precision in Positioning Systems.		
UNIT – III	**AUTOMATED MATERIAL HANDLING AND IDENTIFICATION SYSTEMS**	**(9 Periods)**
Overview of material handling equipment's – Consideration in material handling system design – The 10 principles of Material handling, Material transport equipment, Automated Guided Vehicle system – Types &applications – Vehicle guidance technology – Vehicle management and safety. Automatic identification method- Bar code Technology, Radio frequency identification , Magnetic stripes, Optical Character Recognition, Machine Vision		
UNIT – IV	**MANUFACTURING AUTOMATION AND ROBOTICS**	**(9 Periods)**
Data acquisition systems, virtual instrumentation, interfacing of sensors and actuators with PC, condition monitoring, adaptive control, PLC- basic programming, application in automation. Robot – Itoduction, Classification - Applications of Robo in industry.		
UNIT – V	**AUTOMATED FACTORY**	**(9 Periods)**
Role of modern computer based technologies-Industry 4.0- Artificial Intelligence – Machine Learning- Smart manufacturing- Digital manufacturing- Internet of Things- cloud based Manufacturing- function ,application, benefit		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total:45 Periods**		

TEXT BOOK:

1	*Mikell P. Groover, "**Automation, Production Systems, and Computer-integrated Manufacturing**", Pearson Education,2018.*
2	*Shivanand H K, Benal M M and Koti V, "**Flexible Manufacturing System**", New Age, 2016.*

REFERENCES:

1	*Roger Hanman, **" Computer Integrated Manufacturing: From concepts to realisation"**, Addison –Wesley*
2	*Kant Vajpayee S, **"Principles of Computer Integrated Manufacturing",** Prentice Hall India, 2007.*
3	*Gideon Halevi and Roland Weill, **"Principles of Process Planning – A Logical Approach"** Chapman & Hall, London, 1995.*
4	*P Rao, N Tewari and T.K. Kundra, **"Computer Aided Manufacturing",** Tata McGraw Hill, 2000.*
5	*Alavudeen and Venkateshwaran, **"Computer Integrated Manufacturing",** PHI Learning Pvt. Ltd.,New Delhi, 2013.*
6	*Radhakrishnan P, Subramanian S and Raju V, **"CAD/CAM/CIM",** New Age International Publishers, 3rd Edition, 2008.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Familiarize the manufacturing activities inter relation with computers for plant operations	K2
CO2	Gain Knowledge on Numerical Control systems	K2
CO3	Choose appropriate material handling systems and automatic identification method	K3
CO4	Apply knowledge on of automation and robot in industry	K3
CO5	Familiarize the concept of future automated factory	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	1	1										1	2
CO2	1	1	1	2	2									1	2
CO3	1	2	1	2	2						1	1		1	2
CO4	1	2	1	2	2						1	1		1	2
CO5	1	2	1	2	2						1	1		1	2
22MPE$09	1	2	1	2	2						1	1		1	2
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.1.2,1.3.1,1.4.1,2.2.1,2.2.2,2.2.3,2.2.4,2.3.1,2.4.1,2.4.2,2.4.3,2.4.4,3.2.1,3.2.2,3.2.3,3.3.1,3.3.2,4.1.2,4.1.3,10.1.1														
CO2	1.1.2,1.3.1,1.4.1,2.2.1,2.2.2,2.2.3,2.2.4,2.3.1,2.4.1,2.4.2,2.4.3,2.4.4,3.2.1,3.2.2,3.2.3,3.3.1,3.3.2,4.1.2,4.1.3, 5.1.1,5.1.2														
CO3	1.1.2,1.3.1,1.4.1,2.2.1,2.2.2,2.2.3,2.2.4,2.3.1,2.4.1,2.4.2,2.4.3,2.4.4,3.2.1,3.2.2,3.2.3,3.3.1,3.3.2,4.1.2,4.1.3, 5.1.1,5.1.2,11.1.1,11.1.2, 12.2.1,12.2.2														
CO4	1.1.2,1.3.1,1.4.1,2.2.1,2.2.2,2.2.3,2.2.4,2.3.1,2.4.1,2.4.2,2.4.3,2.4.4,3.2.1,3.2.2,3.2.3,3.3.1,3.3.2,4.1.2,4.1.3, 5.1.1,5.1.2,11.1.1,11.1.2, 12.2.1,12.2.2														
CO5	1.1.2,1.3.1,1.4.1,2.2.1,2.2.2,2.2.3,2.2.4,2.3.1,2.4.1,2.4.2,2.4.3,2.4.4,3.2.1,3.2.2,3.2.3,3.3.1,3.3.2,4.1.2,4.1.3, 5.1.1,5.1.2,11.1.1,11.1.2, 12.2.1,12.2.2														

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	30	40				100
CAT2	10	40	50				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	30	30	40				100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	10	40	50				100
ESE	20	40	40				100

22MPE$10	DESIGN FOR MANUFACTURE

PRE-REQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	Understand the Design Principles and to know the designing concept of machining component, injection moulding and sheet metal for Manufacturing and to produce eco-friendly manner.	
UNIT – I	**DESIGN PRINCIPLES FOR MANUFACTURABILITY**	**(9 Periods)**
Process Capability and its Metrics – General Design Principles of Manufacturability – Material selection – Strength and Mechanical Factors- Geometric Tolerances, Surface Finish, -Assembly Limits –Datum Features – Tolerance Stacks.		
UNIT – II	**FACTORS INFLUENCING FORM DESIGN**	**(9 Periods)**
Influence Factors for Form Design -Physical factors -Size-Arrangement-Efficiency in Casting, Welding, Forging, Rolling, Wire Drawing, Plastic Moulding and Pressure Die Casting.		
UNIT – III	**MACHINING COMPONENT DESIGN**	**(9 Periods)**
Design Features to Facilitate Machining –Twist Drill –Drill Entry and Run Out- Counter Sunk Head Screws-Redesign of Casting based on Parting Line consideration-Pattern, Mould, Parting Line, Cast Holes-Cored Holes, Machined Holes, Identify the possible and probable Parting Line-Design for Economy, Clampability and Accessibility.		
UNIT – IV	**DESIGN FOR INJECTION MOULDING AND SHEET METALS WORKING**	**(9 Periods)**
Design of Injection Moulding System - Materials- Estimation of Molding Cycle Time- Design Guidelines- Case Studies-Recent Trends in Injection Moulding. Dedicated Dies and Press -Working, Press Selection, Turret Press Working, and Design Rules- Case Studies.		
UNIT – V	**DESIGN FOR ENVIRONMENT**	**(9 Periods)**
Introduction to Environmental Objectives – Global Issues – Regional and Local Issues – Basic DFE Methods – Design Guidelines – Lifecycle Assessment - Design to Minimize Material Usage – Design for Disassembly, Recyclability, Remanufacture and Energy Efficiency– Design to Regulations and Standards.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Geoffrey Boothroyd, Peter Dewhurst, Winston A. Knight, "**Product Design for Manufacture and Assembly**", 3rd Edition, CRC Press, 2010.*
2	*Harry Peck, **"Design for Manufacture"**, Pitman Publishers, 1983.*

REFERENCES:

1	*Ramon Bakerjian, **"Design for Manufacturability"**, Tool and Manufacturing Engineers Handbook, Vol.6, Society of Manufacturing Engineers, 1992.*
2	*James G. Bralla, **"Design for Manufacturability Handbook"**, 2nd Edition,* **McGraw** *Hill Book Co., 1998.*
3	*G. E. Dieter, "**Engineering Design: A Materials and Processing Approach",** McGraw Hill International, 1991.*
4	*Roy A. Lindberg, "**Processes and Materials of Manufacture"**, 4th Edition, Prentice-Hall India Publishers, 1990.*
5	*S.Kalpakjian and S.R. Schmid, "**Manufacturing Engineering and Technology"**, 7th Edition, Pearson Publishers, 2013.*
6	*T.E.Graedel and B.R.Allenby, "**Design for the Environment"**, Prentice Hall Publication, 1996.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand and analyse the design principles for manufacturability	K4
CO2	Select the methods for productivity with considerations of influencing factors	K3
CO3	Apply the design considerations for machining of the components	K4
CO4	Understand the component design for Casting and Sheet metal operations	K4
CO5	Able to select the materials for the Eco-friendly machining Environment	K4

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	3	1	1	1	1	3	3	1	1	3		3	1	1
CO2	2	3	3	1	1	1	2	3	3	1	2	2	2	3	2
CO3	3	1	2	1	1	1	3	1	2	1	3	2	2	1	1
CO4	2	2	1	1	2	1	2	2	1	1	2	1	2	2	1
CO5	3	2	3	2	1	1	3	2	3	2	3	3	3	3	2
22MPE$10	2	2	2	1	1	1	2	2	2	1	2	2	2	2	2
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.1.1, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2. 2.1.3, 2.2.3, 2.3.2, 2.4.1, 2.4.2, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.6, 3.3.1, 3.3.2, 3.4.2, 4.1.4, 4.2.1, 4.3.1, 4.3.3, 4.3.4, 5.2.1, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 8.2.2, 10.1.1, 12.1.1, 12.2.1, 12.2.2, 12.3.1
CO2	1.1.1, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2,5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.1, 8.2.2, 9.1.2, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.3.1, 11.1.1, 11.1.2, 11.2.1, 11.3.1, 11.3.2, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO3	1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.3.2, 2.4.1, 2.4.2, 2.4.4, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.3.1, 3.3.2, 3.4.2, 4.1.1, 4.1.2, 4.1.4, 4.2.1, 4.3.1, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.2.2, 8.2.1, 8.2.2, 9.1.2, 9.3.1, 10.1.2, 10.1.3, 10.3.1, 11.1.1, 11.3.1, 11.3.2, 12.2.1, 12.3.1
CO4	1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.4, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.3.1, 3.3.2, 3.4.2, 4.1.1, 4.1.2, 4.1.4, 4.2.1, 4.3.1, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.2.2, 8.2.1, 8.2.2, 9.1.2, 9.3.1, 10.1.2, 10.1.3, 10.3.1, 11.1.1, 11.3.1, 11.3.2, 12.2.1, 12.3.1
CO5	1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.4, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.3.1, 3.3.2, 3.4.2, 4.1.1, 4.1.2, 4.1.4, 4.2.1, 4.3.1, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.2.2, 8.2.1, 8.2.2, 9.1.2, 9.3.1, 10.1.2, 10.1.3, 10.3.1, 11.1.1, 11.3.1, 11.3.2, 12.2.1, 12.3.1

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	30	40	20	-	-	100
CAT2	10	30	40	20	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	10	30	40	20	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	10	30	40	20	-	-	100
ESE	10	30	40	20	-	-	100

22MPE$11	ERGONOMICS IN DESIGN

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To study the mechatronics system and understanding the concepts of integration and design of mechatronics system.	
UNIT – I	**INTRODUCTION AND HUMAN FACTORS**	**(9 Periods)**
Ergonomics - Overview, objective, and application. MME interaction; Human Factors and its fundamentals, mutual task comfort. Anthropometry - Human body, various postures, and movements, measuring techniques; Biomechanics and its applications.		
UNIT – II	**BEHAVIOUR AND PERCEPTION**	**(9 Periods)**
Understanding cognitive elements and communication issues. Human sensory systems and its types. Perception and its approaches; memory and its types; selection, and execution of responses. Human error and risk perception. Design guidelines in cognitive ergonomics and usability evaluation.		
UNIT – III	**VISUAL ISSUES**	**(9 Periods)**
Visual field and system - distant objects, brightness, adaptation, and visual performance. Visual displays - vision and magnification overview and displays, illumination aspects in workplace and devices. Assessment and measuring visual environment.		
UNIT – IV	**ERGONOMIC DESIGN PROCESS**	**(9 Periods)**
Occupational safety and stress at workplace in view to reduce the potential fatigue, errors, discomforts and unsafe acts, workstation design, furniture support. Ergonomics - design methodology, criteria, and checklists. Humanising design: Design and human compatibility, comfort and adaptability aspects		
UNIT – V	**ENVIRONMENTS FACTORS**	**(9 Periods)**
Environmental factors and its influence in human design. Design Ergonomics in India: scope for exploration, Case studies.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Chakrabarti.D* ***"Indian anthropometric dimensions for ergonomic design practice"****, National institute of design. ISBN,1997*
2	*Bhise, V. D.,* ***"Ergonomics in the automotive design process"****, CRC Press,2011*

REFERENCES:

1	*Salvendy, G,* ***"Handbook of human factors and ergonomics"*** *John Wiley and Sons.2012*
2	*Karwowski, W., Soares, M. M., and Stanton, N. A.,* ***"Human factors and ergonomics in consumer product design: Uses and Applications",*** *CRC Press.2011*
3	*Soares, M. M., and Rebelo, F., "****Ergonomics in design: Methods and techniques"*** *CRC Press,2016*
4	*Stack, T., Ostrom, L. T., and Wilhelmsen, C. A.,* ***"Occupational ergonomics: A practical approach"*** *John Wiley and Sons,2016*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand the basic principles of ergonomics.	K1
CO2	Know the ergonomics design principles to be applied in industrial, cognitive and interaction design domains.	K3
CO3	apply in the design of objects, environments, and interfaces	K4

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO 1**	**PO 2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	1	3	2	2	0	1	0	0	0	1	0	0	3	1	2
CO2	3	3	3	3	2	2	2	0	`0	2	2	0	3	2	2
CO3	3	3	3	0	3	2	2	2	0	0	2	2	3	1	2
22MPE$11	2	3	3	2	5	3	2	1	0	3	1	1	3	2	2
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.3, 2.2.1, 2.2.3, 2.2.4, 2.4.4, 4.3.4, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2														
CO2	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 4.1.4, 5.1.2, 5.2.1, 5.3.1, 5.3.2														
CO3	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2														

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	50	20	20	10			100
CAT2	20	30	20	30			100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	40	40	20				100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	30	20	20			100
ESE	50	30	20				100

22MPE$12	**PROCESS PLANNING AND COST ESTIMATION** *(Common to Mech & Prod)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To introduce the process planning concepts, cost estimation for various manufacturing process.	
UNIT- I	**INTRODUCTION TO PROCESS PLANNING**	**(9 Periods)**
Aims and Objectives, Place of process planning in Manufacturing cycle - Process and Production Planning. Drawing interpretation, Dimensional tolerance vs Production processes.		
UNIT- II	**PROCESS PLANNING STEPS**	**(9 Periods)**
Design of a process plan – Selection of production processes, tools and process parameters-Positioning and work holding devices, Selection of inspection devices and tools, Documenting the process plan. Computer-Aided Process Planning (CAPP) – Benefits, Architecture and approaches.		
UNIT- III	**INTRODUCTION TO COST ESTIMATION**	**(9 Periods)**
Importance, Types, Purpose, Components, Procedure, Classification of costs, Cost elements, Cost ladder, Overhead expenses, Break-even analysis - Concept, make or buy decision, assumptions, merits and demerits of breakeven analysis. Applications - Linear, multi product break-even analysis.		
UNIT- IV	**PRODUCT LIFE CYCLE MANGEMENT AND PRODUCTION COST ESTIMATION**	**(9 Periods)**
Product life cycle management - Estimation of production cost for - cast components, welded components, forged components, powder metallurgy parts.		
UNIT- V	**ESTIMATION OF MACHINING TIME AND COST**	**(9 Periods)**
Estimation of Machining time – Lathe operations, Drilling, Milling, Shaping, Planing and Grinding, Cost estimation for machining processes.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Panneerselvam, R. and Sivasankaran, P. "**Process Planning and Cost Estimation**", PHI Learning (P) Ltd., New Delhi, 2015.*
2	*Adithan, M. "**Process Planning and Cost Estimation**", New Age International (P) Ltd., Chennai, 2015.*

REFERENCES:

1	*Thomas E.Vollmann, **"Manufacturing Planning and Control Systems",** Galgotia Publications Pvt. Ltd., New Delhi, 1998.*
2	*Samuel Eilon, **"Elements of Production Planning and Control**", MacMillan, London, 1985.*
3	*Kesavan, R. Elanchezhian, C. and Vijayaramanath, B., **"Process Planning and Cost Estimation",** New Age International (P) Ltd., Chennai, 2019.*
4	*Narang, B.S. and Kumar, V**., "Production and Costing"**, Khanna Publishers, 2014.*
5	*Banga,T.R. and Sharma, S.C., **"Mechanical Estimating and Costing**", Khanna Publishers, New Delhi, 2001.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Discuss the concept of process planning.	K2
CO2	Describe the steps involved in process planning.	K3
CO3	Discuss about cost estimation and Break Even analysis.	K3
CO4	Estimate the manufacturing cost for welded, forged components and powder metallurgy parts.	K4
CO5	Calculate the machining time and cost for various machining processes.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping														
COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2	-	-	-	-	-	-	-	-	1	-	1	2	-	-
CO2	2	1	-	-	2	-	-	-	-	1	-	1	2	1	-
CO3	2	3	-	-	-	-	-	-	-	-	2	1	2	-	-
CO4	2	3	-	-	-	-	-	-	-	-	-	1	2	-	-
CO5	2	3	-	-	-	-	-	-	-	-	-	1	2	-	-
22MPE$12	**2**	**2**	-	-	**1**	-	-	-	-	**1**	**1**	**1**	**2**	**1**	-
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.3.1, 1.4.1, 10.1.1, 10.1.2, 12.2.1, 12.2.2
CO2	1.3.1, 1.4.1, 2.2.4, 5.1.1, 5.2.1, 5.3.1, 10.1.1, 10.1.2, 12.2.1, 12.2.2
CO3	1.1.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 11.1.1, 11.2.1, 12.2.1, 12.2.2
CO4	1.1.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 12.2.1, 12.2.2
CO5	1.1.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 12.2.1, 12.2.2

ASSESSMENT PATTERN– THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	15	68	17	-	-	-	100
CAT2	15	52	33	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	9	43	48	-	-	-	100

22MPE$13	PRINCIPLES OF ROBOTICS

PRE-REQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To impart knowledge on the functional elements of Robotics direct and manipulator differential motion and control and to understand the various path planning techniques of robotics.	
UNIT – I	**BASIC CONCEPTS**	**(9 Periods)**
Brief history - Types of Robots Technology- Robot classifications and specifications- Various manipulators- work cell - Programming languages.		
UNIT – II	**ACTUATORS AND SENSORS**	**(9 Periods)**
Actuators and types, DC motors, BLDC servo motors. Introduction to sensors, characteristics, sensor types-Touch, Potentiometer, Encoder, Force, Range and proximity.		
UNIT – III	**DIRECT AND INVERSE KINEMATICS**	**(9 Periods)**
Mathematical representation of Robots - Position and orientation – Homogeneous transformation-Various joints- Representation using the Denavit Hattenberg parameters -Degrees of freedom-Direct Kinematics - Inverse kinematics- SCARA robot..		
UNIT – IV	**MANIPULATOR DIFFERENTIAL MOTION AND STATICS**	**(9 Periods)**
Linear and angular velocities-Manipulator Jacobian-Prismatic and rotary joints–Inverse -Wrist and arm singularity - Static analysis - Force and moment Balance		
UNIT – V	**PATH PLANNING**	**(9 Periods)**
Definition-Joint space technique-Use of p-degree polynomial-Cubic polynomial-Cartesian space technique - Parametric descriptions - Straight line and circular paths - Position and orientation planning.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*R.K.Mittal and I.J.Nagrath, **"Robotics and Control",** Tata McGraw Hill, New Delhi, 2017.*
2	*M.P.Groover, M.Weiss, R.N. Nageland N. Godrej, **"Industrial Robotics"**, McGraw-Hill Singapore, 2017.*

REFERENCES:

1	*Ashitava Ghoshal, **"Robotics-Fundamental Concepts and Analysis",** Oxford University Press, Sixthimpression, 2010.*
2	*K. K.Appu Kuttan, "**Robotics"**, I K International, 2007.*
3	*Edwin Wise, **"Applied Robotics",** Cengage Learning, 2003.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Select the robot for the various industrial applications	K3
CO2	Analyse the role of the actuators and sensors in manufacturing system.	K4
CO3	Evaluate the robot kinematics of a robot.	K5
CO4	Analyze and control the robot manipulator motion	K3
CO5	Employ the path planning of robots in industries.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	2	2	3	2	2	2	2				2	2	2	2	2
CO2	2	2	3	2	2	2	2				2	2	2	2	2
CO3	3	2	3	2	2	2	2				2	2	2	2	2
CO4	2	2	3	2	2	2	2				2	2	2	2	2
CO5	2	2	3	2	2	2	2				2	2	2	2	2
22MPE$13	2	2	3	2	2	2	2				2	2	2	2	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 6.1.1, 7.1.1, 7.2.2, 11.1.1, 11.3.1, 11.3.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO2	1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 6.1.1, 7.1.1, 7.2.2, 11.1.1, 11.3.1, 11.3.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO3	1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 6.1.1, 7.1.1, 7.2.2, 11.1.1, 11.3.1, 11.3.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO4	1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 6.1.1, 7.1.1, 7.2.2, 11.1.1, 11.3.1, 11.3.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO5	1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 6.1.1, 7.1.1, 7.2.2, 11.1.1, 11.3.1, 11.3.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	30	40	30				100
CAT2	30	40	30				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	30	40	30				100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	40	30				100
ESE	30	40	30				100

22MPE$14	ROBOTIC DRIVES AND CONTROL TECHNIQUES

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To introduce the concepts of robotic drive systems ans associated actuators along with its control systems.	
UNIT – I	**INTRODUCTION**	**(9 Periods)**
Robotics – Mechanical Structure: Manipulators, Mobile robots – Advanced robotics: Field and Service robots – Basics of robot modeling, planning and control.		
UNIT – II	**KINEMATICS AND TRAJECTORY PLANNING**	**(9 Periods)**
Rotation matrix: representation of vector – Euler angles: XYZ and RPY – Homogenous transformations – Direct kinematics: open chain, Denavit-Hartenberg Convention , closed chain – kinematics of typical manipulators – Three-link planar arm, Parallelogram arm, Spherical wrist – Path and trajectories – Joint Space trajectories – Point to Point , motion to point sequence – Operational Space trajectories – Path primitives, position and orientation.		
UNIT – III	**ROBOTIC DRIVES AND ACTUATORS**	**(9 Periods)**
Drive system- Electric drives and hydraulic drives: Modeling, Block scheme, relationship between control input and output- Transmission effects- Position control-Joint actuating system: Transmissions, Servomotors, power amplifiers and power supply.		
UNIT – IV	**ROBOTIC MOTION CONTROL**	**(9 Periods)**
Functional control architecture – Programming environment: Teaching-by-showing, robot oriented programming-Hardware architecture- Joint space control-Decentralized control: Independent control and Feedforward compensation – Centralized control: PD control with gravity compensation, inverse dynamics control, robust control and adaptive control.		
UNIT – V	**FORCE CONTROL AND VISUAL SERVOING**	**(9 Periods)**
Compliance control: Active and Passive – Impedance control- Force control: Inner position and Inner velocity loop-Hybrid force/motion control – Vision for control – visual servoing system: Position based and Image based servoing – Hybrid visual servoing.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Bruno Siciliano et al., "**Robotics: Modelling, Planning And Control**" in advanced textbooks in control and signal processing", Springer Publications, 2009. ISBN:978-1-84628-641-4*
2	*Fu KS, Gonzalez RC and Lee CSG, "**Robotics: Control, Sensing, Vision And Intelligence**" in CAD/Cam, Robotics and Computer Vision, McGraw-Hill Book Company, 1987. ISBN: 0-07-022625-3*

REFERENCES:

1	*Craig, J.J., **Introduction To Robotics: Mechanics and Control**, 2nd Edition, Addison-Wesley, Reading, MA, 1989.*
2	*L. Sciavicco, B. Siciliano, **Modeling And Control Of Robot Manipulators**, Springer, 2002*
3	*Angeles, J., **Fundamentals Of Robotic Mechanical Systems**, Springer-Verlag, New York, NY, 1997*
4	*Shames,I.H, "**Engineering Mechanics-Statics And Dynamics**", 4/e, Prentice-Hall of India Pvt. Ltd., 2005*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Outline the fundamentals of robotic modeling and control	K2
CO2	Solve the problems in robot kinematics and plan the trajectory	K3
CO3	Select appropriate drives and control system for robot design	K3
CO4	Perform robot motion control for various engineering application	K4
CO5	Understand robot force control and visual servoing	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping														
COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3											2	1		3
CO2	3	3	3	2								1	1		3
CO3	3	3	1	2								1	1		3
CO4	3	2	1	1								1	1		3
CO5	3				2							1	1		3
22MPE$14	3	2	1	1	1							1	1		3
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.2.1, 12.1.1														
CO2	1.2.1, 1.4.4, 2.1.2, 2.2.3, 3.1.1, 12.1.1														
CO3	1.2.1, 1.4.4, 2.1.2, 2.2.3, 3.1.1, 3.1.6 , 12.1.1														
CO4	1.2.1, 1.4.4, 2.1.2, 2.2.3, 3.1.1, 3.1.6, 12.1.1,														
CO5	1.2.1, 5.1.1, 5.2.2, 12.1.1, 12.2.2														

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	50	30	20				100
CAT2	50	30	20				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	30	30	40				100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	30	40				100
ESE	40	30	30				100

22MPE$15	KINEMATICS AND DYNAMICS OF ROBOTICS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To learn the techniques of kinematics and dynamics of robotics to analysis and configure robots applications in engineering.	
UNIT – I	**INTRODUCTION**	**(9 Periods)**
Introduction - position and orientation of objects - objects coordinate frame Rotation matrix - Euler angles Roll, pitch and yaw angles coordinate Transformations - Joint variables and position of end effector - Dot and cross products - coordinate frames – Rotations - Homogeneous coordinates.		
UNIT – II	**DIRECT KINEMATICS**	**(9 Periods)**
Link coordinates D-H Representation, The ARM equation. Direct kinematic analysis for Four axis, SCARA Robot and three, five and six axis Articulated Robots.		
UNIT – III	**INVERSE KINEMATICS**	**(9 Periods)**
The inverse kinematics problem, General properties of solutions. Tool configuration, Inverse kinematics of four axis SCARA robot and three and five axis, Articulated robot.		
UNIT – IV	**WORKSPACE ANALYSIS AND TRAJECTORY PLANNING**	**(9 Periods)**
Workspace Analysis, work envelope of a Four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place operations, Joint space technique - continuous path motion, Interpolated motion, straight line motion and Cartesian space technique in trajectory planning.		
UNIT – V	**MANIPULATOR DYNAMICS**	**(9 Periods)**
Introduction, Lagrange's equation kinetic and potential energy. Link inertia Tensor, link Jacobian Manipulator inertia tensor. Gravity, Generalized forces, Lagrange-Euler Dynamic model, Dynamic model of a Two-axis planar robot, Newton Euler formulation, Lagrange Euler formulation, problems.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Robert J. Schilling*, ***"Fundamentals of Robotics Analysis and Control"***, *PHI Learning, 2009*.
2	*Richard D. Klafter, Thomas .A, Chri Elewski, Michael Negin*, "***Robotics Engineering an Integrated Approach"***, *PHI Learning, 2009*.

REFERENCES:

1	*P.A. Janaki Raman*, ***"Robotics and Image Processing An Introduction"***, *Tata Me Graw Hill Publishing company Ltd., 1995.*
2	*Francis N-Nagy Andras Siegler*, ***"Engineering foundation of Robotics"***, *Prentice Hall Inc., 1987.*
3	*Bernard Hodges*, ***"Industrial Robotics",*** *Second Edition, Jaico Publishing house, 1993.*
4	*Tsuneo Yohikwa*, "***Foundations of Robotics Analysis and Control",*** *MIT Press. 2003.*
5	*John J. Craig*, ***"Introduction to Robotics Mechanics and Control",*** *Third Edition, Pearson, 2008.*
6	*Bijay K. Ghosh, Ning Xi, T.J. Tam*, ***"Control in Robtics and Automation Sensor - Based integration",*** *Academic Press, 1999.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Select appropriate orientation techniques for solving coordinate transformation problems.	K1
CO2	Frame and solve direct kinematics for different types of robots.	K2
CO3	Frame and solve inverse kinematics for different types of robots.	K2
CO4	Follow workspace analysis and trajectory planning to implement for different robots.	K3
CO5	Formulate necessary models to solve dynamic problems.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	0	1	3	0	0	0	0	0	0	0	3	1	2
CO2	3	3	0	1	2	0	0	0	0	0	0	0	3	2	2
CO3	3	3	0	0	3	0	0	0	0	0	0	0	3	1	2
CO4	3	3	0	0	3	0	0	0	0	0	0	0	3	2	2
CO5	3	3	0	0	3	0	0	0	0	0	0	0	3	2	2
22MPE$15	3	2	0	1	3	0	0	0	0	0	0	0	3	1	2
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.3, 2.2.1, 2.2.3, 2.2.4, 2.4.4, 4.3.4, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2
CO2	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 4.1.4, 5.1.2, 5.2.1, 5.3.1, 5.3.2
CO3	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2
CO4	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2
CO5	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2

ASSESSMENT PATTERN							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	70	20	10				100
CAT2	50	30	20				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	60	40					100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	50	30	20				100
ESE	50	30	20				100

22MPE$16	ADVANCED MATERIALS FOR ROBOTICS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To study the concept of advanced materials for robotic applications.	
UNIT – I	**INTRODUCTION**	**(9 Periods)**
Introduction - Advanced metallic materials- Fundamental principles of advanced materials and application of advanced materials to robotics using a multidisciplinary science based approach.		
UNIT – II	**METALLURGICAL PROSPECTIVE**	**(9 Periods)**
Liquid-solid transformation-Nucleation and kinetics of growth, interface morphologies, nonequilibrium freezing, segregation. Nucleation in the solid state- transformations, diffusion in solid state, diffusion equations for steady state and transient conditions, Strengthening methods and mechanisms.		
UNIT – III	**STRUCTURAL MATERIALS**	**(9 Periods)**
Structural Materials for Robots – Aluminium, copper, magnesium, steel, nickel and titanium alloys. Recent advances in materials development- Hi-Entropy alloys, functionally gradient materials, shape memory alloys, metallic composite for soft robotics, computational meta materials.		
UNIT – IV	**COMPOSITES IN ROBOTICS**	**(9 Periods)**
Composites in robotics- Types of matrices and reinforcements, principles, properties and applications, stretchable elastomeric sensor and ionic polymer for robotics, kevlar, biodegradable smart materials, macroscopic composites, three-dimensional, periodic cellular architecture. Special processing techniques of material for robotics.		
UNIT – V	**MATERIAL CHARACTERIZATION**	**(9 Periods)**
Introduction to thin film sand sensor material, energy material and refractory materials and characterization- Materials characterization techniques for advanced and robotic material- SEM – TEM- EDAX - Field array NDT techniques for futuristic materials, surface patterning techniques.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Michio Inagaki Feiyu Kang Masahiro Toyoda Hidetaka Konno, "**Advanced Materials Science And Engineering Of Carbon**", 1st Edition, Butterworth-Heinemann, 2013, ISBN: 9780124077898*
2	*Gaskell, David R., "**Introduction To Metallurgical Thermodynamics**", McGraw Hill, 1973*

REFERENCES:

1	*W. D. Callister, "**Materials Science And Engineering: An Introduction**", John Wiley & Sons, 2007.*
2	*Bhushan Bharat, "**Springer Handbook Of Nanotechnology**", Springer, 2017*
3	*Sohel Rana and Raul Fangueiro, "**Advanced Composite Materials For Aerospace Engineering: Processing, Properties And Applications**", Woodhead Publishing, 2016.*
4	*Cao Guozhong, "**Nanostructures & Nanomaterials: Synthesis, Properties & Applications**", Imperial College Press, 2004*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the basics of robotic materials and its metallurgical aspects	K2
CO2	Gain knowledge about thermodynamics of nucleation and strengthening mechanisms	K3
CO3	Analyze metallic, functional and polymer materials and its processing towards robotic applications	K3
CO4	Acquire knowledge in high performance materials and techniques for robotics	K2
CO5	Analyze properties, of robotic materials using advanced material characterization technique	K2

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO 1**	**PO 2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3		1									1	1		
CO2	3		1		2							2	2		
CO3	3		2		2							2	2		
CO4	3		2									2	2		
CO5	3				3							2	1		
22MPE$16	3		1		2							2	2		
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.2.1, 1.4.4, 3.1.1, 12.1.1														
CO2	1.2.1, 1.4.4, 3.1.1, 5.3.2, 12.1.1														
CO3	1.2.1, 1.4.4, 3.1.1, 3.1.6,5.3.2, 12.1.1														
CO4	1.2.1, 1.4.4, 3.1.1, 12.1.1, 12.2.2														
CO5	1.2.1, 5.1.1, 5.2.2, 12.1.1, 12.2.2														

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	50	30	20				100
CAT2	50	30	20				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	30	30	40				100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	30	40				100
ESE	40	30	30				100

22MPE$17	ROBOTS APPLICATIONS AND MAINTENANCE

PRE-REQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To impart knowledge on the various applications of robots and to understand the concept of robots maintenance.	
UNIT – I	**ROBOTS MATERIAL HANDLING SYSTEMS**	**(9 Periods)**
Types of industrial robots - Load handling capacity, general considerations in Robotic material handling - material transfer - machine loading and unloading - CNC machine tool loading- Robot centered cell.		
UNIT – II	**ROBOTS QUALITY MAINTENANCE**	**(9 Periods)**
Robotic vision systems - image representation - object recognition and categorization - depth measurement, image data compression - visual inspection - software considerations.		
UNIT – III	**ROBOTS APPLICATIONS**	**(9 Periods)**
Application of robots in continuous arc welding - Spot welding, Spray painting, assembly operation, cleaning, robot for underwater applications - humanoid robots - medical and military applications.		
UNIT – IV	**ROBOTS SELECTION CRETERIA**	**(9 Periods)**
Factors influencing the choice of a robot - robot performance testing - economics of robotisation- Impact of robot on industry and society. Computational intelligence in robot -Customizing the industrial robot as per application - Industrial case studies of customization and trending application of robots.		
UNIT – V	**ROBOTS MAINTENANCE**	**(9 Periods)**
Breakdown, preventive, predictive maintenance – checklist, schedule, procedure. Trouble shooting - robot maintenance costs - safety measures – Industrial robot, Medical robot, Robot in Military application - Concept of Robotic cell health.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Richaerd D Klafter, Thomas Achmielewski and Mickael Negin, **"Robotic Engineering – An Integrated Approach"** Prentice Hall India, New Delhi, 2001.*
2	*M.P.Groover, M.Weiss, R.N. Nageland N. Godrej, **"Industrial Robotics"**, McGraw-Hill Singapore, 2017.*

REFERENCES:

1	*S.R. Deb, **"Robotics Technology and Flexible Automation",** Tata McGraw-Hill Education, 2009.*
2	*K. K.Appu Kuttan, "**Robotics"**, I K International, 2007.*
3	*Goswami Ambarish, Vadakkepat Prahlad, **"Humanoid Robotics: A Reference"**, Springer, 2019.*
4	Mark R. Miller; Rex Miller, "Robots and Robotics: Principles, Systems, and Industrial Applications", McGraw-Hill Education, 2017.

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Select the robot for the material handling applications.	K4
CO2	Apply the knowledge on robots in machine vision applications.	K4
CO3	Make use of robots in processing applications.	K4

CO4	Identify the robot for the customized applications.	K4
CO5	Take part in the preventive maintenance and troubleshooting of robots.	K4

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	2	2	3	2	2	2	2	1	1	1	2	2	2	2	2
CO2	2	2	3	2	2	2	2	1	1	1	2	2	2	2	2
CO3	3	2	3	2	2	2	2	1	1	1	2	2	2	2	2
CO4	2	2	3	2	2	2	2	1	1	1	2	2	2	2	2
CO5	2	2	3	2	2	2	2	1	1	1	2	2	2	2	2
22MPE$17	2	2	3	2	2	2	2	1	1	1	2	2	2	2	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 6.1.1, 7.1.1, 7.2.2, 8.2.1, 8.2.2, 9.1.2, 10.3.1, 10.3.2, 11.1.1, 11.3.1, 11.3.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO2	1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 6.1.1, 7.1.1, 7.2.2, 8.2.1, 8.2.2, 9.1.2, 10.3.1, 10.3.2, 11.1.1, 11.3.1, 11.3.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO3	1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 6.1.1, 7.1.1, 7.2.2, 8.2.1, 8.2.2, 9.1.2, 10.3.1, 10.3.2, 11.1.1, 11.3.1, 11.3.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO4	1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 6.1.1, 7.1.1, 7.2.2, 8.2.1, 8.2.2, 9.1.2, 10.3.1, 10.3.2, 11.1.1, 11.3.1, 11.3.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO5	1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 6.1.1, 7.1.1, 7.2.2, 8.2.1, 8.2.2, 9.1.2, 10.3.1, 10.3.2, 11.1.1, 11.3.1, 11.3.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	30	20	30	20			100
CAT2	30	20	30	20			100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	30	20	30	20			100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	20	30	20			100
ESE	30	20	30	20			100

22MPE$18	DRONE TECHNOLOGY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To inculcate specialized knowledge in an unmanned aircraft system for the societal usage and to introduce the custom design and control of the unmanned aerial vehicle for the future application.	
UNIT – I	**INTRODUCTION IN UAS**	**(9 Periods)**
UAV – Applications of UAV – needs of unmanned aircraft – The systemic basis UAS – System Composition - Transportation in UAV, Remotely .Piloted. Aircraft - Fixed-Wing, Vertical. Take-off and Landing.		
UNIT – II	**THE DESIGN OF UAV SYSTEMS**	**(9 Periods)**
Aerodynamics and Airframe Configuration – Characteristics of Aircraft Types – Design Standards and Regularity Aspects – Aspects of Airframe Design – Design for Stealth – Pay Loads – Design for Reliability – Design for Manufacture and Development.		
UNIT – III	**CONTROL AND COMMUNICATION SYSTEMS**	**(9 Periods)**
Communication Systems in UAV – Control and Stability in UAV – Navigation Systems – Launch and Recovery – Control Stations – Support Equipment.		
UNIT – IV	**TESTING FOR CERTIFICATION IN UAV**	**(9 Periods)**
System Development and Certification – System Ground Testing – System In-flight Testing – Operational Trails and Full Certification – UAV System Deployment.		
UNIT – V	**FUTURE OF UAV**	**(9 Periods)**
Role of UAV in Army, Naval and Air Force – Civilian, Paramilitary and Commercial Roles – UAS Future – Future Prospects and Challenges – UAV Systems Continuing Evolution – UAS Organisations.		
Lecture: 45 Periods Tutorial:0 Periods Practical: 0 Periods Total:45 Periods		

TEXT BOOK:

1	*Reg Austin – "**Unmanned Aircraft Systems**"- Wiley Publications - 2010*
2	*Richard K. Barnhart – "**Introduction To Unmanned Aircraft System"** CRC Press, 2012*

REFERENCES:

1	*Gundlach. Jay, **"Designing Unmanned Aircraft Systems"** American Institute of Aeronautics and Astronautics, 2012*
2	*Kimon P. Valavanis "**Intelligent Systems, Control and Automation: Science and Engineering"** Springer Publications, 2009*
3	*Yasmina Bestaoui Sebbane, "**Smart Autonomous Aircraft Flight Control and Planning for UAV"** CRC Press, 2016*
4	*Paul Gerin Fahlstrom and Thomas James Gleason "**Introduction to UAV Systems**" John Wiley & Sons, Ltd., Publication, 2012.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Apply basic technologies to identify UAV system.	K3
CO2	Design the UAV based on an aerodynamics and load.	K3
CO3	Identify the control and communication system for UAV.	K3
CO4	Apply the testing and certification of UAV.	K3
CO5	Design the future requirement UAV for application.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	3	2	3	1	3	1	2	1	2	2	2	1	1	
CO2	3	3	2	3	1	3	1	2	1	2	2	2	1	2	
CO3	3	3	2	3	1	3	1	2	1	2	2	2	1	2	
CO4	3	3	2	3	1	3	1	2	1	2	2	2	1	2	
CO5	3	3	2	3	1	3	1	2	1	2	2	2	1	2	
22MPE$18	3	3	2	3	1	3	1	2	1	2	2	2	1	2	
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.4, 3.1.1, 3.1.3, 3.1.6, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 4.1.1, 4.1.3, 4.1.4, 4.2.1, 4.3.1, 4.3.4, 5.1.1, 6.1.1, 6.2.1, 7.1.1, 8.2.1, 5.2.2, 9.1.1, 9.1.2, 10.1.1, 10.1.2, 10.1.3, 10.3.1, 11.3.1, 11.3.2, 12.1.1, 12.2.1, 12.2.2, 12.3.2.
CO2	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.4, 3.1.1, 2.1.3, 3.1.6, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 4.1.1, 4.1.3, 4.1.4, 4.2.1, 4.3.1, 4.3.4, 5.1.1, 6.1.1, 6.2.1, 7.1.1, 8.2.1, 8.2.2, 9.1.1, 9.1.2, 10.1.1, 10.1.2, 10.1.3, 10.3.1, 11.3.1, 11.3.1, 11.3.2, 12.1.1, 12.2.1, 12.2.2, 12.3.2.
CO3	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.4, 3.1.1, 2.1.3, 3.1.6, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 4.1.1, 4.1.3, 4.1.4, 4.2.1, 4.3.1, 4.3.4, 5.1.1, 6.1.1, 6.2.1, 7.1.1, 8.2.1, 8.2.2, 9.1.1, 9.1.2, 10.1.1, 10.1.2, 10.1.3, 10.3.1, 11.3.1, 11.3.1, 11.3.2, 12.1.1, 12.2.1, 12.2.2, 12.3.2.
CO4	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.4, 3.1.1, 2.1.3, 3.1.6, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 4.1.1, 4.1.3, 4.1.4, 4.2.1, 4.3.1, 4.3.4, 5.1.1, 6.1.1, 6.2.1, 7.1.1, 8.2.1, 8.2.2, 9.1.1, 9.1.2, 10.1.1, 10.1.2, 10.1.3, 10.3.1, 11.3.1, 11.3.1, 11.3.2, 12.1.1, 12.2.1, 12.2.2, 12.3.2.
CO5	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.4, 3.1.1, 2.1.3, 3.1.6, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 4.1.1, 4.1.3, 4.1.4, 4.2.1, 4.3.1, 4.3.4, 5.1.1, 6.1.1, 6.2.1, 7.1.1, 8.2.1, 8.2.2, 9.1.1, 9.1.2, 10.1.1, 10.1.2, 10.1.3, 10.3.1, 11.3.1, 11.3.1, 11.3.2, 12.1.1, 12.2.1, 12.2.2, 12.3.2.

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	30	40				100
CAT2	30	20	50				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	30	50				100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	30	40				100
ESE	30	20	50				100

22MPE$19	AUTOMATION IN MANUFACTURING

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To understand the concept of automation involved in industries.	
UNIT – I	**INTRODUCTION TO AUTOMATION**	**(9 Periods)**
Introduction: Importance of automation in the manufacturing industry - Use of mechatronics - Systems required - Design of an automated system: Building blocks of an automated system - working principle and examples - Fabrication - Fabrication or selection of various components of an automated system - Specifications of various elements - Use of design data books and catalogues.		
UNIT – II	**SENSORY DEVICES & MICROPROCESSORS**	**(9 Periods)**
Introduction to sensor technology-various sensors, transducers- Performance Terminology - Displacement, Position and Proximity -Velocity and Motion – Fluid pressure - Temperature - Light sensors - Selection of sensors – Signal processing - Microprocessor Technology: Architecture - Pin configuration - signal conditioning and data acquisition, use of microprocessor or micro controllers - Configurations. Working.		
UNIT – III	**DRIVES AND MECHANISMS**	**(9 Periods)**
Drives: electrical drives - types, selection criteria, construction and operating principle - Mechanisms: Ball screws, linear motion bearings, cams, systems controlled by camshafts - Electronic cams, indexing mechanisms, tool magazines, and transfer systems.		
UNIT – IV	**HYDRAUILIC AND PNEUMATIC SYSTEMS**	**(9 Periods)**
Hydraulic systems: hydraulic power pack, pumps and valves - Hydraulic systems: designing of hydraulic circuits - Pneumatic systems: configurations, compressors, valves, distribution and conditioning.		
UNIT – V	**CNC TECHNOLOGY**	**(9 Periods)**
Classification of CNC Machine Tools – Elements of CNC machine drives & controls - types of CNC control - Machine Axes, Absolute & incremental system, CNC programming basics - part programming - G & M Codes, tool length compensation, cutter radius and tool nose radius compensation, do loops, subroutines, canned cycles, mirror image – safety aspects		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Alexander FP,* ***"Manufacturing Automation & Design Engineer"****, 2021.*
2	*Beno Benhabib,* ***"Manufacturing: Design, Production, Automation, and Integration"****, Marcel Dekker, 2013*

REFERENCES:

1	*Hari Vasudevan, Vijaya Kumar N. Kottur, Amool A. Raina, "****Proceedings of International Conference on Intelligent Manufacturing and Automation"****, Springer, New York, 2018.*
2	*Groover, M. P.,* ***Automation, Production Systems, and Computer-Integrated Manufacturing,*** *Prentice Hall, 2001*
3	*Geoffrey Boothroyd,* ***"Assembly Automation and Product Design",*** *Second Edition, Taylor and Francis Group.*
4	*Parr, A. A.,* ***Hydraulics and pneumatics****, Elsevier, 1999.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand and analyse the design principles for manufacturability.	K4
CO2	Know the concept of digital control devices & Microprocessors.	K3
CO3	To gain knowledge on drives and mechanisms used in automation	K4
CO4	Understand the concept of hydraulic and pneumatic systems.	K4,
CO5	Able to create a programme for the part configuration.	K6

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	1	1	2	1	2	2	2	1	2	2	1	1	1
CO2	3	3	2	3	3	1	1	2	2	2	1	3	2	2	2
CO3	3	2	1	2	2	2	2	1	2	1	2	2	2	3	2
CO4	1	3	2	2	2	2	1	1	2	1	2	2	3	2	2
CO5	2	2	1	2	2	1	2	2	2	2	1	2	3	2	3
22MPE$19	2	2	1	2	2	1	2	2	2	1	1	2	2	2	2
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 3.1.1,
CO2	1.2.1, 1.3.1, 1.4.1, 2.1.1
CO3	1.2.1, 1.3.1, 2.1.1, 2.1.2
CO4	1.2.1, 2.1.2, 3.1.1, 4.1.2
CO5	1.2.1,1.4.1, 4.1.1, 4.1.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	25	25	25	25	--	--	100
CAT2	25	20	25	20	--	10	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	25	25	25	25	--	--	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	25	25	20	--	10	100
ESE	30	30	30	10	--	--	100

22MPE$20	**LEAN MANUFACTURING** *(Common to Mech & Prod)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To craft the students to acquire knowledge in lean manufacturing tools, understand various phases involved and methodology in implementing lean in manufacturing scenario.	
UNIT- I	**FOUNDATION AND CONCEPTS OF LEAN**	**(9 Periods)**
Historical evolution of lean manufacturing - Objectives of lean manufacturing - Key principles and implications of lean manufacturing - Traditional verses lean manufacturing. – Ford System – Growing Dysfunction –– Ten steps to lean production - Necessity of Lean Production – Systems and lean thinking – Construction of Lean Production - Lean images and Lean Activities.		
UNIT- II	**LEAN TOOLS AND METHODOLOGY**	**(9 Periods)**
Primary tools – Implementing 5S, Workplace organization – Stability - Just-In-Time –Takt time - One piece flow – Pull, Cellular systems, Six Sigma. SMED: Single minute exchange of dies – Theory and practice of the SMED system - TPM, Pillars of TPM, Conditions for TPM success, TPM implementation process - Overall Equipment Effectiveness - computation of OEE.		
UNIT- III	**VALUE STREAM MAPPING**	**(9 Periods)**
Process Mapping and Value Stream Mapping - Current state map – Future state map – VSM symbols – Mapping tips - Need for process maps - types and its construction - steps in preparing VSM - Comparison of CSVAM and FSVSA – Simulation scenario case studies.		
UNIT- IV	**INTEGRATED QUALITY**	**(9 Periods)**
Development and necessity – Poke Yoke – mistake proofing - quality improvement – Leveling and Visual management. Common errors – Inspection system and Zone control – Using Poke Yokes – Jidoka implementation -Process capability study – Lean six sigma.		
UNIT- V	**LEAN INVOLVEMENT AND CULTURE**	**(9 Periods)**
Necessity of involvement – Waste of Humanity – Activities supporting involvement – Kaizen Circle Activity – Practical Kaizen Training – Key factors in Practical Kaizen Training – Lean Culture – Standardization – Standards and abnormality control – 'Five Why' analysis.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Period**		

TEXT BOOK:

1	*Dennis P **"Lean Production Simplified: A Plain Language Guide to the World's Most Powerful Production System"**, Productivity Press, New York, 2009.*
2	*Liker, J and Meier, **D "The Toyota Way"**, Field book, McGraw-Hill, 2010.*

REFERENCES:

1	*Devadasan S R, Mohan Sivakumar V, Murugesh R and Shalij P R, **"Lean and Agile Manufacturing: Theoretical, Practical and Research Futurities"**, Prentice Hall of India Learning Limited, New Delhi, 2012.*
2	*Gopalakrishnan N, **"Simplified Lean Manufacture: Elements, Rules, Tools and Implementation"**, Prentice Hall of India Learning Private Limited, India, 2010.*
3	*Bill Carreira, **"Lean Manufacturing that Works: Powerful Tools for Dramatically Reducing Wastes and Maximizing Profits"**, Prentice Hall of India Learning Private Limited, India, 2009.*
4	*Don Tapping, Tom Luyster and Tom Shuker **"Value Stream Management: Eight Steps to Planning, Mapping and Sustaining Lean Improvements"**, Productivity Press, New York, USA, 2007.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Describe about the origin and foundation of lean production	K2
CO2	Explain various lean tools and methodologies.	K2
CO3	Explain the methods and processes of Value Stream Mapping.	K2
CO4	Describe about quality in lean system using various techniques.	K3
CO5	Describe about lean involvement and culture.	K2

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	2	3	2	0	3	0	2	3	1	2	2	2	2
CO2	2	3	3	3	3	3	3	1	3	3	2	3	3	3	3
CO3	2	3	2	3	3	0	3	2	3	3	1	3	2	2	3
CO4	2	3	3	3	3	0	3	0	3	3	2	3	2	2	2
CO5	2	3	2	3	3	3	3	2	3	3	2	2	1	2	2
22MPE$20	2	3	3	3	3	2	3	1	3	3	2	3	2	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.2, 2.2.3, 2.4.3, 3.1.1, 3.1.4, 3.2.1, 3.3.1, 3.3.2, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.2, 5.2.2, 5.3.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.1.2, 9.2.1, 9.2.3, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.3.2.
CO2	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 9.2.2, 9.2.3, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.2, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2.
CO3	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.6, 3.2.1, 3.2.3, 3.3.1, 3.3.2, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 9.2.3, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.3.1, 12.3.2.
CO4	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.1.1, 9.1.2, 9.2.1, 9.2.2, 9.2.3, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.2, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.2
CO5	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.3, 3.3.1, 3.3.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 9.2.2, 9.2.3, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.2, 11.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.1, 12.3.2

ASSESSMENT PATTERN– THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	50	20	-			100
CAT2	30	50	20	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	40	40	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	40	40	-	-	-	100
ESE	42	42	16	-	-	-	100

22MPE$21	GREEN MANUFACTURING DESIGN AND PRACTICES

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To introduce the concept of environmental design and to impart knowledge on concept of green co-rating and its need	
UNIT – I	**DESIGN FOR ENVIRONMENT AND LIFE CYCLE ASSESSMENT**	**(9 Periods)**
Environmental effects of design -selection of natural friendly material - Eco design - Environmental damage Material flow and cycles – Material recycling – Emission less manufacturing- Industrial Ecology – Pollution prevention – Reduction of toxic emission – design for recycle. Life Cycle Assessment - Multipath way and Cumulative Risk Assessment - Reclamation and Recycling of Waste		
UNIT – II	**AIR POLLUTION SAMPLING AND MEASUREMENT**	**(9 Periods)**
Primary and Secondary Pollutants, Automobile Pollutants-Industrial Pollution, Air quality Standards, dispersion of air Pollutants- atmosphere dispersion equation- Gaussian Plume Model, Air pollution sampling-collection of gaseous air pollutants-particulate pollutants-Analysis of air pollutants-sulfur dioxide-nitrogen dioxide, carbon monoxide, oxidants and ozone, Air pollution Legislation, Act and Regulations.		
UNIT – III	**NOISE POLLUTION AND CONTROL**	**(9 Periods)**
Frequency and Sound Levels, contours of Loudness. Effect of human-Environment and properties, Natural and Anthrogenic Noise Sources, Measuring Instruments for frequency and Noise levels, Masking of sound,-Types, Kinetics, Treatment of noise at source-Path and Reception-Sources of noise-Effects of noise-Occupational Health hazards.		
UNIT – IV	**WATER DEMAND AND WATER QUALITY**	**(9 Periods)**
Factors affecting consumption, Variation, Contaminants in water, Nitrates, Fluorides, Radio activity in water, Criteria, for different impurities in water for portable and non-portable use, Point and non-point Source of pollution, Major pollutants of Water, Water Quality Requirement for different uses, Global water crisis issues.		
UNIT – V	**GREEN CO-RATING**	**(9 Periods)**
Ecological Footprint - Need For Green Co-Rating – Green Co-Rating System – Intent – System Approach – Weightage- Assessment Process – Types of Rating – Green Co-Benefits – Case Studies of Green Co-Rating		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1.	*Editors: Mrityunjay Singh, Tatsuki Ohji, Rajiv Asthana, "**Green and Sustainable Manufacturing of Advanced Material**", Elsevier, First Edition - 2015*
2.	*Dr. H.S. Bhatia, "**A Text Book of Environmental Pollution and Control**"JDM Publishers & Distributors, India, 2022*

REFERENCES:

1.	*Gradel.T.E. and B.R. Allenby**, Industrial Ecology**, Prentice Hall – 2010*
2.	*S. Thirumalai Kumaran, Tae Jo Ko, **"Sustainable Machining and Green Manufacturing",** Wiley-Scrivener; 1st edition, 2024*
3.	*David A. Dornfeld, **"Green Manufacturing: Fundamentals and Applications (Green Energy and Technology",** Springer-Verlag New York Inc.; 1st ed. 2013*
4.	*Rao M.N. and Dutta A.K, **"Wastewater treatment"** , Oxford & IBH publishing Co. Pvt. Ltd., New Delhi, Second Edition, 2017.*
5.	***Christian N. Madu, "Handbook of Environmentally Conscious Manufacturing**, Kluwer Academic Publishers, Boston, 2001*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Know the concept of environmental design,life cycle assessment and selection of eco-friendly materials	K2
CO2	Analyze manufacturing processes towards minimization or prevention of environmental pollution.	K3
CO3	Infer Noise pollution Concepts in green sustainable manufacturing and knowledge about occupational safety hazards.	K3
CO4	To impart best practices to sustain nature water resources and prevention methods of water pollution for sustainable manufacturing.	K3
CO5	Evaluate green co-rating and its benefits.	K4

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	2	1	1	2	1	2	2	2	1	2	2	2	3	2
CO2	2	3	2	3	3	1	1	2	2	2	1	3	2	3	2
CO3	2	3	1	3	2	2	1	1	2	2	2	2	2	3	2
CO4	3	3	2	3	2	2	1	1	2	2	2	2	2	3	2
CO5	2	2	1	2	2	1	2	2	2	1	2	2	2	3	2
22MPE$21	2	3	1	3	2	2	1	1	2	2	2	2	2	3	2
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 3.1.1
CO2	1.2.1, 1.3.1, 1.4.1, 2.1.1
CO3	1.2.1, 1.3.1, 2.1.1, 2.1.2
CO4	1.2.1, 2.1.2, 3.1.1
CO5	1.2.1,1.4.1, 4.1.1

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	25	25	25	25	--	--	100
CAT2	30	20	30	20	--	--	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	25	25	25	25	--	--	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	20	35	25	--	--	100
ESE	30	30	30	10	--	--	100

22MPE$22	ENVIRONMENT SUSTAINABILITY AND IMPACT ASSESSMENT

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To emphasize the importance of impact assessment to promote sustainability and cleaner production with the help of awareness on carbon trading.	
UNIT – I	**SUSTAINABLE DEVELOPMENT**	**(9 Periods)**
Concepts of Sustainable Development - Indicators of Sustainability – Sustainability Strategies, Barriers to Sustainability - Resource Degradation - Industrialization and Sustainable Development - Socio Economic Policies for Sustainable Development.		
UNIT – II	**CLEANER PRODUCTION**	**(9 Periods)**
Clean Development Mechanism - Principles and Concepts of Cleaner Production - Definition - Importance - Historical Evolution - Benefits - Promotion - Barriers - Source Reduction Techniques - Process and Equipment Optimization, Reuse, Recovery, Recycle, Raw Material Substitution.		
UNIT – III	**CARBON TRADING**	**(9 Periods)**
Green House Gases and Carbon Credit - Carbon Sequestration- Sustainable Development through Trade - Carbon Trading – Carbon footprint.		
UNIT – IV	**INTRODUCTION, IMPACT IDENTIFICATION AND PREDICTION**	**(9 Periods)**
Historical development of Environmental Impact Assessment (EIA). EIA in Project Cycle. Legal and Regulatory aspects in India. – Types and limitations of EIA – EIA process- screening –scoping - setting – analysis – mitigation. Matrices – Networks – Checklists –Cost benefit analysis Prediction tools for EIA – Mathematical modeling for impact prediction – Assessment of impacts – air – water – soil – noise – biological.		
UNIT – V	**ENVIRONMENTAL RISK ASSESSMENT AND MANAGEMENT**	**(9 Periods)**
Environmental risk assessment framework-Hazard identification -Dose Response Evaluation – Exposure Assessment – Exposure Factors, Tools for Environmental Risk Assessment– HAZOP and FEMA methods – Event tree and fault tree analysis – Multimedia and multipath way exposure modeling of contaminant- Risk Characterization Risk communication – Emergency Preparedness Plans –Design of risk management programs.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical:0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*NAPTA, **"Safety, Health, and Environment"**, 2nd Edition, Pearson Publications, 2019.*
2	*Wathern, P, Taylor and Francis Group, **"Environmental Impact Assessment"**- Theory and Practice," U.K. 2015.*

REFERENCES:

1	*John Blewitt, **"Understanding Sustainable Development"**, Third edition, Taylor & Francis Ltd., 2017.*
2	*Francisco Jose Gomes da Silva, **"Cleaner Production: Toward a Better Future"**, Ronny Miguel Gouveia , Springer Publications, 2020*
3	*Subramanian SenthilkannanMuthu, **"The Carbon Footprint Handbook"**, Taylor & Francis Ltd., 2015.*
4	*Raghavan K. V. and Khan A A **"Methodologies in Hazard Identification and Risk Assessment"**, by CLRI, 2010*
5	*Lawrence, D.P., **"Environmental Impact Assessment: Practical Solutions to Recurrent Problems"**, John Wiley & Sons, Canada (2003)*
6	*Cutter, **"Environmental Risk and Hazards"**, S.L Hall of India Pvt. Ltd., New Delhi, BimalKanti Paul 2011.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Implement the sustainable development through various strategies.	K2
CO2	Execute various practices of cleaner production	K2
CO3	Evaluate carbon footprint to achieve sustainable development.	K2
CO4	Interpret the importance of environment assessment studies in project development.	K2
CO5	Evaluate the risk assessment based on dose response analysis	K2

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping														
COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	1	1	1	0	0	3	0	0	0	0	0	1	0	0
CO2	2	1	1	1	1	0	0	0	0	0	0	0	1	0	0
CO3	0	2	1	1	1	0	3	0	0	0	0	0	1	0	0
CO4	2	2	2	1	1	0	3	0	0	0	0	0	1	0	0
CO5	2	2	2	1	2	0	2	1	0	0	0	0	1	0	0
22MPE$22	2	2	1	1	1	0	3	1	0	0	0	0	1	0	0
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.2.1,1.3.1,1.4.1,2.2.3,3.1.1,3.1.5,4.1.1,4.1.2,7.1.2,7.2.1,7.2.2
CO2	1.2.1,1.3.1,2.1.2,2.2.3,2.3.1,3.1.5,3.1.6,3.2.1,4.1.1,4.1.3,5.3.1
CO3	2.1.2,2.2.1,2.2.3,2.2.4,2.4.2,3.1.1,3.1.5,3.1.6,3.3.1,4.1.1,4.1.3,4.3.1,5.1.1,7.1.2,7.2.1,7.2.2
CO4	1.2.1,1.3.1,2.1.1,2.1.2,2.1.3,2.2.2,2.2.3,2.4.3,3.1.4,3.1.5,3.1.6,3.2.1,3.2.3,3.3.1,4.1.1,4.1.3,4.3.1,5.1.1,7.1.1,7.1.2,7.2.2
CO5	1.3.1,1.4.1,2.2.1,2.2.3,2.2.4,2.3.2,2.4.3,3.1.5,3.1.6,3.2.1,3.2.2,3.2.3,3.3.1,3.3.2,4.1.1,4.1.2,4.1.3,5.1.1,5.1.2,5.2.1,7.1.2,7.2.1,8.2.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	40	20				100
CAT2	40	40	20				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	40	40	20				100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	40	40	20				100
ESE	40	40	20				100

22MPE$23	ENERGY SAVING MACHINERY AND COMPONENTS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objective	To introduce the various energy saving machineries and components to the students for the purpose of conserving energy.	
UNIT – I	**BASICS OF ELECTRICAL ENERGY USAGE**	**(9 Periods)**
Fuel to Power : Cascade Efficiency – Electricity Billing : Components and Costs – kVA – Need and Control – Determination of kVA demand and Consumption – Time of Day Tariff – Power Factor Basics – Penalty Concept for PF – PF Correction – Demand Side Management (a brief) - energy monitoring, measurement and analysis		
UNIT – II	**TRANSFORMERS AND MOTORS**	**(9 Periods)**
Transformer – Basics and Types – Performance Prediction - Energy Efficient Transformers - Motors : Specification and Selection – Efficiency / Load Curve – Load Estimation – Assessment of Motor Efficiency under operating conditions – Factors affecting performance – ill effects of Rewinding and Over sizing - Energy Efficient Motors – . Transmission Line Parameters – Transmission Line Losses.		
UNIT – III	**FANS, PUMPS AND COMPRESSORS**	**(9 Periods)**
Basics – Selection – Performance Evaluation – Cause for inefficient operation – scope for energy conservation – methods adopted for effecting ENCON – Economics of ENCON adoption in all the 3 utilities		
UNIT – IV	**ILLUMINATION AND ENERGY EFFICIENT DEVICES**	**(9 Periods)**
Specification of luminaries - Types - Efficacy - Selection and Application - ENCON Avenues and Economic Proposition - New Generation Luminaries (LED - Induction Lighting) - Soft Starters- Auto Star - Delta - Star Starters- APFC - Variable Speed and Frequency Drives - Time Sensors - Occupancy Sensors		
UNIT – V	**CO2 MITIGATION AND CASE STUDIES**	**(9 Periods)**
Evaluation for 3 / 4 Typical Sectors – PAT Scheme (an introduction) – CO2 Mitigation - Energy Conservation - Cost Factor. Case Studies on Industrial Energy Audit		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Hamies, **"Energy Auditing and Conservation ; Methods Measurements, management and Case Study"**, Hemisphere, Washington, 1980*
2	*Trivedi, PR and Jolka KR, **" Energy Management"**, Commonwealth Publication, New Delhi, 1997*

REFERENCES:

1	*Handbook on **"Energy Efficiency"**, TERI, New Delhi, 2001*
2	*Peters, Kraushaar and Ristenen, **"Sustainable Energy, beta – test – draft, Energy and Problems of a Technical Society"**, 1993*
3	*Guide book for National Certification Examination for Energy Managers and Energy Auditors (**www.energymanagertraining.com**)*
4	*Nagrath IJ and Kothari DP, "**Power system engineering**", TMH, 2007*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Acquire knowledge on various energy saving machinery and components.	K1
CO2	Understand the various methods of conservation of energy.	K1
CO3	Evaluate the performance and energy conservation of fans, pumps and compressors.	K2
CO4	Analysis the various energy efficiency devices.	K3
CO5	Evaluate CO2 mitigation and cost factor.	K2

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO 1**	**PO 2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	3	2	2	3	3	1	1	1	2	2	2	1	2	3
CO2	2	2	2	2	2	2	2	1	1	1	3	2	2	2	2
CO3	3	2	2	2	2	2	2	1	1	2	2	1	2	1	2
CO4	2	3	2	2	2	3	2	1	2	1	2	2	2	1	2
CO5	3	2	2	3	1	3	3	2	1	2	3	2	3	1	2
22MPE$23	3	2	2	2	2	2	2	1	1	2	2	2	2	2	2
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.3, 2.2.1, 2.2.3, 2.2.4, 2.4.4, 4.3.4, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2
CO2	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 4.1.4, 5.1.2, 5.2.1, 5.3.1, 5.3.2
CO3	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2
CO4	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2
CO5	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	70	20	10				100
CAT2	50	30	20				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	60	40					100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	50	30	20				100
ESE	50	30	20				100

22MPE$24	GREEN SUPPLY CHAIN MANAGEMENT

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To make the students learn and gain an awareness of the different stakeholders involved in green supply chain management.	
UNIT – I	**INTRODUCTION**	**(9 Periods)**
Basic concepts of green supply chain management - green supply chain framework - the origins of supply chains - the evolution of supply chains - from traditional to green supply chain - paradoxes in green supply chain.		
UNIT – II	**BARRIERS AND GREEN PROCUREMENT**	**(9 Periods)**
Internal barriers - external barriers - internal motivators and drivers - external motivators and drivers - green procurement - factors that contribute to increasing interest in green procurement - green procurement life cycle - barriers to broader adoption of green procurement.		
UNIT – III	**GREEN PRODUCTION AND OUTBOUND LOGISTICS**	**(9 Periods)**
Introduction - green production design - green production stages - green transportation - green practices in transportation/distribution - European union sustainability guidelines - expected benefits and challenges of green transportation/distribution.		
UNIT – IV	**GREEN PACKAGING AND REVERSE LOGISTICS**	**(9 Periods)**
Environmental labeling and labels - eco-label types - waste management and environmental policy - case study: waste electrical and electronic equipment - case study: excavation, construction and demolition waste management - decision-making methodological framework for construction waste management.		
UNIT – V	**DECISION MAKING AND TECHNOLOGIES OF MARKETING**	**(9 Periods)**
Introduction to assessment methods - frameworks and methods - assessment indicators - making ICT solutions for managing green practices - GrICT solutions - business intelligence - making ICT solutions using green practices - ecoCycle: an easy life cycle analysis tool.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Charisios Achillas, Dionysis D. Bochtis, Dimitrios Aidonis and Dimitris Folinas* ***"Green Supply Chain Management"****, Routledge, 1st Edition, 2019.*
2	*Hsiao-Fan Wang and Surendra M.Gupta,* ***"Green Supply Chain Management: Product Life Cycle Approach"****, McGraw-Hill Education, 1st Edition, 2011.*

REFERENCES:

1	*Mohammed Majeed, Kirti Agarwal and Ahmed Tijani,* ***"Green Supply Chain Management"****, CRC Press, 2024.*
2	*Venkatesh Ganapathy,* ***"Introduction to Green Supply Chain Management"****, bookboon, 2024.*
3	*Joseph Sarkis and Yijie Dou,* ***"Green Supply Chain Management: A Concise Introduction"****, Routledge, 2018.*
4	*Arunachalam Rajagopal,* ***"Green Supply Chain Management: A Practical Approach"****, Replica, 2021.*
5	*Mehmood Khan, Matloub Hussain and Mian M. Ajmal,* ***"Green Supply Chain Management for Sustainable Business Practice"****, IGI Global, 1st Edition, 2016.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Learn about green supply chain management from multiple perspectives.	K3
CO2	Identify the barriers and green procurement.	K3
CO3	Develop the green production, transportation and distribution.	K3
CO4	Identify the environmental labeling and waste management and environmental policy.	K3
CO5	Analyze and compile reports of decision making and various technologies of marketing.	K4

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	2	1	1	3	1	1	1	2	1	1	1	1
CO2	3	2	1	1	1	1	3	1	1	1	2	1	2	2	3
CO3	3	2	1	2	1	1	3	1	1	1	2	1	2	2	2
CO4	3	3	1	2	1	1	3	1	1	1	2	1	2	2	2
CO5	3	2	1	1	3	1	3	1	1	1	2	1	1	1	1
22MPE$24	3	2	1	2	2	1	3	1	1	1	2	1	2	2	1
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.1.1, 1.1.2, 1.3.1, 2.1.2, 2.1.2, 3.1.1, 4.1.1, 4.1.2, 4.2.1, 5.1.1, 5.1.2, 5.2.1, 6.1.1, 7.1.1, 7.2.1, 8.1.1, 9.1.1, 10.1.1, 11.1.1, 11.2.1, 12.1.1
CO2	1.1.1, 1.1.2, 1.3.1, 2.1.2, 2.1.2, 3.1.1, 4.1.1, 4.1.2, 4.2.1, 5.1.1, 5.1.2, 5.2.1, 6.1.1, 7.1.1, 7.2.1, 8.1.1, 9.1.1, 10.1.1, 11.1.1, 11.2.1, 12.1.1
CO3	1.1.1, 1.1.2, 1.3.1, 2.1.2, 2.1.2, 3.1.1, 4.1.1, 4.1.2, 4.2.1, 5.1.1, 5.1.2, 5.2.1, 6.1.1, 7.1.1, 7.2.1, 8.1.1, 9.1.1, 10.1.1, 11.1.1, 11.2.1, 12.1.1
CO4	1.1.1, 1.1.2, 1.3.1, 2.1.2, 2.1.2, 3.1.1, 4.1.1, 4.1.2, 4.2.1, 5.1.1, 5.1.2, 5.2.1, 6.1.1, 7.1.1, 7.2.1, 8.1.1, 9.1.1, 10.1.1, 11.1.1, 11.2.1, 12.1.1
CO5	1.1.1, 1.1.2, 1.3.1, 2.1.2, 2.1.2, 2.3.1, 2.3.2, 3.1.1, 4.1.1, 4.1.2, 4.2.1, 5.1.1, 5.1.2, 5.2.1, 6.1.1, 7.1.1, 7.2.1, 8.1.1, 9.1.1, 10.1.1, 11.1.1, 11.2.1, 12.1.1

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	60	20				100
CAT2	20	40	20	20			100
Individual Assessment 1 / Case Study 1 / Seminar 1 / Project 1	20	60	20				100
Individual Assessment 2 / Case Study 2 / Seminar 2 / Project 2	20	40	20	20			100
ESE	20	40	20	20			100

22MPE$25	**DESIGN OF PRESSURE VESSELS** *(Use of Approved Boiler Table is permitted)*	**SEMESTER $**

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To impart specialized knowledge in pressure vessels stresses, pressure vessels support, local load in pressure vessel, nozzle and shell design procedure for the steam generation systems.	
UNIT – I	**STRESSES IN PRESSURE VESSELS**	**(9 Periods)**
Stress Analysis – Stress/Failure theories – Failures in Pressure Vessels – Loadings and Stresses on Pressure Vessels – Thermal Stresses - Discontinuity Stresses - Fatigue Analysis.		
UNIT – II	**GENERAL DESIGN OF PRESSURE VESSELS**	**(9 Periods)**
General Vessel Formulas – External Pressure Design – Calculations of MAP, MAWP, and Test Pressures – Stresses in Head – Design of Intermediate Heads, Toriconical Transitions, Flanges, Covers, Internal Support Beds – Nozzle Reinforcement – Minimum Design Metal Temperature (MDMT) – Estimating Weights of Vessel and Vessel Components.		
UNIT – III	**DESIGN OF VESSEL SUPPORTS**	**(9 Periods)**
Wind Design – Seismic Design for Vessels on Unbraced Legs, Braced Legs, Rings, Lugs and Skirt – Design of Horizontal Vessels on Saddles, Saddle Supports for Large Vessels, Base Plates for Legs, Lug Supports and Base Details for Vertical Vessels.		
UNIT – IV	**SPECIAL DESIGNS**	**(9 Periods)**
Stresses at Circumferential Ring Stiffeners – Design of Large-Diameter Nozzle openings, Design of Cone-Cylinder Intersections, Ring Girders, Baffles and Vessels with Refractory Linings – Tower Deflection – Vibrations of Tall Towers and Stacks.		
UNIT – V	**LOCAL LOADS**	**(9 Periods)**
Stresses at Circular Rings – Design of Partial Ring Stiffeners – Attachment Parameters – Stresses in Cylindrical and Spherical Shells from External Local Loads.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total:45 Periods**		

TEXT BOOK:

1	*Dennis R. Moss – "**Pressure Vessels Design Manual**"- Butterworth Heinemann-Elsevier Publishing - 2013*
2	Spence, J.; Tooth, A. S."***Pressure Vessel Design : Concepts and Principles***" Taylor & Francis Routledge 1994

REFERENCES:

1	*Josef L. Zeman "**Pressure Vessel Design The Direct Route"** Henri van Dorssen Publisher, Energy Elsevier Ltd, 2006*
2	*Subhash Reddy Gaddam "**Design of Pressure Vessels**" CRC Press, 2020*
3	*Donatello Annaratone "**Pressure Vessel Design**" Springer publication, 2007*
4	*Krishna P. Singh, Alan I. Soler "**Mechanical Design of Heat Exchangers: And Pressure Vessel Components**" Springer-Verlag publication.1984.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Analyze the stresses in pressure vessel parts.	K3
CO2	Apply the general design concept to the pressure vessels	K3
CO3	Apply concept to pressure vessel supports design	K3
CO4	Analyse the additional parts selection and application	K3
CO5	Analyse the local loads cause and effect on the shells.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	2	2	2	3	1	1	2	1	3	1		1
CO2	3	2	1	2	2	2	3	1	1	2	1	3	1		1
CO3	3	2	2	2	2	2	3	1	0	2	2	3	1		1
CO4	3	2	3	2	2	2	3	1	1	2	2	3	1		1
CO5	3	2	2	2	2	2	3	1	1	2	2	3	1		1
22MPE$25	3	2	2	2	2	2	3	2	1	2	2	3	1		1
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.3, 3.1.2, 3.1.3, 3.1.5, 3.2.1, 3.2.3, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.4, 4.2.1, 4.3.1, 4.3.2, 5.1.1, 5.2.2, 5.3.2, 6.1.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 9.1.2, 9.2.4, 10.1.1, 10.2.2, 10.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.2, 12.3.1, 12.3.2
CO2	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.4, 3.1.2, 3.1.6, 3.2.2, 3.4.2, 4.1.1, 4.1.4, 4.2.1, 4.3.1, 4.3.3, 5.1.2, 5.2.2, 5.3.2, 6.1.1, 7.1.2, 7.2.1, 7.2.2, 8.2.2, 9.2.2, 10.1.1, 10.2.2, 10.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.1, 12.3.1, 12.3.2
CO3	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.2.1, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 3.1.2, 3.1.3, 3.1.4, 3.1.6, 3.2.3, 3.3.1, 3.4.1, 4.2.2, 4.3.2, 4.3.4, 5.1.1, 5.1.2, 5.3.1, 6.1.1, 7.1.1, 7.1.2, 7.2.2, 8.2.1, 10.1.1, 10.1.3, 10.2.2, 11.1.1, 11.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.1, 12.3.1, 12.3.2
CO4	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.3.1, 2.4.1, 2.4.1, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.2.1, 4.3.3, 4.3.4, 5.1.1, 5.2.2, 5.3.1, 6.2.1, 7.1.2, 7.2.1, 7.2.2, 8.2.2, 9.1.2, 9.2.4, 10.1.1, 10.2.2, 10.3.1, 11.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.1, 12.3.1, 12.3.2
CO5	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.3.1, 2.4.1, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.4.1, 4.1.1, 4.2.1, 4.3.1, 4.3.3, 5.1.1, 5.2.2, 5.3.1, 6.2.1, 7.1.1, 7.1.2, 7.2.2, 8.1.1, 9.1.2, 9.2.1, 10.1.1, 10.1.3, 10.2.2, 10.3.1, 11.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	30	40				100
CAT2	30	20	50				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	30	50				100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	30	40				100
ESE	30	20	50				100

22MPE$26	FAILURE ANALYSIS AND NDT TECHNIQUES

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To draw the ability to understand the root-cause for the real world metallurgical failures and provide a basic understanding with the different nondestructive testing techniques and associated practical applications.	
UNIT – I	**FAILURE ANALYSIS – I**	**(9 Periods)**
Causes of materials failure – Characteristics of ductile and brittle failure – Optical, scanning and transmission electron fractrographic features of ductile and brittle fracture – Fatigue failure – Factors affecting fatigue failure – Loading conditions and types of fatigue failure. Failure analysis – Methodology – Tools and techniques of failure analysis.		
UNIT – II	**FAILURE ANALYSIS – II**	**(9 Periods)**
Corrosion related failures – Wear failure – High temperature failures – Materials design related failure – Failure data retrieval – Procedural steps for investigation of a failure for failure analysis – Defects in materials and their role in failure of engineering components – Case studies in failure analysis – Improvements derived from failure analysis – Application of fracture mechanics concepts to design for safety.		
UNIT – III	**LPT AND MPT TECHNIQUES**	**(9 Periods)**
Fundamentals non-destructive testing (NDT) – Scope and limitations of NDT – Visual examination methods and aids – Liquid Penetrant Testing (LPT) method – Fluorescent penetrant testing method – Sensitivity; application and limitations – Magnetic Particle Testing (MPT) – Definition and principle – Magnetizing technique – Fluorescent magnetic particle testing method – Procedure, equipment sensitivity and limitations.		
UNIT – IV	**ULTRASONIC AND RADIOGRAPHIC TESTING**	**(9 Periods)**
Principle of Ultrasonic Testing (UT) – Methods of UT – Defects in welded products by UT – Thickness determination by UT – X-ray and Gamma-Ray radiography – Industrial radiography techniques (RT) – Basic principle – Inspection techniques – Interpretation of radiographs – Applications and Limitations – Safety in industrial radiography.		
UNIT – V	**LEAK AND EDDY CURRENT TESTING**	**(9 Periods)**
Definition of leak and types – Principle and various methods of pressure and leak testing – Application and limitation – Eddy current testing – Principle, instrument and techniques – Sensitivity – Application and limitations – Thermal methods of NDT.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Balan K P,* ***Metallurgical Failure Analysis: Techniques and Case Studies,*** *BS Publications, 2019.*
2	*Prasad J, Nair C. G. K.,* ***Non-Destructive Test and Evaluation of Materials****, Tata McGraw-Hill Education, 2nd Edition, 2017.*

REFERENCES

1	*Colangelo, Heiser,* ***Analysis of Metallurgical Failures****, John Wiley & Sons, 2nd Edition, 1986.*
2	Baldev Raj, Jayakumar T, Thavasimuthu M, ***Practical Non-Destructive Testing***, *Narosa Publishing, 2002.*
3	*Hellier C,* ***Handbook of NonDestructive Evluation****, McGraw-Hill Professional,2nd Edition, 2020.*
4	*Raj, B, Jayakumar T, Thavasimuthu M,* ***Practical Non Destructive Testing****, Alpha Science International Limited, 3rd Edition, 2002.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Analyze the materials failure due to brittle, ductile and fatigue fractures.	K4
CO2	Learn about the corrosion failure, wear and high temperature failures and analyze their role in failure of engineering components	K4
CO3	Understand the liquid penetrant and magnetic particle testing methods which enable to carry out various inspection in accordance with the established procedures.	K2
CO4	Apply the ultrasonic and radiography testing methods to perform inspection on applications.	K3
CO5	Apply the leak and pressure testing and eddy current testing techniques for applications.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	1	1	2	1	2	3	1	-	-	-	-	-	-	1
CO2	2	1	1	2	1	2	3	1	-	-	-	-	-	-	1
CO3	-	-	-	2	1	2	3	1	-	-	-	-	-	-	1
CO4	-	-	-	2	1	2	3	1	-	-	-	-	-	-	1
CO5	-	-	-	2	1	2	3	1	-	-	-	-	-	-	1
22MPE$26	1	1	1	3	3	3	3	3	-	-	-	-	-	-	3
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.3.1,1.4.1,2.4.3,2.4.4,3.1.1,3.1.4,3.1.5,4.1.1,4.1.2,4.1.3,4.1.4,5.2.1,5.3.2,6.2.1,7.1.1,7.1.2,7.2.2,8.2.2														
CO2	1.3.1,1.4.1,2.4.3,2.4.4,3.1.1,3.1.4,3.1.5,4.1.1,4.1.2,4.1.3,4.1.4,5.2.1,5.3.2,7.1.1,7.1.2,7.2.2,8.2.2														
CO3	4.1.1,4.1.2,4.1.3,4.1.4,5.2.1,5.3.2,7.1.1,7.1.2,7.2.2,8.2.2														
CO4	4.1.1,4.1.2,4.1.3,4.1.4,5.2.1,5.3.2,7.1.1,7.1.2,7.2.2,8.2.2														
CO5	4.1.1,4.1.2,4.1.3,4.1.4,5.2.1,5.3.2,7.1.1,7.1.2,7.2.2,8.2.2														

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	20	20	30	10	10	100
CAT2	10	20	20	30	10	10	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	10	20	20	30	10	10	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	10	20	20	30	10	10	100
ESE	10	20	20	30	10	10	100

22MPE$27	MATERIAL PROCESSING AND SOLID PROCESSING EQUIPMENTS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To know the need for use, application and design of different material handling techniques, equipment's and machines for common use and in industrial sector	
UNIT – I	**MATERIALS HANDLING EQUIPMENT**	**(9 Periods)**
Introduction – Importance of material handling – Principle of material handling – Factors influences the choice of material handling - Types - Selection and applications – Scope of material handling. Basic kinds of material handling problems – Methods to analyze material handling problems.		
UNIT – II	**DESIGN OF LOAD HANDLING ATTACHMENTS AND HOIST DRIVES**	**(9 Periods)**
Design of forged hooks and eye hooks - crane grabs - lifting magnets - Grabbing attachments - Design of arresting gear. Hand and power drives - Travelling gear - Rail travelling mechanism - cantilever and monorail cranes -selecting the motor ratings.		
UNIT – III	**CONVEYORS**	**(9 Periods)**
Types - description - design and applications of Belt conveyors, apron conveyors and escalators Pneumatic conveyors, Screw conveyors and vibratory conveyors.		
UNIT – IV	**ELEVATORS**	**(9 Periods)**
Bucket elevators: design - loading and bucket arrangements - Cage elevators - shaft way, guides, counter weights, hoisting machine, safety devices - Design of fork lift trucks.		
UNIT – V	**SOLID PROCESSING EQUIPMENTS**	**(9 Periods)**
Jaw and roll crushers – Size and power rating, Capacity estimation, Critical operating speed, Power consumption estimation. Tubular ball mill – Design and Estimation of capacity, Electrical drive of ball mill. Screening and classifiers – basic design features, operation of straight screens and classifiers – capacity and selection.		
Contact Periods: **Lecture: 45 Periods Tutorial: 00 Periods Practical: 00 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Rudenko,N.,**"Materialshandlingequipment"**,ELnveePublishers,1970*
2	*Spivakovsy,A.O. and Dyachkov,V.K., **"Conveying Machines"**, Volumes I and II, MIS publication,1985.*

REFERENCES:

1	*Jacob Fruciitbaum, **"Bulk Materials Handling Handbook"**Springer, 2013.*
2	*J. Verschoof,"**Cranes: Design, Practice, and Maintenance"** Second Edition, Wiley, 2002.*
3	*A.Kulwiec, **"Materials Handling Handbook"**,Vol. 1 & 2, Second Edition, Wiley India Pvt Ltd, 2009.*
4	*Ashok Gupta, **"Mineral Processing Design and Operations – An Introduction",** Second Edition, Technology and Engineering, Elsevier, 2016.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Appreciate the importance of material handling and select appropriate tools for specific application.	K1
CO2	Design Load handling attachments and drivs for hoists.	K3
CO3	Design different types of conveyor system.	K3
CO4	Design different types of elevators and its attachments.	K3
CO5	Estimate the power rating and capacity of various solid processing equipment's.	K2

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO 1**	**PO 2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	0	2	2	2	0	0	0	0	0	0	1	0	1	2	1
CO2	2	2	2	1	0	0	0	0	0	0	2	0	1	2	1
CO3	2	2	2	1	0	0	0	0	0	0	2	0	1	2	1
CO4	2	2	2	1	0	0	0	0	0	0	2	0	1	2	1
CO5	2	2	2	1	0	0	0	0	0	0	2	0	1	2	1
22MPE$27	2	2	2	1	0	0	0	0	0	0	2	0	1	2	1
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 3.1.1, 3.1.2, 3.1.3, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 4.1.1, 4.1.2, 4.2.1, 11.2.1														
CO2	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.3, 2.2.4, 2.4.1, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 4.1.1, 4.2.1, 11.2.1, 11.3.1														
CO3	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.3, 2.2.4, 2.4.1, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 4.1.1, 4.2.1, 11.2.1, 11.3.1														
CO4	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.3, 2.2.4, 2.4.1, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 4.1.1, 4.2.1, 11.2.1, 11.3.1														
CO5	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.3, 2.2.4, 2.4.1, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 4.1.1, 4.2.1, 11.2.1, 11.3.1														

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	50	40	10				100
CAT2	40	40	20				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	40	10				100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	40	40	20				100
ESE	45	40	15				100

22MPE$28	ROTATING MACHINERY DESIGN

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To inculcate the required knowledge to know about the rotating machines analysis, data interpretation of machineries, sizing of steam turbines, compressors components and pumps performance	
UNIT – I	**DESIGN AND ANALYSIS OF ROTATING MACHINES**	**(9 Periods)**
Rotordynamic Analysis – Torsional Analysis – Hydrodynamic Bearings – Tower's Experiments – Reynolds Equation- Rotor Vibration - Natural Frequencies and Resonance - Gyroscopic Effects - Casing and Foundation Effects - Forced Response Analysis – Mechanical and Fluid Excitation Forces - Rotordynamic Stability - Sub synchronous Whirl & Whip.		
UNIT – II	**UNDERSTANDING ROTATING MACHINERY**	**(9 Periods)**
Pattern Recognition – Static Versus Dynamic Data – Trends with Step Changes – Upward and Downward Trends – Cyclic Trends – Induced Draft Fan Experiences Unpredictable Vibration – Erratic Vibration Related to Rotor Instability – Some Rules of Thumb.		
UNIT – III	**STEAM TURBINES**	**(9 Periods)**
How Steam Turbines Work – Steam Generation – Waste Heat Utilization - The Rankine Cycle - General Purpose Steam Turbine Sizing - General Purpose, Back Pressure, Steam Turbines - Single Stage Back Pressure Steam Turbine - Sizing Procedure.		
UNIT – IV	**COMPRESSORS**	**(9 Periods)**
Compressibility Factor (Z) – Ideal Gas Law – Visualizing Gas Flow - Operating Requirements - Critical Components - Aerodynamic Matching - Reciprocating Compressor - Load Ratings - Gas Loads - Non-Reversing Gas Loads - Non-Reversing Rod Conditions Matrix - Ways to Protect Your Compressor.		
UNIT – V	**PUMPS**	**(9 Periods)**
Use of Pumps – Centrifugal Pump – Head Versus Pressure – Centrifugal Pump Performance - Determining the Efficiency of a Motor-Driven Centrifugal Pump - Liquid Properties - Liquid Characteristics.		
Contact periods: **Lecture: 45 Periods Tutorial:0 Periods Practical: 0 Periods Total:45 Periods**		

TEXT BOOK:

1	*Robert X. Perez – "**Design, Modeling and Reliability in Rotating Machinery**"- Wiley Publishing - 2022*
2	Yahya, S.M., "***Turbines, Compressors and Fans***", Tata McGraw Hill Publishing Company, 2020

REFERENCES:

1	*Gerhard Schweitzer,Eric H. Maslen " **Magnetic Bearings: Theory, Design, and Application to Rotating Machinery**" Springer-Verlag Berlin Heidelberg publisher, 2010.*
2	*Earl Logan, Jr., "**Hand book of Turbo Machinery**", CRC Press., 2009.*
3	*R. K. Turton "**Rotodynamic Pump Design**" Cambridge University Press, 2005.*
4	*Sadhu Singh, Sukumar Pati "**Thermal Engineering**" Pearson India Education Services Pvt. Ltd, 2018.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Analyze the design and analysis of rotating machines	K3
CO2	Apply and identify the vibration related to rotor instability	K3
CO3	Analyse and decide the sizing of the steam turbine	K3
CO4	Select the compressors based on the loading and matching of the application.	K3
CO5	Identify the suitable pumps for the application.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	2	2	2	3	1	1	2	1	3			
CO2	3	2	1	2	2	2	3	1	1	2	1	3			
CO3	3	2	2	2	2	2	3	1	0	2	2	3			
CO4	3	2	3	2	2	2	3	1	1	2	2	3			
CO5	3	2	2	2	2	2	3	1	1	2	2	3			
22MPE$28	3	2	2	2	2	2	3	1	1	2	2	3			
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.3, 3.1.2, 3.1.3, 3.1.5, 3.2.1, 3.2.3, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.4, 4.2.1, 4.3.1, 4.3.2, 5.1.1, 5.2.2, 5.3.2, 6.1.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 9.1.2, 9.2.4, 10.1.1, 10.2.2, 10.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.2, 12.3.1, 12.3.2
CO2	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.4, 3.1.2, 3.1.6, 3.2.2, 3.4.2, 4.1.1, 4.1.4, 4.2.1, 4.3.1, 4.3.3, 5.1.2, 5.2.2, 5.3.2, 6.1.1, 7.1.2, 7.2.1, 7.2.2, 8.2.2, 9.2.2, 10.1.1, 10.2.2, 10.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.1, 12.3.1, 12.3.2
CO3	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.2.1, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 3.1.2, 3.1.3, 3.1.4, 3.1.6, 3.2.3, 3.3.1, 3.4.1, 4.2.2, 4.3.2, 4.3.4, 5.1.1, 5.1.2, 5.3.1, 6.1.1, 7.1.1, 7.1.2, 7.2.2, 8.2.1, 10.1.1, 10.1.3, 10.2.2, 11.1.1, 11.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.1, 12.3.1, 12.3.2
CO4	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.3.1, 2.4.1, 2.4.1, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.2.1, 4.3.3, 4.3.4, 5.1.1, 5.2.2, 5.3.1, 6.2.1, 7.1.2, 7.2.1, 7.2.2, 8.2.2, 9.1.2, 9.2.4, 10.1.1, 10.2.2, 10.3.1, 11.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.1, 12.3.1, 12.3.2
CO5	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.3.1, 2.4.1, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.4.1, 4.1.1, 4.2.1, 4.3.1, 4.3.3, 5.1.1, 5.2.2, 5.3.1, 6.2.1, 7.1.1, 7.1.2, 7.2.2, 8.1.1, 9.1.2, 9.2.1, 10.1.1, 10.1.3, 10.2.2, 10.3.1, 11.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	30	40				100
CAT2	30	20	50				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	30	50				100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	30	40				100
ESE	30	20	50				100

22MPE$29	THERMAL AND FIRED EQUIPMENT DESIGN

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To familiarize and appreciate different modes of heat and mass transfer and its applications on imparting the knowledge of combustion and burner design. To acquire the exposure in heat exchanger designs and cooling tower design.	
UNIT – I	**HEAT TRANSFER**	**(9 Periods)**
Different modes of heat transfer in fluidized bed– bed to wall heat transfer – gas to solid heat transfer – radiant heat transfer – heat transfer to immersed surfaces. Methods for improvement – external heat exchangers– heat transfer and part load operations.		
UNIT – II	**COMBUSTION AND GASIFICATION**	**(9 Periods)**
Fluidized bed combustion and gasification–stages of combustion of particles–performance–start –up methods. Pressurized fluidized beds.		
UNIT – III	**DESIGN CONSIDERATIONS OF FIRED EQUIPMENTS**	**(9 Periods)**
Design of distributors–stoichiometric calculations–heat and mass balance–furnace and burner Design for different fuels-design of heating surfaces–gas solid separators.		
UNIT – IV	**DESIGN CONSIDERATIONS OF HEAT EXCHANGERS**	**(9 Periods)**
Heat transfer and pressure loss – flow configuration – effect of baffles – effect of deviations from ideality – design of double pipe – finned tube – shell and tube heat exchangers – simulation of heat exchangers- Types–merits and demerits–design of compact heat exchangers, plate heat exchangers– performance influencing parameters– limitations.		
UNIT – V	**DESIGN CONSIDERATIONS OF CONDENSERS AND COOLING TOWERS**	**(9 Periods)**
Design of surface and evaporative condensers–cooling tower –performance characteristics		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Yunus Cengel,* ***"Heat Transfer"****, McGraw Hill Company, 2008*
2	*Frank P Incropera and David P. Dewitt,* ***"Fundamentals of Engineering Heat and Mass Transfer"****, John Wiley and Sons, 2010.*

REFERENCES:

1	*Ozisik M.N.,* ***"Heat Transfer",*** *McGraw Hill Book Co., 2005*
2	*Yadav R.,* ***"Heat and Mass Transfer"****, Central Publishing House, Allahabad, 2018.*
3	*SadikKakac, Hongtan Liu, Anchasa Pramuanjaroenkij,* ***"Heat Exchangers Selection, Rating and Thermal Design"****, CRC Press, Fourth Edition, 2020.*
4	*Ramesh K.Shah, Dušan P.Sekulić,* ***"Fundamentals of heat exchanger design"****, John Wiley & Sons, 2024.*
5	*Howard,J.R.(Ed),* ***"Fluidized Beds: Combustion and Applications"****, Applied Science Publishers, New York, 1983.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand the basic modes of heat transfer.	K1
CO2	Understand the principles of combustion and its characteristics.	K2
CO3	Analyze the design parameters for burners and furnace.	K1
CO4	Design heat exchangers and its suitable equipment's.	K2
CO5	Evaluate performance characteristics of condenser and cooling tower.	K1

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	2	3	1	1	1	2	2	1	2	1	2	1	2	
CO2	1	2	2	1	1	2	1	1	1	1	1	1	1	3	
CO3	1	3	3	2	2	2	1	1	1	2	1	2	1	2	
CO4	1	2	2	1	1	1	2	2	1	1	1	1	1	3	
CO5	1	3	2	2	1	1	1	1	1	2	1	2	1	2	
22MPE$29	1	2	2	1	1	1	1	1	1	2	1	2	1	2	
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.1.1, 2.1.3, 3.1.3, 4.1.1, 5.1.1, 7.1.2
CO2	1.3.1, 2.2.4, 2.4.2, 3.1.6, 4.2.1, 5.1.1, 7.1.2, 11.2.1, 12.1.2, 12.3.2
CO3	1.1.2, 2.2.4, 3.4.1, 4.2.1, 7.1.1
CO4	1.3.1, 2.1.3, 4.1.1, 12.3.2
CO5	1.3.1, 2.4.2, 3.1.6, 4.2.1, 5.1.1, 11.2.1, 12.1.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	30	10	10	10	10	100
CAT2	10	10	20	20	20	20	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	30	30	10	10	10	10	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	10	10	20	20	20	20	100
ESE	25	20	15	15	15	10	100

22MPE$30	INDUSTRIAL ENGINEERING

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	Enable the students to apply engineering principles and quality tools in the work environment and work collaboratively.	
UNIT – I	**FORECASTING METHODS**	**(9 Periods)**
Characteristics and Principles of forecasting – Qualitative methods – Delphi technique, Market Research – Time-series analysis – Moving averages – Exponential smoothing method – Regression models – Measurement of forecast errors – Break Even analysis – Elements of Cost – Tutorial problems.		
UNIT – II	**FACILITIES PLANNING AND WORK STUDY**	**(9 Periods)**
An overview of facilities planning – Engineering economic analysis – Facilities location problems – Types of layouts – Computerized layout planning – Group Technology – Objectives of Work Study – Method Study – Time Study – Work Measurement Techniques – Principles of Motion Economy – Motion Study – Predetermined Motion Time System (PMTS) – Work Sampling Techniques – Ergonomics.		
UNIT – III	**AGGREGATE PLANNING**	**(9 Periods)**
Objectives of aggregate planning – Development of master production schedule – Capacity planning – Materials requirements planning (MRP-I) – Designing and managing the MRP System – Manufacturing resources planning (MRP-II) – Enterprises resources planning (ERP).		
UNIT – IV	**SCHEDULING OF OPERATIONS**	**(9 Periods)**
Operations planning and scheduling – Scheduling techniques – Stages in scheduling – Loading, dispatching, expediting – Machine loading charts – Priority sequencing – Dynamic Sequencing Rules – Batch scheduling – Economic batch quantity – Scheduling in Repetitive, batch and job shop production – Resource balancing – Flexible manufacturing system.		
UNIT – V	**PROJECT MANAGEMENT**	**(9 Periods)**
Categories of projects – Project life cycle phase – Roles and responsibilities of project leader – Project management – Scope – Tools and techniques – Work Breakdown Structure – Validation and control – Project risk management – Identification of risks - Qualitative and quantitative risk analysis – Control risks – Preparation of cost estimation.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Panneerselvam R, **"Production and Operations Management"**, Prentice Hall of India, 3rd Edition, New Delhi, 2012*
2	*Khanna OP, "**Industrial Engineering and Management**", 17th Edition, Dhanpat Rai Publications, New Delhi, 2018.*

REFERENCES:

1	*Vollman T.E, **"Manufacturing Planning and Control systems"**, Galgotia Publications, 2004.*
2	*Elwood S. Buffa, and Rakesh K.Sarin, **"Modern Production and Operations Management"**, 8th Edition. John Wiley and Sons, 2007.*
3	*Prasana Chandra, **"Project Planning Analysis selection financing Implementation and Review"**, Tata Mc Graw Hill Publication, 7th edition, 2023.*
4	*Nadha Muni Reddy C, **"Industrial Engineering and Management"**, New Age International (P) Ltd., Publishers, 2011.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Apply forecasting tools to analyze the demand pattern and forecast the demand.	K3
CO2	Familiarize the various facilities' layouts and work study techniques.	K2
CO3	Understand the aggregate production planning.	K2
CO4	Develop the best scheduling of operations in the workplace.	K6
CO5	Analyze the risks involved in projects and control the risks.	K4

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping														
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	1	-	-	3	2	-	-	-	-	-	-	-	2	2	2
CO2	-	-	-	-	-	2	-	-	1	2	-	1	-	-	-
CO3	-	-	2	3	-	-	-	-	-	-	-	-	2	2	3
CO4	-	-	-	2	1	-	-	-	-	-	-	-	-	2	-
CO5	-	-	-	-	-	-	-	-	-	2	-	1	-	-	2
22MPE$30	1	-	1	2	1	1	-	-	1	1	-	1	1	2	2
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.1.1, 4.1.2, 4.1.3, 4.1.4, 4.3.1, 4.3.2, 4.3.3,4.3.4,5.2.1,5.3.1,5.3.2														
CO2	6.2.1, 9.1.1,9.1.2, 10.1.1., 10.2.1, 10.3.1,11.1.1, 10.3.1, 10.3.2, 12.3.2														
CO3	3.1.1, 3.1.2, 3.1.3,3.1.4, 3.1.5, 3.3.2, 4.1.1,4.1.2, 4.1.4, 4.2.1, 4.3.1, 4.3.2,4.3.3,4.3.4														
CO4	4.1.3, 4.3.2, 4.3.3,4.3.4, 5.3.1,5.3.2														
CO5	10.1.3, 10.3.1, 10.3.2, 12.3.2														

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	20	30	20	10	10	100
CAT2	10	20	30	20	10	10	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	10	20	30	20	10	10	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	10	20	30	20	10	10	100
ESE	10	20	30	20	10	10	100

22MPE$31	COMPUTATIONAL SOLID MECHANICS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To understand the Finite Element Methods solutions for elastic, linear and nonlinear elastic problems under various loading conditions.	
UNIT – I	**BASICS OF ELASTICITY**	**(9 Periods)**
Stress-Strain relations and general equations of elasticity in Cartesian, Polar and curvilinear 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	**THE FINITE ELEMENT METHOD FOR LINEAR ELASTICITY**	**(9 Periods)**
Derivation and implementation of a basic 2D FE code with triangular constant strain elements, Generalization of finite element procedures for linear elasticity: interpolation and numerical integration in 1D, 2D and 3D, Deriving finite element equations - constructing variational forms; mixed methods., Accuracy and convergence		
UNIT – III	**KINEMATICS OF FINITE ELEMENT NON LINEAR ANALYSIS**	**(9 Periods)**
Formulation of Incremental Equations of motions- Deformation Gradient, Stress Tensor analysis, Continuum Mechanics incremental Langrangian Formulations, Linearized Kinematics, Material Time Derivative.		
UNIT – IV	**KINETICS OF FINITE ELEMENT NON LINEAR ANALYSIS**	**(9 Periods)**
Cauchy Stress Tensor, Linearization of Principal of Virtual Work, Linearization of External Virtual Work General matrix Equations of Displacement, Work conjugacy, Structural Elements-Truss and Cabel Elements, Beam and axisymmetric Shell Elements.		
UNIT – V	**ITERATIVE SOLUTIONS AND PRACTICAL CONSIDERATIONS**	**(9 Periods)**
Newton Raphson Method, Damped Newton Raphson Method, Quasi Newton Method, Linear search Method, Gradient Flow Method, Nonlinear Least sqares, Collapse and Buckling Analysis, Effects of Element Distortation, Effect of order of Numerical Integration.		
Contact Periods: **45 Periods** **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK

1	*K.J. Bathe,* ***"Finite Element Procedures",*** *2nd Edn., Prentice Hall, 2007*
2	*Allan F. Bower,* ***"Applied Mechanics of Solids",*** *CRC Press Inc; 2nd edition, 2009*

REFERENCES

1	*T. Belythschko, W.K. Liu and B. Moran,* ***"Nonlinear Finite Elements for Continua and Structures",*** *Wiley, 2013.*
2	*Antonio J. Gil, J. Bonet, and Richard D. Wood,* ***"Nonlinear Solid Mechanics for Finite Element Analysis: Statics",*** *Cambridge University Press,2016*
3	*P. Wriggers,* ***"Nonlinear Finite Element Methods",*** *Springer, 2008.*
4	*Richard D.Klafter, Thomas A.Chmielewski and Micheal Negin,* ***"Robotic engineering –An Integrated Approach",*** *Prentice Hall Inc, Englewoods Cliffs, 2021.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Appreciate the governing differential equations describing the elastic behavior of three dimensional systems	K5
CO2	Understand Finite Element techniques basics for Elastic problems solutions.	K5
CO3	Formulate analytical techniques of Finite Element Methods Non Linear problems solutions.	K5
CO4	Comprehend the kinetics of finite element nonlinear analysis.	K5
CO5	Learn the iterative solution procedure for various practical examples.	K5

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	1	3	2	1	0	1	0	2	1	1	1
CO2	3	3	3	3	3	3	3	3	2	2	3	3	2	2	2
CO3	2	2	3	3	2	3	2	2	1	2	2	1	2	2	3
CO4	2	2	3	3	2	3	2	2	1	2	2	1	3	3	3
CO5	2	2	3	3	2	3	2	2	1	2	2	1	3	3	3
22MPE$31	2	2	3	3	2	3	2	2	1	2	2	2	2	2	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.1,2.2.4,2.4.1,2.4.3,2.4.4,4.1.1,7.1.1,10.1.1,10.1.2,10.1.3,10.3.1,11.3.1,12.3.1
CO2	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.1,2.2.4,2.4.1,2.4.3,2.4.4,4.1.1,4.3.4,5.1.1,7.1.1,10.1.1,10.1.2,10.1.3,10.3.1,11.3.1,12.3.1
CO3	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.1,2.2.4,2.4.1,2.4.3,2.4.4,4.1.1,4.3.4,5.1.1,7.1.1,10.1.1,10.1.2,10.1.3,10.3.1,11.3.1,12.3.1
CO4	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.1,2.2.4,2.4.1,2.4.3,2.4.4,4.1.1,4.3.4,5.1.1,7.1.1,10.1.1,10.1.2,10.1.3,10.3.1,11.3.1,12.3.1
CO5	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.1,2.2.4,2.4.1,2.4.3,2.4.4,4.1.1,4.3.4,5.1.1,7.1.1,10.1.1, 10.1.2,10.1.3,10.3.1,11.3.1,12.3.1

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	10	20	20	20	30	0	100
CAT2	10	20	20	20	30	0	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	10	20	20	20	30	0	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	10	20	20	20	30	0	100
ESE	10	20	20	20	30	0	100

22MPE$32	COMPUTATIONAL FLUID DYNAMICS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To impart knowledge of the basic tools for numerical simulation of fluid flow and heat transfer processes.	
UNIT – I	**FUNDAMENTALS OF CFD**	**(9 Periods)**
Basics of CFD - conservation equation– mass, momentum and energy equations - conservative forms of the equations and general description- classification into various types of equations - elliptic, parabolic and hyperbolic - initial and boundary conditions - overview of numerical methods.		
UNIT – II	**DISCRETIZATION AND FINITE DIFFERENCE METHOD**	**(9 Periods)**
Methods of deriving discretization equations – comparison of finite difference, finite volume and finite element techniques - forward, backward and central difference schemes, transient one- and two-dimensional conduction – implicit, explicit and Crank Nicolson finite difference methods for viscous flows - stability analysis and error estimation.		
UNIT – III	**FINITE VOLUME METHOD**	**(9 Periods)**
Finite volume formulation of steady one-dimensional convection and diffusion problems - central, upwind, hybrid formulations and comparison for convection-diffusion problems - discretization equations for two-dimensional convection and diffusion - representation of the pressure gradient term and continuity equation – momentum equations – pressure-velocity coupling - pressure-correction methods.		
UNIT – IV	**TURBULENCE MODELING**	**(9 Periods)**
Types of turbulence modeling– Reynolds time averaging – Reynolds-averaged Navier-Stokes equations – Boussinesq eddy viscosity approximation - zero equation model, one equation model, two equation K-I models and advanced models.		
UNIT – V	**GRID GENERATION**	**(9 Periods)**
Choice of grid, grid-oriented velocity components, cartesian velocity components, staggered and collocated grid arrangements, algebraic grid generation - differential grid generation - unstructured grid generation – adaptive grids - modern developments in grid generation.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*John D. Anderson, Jr.,* ***"Computational Fluid Dynamics: The Basics with Applications"****, McGraw Hill Education, Indian Edition, New Delhi, 2017.*
2	*Versteeg. H and Malalasekera. W., "****An Introduction to Computational Fluid Dynamics: The finite volume Method"****, Pearson Education Limited., 2nd Edition, 2007.*

REFERENCES:

1	*Dale A. Anderson, John C. Tannehill and Richard H. Pletcher,* ***"Computational Fluid Mechanics and Head Transfer",*** *CRC Press, 3rd Edition, 2014.*
2	*Muralidhar, K and Sundararajan, T.,* ***"Computational Fluid Flow and Heat Transfer",*** *Narosa Publishing House, New Delhi, 4th Edition, 2014.*
3	*Chung, T. J.,* ***"Computational Fluid Dynamics"****, Cambridge University Press, 2nd Edition, 2014.*
4	*Anil W. Date.,* ***"Introduction to Computational Fluid Dynamics"****, Cambridge University Press, 2005.*
5	*Reddy, J. N. and Gartling, D. K.,* ***"The Finite Element Method in Heat Transfer andFluid Dynamics"****, CRC Press, 3rdEdition, 2010.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Appreciate different types of PDEs that arise in fluid flow and heat transfer problems.	K4
CO2	Evaluate different discretization techniques opted in CFD.	K5
CO3	Understand the various solutions for the techniques adopted.	K4
CO4	Analyze the concepts of turbulence modeling.	K4
CO5	Propose the concepts of grid generation.	K4

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	1	2	1	-	-	-	-	-	-	1	3	2	2
CO2	3	3	1	2	1	-	-	-	-	-	-	1	2	1	3
CO3	3	3	1	2	1	-	-	-	-	-	-	1	2	3	3
CO4	3	3	1	3	1	-	-	-	-	-	-	1	3	2	3
CO5	3	3	1	3	1	-	-	-	-	-	-	1	2	1	2
22MPE$32	3	3	1	2	1	-	-	-	-	-	-	1	2	2	3
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.1.1, 1.3.1, 2.1.2, 2.1.3, 3.1.1,3.1.3, 4.3.1, 5.1.2, 5.2.1,12.1.1
CO2	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.3.1, 2.4.2, 3.1.2, 4.3.1, 5.2.1, 12.1.1
CO3	1.1.1, 1.2.1, 1.3.1,1.4.1, 2.1.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.3, 2.4.4, 3.1.1, 4.1.3, 4.3.1, 5.1.2, 12.1.1
CO4	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 3.1.3, 4.1.3, 4.1.4, 4.3.1, 4.3.2, 4.3.3, 5.2.1, 12.1.1
CO5	1.1.1, 1.2.1,1.3.1,1.4.1, 2.1.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.3, 4.3.1, 5.1.2, 12.1.1

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	20	20	30	10		100
CAT2	20	25	25	30			100
Individual Assessment 1 / Case Study 1 / Seminar 1 / Project 1	20	20	20	30	10		100
Individual Assessment 2 / Case Study 2 / Seminar 2 / Project 2	20	25	25	30			100
ESE	10	20	30	30	10		100

22MPE$33	THEORY ON COMPUTATION AND VISUALISATION	SEMESTER $

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To learn the fundamental mathematics of Finite Automata required for understanding the very basics of computer languages and Graphical Visualization.	
UNIT – I	**BASIC MATHEMATICAL TECHNIQUES**	**(9 Periods)**
Sets, Functions, Logical statements, Proofs, Relations, Languages, Principal of Mathematical Induction, Strong Principle, Recursive Definitions, Structural Induction.		
UNIT – II	**FINITE AUTOMATA AND THE LANGUAGES**	**(9 Periods)**
Definitions, Illustration of string search algorithm, Lexical analysis, the union, Intersection, or difference of any two languages, minimizing the number of states in a finite automaton, Regular Expressions, Regular Languages, Nondeterministic finite automata, Conversion from NFA to FA, .Kleene's Theorem		
UNIT – III	**CONTEXT-FREE LANGUAGES AND PUSHDOWN AUTOMATA**	**(9 Periods)**
Regular grammars for regular languages, context-free grammar-definitions and examples, derivation trees and ambiguity , Chomsky normal form, push down automata- definitions and examples, deterministic pushdown automata, PDA from a given CFG, CFG from a given PDA, parsing- bottom-up parser.		
UNIT – IV	**NON-CONTEXT-FREE LANGUAGES AND TUTRING MACHINES**	**(9 Periods)**
The pumping lemma for context-free languages, intersections and complements of CFL, decision problems involving Context-free languages, Turing machines: A general model of computation, turing machines as language acceptors, turing machines that compute Partial functions , combining turing machines, multi tape turing machines.		
UNIT – V	**VISUALIZATION DESIGN**	**(9 Periods)**
Theory of data graphics, Sources of Graphical Integrity In The Visual Display of Quantitative Information, Data-Ink and Graphical Redesign, Data-Ink Maximization and Graphical design, Multi functioning graphical element, Data Density and Small Multiples, Aesthetic and techniques in data graphical design.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKs:

1	*Michael Sipser,"**Introduction to the Theory of Computation"** Cengage India Private Limited, 2014*
2	*John Martin,"**Introduction to Languages and the Theory of Computation**",Pearson Education India, 2010*

REFERENCES:

1	*Adesh K. Pandey, "**An introduction to automata theory and formal languages"**, S.K. Kataria & Sons, 2013*
2	*Deniel I. Cohen, "**Introduction to computer theory**", John Wiley & Sons, Inc, 2007*
3	*Marvin L. Minsky, "**Computation: Finite and Infinite**". Prentice-Hall,2010*
4	*Edward Tufte**,"The Visual Display of Quantitative Information"**, Graphics Pr, 2001*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Apply the concept of discrete mathematics used in computer languages.	K3
CO2	Explain the different regular languages and their relationship.	K3
CO3	Classify and construct grammars for different languages	K3
CO4	Apply the knowledge of regular languages into Turing machine	K3
CO5	Explain the data visualization and Graphical Information used in computer languages.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO 1**	**PO 2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	3	2	1	1	0	0	1	0	2	1	3	1		
CO2	3	3	2	1	1	0	0	1	0	2	1	3	1		
CO3	3	3	2	1	1	0	0	1	0	2	1	3	1		
CO4	3	3	2	1	1	0	0	1	0	2	1	3	1		
CO5	3	2	2	1	1	0	0	1	0	2	1	3	1		
22MPE$33	3	3	2	1	1	0	0	1	0	2	1	3	1		
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.1,2.3.1,2.3.2,2.4.1,2.4.2,2.4.3,2.4.4,3.1.1,3.1.2,3.1.3,3.1.6, 3.2.1,3.3.2,3.4.1,4.1.1,5.2.2,5.3.2,8.2.1,10.1.1,10.1.2,10.3.1,11.3.1,12.1.1,12.2.1,12.2.2,12.3.1,12.3.2														
CO2	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.1,2.3.1,2.3.2,2.4.1,2.4.2,2.4.3,2.4.4,3.1.1,3.1.2,3.1.3,3.1.6, 3.2.1,3.3.2,3.4.1,4.1.1,5.2.2,5.3.2,8.2.1,10.1.1,10.1.2,10.3.1,11.3.1,12.1.1,12.2.1,12.2.2,12.3.1,12.3.2														
CO3	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.1,2.3.1,2.3.2,2.4.1,2.4.2,2.4.3,2.4.4,3.1.1,3.1.2,3.1.3,3.1.6, 3.2.1,3.3.2,3.4.1,4.1.1,5.2.2,5.3.2,8.2.1,10.1.1,10.1.2,10.3.1,11.3.1,12.1.1,12.2.1,12.2.2,12.3.1,12.3.2														
CO4	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.1,2.3.1,2.3.2,2.4.1,2.4.2,2.4.3,2.4.4,3.1.1,3.1.2,3.1.3,3.1.6, 3.2.1,3.3.2,3.4.1,4.1.1,5.2.2,5.3.2,8.2.1,10.1.1,10.1.2,10.3.1,11.3.1,12.1.1,12.2.1,12.2.2,12.3.1,12.3.2														
CO5	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.4.2,2.4.3,2.4.4,3.1.1,3.1.6,3.2.1,3.3.2,3.4.1,4.1.1,5.2.2,5.3.2, 8.2.1,10.1.1,10.1.2,10.3.1,11.3.1,12.1.1,12.2.1,12.2.2,12.3.1,12.3.2														

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	20	60				100
CAT2	20	20	60				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	20	60				100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	20	60				100
ESE	20	20	60				100

22MPE$34	COMPUTATIONAL BIO-MECHANICS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To make the students learn and gain knowledge about the use of computational modeling of biomechanical phenomena ranging from cellular to tissue to organ scales.	
UNIT – I	**INTRODUCTION TO MECHANICS**	**(9 Periods)**
Introduction – scalars and vectors - statics - moments of force and couple – dynamics – linear motion - Newton's laws of motion - kinetics – velocity and acceleration - kinematics – link segment models - introduction to constitutive equations – constitutive equations of nonviscous fluid - Newtonian viscous fluid and Hookean elastic solid.		
UNIT – II	**BIOSOLID MECHANICS**	**(9 Periods)**
Constitutive equation of viscoelasticity – Maxwell and Voight models, anisotropy - hard tissues – structure, blood circulation, viscoelastic properties - soft tissues – structure, functions, material properties and modeling – cartilage, tendons and ligaments skeletal muscle – muscle action, Hill's models, mathematical modeling, bone fracture mechanics, implants for bone fractures.		
UNIT – III	**BIOFLUID MECHANICS**	**(9 Periods)**
Intrinsic fluid properties – rheological properties of blood, Pressure-flow relationship for non-Newtonian fluids, effect of pulsatility, boundary layer separation, structure of blood vessels, material properties and modeling of blood vessels, heart – cardiac muscle characterization, native heart valves – mechanical properties and valve dynamics, prosthetic heart valve fluid dynamics.		
UNIT – IV	**BIOMECHANICS OF JOINTS**	**(9 Periods)**
Skeletal joints - forces and stresses in human joints - analysis of rigid bodies in equilibrium – free body diagrams - structure of joints, types of joints, biomechanical analysis of elbow, shoulder, spinal column, hip, knee and ankle, lubrication of synovial joints, gait analysis, motion analysis.		
UNIT – V	**COMPUTATIONAL MODELING**	**(9 Periods)**
Introduction to finite element analysis - finite element analysis of lumbar spine - computational models of tissue and organ biomechanics - computational models of cell biomechanics - multiscale computational models in biomechanics.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Masao Tanaka, Shigeo Wada and Masanori Nakamura,* ***"Computational Biomechanics Theoretical Background and Biological/Biomedical Problems"****, Springer, 1st Edition, 2012.*
2	*Subrata Pal,* ***"Textbook of Biomechanics"****, Viva Books Private Limited, 2017.*

REFERENCES:

1	*Karol Miller and Poul Nielsen,* ***"Computational Biomechanics for Medicine"****, Springer, 2020.*
2	*Y.C. Fung,* ***"Bio-Mechanics- Mechanical Properties of Tissues"****, Springer-Verlag, 1998.*
3	*Jay D. Humphrey, Sherry De Lange,* ***"An Introduction to Biomechanics: Solids and Fluids, Analysis and Design"****, Springer Science Business Media, 2004.*
4	*Krishna B. Chandran, Ajit P. Yoganathan and Stanley E. Rittgers,* ***"Biofluid Mechanics: The Human Circulation"****, Taylor and Francis, 2014.*
5	*Sheraz S. Malik and Shahbaz S. Malik,* ***"Orthopaedic Biomechanics Made Easy"****, Cambridge University Press, 2015.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the principles of mechanics.	K3
CO2	Explain the fundamentals of bio-solid mechanics.	K3
CO3	Outline the principles of biofluid dynamics.	K3
CO4	Apply the knowledge of joint mechanics.	K3
CO5	Give examples of computational mathematical modelling applied in biomechanics.	K4

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	3	3	2	1	3	-	-	-	-	1	1	1	1
CO2	3	1	2	1	1	1	3	-	-	-	-	1	2	2	3
CO3	3	1	2	2	2	1	3	-	-	-	-	1	2	2	2
CO4	2	1	3	1	1	1	3	-	-	-	-	1	2	2	2
CO5	3	3	3	2	2	1	3	-	-	-	-	1	1	1	1
22MPE$34	3	1	2	1	2	1	3	-	-	-	-	1	2	2	1
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.1.1, 1.3.1, 2.1.2, 2.1.3, 3.1.1, 3.1.3, 4.3.1, 5.1.2, 5.2.1, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 12.1.1
CO2	1.1.1, 1.3.1, 2.1.2, 2.1.3, 3.1.1, 4.3.1, 5.1.2, 5.2.1, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 12.1.1
CO3	1.1.1, 1.3.1, 2.1.2, 2.1.3, 3.1.1, 4.3.1, 5.1.2, 5.2.1, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 12.1.1
CO4	1.1.1, 1.3.1, 2.1.2, 2.1.3, 3.1.1,3.1.2, 3.1.3, 4.3.1, 5.1.2, 5.2.1, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 12.1.1
CO5	1.1.1, 1.3.1, 2.1.2, 2.1.3, 3.1.1, 3.1.3, 4.3.1, 5.1.2, 5.1.2, 5.2.1, 5.3.1, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 12.1.1

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	30	50				100
CAT2	20	20	30	30			100
Individual Assessment 1 / Case Study 1 / Seminar 1 / Project 1	20	30	50				100
Individual Assessment 2 / Case Study 2 / Seminar 2 / Project 2	20	20	30	30			100
ESE	20	20	40	20			100

22MPE$35	CAD AND CAE

PRE-REQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To understand and integrate CAD and CAE workflows for comprehensive design and analysis and to acquire knowledge on the concept linear and non-linear analysis, impact analysis in various engineering problems.	
UNIT – I	**INTRODUCTION TO CAD AND CAE**	**(9 Periods)**
Overview of CAD and CAE concepts in design analysis cycle-sketching-part modeling and assembly modeling- constrains in geometrical and dimensional. Model generation for CAE - Solid modeling- feature and primitive approaches. Surface modeling–ruled surface-surface of revolution- swept surface. Geometric Modeling and Simplification Techniques for CAD Models for CAE Validation.		
UNIT – II	**CAD MODEL FOR CAE VALIDATION**	**(9 Periods)**
Preprocessing of CAD model - Geometry Cleanup- Simplification and Idealization- Material assignment- Boundary Conditions setup- mesh Generation-. Meshing-surface mesh-solid mesh-volume mesh. Free and Mapped meshing -Mesh quality- mesh refinement.		
UNIT – III	**ANALYSIS PEROFORMING IN CAE**	**(9 Periods)**
Data exchange between CAD and CAE- importing CAD models- domain extraction – assigning load and supports-Analysis by Finite Element Approach- structural analysis- heat transfer analysis -coupled-field analysis. Multi-physics analysis- Electro-thermal Analysis- Fluid-structure Interaction (FSI) - Thermal-mechanical Coupling- Electromagnetic-thermal Analysis.		
UNIT – IV	**NON-LINEAR MODEL AND ANALYSIS**	**(9 Periods)**
Concept of linear and non-linear analysis- computational procedure. Challenges in non-linear analysis-converging issues. Material Nonlinearity Modeling - Plasticity Models - Hyperelastic Models - Viscoelastic Models. Impact analysis- Penetration Analysis-component impact analysis-case study.		
UNIT – V	**FLOW MODEL AND ANALYSIS**	**(9 Periods)**
Introduction of fluid flow simulation- finite and infinite control volume. Flow domain- internal and external. Boundary condition-inlet, outlet, wall conditions. Porous zone modeling - Packed beds – Filter papers – Perforated plates. Modeling and analysis of turbulent flow- mixture turbulence model- dispersed turbulence model-turbulence model for each phase-case study.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Ibrahim Zeid and R. Sivasubramanian, **"CAD/CAM Theory and Practice",** Revised First special Indian Edition, Tata McGraw Hill Publication, 2009*
2	*Jacob Fish and Ted Belytschko. **"A First Course in Finite Elements",** 2007.*
3	*G.P.Sutton, "**Rocket Propulsion Elements**", 9th Edition, A wiley interscience publication, US 2017.*

REFERENCES:

1	*Chris McMohan and Jimmi Browne, "**CAD/CAM Principles, Practice and Manufacturing Management"**, Pearson Education Asia, Ltd, 2000.*
2	*Zeid, I., **"CAD/CAM",** McGraw Hill Publication, 2009.*
3	*R. D. Cook, D. S. Malku "**Concepts & Application of Finite Element Analysis"** (John Wiley & Sons)*
4	*Seshu.P, **Textbook of Finite Element Analysis**, PHI Learning Pvt. Ltd., NewDelhi, 2012.*
5	*H. Versteeg and W. Malalasekera "**An Introduction to Computational Fluid Dynamics: The Finite Volume Method".***

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify fundamental concepts of geometrical modeling, constraints, and parametric modeling techniques importance in CAD.	K2
CO2	Apply the CAD and CAE workflows for comprehensive design, meshing and analyse of engineering systems.	K3
CO3	Validate the principles of finite element analysis (FEA), including meshing techniques, material models, and boundary conditions.	K4
CO4	Distinguish the linear and nonlinear models, challenging in non-linear analysis, impact analysis.	K4
CO5	Interpret proficiency in fluid flow simulation techniques, porous zone modelling, analysing turbulent flows using different turbulence models.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	3	3	2	3	3	2	2	2	2	2	3	2
CO2	3	3	2	3	3	2	3	2	2	3	2	2	2	3	2
CO3	2	3	3	3	3	2	3	2	2	2	2	2	2	3	2
CO4	3	2	3	3	3	2	3	2	3	2	2	2	2	3	2
CO5	3	3	3	3	3	2	3	2	3	3	2	2	2	3	2
22MPE$35	3	3	3	3	3	2	3	2	2	3	2	2	2	3	2
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 6.1.1, 7.1.1,7.1.2, 7.2.2, 11.1.1, 11.3.1, 11.3.2, 12.2.2, 12.3.1, 12.3.2
CO2	1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 6.1.1, 7.1.1,7.1.2, 7.2.2, 11.1.1, 11.3.1, 11.3.2, 12.3.1, 12.3.2
CO3	1.1.2, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 6.1.1, 7.1.1,7.1.2, 7.2.2, 11.1.1, 11.3.1, 11.3.2, 12.2.2, 12.3.1, 12.3.2
CO4	1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.3, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 6.1.1, 7.1.1,7.1.2, 7.2.2, 11.1.1, 11.3.1, 11.3.2, 12.3.1, 12.3.2
CO5	1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 6.1.1, 7.1.1,7.1.2, 7.2.2, 11.1.1, 11.3.1, 11.3.2, 12.2.2, 12.3.1, 12.3.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	25	30	30	15			100
CAT2	25	30	30	15			100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	25	30	30	15			100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	25	30	30	15			100
ESE	25	30	30	15			100

22MPE$36	MACHINE LEARNING FOR INTELLIGENT SYSTEMS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To gain exposure on basic machine learning, clustering and segmentation methods, fuzzy logic, neural networks, RNN and Reinforcement learning.	
UNIT – I	**INTRODUCTION TO MACHINE LEARNING**	**(9 Periods)**
Philosophy of learning in computers, Overview of different forms of learning, Classifications vs. Regression, Evaluation metrics and loss functions in Classification, Evaluation metrics and loss functions in Regression, Applications of AI in Robotics.		
UNIT – II	**CLUSTERING AND SEGMENTATION METHODS**	**(9 Periods)**
Introduction to clustering, Types of Clustering, Agglomerative clustering, K-means clustering, Mean Shift clustering, K-means clustering application study, Introduction to recognition, K-nearest neighbor algorithm, KNN Application case study, Principal component analysis (PCA), PCA Application case study in Feature Selection for Robot Guidance.		
UNIT – III	**FUZZY LOGIC**	**(9 Periods)**
Introduction to Fuzzy Sets, Classical and Fuzzy Sets, Overview of Classical Sets, Membership Function, Fuzzy rule generation, Fuzzy rule generation, Operations on Fuzzy Sets, Numerical examples, Fuzzy Arithmetic, Numerical examples, Fuzzy Logic, Fuzzification, Fuzzy Sets, Defuzzification, Application Case Study of Fuzzy Logic for Robotics Application		
UNIT – IV	**NEURAL NETWORKS**	**(9 Periods)**
Mathematical Models of Neurons, ANN architecture, Learning rules, Multi-layer Perceptrons, Back propagation, Introduction of Neuro-Fuzzy Systems, Architecture of Neuro Fuzzy Networks, Application Case Study of Neural Networks in Robotics		
UNIT – V	**RNN AND REINFORCEMENT LEARNING**	**(9 Periods)**
Unfolding Computational Graphs, Recurrent neural networks, Application Case Study of recurrent networks in Robotics, Reinforcement learning, Examples for reinforcement learning, Markov decision process, Major components of RL, Q-learning. Application Case Study of reinforcement learning in Robotics		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Ethem Alpaydin, "**Introduction to Machine Learning 3e (Adaptive Computation and Machine Learning Series)**", Fourth Edition, MIT Press, 2020*
2	*Micheal Negnevitsky, **Artificial Intelligence: A Guide to Intelligent Systems, 3rd Edition, Addision Wesley, England,** 2011*

REFERENCES:

1	*Stephen Marsland, "**Machine Learning – An Algorithmic Perspective**", Second Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014.*
2	*Tom M Mitchell, "**Machine Learning**", First Edition, McGraw Hill Education, 2017*
3	*Trevor Hastie, Robert Tibshirani, Jerome Friedman, "**The Elements of Statistical Learning**", Second Edition ,Springer, 2017*
4	*Bruno Siciliano, Oussama Khatib, "**Handbook of Robotics**", 2016 2nd Edition, Springer*
5	*Simon Haykin, "**Neural Networks and Learning Machines: A Comprehensive Foundatio**n", Third Edition, Pearson, delhi 2016.*
6	*Timothy J Ross, "**Fuzzy Logic with Engineering Applications**", 4th Edition, Chichester, 2011, Sussex Wiley.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand basic machine learning techniques such as regression, classification	K2
CO2	Understand about clustering and segmentation	K3
CO3	Model a fuzzy logic system with fuzzification and defuzzification	K3
CO4	Understand the concepts of neural networks and neuro fuzzy networks.	K3
CO5	Gain knowledge on Reinforcement learning.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping														
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	3	2	1	1	3	3	2	3	1	3	2	3	2
CO2	3	2	3	2	1	1	3	3	2	3	2	3	2	3	2
CO3	3	2	3	2	1	1	3	3	2	3	3	3	2	3	2
CO4	3	2	3	2	1	1	3	3	2	3	4	3	2	3	2
CO5	3	2	3	2	1	1	3	3	2	3	5	3	2	3	2
22MPE$36	3	2	3	2	1	1	3	3	2	3	1	3	2	3	2
1– Slight, 2 – Moderate, 3 – Substantial															
CO1	1.1.1, 2.1.1, 3.1.1, 4.1.1														
CO2	1.1.1, 1.2.1, 2.1.1, 2.2.1, 3.1.1, 3.3.1, 3.3.2, 3.4.1														
CO3	1.1.1, 1.2.1, 2.1.1, 2.2.1, 3.1.1, 3.3.1, 3.3.2, 3.4.1														
CO4	1.1.1, 1.2.1, 2.1.1, 2.2.1, 3.1.1, 3.3.1, 3.3.2, 3.4.1														
CO5	1.1.1, 1.2.1, 2.1.1, 2.2.1, 3.1.1, 3.3.1, 3.3.2, 3.4.1														

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	30	40				100
CAT2	30	30	40				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	30	20	40	10			100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	20	30	20			100
ESE	30	20	40	10			100

22MPE$37	TOTAL QUALITY MANAGEMENT

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To facilitate the understanding of total quality management principle, processes and to develop a product with the required quality at affordable price with the satisfaction of customer	
UNIT – I	**QUALITY CONCEPTS**	**(9 Periods)**
Introduction, need for quality, evolution of quality, definitions of quality, product quality and service quality; Basic concepts of TQM, TQM framework, contributions of Deming, Juran and Crosby. Barriers to TQM; Quality statements, customer focus, customer orientation & satisfaction, customer complaints, customer retention; costs to quality, case studies.		
UNIT – II	**TQM PRINCIPLES**	**(9 Periods)**
TQM principles; leadership, strategic quality planning; Quality councils, employee involvement, motivation; Empowerment; Team and Teamwork; Quality circles, recognition and reward, performance appraisal; Continuous process improvement; PDCA cycle, 5S, Kaizen, e-Kanban; Supplier partnership, Partnering, Supplier rating & selection, Quality Awards.		
UNIT – III	**STATISTICAL PROCESS CONTROL**	**(9 Periods)**
The seven traditional tools of quality; New management tools; Statistical fundamentals, population and sample, normal curve, control charts for variables, attributes and its applications, process capability; Six sigma, concepts, methodology, certification, applications to manufacturing, service sector including IT.		
UNIT IV	**TOOLS AND TECHNIQUES**	**(9 Periods)**
Benchmarking needs and benefits, benchmarking process, Quality function deployment (QFD); house of quality, Taguchi quality loss function, Total productive maintenance (TPM); pillars of TPM, Failure Mode Effective Analysis (FMEA); Failure rate, types of FMEA, stages of FMEA, Case studies.		
UNIT V	**QUALITY SYSTEMS**	**(9 Periods)**
Introduction to ISO 9000 and other quality system; ISO 9001:2015 quality system, elements, implementation of quality system, documentation, quality auditing, QS 9000, ISO 14000; concept, requirements and benefits, integrating ISO 14000 with ISO 9000, ISO45000, IATF16949; Implementation of TQM in manufacturing industry.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Dale H.Besterfield, et al., "**Total Quality Management**", Pearson Education, 2008.*
2	*Subburaj Ramasamy, "**Total Quality Management**", Tata McGraw Hill, 2008.*

REFERENCES:

1	*James R.Evans & William M.Lidsay, "**The Management and Control of Quality**", Thomson Learning, 2002.*
2	*Janakiraman B. and Gopal R.K., "**Total Quality Management**", Prentice Hall India, 2006.*
3	*Mukherjee P.N. "**Total Quality Management**",PHI Publishers,2006*
4	*P.N.Mukherjee, "Total Quality Management", Prentice – Hall of India Priovate Limited,2006*
5	*Feigenbaum.A.V. "**Total Quality Management**", McGraw-Hill, 1991.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the principle of strategic planning, Deming philosophy and leadership concepts in industries.	K2
CO2	Apply the principle of TQM in industries.	K3
CO3	Evaluate statistical process control in industries.	K3
CO4	Select appropriate quality tools to meet industrial requirements.	K3
CO5	Implement appropriate quality standards for industries.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	2	3	2	0	3	0	2	3	1	2	2	2	2
CO2	2	3	3	3	3	3	3	1	3	3	2	3	3	3	3
CO3	2	3	2	3	3	0	3	2	3	3	1	3	2	2	3
CO4	2	3	3	3	3	0	3	0	3	3	2	3	2	2	2
CO5	2	3	2	3	3	3	3	2	3	3	2	2	1	2	2
22MPE$37	2	3	3	3	3	2	3	1	3	3	2	3	2	2	3
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.2, 2.2.3, 2.4.3, 3.1.1, 3.1.4, 3.2.1, 3.3.1, 3.3.2, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.2, 5.2.2, 5.3.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.1.2, 9.2.1, 9.2.3, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.3.2.
CO2	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 9.2.2, 9.2.3, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.2, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2.
CO3	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.6, 3.2.1, 3.2.3, 3.3.1, 3.3.2, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 9.2.3, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.3.1, 12.3.2.
CO4	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.1.1, 9.1.2, 9.2.1, 9.2.2, 9.2.3, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.2, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.2
CO5	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.3, 3.3.1, 3.3.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 9.2.2, 9.2.3, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.2, 11.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.1, 12.3.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	50	20	-			100
CAT2	30	50	20	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	40	40	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	40	40	-	-	-	100
ESE	40	40	20	-	-	-	100

22MPE$38	GAS DYNAMICS AND JET PROPULSION *(Use of Approved Gas Table is permitted)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To facilitate the understanding of total quality management principle, processes and to develop a product with the required quality at affordable price with the satisfaction of customer	
UNIT – I	**BASIC CONCEPTS AND ISENTROPIC FLOWS**	**(9 Periods)**
Energy and momentum equations of compressible fluid flows - Stagnation states, Mach waves and Mach cone – Effect of Mach number on compressibility – Isentropic flow through variable ducts Nozzle and Diffusers		
UNIT – II	**FLOW THROUGH DUCTS**	**(9 Periods)**
Flows through constant area ducts with heat transfer (Rayleigh flow) and Friction (Fanno flow) Friction Choking and Its Consequences, variation of flow properties.		
UNIT – III	**NORMAL AND OBLIQUE SHOCKS**	**(9 Periods)**
Governing equations – Variation of flow parameters across the normal and oblique shocks – Prandtl Meyer Flow around Concave and Convex Corners, Prandtl – Meyer relations – Applications.		
UNIT IV	**JET PROPULSION**	**(9 Periods)**
Theory of jet propulsion – Thrust equation – Thrust power and propulsive efficiency – Operating principle, cycle analysis and use of stagnation state performance of ram jet, turbojet, and turbofan and turbo prop engines.		
UNIT V	**SPACE PROPULSION**	**(9 Periods)**
Types of rocket engines: Solid, Liquid and Hybrid Propellant Rockets – Propellants-feeding systems – Ignition and combustion – Theory of rocket propulsion – Performance study – Staging – Terminal and characteristic velocity - Applications – space flights.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*E.Rathakrishnan. "**Gas Dynamics**" Prentice Hall of India private limited, 2012.*
2	*Yahya, S.M. "**Fundamentals of Compressible Flow with aircraft and rocket propulsion**", New Age International (P) Limited, New Delhi, 2016.*
3	*G.P.Sutton, "**Rocket Propulsion Elements**", 7th Edition, A wiley interscience publication, US 2001.*

REFERENCES:

1	*Hill. P. and C. Peterson, "**Mechanics and Thermodynamics of Propulsion**", Addison – Wesley Publishing company, 1992.*
2	*Zucrow. N.J., "**Aircraft and Missile Propulsion**", Vol.1 & II, John Wiley, 1975.*
3	*Zucrow. N.J., "**Principles of Jet Propulsion and Gas Turbines**", John Wiley, New York, 1970.*
4	*Anderson, J.D., "**Modern Compressible flow**", 3rd Edition, McGraw Hill, 2003.*
5	*V.Babu., "**Fundamentals of Gas Dynamics**", Athena Academic Ltd, UK, 2015.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Apply the concepts of isentropic flow in practical applications.	K2
CO2	Analyze the flow phenomena in ducts.	K3
CO3	Identify and analyze the normal and oblique shocks.	K4
CO4	Design the jet propulsion engine systems.	K4
CO5	Select and design space propulsion systems.	K4

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	2	2	2	3	1	1	2	1	3	3	2	1
CO2	3	2	1	2	2	2	3	1	1	2	1	3	3	2	1
CO3	3	2	2	2	2	2	3	1	-	2	2	3	3	2	1
CO4	3	2	3	2	2	2	3	1	1	2	2	3	3	2	1
CO5	3	2	2	2	2	2	3	1	1	2	2	3	3	2	1
22MPE$38	3	2	2	3	2	2	3	1	1	2	2	3	3	2	1
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.3, 3.1.2, 3.1.3, 3.1.5, 3.2.1, 3.2.3, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.4, 4.2.1, 4.3.1, 4.3.2, 5.1.1, 5.2.2, 5.3.2, 6.1.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 9.1.2, 9.2.4, 10.1.1, 10.2.2, 10.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.2, 12.3.1, 12.3.2
CO2	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.4, 3.1.2, 3.1.6, 3.2.2, 3.4.2, 4.1.1, 4.1.4, 4.2.1, 4.3.1, 4.3.3, 5.1.2, 5.2.2, 5.3.2, 6.1.1, 7.1.2, 7.2.1, 7.2.2, 8.2.2, 9.2.2, 10.1.1, 10.2.2, 10.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.1, 12.3.1, 12.3.2
CO3	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.2.1, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 3.1.2, 3.1.3, 3.1.4, 3.1.6, 3.2.3, 3.3.1, 3.4.1, 4.2.2, 4.3.2, 4.3.4, 5.1.1, 5.1.2, 5.3.1, 6.1.1, 7.1.1, 7.1.2, 7.2.2, 8.2.1, 10.1.1, 10.1.3, 10.2.2, 11.1.1, 11.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.1, 12.3.1, 12.3.2
CO4	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.3.1, 2.4.1, 2.4.1, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.2.1, 4.3.3, 4.3.4, 5.1.1, 5.2.2, 5.3.1, 6.2.1, 7.1.2, 7.2.1, 7.2.2, 8.2.2, 9.1.2, 9.2.4, 10.1.1, 10.2.2, 10.3.1, 11.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.1, 12.3.1, 12.3.2
CO5	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.3.1, 2.4.1, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.4.1, 4.1.1, 4.2.1, 4.3.1, 4.3.3, 5.1.1, 5.2.2, 5.3.1, 6.2.1, 7.1.1, 7.1.2, 7.2.2, 8.1.1, 9.1.2, 9.2.1, 10.1.1, 10.1.3, 10.2.2, 10.3.1, 11.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	40	25	15			100
CAT2	30	30	30	10			100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	30	30	25	15			100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	25	35	20	20			100
ESE	25	30	25	20			100

22MPE$39	WELDING TECHNOLOGY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To study the welding processes, understanding of inspection methods of welded products and also helps to know the material considerations of this operation.	
UNIT – I	**GAS, ARC AND RESISTANCE WELDING PROCESSES**	**(9 Periods)**
Classification and characteristics - Welding processes and Methods - Gas Welding - Gas welding equipments, flame characteristics - Arc welding processes -SMAW - Electrodes - Gas metal arc welding – Flux cored arc welding – Submerged arc welding – GTAW – Principles of Resistance welding – Spot Welding - Seam welding, Seamless welding – Percussion welding.		
UNIT – II	**SPECIAL WELDING PROCESSES**	**(9 Periods)**
Ultrasonic welding - Explosive welding- diffusion welding - Friction welding - Plasma - Transferred welding - Electron beam welding - Laser beam welding - Friction stir welding - Allied welding processes - Brazing and Soldering .		
UNIT – III	**WELDING METALLURGY**	**(9 Periods)**
Weld thermal cycles – Heat Affected Zone (HAZ) – Weldability of carbon steels, Cast Iron, Stainless steel, aluminum and its alloys, Copper, Titanium alloys, low alloy steels and Magnesium - Hydrogen embrittlement – Pro and post weld heat Treatments.		
UNIT IV	**WELDING OF SIMILAR AND DISSIMILAR METALS**	**(9 Periods)**
Welding similar and dissimilar metals - welding of ceramics, composites, micro welding of thin components - Defects in weldments, mechanism - reasons and remedies of cold cracking - hot cracking- reheated cracking and lamellar tearing.		
UNIT V	**DESIGN OF WELD JOINTS, WELDABILITY, INSPECTION AND TESTING OF WELDMENTS**	**(9 Periods)**
Design of weld joints and problems – welding symbols - Testing of welds – quality in weldment – weldability assessment and weldability tests - destructive and NDT evaluation of weldments - procedure for destructive testing - tensile, bending and toughness tests - magnetic particle test - X Ray, gamma, ultrasonic and acoustic tests.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Parmer R.S., "**Welding Engineering and Technology**", Khanna Publishers, New Delhi, 1997.*
2	*Howard B. Cary, Scott C. Helaer., "Modern Welding Technology", Pearson Education. Ltd, 2011.*

REFERENCES:

1	*Nadkarni S.V., "**Modern Arc Welding Technology**", South Asia Books, 1988.*
2	*Little R.L., "**Welding and welding Technology**", Tata McRaw Hill Publishing Co.,Ltd. , New Delhi, 1989.*
3	*A.Elango, K.Kalaiselvan, "**Laser Welding Technology**", Anuradha Publications, Chennai,2016.*
4	*O.P.Khanna, "**Welding Technology**", DhanpatRai and sons, 2008.*
5	*Baldev Raj, V. Shankar, A.K.Bhaduri, "**Welding Technology for Engineers**", Alpha Science International, 2006.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Provide the principle of the welding process for joints production to the machine products	K2
CO2	Operate the latest and special welding process for uncommon new and specialized components	K3
CO3	Evaluate the physical and chemical properties change due to the welding	K3
CO4	Join the different dissimilar materials as per requirement	K2
CO5	Inspect its quality of welded portion of machine component.	K2

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	3	-	-	1	2	-	-	-	1	1	1	1	1
CO2	2	2	3	-	-	1	2	-	-	-	1	1	1	1	1
CO3	2	2	3	-	-	1	2	-	-	-	1	1	1	1	1
CO4	2	2	3	-	-	1	2	-	-	-	1	1	1	1	1
CO5	2	2	3	-	2	1	2	-	-	-	1	1	1	1	1
22MPE$39	2	2	3	-	1	1	2	-	-	-	1	1	1	1	1
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.3, 3.1.2, 3.1.3, 3.1.5, 3.2.1, 3.2.3, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.4, 4.2.1, 4.3.1, 4.3.2, 5.1.1, 5.2.2, 5.3.2, 6.1.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 9.1.2, 9.2.4, 10.1.1, 10.2.2, 10.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.2, 12.3.1, 12.3.2														
CO2	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.4, 3.1.2, 3.1.6, 3.2.2, 3.4.2, 4.1.1, 4.1.4, 4.2.1, 4.3.1, 4.3.3, 5.1.2, 5.2.2, 5.3.2, 6.1.1, 7.1.2, 7.2.1, 7.2.2, 8.2.2, 9.2.2, 10.1.1, 10.2.2, 10.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.1, 12.3.1, 12.3.2														
CO3	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.2.1, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 3.1.2, 3.1.3, 3.1.4, 3.1.6, 3.2.3, 3.3.1, 3.4.1, 4.2.2, 4.3.2, 4.3.4, 5.1.1, 5.1.2, 5.3.1, 6.1.1, 7.1.1, 7.1.2, 7.2.2, 8.2.1, 10.1.1, 10.1.3, 10.2.2, 11.1.1, 11.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.1, 12.3.1, 12.3.2														
CO4	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.3.1, 2.4.1, 2.4.1, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.2.1, 4.3.3, 4.3.4, 5.1.1, 5.2.2, 5.3.1, 6.2.1, 7.1.2, 7.2.1, 7.2.2, 8.2.2, 9.1.2, 9.2.4, 10.1.1, 10.2.2, 10.3.1, 11.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.1, 12.3.1, 12.3.2														
CO5	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.3.1, 2.4.1, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.4.1, 4.1.1, 4.2.1, 4.3.1, 4.3.3, 5.1.1, 5.2.2, 5.3.1, 6.2.1, 7.1.1, 7.1.2, 7.2.2, 8.1.1, 9.1.2, 9.2.1, 10.1.1, 10.1.3, 10.2.2, 10.3.1, 11.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2														

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	60	20				100
CAT2	20	60	20				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	60	20				100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	60	20				100
ESE	20	60	20				100

22MPE$40	ENTREPRENEURIAL DEVELOPMENT

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To identify and apply entrepreneurial concepts, and act responsibly and ethically in selecting opportunities, managing resources, and utilizing support from government and financial institutions.	
UNIT – I	**INTRODUCTION TO ENTREPRENEURSHIP**	**(9 Periods)**
Evolution of the concept of entrepreneurship, Characteristics of entrepreneurs, Functions of entrepreneurs, Types of Entrepreneurs, Differences with managers, Growth of entrepreneurship in India, Role of entrepreneurship in economic development, Factors affecting growth of entrepreneurship, Entrepreneurial competencies – Business model canvas		
UNIT – II	**START-UP OF ENTREPRENEURIAL VENTURES**	**(9 Periods)**
Opportunity identification and selection, Establishment of incubation centres, Formulation of business plans, Project appraisal-Methods, Financing of ventures- Sources of finance-Internal and external sources, Forms of ownership, Legal issues of setting of ventures- Patents, Copyrights, trademarks		
UNIT – III	**SUPPORT SYSTEM FOR ENTREPRENEURS**	**(9 Periods)**
Institutional support for entrepreneurs- Commercial banks, Other financial institutions, Taxation benefits- Tax holiday, Investment allowance, Rehabilitation allowance, Amortization of certain preliminary expenses, Important provisions of the Industrial Policy Resolution – Government policies- Introduction to proposal writing.		
UNIT IV	**MANAGEMENT OF THE VENTURES**	**(9 Periods)**
People Management- Leadership, Motivation, Communication, challenges caused by workforce diversity, Working Capital Management- Assessment of working capital, Factors determining working capital requirement, Working capital cycle, Inventory Management- Motives for holding inventories, Methods of inventory management.		
UNIT V	**STRATEGIES FOR GROWTH, SUCCESSION PLANNING, ENDING THE VENTURE**	**(9 Periods)**
Growth strategies- Penetration of market, Product development, Market development, Diversification, External sources for growth- Joint ventures, Acquisitions, Mergers and Franchising, Succession planning- Transfer to family members, Selling the business, bankruptcy laws in India.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Khanka,S.S., "**Entrepreneurial Development**" S.Chand & Company Private Limited, New Delhi, 2015*
2	*Hisrich, Manimala, Peters, Shepherd, "**Entrepreneurship**" McGraw Hill Education Private Limited, New Delhi, 2014*

REFERENCES:

1	*Bruee R Barringer and Duane Ireland, "**Entrepreneurship – Successfully Launching New Ventures**", Pearson – Prentice Hall, 2006.*
2	*Marc J Dollinger, "**Entrepreneurship – Strategies and Resources**", Pearson Education, 2003.*
3	*Mary Coulter, "**Entrepreneurship in Action**", Prentice Hall of India, 2006.*
4	*Robert D Hisrich, Michael P Peters and Dean Shepherd, "**Entrepreneurship**", Tata McGraw Hill, 2007.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Provide an accurate self-analysis for an entrepreneurial career.	K2
CO2	Find an attractive market and decide on the most suitable source of finance for the same.	K3
CO3	Design and develop an entrepreneurial venture that would enjoy the maximum support from financial institutions and the Government.	K3
CO4	Successfully meet the challenges of motivating and communicating with a diverse workforce.	K3
CO5	Find alternative strategies to save a venture that is unable to sustain on its own.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1												3	3		2
CO2					2						2		1		
CO3								1	1			1			1
CO4								2	2	3					3
CO5				1				2					3		1
22MPE$40				1	1			1	1	1	1	1	1		1
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.2, 2.2.3, 2.4.3, 3.1.1, 3.1.4, 3.2.1, 3.3.1, 3.3.2, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.2, 5.2.2, 5.3.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.1.2, 9.2.1, 9.2.3, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.3.2.
CO2	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 9.2.2, 9.2.3, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.2, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2.
CO3	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.6, 3.2.1, 3.2.3, 3.3.1, 3.3.2, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 9.2.3, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.3.1, 12.3.2.
CO4	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.1.1, 9.1.2, 9.2.1, 9.2.2, 9.2.3, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.2, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.2
CO5	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.3, 3.3.1, 3.3.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 9.2.2, 9.2.3, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.2, 11.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.1, 12.3.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	50	20	-			100
CAT2	30	50	20	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	40	40	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	40	40	-	-	-	100
ESE	40	40	20	-	-	-	100

22COE$01	DISASTER MANAGEMENT AND MITIGATION *(Common to All Branches)*					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**OE**	**3**	**0**	**0**	**3**
Course Objective	To impart knowledge to create appropriate planning, preparation and response for emergency treatment in disaster situation					
UNIT – I	**INTRODUCTION TO DISASTERS**					**9 Periods**
Definition: Disaster, Hazard, Vulnerability, Resilience, Risks – Disasters: Classification, Causes, Impacts - Global Trends in Disasters: Urban Disasters, Pandemics, Complex Emergencies, Climate Change- Dos and Don'ts during various types of Disasters.						
UNIT – II	**HAZARDS AND RISK VULNERABILITY**					**9 Periods**
Hazard Identification and Hazard Profiling - Hazard Analysis - Types of hazards - Natural and technological Components of Risk- likelihood and Consequence, Trends and Computation of likelihood and Consequence. Risk Evaluation – Purpose, Risk Acceptability, Alternatives, Personnel. Political/ Social, Economic. Vulnerability-Physical Profile, Social Profile, Environmental Profile, Economic Profile - Factors Influencing Vulnerability, Risk Perception.						
UNIT – III	**MITIGATION AND PREPAREDNESS**					**9 Periods**
Mitigation - Types, Obstacles, Assessment and Selection of Mitigation options, Emergency Response capacity, Incorporating Mitigation into Development and Relief Projects. Preparedness- Government Preparedness, Public Preparedness, Media as a Public educator. Obstacles to public education and preparedness.						
UNIT – IV	**RESPONSE AND RECOVERY**					**9 Periods**
Response the Emergency- Pre disaster, post disaster, Provision of Water, Food and Shelter, Volunteer Management, Command, Control and Coordination. Recovery- Short Term and Long-term Recovery- Components of Recovery- Planning, Coordination, Information, Money and Supplies, Allocation of Relief Funds, Personnel. Types of Recovery- Government, Infrastructure, Debris Removal Disposal and Processing, Environment, Housing, Economic and Livelihood, Individual, Family and Social Recovery- Special Considerations in Recovery.						
UNIT – V	**DISASTER MANAGEMENT: APPLICATIONS AND CASE STUDIES**					**9 Periods**
Concept of Environmental Health and Safety Management – Elements of Environmental Health and Safety Management Policy and implementation and review – ISO 45001-Strucure and Clauses-Case Studies.						
Contact Periods: **Lecture: 45 Periods Tutorial: 00 Periods Practical: 00 Periods Total: 45 Periods**						

TEXT BOOKS :

1	*Singhal J.P.* ***"Disaster Management",*** *Laxmi Publications, 2010.*
2	*Tushar Bhattacharya,* ***"Disaster Science and Management",*** *McGraw Hill India Education Pvt. Ltd., 2012.*

REFERENCES:

1	*Govt. of India: Disaster Management Act , Government of India, New Delhi, 2005.*
2	*Government of India, National Disaster Management Policy,2009.*
3	*Gupta Anil K, Sreeja S. Nair.* ***"Environmental Knowledge for Disaster Risk Management"****, NIDM, New Delhi, 2011*
4	*Kapur Anu Vulnerable India:* ***A Geographical Study of Disasters****, IIAS and Sage Publishers, New Delhi, 2010*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Identify the types of disasters, causes and their impact on environment and society	K2
CO2	Assess vulnerability and various methods of risk reduction measures as well as mitigation.	K2
CO3	Comprehend the mitigation and preparedness process.	K2
CO4	Describe about response and recovery process during disaster.	K2
CO5	Perform disaster damage assessment and management.	K2

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	1		1		2	3	3	2	2	2		3	2		2
CO2	1		1		2	3	3	2	2	2		3	2		2
CO3	1		1		2	3	3	2	2	2		3	2		2
CO4	1		1		2	3	3	2	2	2		3	2		2
CO5	1		1		2	3	3	2	2	2		3	2		2
22COE$01	1		1		2	3	3	2	2	2		3	2		2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 3.1.5, 5.1.1, 5.2.1, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 8.1.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 10.1.1, 10.1.2, 10.1.3
CO2	1.2.1, 3.1.5, 5.1.1, 5.2.1, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, **7.2.2,** 8.1.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 10.1.1, 10.1.2, 10.1.3
CO3	1.2.1, 3.1.5, 5.1.1, 5.2.1, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 10.1.1, 10.1.2, 10.1.3
CO4	1.2.1, 3.1.5, 5.1.1, 5.2.1, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 10.1.1, 10.1.2, 10.1.3
CO5	1.2.1, 3.3.6, 5.1.1, 5.2.1, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 10.1.1, 10.1.2, 10.1.3

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	40	40	20	-	-	-	100
CAT2	40	40	20	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	-	25	50	25	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	-	25	50	25	-	-	100
ESE	30	30	40	-	-	-	100

22COE$02	**WATER SANITATION AND HEALTH** *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objective	To understand the overview of Environment, Health and Safety (EHS) in industries and related Indian regulations, types of Health hazards, effect, assessment and control methods and EHS Management System	
UNIT – I	**INTRODUCTION**	**9 Periods**
Need for developing Environment, Health and Safety systems in work places- International initiatives, National Policy and Legislations on EHS in India - Regulations and Codes of Practice - Role of Trade Union Safety Representatives – Ergonomics.		
UNIT – II	**OCCUPATIONAL HEALTH AND HYGIENE**	**9 Periods**
Definition of occupational health and hygiene - Categories of health hazards – Exposure pathways and human responses–Exposure Assessment-occupational exposure limits - Hierarchy of control measures - Role of personal protective equipment and the selection criteria.		
UNIT – III	**WORKPLACE SAFETY AND SAFETY SYSTEMS**	**9 Periods**
Features of Satisfactory and Safe design of work premises – good housekeeping - lighting and color, Ventilation and Heat Control, Noise, Chemical and Radiation Safety – Electrical Safety – Fire Safety – Safety at Construction sites, ETP – Machine guarding – Process Safety, Working at different levels.		
UNIT – IV	**HAZARDS AND RISK MANAGEMENT**	**9 Periods**
Safety appraisal – Job Safety Analysis-Control techniques – plant safety inspection – Accident investigation - Analysis and Reporting – Hazard and Risk Management Techniques –Onsite and Offsite emergency Plans. Employee Participation- Education and Training- Case Studies.		
UNIT – V	**ENVIRONMENTAL HEALTH AND SAFETY MANAGEMENT**	**9 Periods**
Concept of Environmental Health and Safety Management – Elements of Environmental Health and Safety Management Policy and implementation and review – ISO 45001-Strucure and Clauses-Case Studies.		
Contact Periods: **Lecture: 45 Periods Tutorial: 00 Periods Practical: 00 Periods Total: 45 Periods**		

TEXT BOOKS:

1	***Industrial Health and Safety Acts and Amendments****, by Ministry of Labour and Employment, Government of India.*
2	*Dr.K.U.Mistry, Siddharth Prakashan, **"Fundamentals of Industrial Safety and Health"**, 2012*

REFERENCES:

1	*Bill Taylor, **"Effective Environmental, Health, and Safety Management Using the Team Approach",** Culinary and Hospitality Industry Publications Services, 2005.*
2	*Nicholas P.Cheremisinoff and Madelyn L. Graffia, **"Environmental and Health and Safety Management"**, William Andrew Inc. NY, 1995.*
3	*Brian Gallant, **"The Facility Manager's Guide to Environmental Health and Safety"** , Government Inst Publ., 2007.*
4	*https://archive.nptel.ac.in/courses/114/106/114106017/*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Outline the needs for EHS in industries and related Indian regulations	K2
CO2	Assess the various types of Health hazards, effect, assessment and control methods	K2
CO3	Identity the various safety systems in working environments	K2
CO4	Select the methodology for preparation of Emergency Plans and Accident investigation	K3
CO5	Describe the EHS Management System and its elements	K2

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	2		1		3	3	3	2	1		2		1	1	
CO2	2		1		3	3	3	2	1		2		1	1	
CO3	2		1		3	3	3	2	1		2		1	1	
CO4	2		1		3	3	3	2	1		2		1	1	
CO5	2		1		2	3	3	2	1		2		1	1	
22COE$02	2		1		3	3	3	2	1		2		1	1	

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 1.3.1, 3.1.4, 3.1.5, 5.1.1, 5.2.1, 5.2.2, 5.3.1, 6.1.1, 6.2.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.2, 11.1.1, 11.2.1.
CO2	1.2.1, 1.3.1, 3.1.4, 3.1.5, 5.1.1, 5.2.1, 5.2.2, 5.3.1, 6.1.1, 6.2.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.2, 11.1.1, 11.2.1.
CO3	1.2.1, 1.3.1, 3.1.4, 3.1.5, 5.1.1, 5.2.1, 5.2.2, 5.3.1, 6.1.1, 6.2.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.2, 11.1.1, 11.2.1.
CO4	1.2.1, 1.3.1, 3.1.4, 3.1.5, 5.1.1, 5.2.1, 5.2.2, 5.3.1, 6.1.1, 6.2.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.2, 11.1.1, 11.2.1.
CO5	1.2.1, 1.3.1, 3.1.4, 3.1.5, 5.1.1, 5.2.1, 5.2.2, 5.3.1, 6.1.1, 6.2.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.2, 11.1.1, 11.2.1.

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	40	40	20	-	-	-	100
CAT2	40	40	20	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	-	25	50	25	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	-	25	50	25	-	-	100
ESE	30	30	40	-	-	-	100

22MOE$03	NANOTECHNOLOGY AND SURFACE ENGINEERING

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objectives	To educate the production techniques and characterization techniques of nano materials and to familiarize about the surface modification techniques using nano materials.	
UNIT – I	**ELEMENTS OF NANO-SCIENCE AND NANOTECHNOLOGY**	**(9 Periods)**
Engineering scale of nanotechnology, different classes of nano-materials, synthesis of nano-materials, fabrication and characterization of nanostructures, Engineering applications-Cosmetics and Consumer Goods, Nano Sensor, Nano catalysts, Water Treatment and the Environment, Paints, Food and Agriculture Industry.		
UNIT – II	**NANOTECHNOLOGY AND CERAMICS**	**(9 Periods)**
Introduction, Vapor Condensation Methods, Sputtering, Laser Method, Spray Pyrolysis, Thermo Chemical /Flame Decomposition of metal organic Precursors methods		
UNIT – III	**CHARACTERIZATION OF NANOMATERIALS**	**(9 Periods)**
X-Ray Diffraction (XRD), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy, UV / Visible Spectroscopy.		
UNIT – IV	**SURFACE ENGINEERING**	**(9 Periods)**
Introduction to surface engineering, Scope of surface engineering for different engineering materials, Surface Preparation methods such as Chemical, Electrochemical, Mechanical: Sand Blasting, Shot peening, Shot blasting, Hydro-blasting, Vapor Phase Degreasing etc., Coatings: Classification, Properties and applications of Various Coatings.		
UNIT – V	**SURFACE MODIFICATION TECHNIQUES**	**(9 Periods)**
Surface modification by use of directed energy beams, Plasma, Sputtering & Ion Implantation. Surface modification by Friction stir processing. Surface composites.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*G. Cao, **"Nanostructures and Nanomaterials: Synthesis",** Properties and Applications by Imperial College Press, 2nd edition, 2011.*
2	*Keith Austin "**Surface Engineering Hand Book**", London : Kogan Page, 1998*

REFERENCES:

1	*Gregory Timp, "**Nanotechnology",** Springer, 2012*
2	*Dheerendra Kumar Dwivedi, **"Surface Engineering: Enhancing Life of Tribological Components"**, Springer, 2018*
3	*D. Phil Woodruff,**"Modern Techniques of Surface Science**", Cambridge University Press, 2016*
4	*Sulabha K. Kulkarni ,**"Nanotechnology: Principles and Practices**", Springer, 2019*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Choose appropriate nano material and its manufacturing method.	K1
CO2	Select most suitable technique to deposit a layer of nano material on ceramic surface.	K2
CO3	Identify appropriate techniques to characterize nano materials.	K2
CO4	Select surface preparation, coating techniques and predict their combinational effect for engineering applications.	K2
CO5	Adopt different techniques to modify surfaces and make surface composites as per requirement.	K2

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO 1**	**PO 2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	0	1	2	1	1	0	0	0	0	0	0	0	2	2	3
CO2	0	1	2	1	1	0	0	0	0	0	0	0	2	2	3
CO3	0	1	2	1	1	0	0	0	0	0	0	0	2	2	3
CO4	0	2	2	1	1	0	0	0	0	0	1	0	2	3	3
CO5	0	1	2	1	1	0	0	0	0	0	1	0	3	2	3
22MOE$03	0	1	2	1	1	0	0	0	0	0	1	0	2	2	3
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	2.2.2, 2.2.3, 2.2.4, 2.3.1, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 4.1.1, 4.3.4, 5.1.2														
CO2	2.2.2, 2.2.3, 2.2.4, 2.3.1, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 4.1.1, 4.3.4, 5.1.2														
CO3	2.2.2, 2.2.3, 2.2.4, 2.3.1, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 4.1.1, 4.3.4, 5.1.2														
CO4	2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 4.1.1, 4.3.4, 5.1.2, 5.3.1, 11.3.1														
CO5	2.2.2, 2.2.3, 2.2.4, 2.3.1, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 4.1.1, 4.3.4, 5.1.2, 5.3.1, 11.3.1														

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	50	50					100
CAT2	30	70					100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50					100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	70					100
ESE	40	60					100

22MOE$04	INDUSTRIAL SAFETY MANAGEMENT

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objectives	To learn the techniques of industrial safety and management to implement and solve safety problems in engineering.	
UNIT – I	**ENVIRONMENT AND SAFETY PHILOSOPHY**	**(9 Periods)**
Henrichs Axioms Of Industrial Safety - Concepts Of Safety – Ethics of environmental conservation – Environmental Impact Assessment – Environmental economics – Safety philosophy – Planning for safety – Organising for safety – Directing for safety - Role of Occupier and Factory Manager, Factory Safety Committee, Structure and Functions and Working Tenure Details		
UNIT – II	**SAFETY APPRAISAL AND CONTROL TECHNIQUES**	**(9 Periods)**
Plant and equipment safety appraisal techniques – Laws and regulation – Hazards and Risks – Major accident hazard control – Importance of Disaster management		
UNIT – III	**ACCIDENT PREVENTION AND SAFETY MANAGEMENT**	**(9 Periods)**
Incident - Accident - Injury - Dangerous occurrence - Unsafe Act - Unsafe Conditions - Hazards - Error, Oversight - Mistake , Near Miss - Measurement of safety performance - Key elements of Safety Management system (ISO 14001, OHSAS 18001 etc.). ILO Legislations – Convention and Recommendation concerning Safety, Health and Environment – Objectives of Health, Safety and Environment Policy, Responsibility for Implementation of HSE Policy.		
UNIT – IV	**SAFETY MANAGEMENT IN INDUSTRIES**	**(9 Periods)**
Safe Guarding of machines – Manual handling and storage of materials – Mechanical handling of materials – Hand tools and portable power tools – Electrical hazards – Earth , insulation and continuity tests – Industrial lighting – Safety of pressure vessels – Ventilation and heat control – Housekeeping – Special precautions - Safety in Construction Industry – Safety in Engineering Industry – Safety in Chemical Industries – Safety in Textile Industries – Safety in Dock and Port – Transportation Safety – Safety in Fire and explosive industries.		
UNIT – V	**INDUSTRIAL HYGIENE AND POLLUTION CONTROL**	**(9 Periods)**
Industrial Hygiene – Air sampling – Noise and vibration – Industrial physiology - Occupational health – Personal Protective Equipment's – Pollution Control strategies.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Akhil Kumar Das,* ***"Principles of Industrial Safety Management":Understanding the Ws of Safety at Work"*** *PHI Learning , 2021*
2	*Jain R K and Sunil.S.Rao,* ***"Industrial Safety Health and Environment Management System"****, Seventh reprint, Khanna publishers, 2023.*

REFERENCES:

1	*Prathibha Bansal and Anupama Prashar,* ***"Industrial safety and Environment"****, S.K.Kattaria Sons, 2005.*
2	*A.K.Gupta,* ***"Industrial safety and Environment"****, Laxmi Publication Pvt Limited, 2008.*
3	***"Accident Prevention Manual For Industrial Operations****", N.S.C Chicago, 13th Edition 2009.*
4	*Dan Petersen,* ***"Techniques of Safety Management****", Americal Society of Safety Emgineers, 4th edition, 2003.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand Environment and safety philosophy.	K1
CO2	Frame Safety appraisal and control technique to create safety management.	K2
CO3	Follow accident prevention procedure to solve safety problem.	K2
CO4	Implement safety management for Industries.	K3
CO5	Follow Industrial Hygiene and Pollution control	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	0	1	3	0	0	0	0	0	0	0	3	1	2
CO2	3	3	0	1	2	0	0	0	0	0	0	0	3	2	2
CO3	3	3	0	0	3	0	0	0	0	0	0	0	3	1	2
CO4	3	3	0	1	2	0	0	0	0	0	0	0	3	2	2
CO5	3	3	0	0	3	0	0	0	0	0	0	0	3	1	2
22MOE$04	3	3	0	1	3	0	0	0	0	0	0	0	3	1	2
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.3, 2.2.1, 2.2.3, 2.2.4, 2.4.4, 4.3.4, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2														
CO2	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 4.1.4, 5.1.2, 5.2.1, 5.3.1, 5.3.2														
CO3	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2														
CO4	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 4.1.4, 5.1.2, 5.2.1, 5.3.1, 5.3.2														
CO5	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2														

ASSESSMENT PATTERN							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	70	20	10				100
CAT2	50	30	20				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	60	40					100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	50	30	20				100
ESE	50	30	20				100

22EOE$05	RENEWABLE POWER GENERATION SYSTEMS *(Common to All Branches)*				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	OE	3	0	0	3
Course Objectives	To understand energy scenarios, energy sources and their utilization, society's present needs and future energy demands, the principles of renewable energy conversion systems				

UNIT – I	**ENERGY SCENARIO**	**9 Periods**

Principles of renewable energy; energy and sustainable development, fundamentals and social implications. worldwide renewable energy availability, renewable energy availability in India, brief descriptions on solar energy, wind energy, tidal energy, wave energy, ocean thermal energy, biomass energy, geothermal energy, oil shale. Introduction to Internet of energy (IOE).

UNIT – II	**SOLAR ENERGY**	**9 Periods**

Solar Energy: Fundamentals; Solar Radiation; Estimation of solar radiation on horizontal and inclined surfaces; Solar radiation Measurements- Pyrheliometers, Pyrometer, Sunshine Recorder. Solar Thermal systems: Flat plate collector; Solar distillation; Solar pond electric power plant. Solar electric power generation- Principle of Solar cell, Photovoltaic system for electric power generation, advantages, Disadvantages and applications of solar photovoltaic system.

UNIT – III	**WIND AND BIOMASS ENERGY**	**9 Periods**

Wind Energy: Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, Basic components of wind energy conversion system (WECS); Classification of WECS- Horizontal axis- single, double and multi blade system. Vertical axis- Savonius and Darrieus types.

Biomass Energy: Introduction; Photosynthesis Process; Biofuels; Biomass Resources; Biomass conversion technologies -fixed dome; Urban waste to energy conversion; Biomass gasification (Downdraft).

UNIT – IV	**TIDAL AND OCEAN THERMAL ENERGY**	**9 Periods**

Tidal Power: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, advantages and limitations.

Ocean Thermal Energy Conversion: Principle of working, OTEC power stations in the world, problems associated with OTEC.

UNIT – V	**GREEN ENERGY**	**9 Periods**

Introduction, Fuel cells: Classification of fuel cells – H_2; Operating principles, Zero energy Concepts. Benefits of hydrogen energy, hydrogen production technologies (electrolysis method only), hydrogen energy storage, applications of hydrogen energy, problem associated with hydrogen energy.

Contact Periods: (Times New Roman, Size 11, BOLD, Sentence case)

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK (Maximum 2):

1	G D Rai, Non Conventional Energy sources, Khanna Publication, Fourth Edition, 2009
2	Boyle, "Renewable Energy – Power For A Sustainable Future", Oxford, 2012

REFERENCES (Minimum 4 and Maximum 6):

1	S Rao,B.B.Parulekhar, "Energy Technology 3/e: Nonconventional, Renewable and Conventional", Khanna Publishers, 1994
2	G. N. Tiwari,"Solar Energy - Fundamentals, Design, Modelling and Applications", 2002
3	Gilbert M. Masters, "Renewable and Efficient Electric Power Systems" Wiley,2005
4	Shobh Nath Singh, "Non-Convention Energy Resources", Pearson, 2018

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Describe the environmental aspects of renewable energy resources in comparison with various conventional energy systems, their prospects and limitations.	K2
CO2	Summarize the use of solar energy and the various components used in the energy production with respect to applications like - heating, cooling, desalination, electric power generation.	K2
CO3	Apply the conversion principles of wind and tidal energy for the production of electric power generation	K3
CO4	Apply the concept of biomass energy resources and green energy for developing sustainable electric power generation set-up	K3
CO5	Analyze the basic knowledge of ocean thermal energy conversion and hydrogen energy and hence design & evaluate the power generation system	K4

COURSE ARTICULATION MATRIX :

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO2**	**PSO3**
CO1	3	3	3	3	3	3	3	-	-	-	-	3	3	3	2
CO2	3	3	3	3	3	3	3	-	-	-	-	3	3	3	2
CO3	3	3	3	3	3	3	3	-	-	-	-	3	3	3	2
CO4	3	3	3	3	3	3	3	-	-	-	-	3	3	3	2
CO5	3	3	3	3	3	3	3	-	-	-	-	3	3	3	2
22EOE$05	3	3	3	3	3	3	3	-	-	-	-	3	3	3	2
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping

CO1	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.1,2.2.2,2.2.3,2.2.4,2.3.1,2.3.2,2.4.1,2.4.2,2.4.3,2.4.4,3.1.1,3.1.2,3.1.3,3.1.4,3.1.5,3.1.6,3.2.1,3.2.2,3.2.3,3.3.1,3.3.2,3.4.1,3.4.2,4.1.1,4.1.2,4.1.3,4.1.4,4.2.1,4.2.2,4.3.1,4.3.2,4.3.3,4.3.4,5.1.1,5.1.2,5.2.1,5.2.2,5.3.1,5.3.2,6.1.1,6.2.1,7.1.1,7.1.2,7.2.1,7.2.2,12.1.1,12.1.2,12.2.1,12.2.2,12.3.2.
CO2	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.1,2.2.2,2.2.3,2.2.4,2.3.1,2.3.2,2.4.1,2.4.2,2.4.3,2.4.4,3.1.1,3.1.2,3.1.3,3.1.4,3.1.5,3.1.6,3.2.1,3.2.2,3.2.3,3.3.1,3.3.2,3.4.1,3.4.2,4.1.1,4.1.2,4.1.3,4.1.4,4.2.1,4.2.2,4.3.1,4.3.2,4.3.3,4.3.4,5.1.1,5.1.2,5.2.1,5.2.2,5.3.1,5.3.2,6.1.1,6.2.1,7.1.1,7.1.2,7.2.1,7.2.2,12.1.1,12.1.2,12.2.1,12.2.2,12.3.2.
CO3	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.1,2.2.2,2.2.3,2.2.4,2.3.1,2.3.2,2.4.1,2.4.2,2.4.3,2.4.4,3.1.1,3.1.2,3.1.3,3.1.4,3.1.5,3.1.6,3.2.1,3.2.2,3.2.3,3.3.1,3.3.2,3.4.1,3.4.2,4.1.1,4.1.2,4.1.3,4.1.4,4.2.1,4.2.2,4.3.1,4.3.2,4.3.3,4.3.4,5.1.1,5.1.2,5.2.1,5.2.2,5.3.1,5.3.2,6.1.1,6.2.1,7.1.1,7.1.2,7.2.1,7.2.2,12.1.1,12.1.2,12.2.1,12.2.2,12.3.2.
CO4	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.1,2.2.2,2.2.3,2.2.4,2.3.1,2.3.2,2.4.1,2.4.2,2.4.3,2.4.4,3.1.1,3.1.2,3.1.3,3.1.4,3.1.5,3.1.6,3.2.1,3.2.2,3.2.3,3.3.1,3.3.2,3.4.1,3.4.2,4.1.1,4.1.2,4.1.3,4.1.4,4.2.1,4.2.2,4.3.1,4.3.2,4.3.3,4.3.4,5.1.1,5.1.2,5.2.1,5.2.2,5.3.1,5.3.2,6.1.1,6.2.1,7.1.1,7.1.2,7.2.1,7.2.2,12.1.1,12.1.2,12.2.1,12.2.2,12.3.2.
CO5	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.1,2.2.2,2.2.3,2.2.4,2.3.1,2.3.2,2.4.1,2.4.2,2.4.3,2.4.4,3.1.1,3.1.2,3.1.3,3.1.4,3.1.5,3.1.6,3.2.1,3.2.2,3.2.3,3.3.1,3.3.2,3.4.1,3.4.2,4.1.1,4.1.2,4.1.3,4.1.4,4.2.1,4.2.2,4.3.1,4.3.2,4.3.3,4.3.4,5.1.1,5.1.2,5.2.1,5.2.2,5.3.1,5.3.2,6.1.1,6.2.1,7.1.1,7.1.2,7.2.1,7.2.2,12.1.1,12.1.2,12.2.1,12.2.2,12.3.2.

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	20	30	30			100
CAT2	20	20	30	30			100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	20	30	30			100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	20	30	30			100
ESE	20	20	30	30			100

22EOE$06	SMART GRID TECHNOLOGY *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objectives	To provide a comprehensive understanding of Smart Grid Technology, including its components, functions, applications and implications for Energy Management and Distribution.	
UNIT – I	**BASICS OF POWER SYSTEMS**	**9 Periods**
Basics of Power Systems: Load and Generation - Power Flow Analysis- Economic Dispatch and Unit Commitment Problems. Smart Grid: Definition – Applications- Government and Industry- Standardization		
UNIT – II	**SMART GRID COMMUNICATIONS**	**9 Periods**
Two-way Digital Communications Paradigm - Network Architectures - IP-based Systems - Power Line Communications - Advanced Metering Infrastructure		
UNIT – III	**WIDE AREA MEASUREMENT**	**9 Periods**
Sensor Networks - Phasor Measurement Units- Communications Infrastructure- Fault Detection and Self-Healing Systems -Applications and Challenge		
UNIT – IV	**SECURITY AND PRIVACY**	**9 Periods**
Cyber Security Challenges in Smart Grid - Load Altering Attacks- False Data Injection Attacks- Defense Mechanisms - Privacy Challenges- Cyber Security Standards		
UNIT – V	**ECONOMICS AND MARKET OPERATIONS**	**9 Periods**
Introduction, Reasons for restructuring / deregulation of power industry, Understanding the restructuring process - Entities involved. The market place mechanisms-Energy and Reserve Markets- Market Power - Generation Firms- Locational Marginal Prices- Financial Transmission Rights		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK :

1	*Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage "***Smart Grid Technologies and applications"** *John Wiley Publishers Ltd., 2012.*
2	*P. Venkatesh, B.V. Manikandan, S. Charles Raja, A. Srinivasan "***Electrical Power Systems- Analysis, Security and Deregulation"** *PHI Learning Private Limited, New Delhi, 2012.*

REFERENCES

1	*Lars T. Berger, Krzysztof Iniewski "***Smart Grid applications, Communications and Security***" John Wiley Publishers Ltd., 2012***.**
2	*Yang Xiao,* **"Communication and Networking in Smart Grids",** *CRC Press Taylor and Francis Group, 2012.*
3	*Caitlin G. Elsworth,* **"The Smart Grid and Electric Power Transmission"***, Nova Science Publishers Inc, August 2010*
4	*Lars T. Berger, Krzysztof Iniewski "***Smart Grid applications, Communications and Security***" John Wiley Publishers Ltd., 2012***.**

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Recollect the fundamentals of conventional power systems and learn the concept of smart grid	K1
CO2	Interpret the role of communication Technologies in a smart grid	K2
CO3	Apply the state-of-the-art measurement and protection techniques for reliable grid	K3
CO4	Utilize the techniques for ensuring safety and security of the smart grid	K3
CO5	Analyze the economical aspects of the smart grids	K4

COURSE ARTICULATION MATRIX :

a) CO and PO Mapping															
COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	2	2	2	2	2	2	-	-	1	1	-	3	2	1
CO2	3	3	1	2	2	-	-	-	-	2	3	2	3	2	1
CO3	3	3	1	2	2	-	-	-	-	2	3	2	3	3	2
CO4	3	3	1	2	2	3	2	2	1	-	-	3	3	3	2
CO5	3	2	2	2	2	-	2	2	-	1	3	3	3	3	2
22EOE$06	3	3	1	2	2	3	2	2	1	2	3	3	3	3	2
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.2.1,1.3.1,1.4.1,2.3.1,2.3.2,2.4.4,3.1.3,3.1.6,3.2.1,4.1.4,4.2.1,4.3.4,5.1.1,5.3.1,6.1.1,7.1.1,7.2.2, 10.1.1,10.3.1,11.1.1
CO2	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.2,2.1.3,2.2.1,2.2.3,2.3.1,2.3.2,2.4.1,2.4.2,2.4.3,2.4.4,3.1.6,3.2.1 3.2.2,3.2.3,4.1.1,4.1.3,4.1.4,5.1.1,5.2.1,5.3.1,12.1.2,12.2.2,12.3.2,10.1.1,10.2.2,10.3.1,11.1.1,1 1.2.1,11.3.1,11.3.2,12.3.1,12.3.2
CO3	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.2,2.1.3,2.2.1,2.2.3,2.3.1,2.3.2,2.4.1,2.4.2,2.4.3,2.4.4,3.1.6,3.2.1 3.2.2,3.2.3,4.1.1,4.1.3,4.1.4,5.1.1,5.2.1,5.3.1,12.1.2,12.2.2,12.3.2,10.1.1,10.2.2,10.3.1,11.1.1,1 1.2.1,11.3.1,11.3.2,12.3.1,12.3.2
CO4	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.2,2.1.3,2.2.1,2.2.3,2.3.1,2.3.2,2.4.1,2.4.2,2.4.3,2.4.4,3.1.6,3.2.1 3.2.2,3.2.3,4.1.1,4.1.3,4.1.4,5.1.1,5.2.1,5.3.1,8.2.2,9.1.2,7.2.1,7.2.2,6.2.1,6.1.1,5.3.2,5.3.1,5.3.2 12.1.2,12.2.2,12.3.2,
CO5	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.2,2.1.3,2.2.1,2.2.3,2.3.1,2.3.2,2.4.1,2.4.2,2.4.3,2.4.4,3.1.6,3.2.1 3.2.2,3.2.3,4.1.1,4.1.3,4.1.4,5.1.1,5.2.1,5.3.1,12.1.2,12.2.2,12.3.2

ASSESSMENT PATTERN							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	30	40	20			100
CAT2	10	30	40	20			100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1		30	30	20	20		100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2		30	30	20	20		100
ESE	10	30	40	20			100

22LOE$07	**CMOS VLSIDESIGN** *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objective	To introduce various aspects of CMOS logic design in combinational and sequential circuit to design CMOS VLSI system components	
UNIT – I	**CMOSLOGICDESIGN**	**9 Periods**
Inverter- CMOS Logic Gates: Compound Gates – Pass Transistors and Transmission Gates – Tristated – Multiplexers –CMOS Fabrication and Layout: Fabrication Process – Layout Designrule–GateLayouts–StickDiagrams–DesignPartitioning.		
UNIT – II	**MOSTRANSISTORTHEORY**	**9 Periods**
Introduction – Long Channel I-V Characteristics – C-V Characteristics – Non-ideal I-V Effects – DC Transfer Characteristics – CMOS Technologies – Sources of Power Dissipation - DynamicPower–Static Power.		
UNIT – III	**COMBINATIONALCIRCUITDESIGN**	**9 Periods**
CircuitFamilies:StaticCMOS–RatioedCircuits–CascodeVoltageSwitchLogic–Dynamic Circuits–PassTransistorCircuits.Silicon-on-InsulatorCircuitDesign–SubthresholdCirucitDesign.		
UNIT – IV	**SEQUENTIALCIRCUITDESIGN**	**9 Periods**
Sequentialstaticcircuits–Circuitdesignoflatchedandflip-flops–Sequencingdynamiccircuits –Synchronizers–Wavepipelining -VLSIclocking:CMOS clockingstyles-Pipelinedsystems-Clockgenerationanddistribution.		
UNIT – V	**DESIGNOFVLSISYSTEMS**	**9 Periods**
System Specifications – Structural Gate Level Modeling – Switch Level Modeling – BehavioralandRTL Modeling-Addition/subtraction–Comparators–counters––Multiplexers-BinaryDecoders – Comparators – Priority Encoders – Latches - Flip-Flops and Registers – SRAM –DRAM–ROM.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*N. Weste and David Money Harris, "**CMOS VLSI Design**", Fourth Edition, PearsonEducation,2011*
2	*Uyemura, John P, "**Introduction to VLSI Circuits and Systems**", Wiley & Sons, 8th Reprint 2009*

REFERENCES:

1	*JanM.Rabaey,"**DigitalIntegratedCircuits:ADesignPerspective**",PHI,SecondEdition,2012.*
2	*R.JacobBaker,"**CMOS:CircuitDesign,Layout,andSimulation**",Wiley-IEEE,RevisedSecondEdition,2008.*
3	*Pucknell,"**BasicVLSIDesign**",PrenticeHall,2006.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Realize the CMOS logic design	K2
CO2	Explain the basic MOS transistor theory and power dissipation in CMOS logic.	K2
CO3	Develop combinational circuit design of CMOS logic	K3
CO4	Interpret sequential circuit design of CMOS logic	K2
CO5	Model the digital system using Hardware Description Language	K2

COURSE ARTICULATION MATRIX :

a) CO and PO Mapping														
COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	3	2	-	-	2	-	-	-	2	-	3	3	1	3
CO2	3	2	1	-	-	2	-	-	-	2	-	3	2	1	2
CO3	3	3	2	-	-	2	-	-	-	2	-	3	3	1	3
CO4	3	3	2	-	-	2	-	-	-	2	-	3	3	1	3
CO5	3	3	2	-	-	2	-	-	-	2	-	3	3	1	3
22LOE$07	**3**	**3**	**2**	-	-	**2**	-	-	-	**2**	-	**3**	**3**	**1**	**3**
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 3.4.2, 6.1.1, 10.1.1, 10.1.2, 10.1.3, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO2	1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 3.1.4, 3.3.2, 3.4.1, 3.4.2, 6.1.1, 10.1.1, 10.1.2, 10.1.3, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO3	1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 6.1.1, 10.1.1, 10.1.2, 10.1.3, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO4	1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 3.4.2, 6.1.1, 10.1.1, 10.1.2, 10.1.3, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO5	1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 3.4.2, 6.1.1, 10.1.1, 10.1.2, 10.1.3, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	40	20				100
CAT2	40	40	20				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1		50	50				100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2		50	50				100
ESE	40	40	20				100

22LOE$08	MOBILE COMMUNICATION

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objective	To understand and recall the mobile radio propagation, cellular architectures, equalization and diversity techniques, digital modulation techniques and various wireless network standards.	
UNIT – I	**MOBILE RADIO PROPAGATION**	**9 Periods**
Review of free-space propagation - Radio Wave Propagation in wireless environment - Free Space Propagation Model - Ground Reflection Model, Diffraction, Scattering - Practical link budget design - Small scale fading - Time dispersion parameters - Coherence bandwidth - Doppler spread & Coherence time, Fading due to Multipath time delay spread - Fading due to Doppler spread.		
UNIT – II	**CELLULAR CONCEPT**	**9 Periods**
Hexagonal cell-Cell clustering-Frequency Reuse-Static and dynamic channel assignment strategies - Handoff Strategies - Interference and System Capacity - Trunking - Capacity in Cellular Systems. Multiple Access Techniques: FDMA, TDMA, CDMA, OFDMA.		
UNIT – III	**MULTIPATH MITIGATION TECHNIQUES**	**9 Periods**
Equalization – Adaptive equalization: Linear and Non-Linear equalization, - Diversity – Micro and Macro diversity - Diversity combining techniques - Rake receiver- MIMO Coding: Alamouti Scheme (Qualitative)		
UNIT – IV	**MODULATION TECHNIQUES**	**9 Periods**
Modulation in cellular wireless systems: Binary Phase Shift Keying (BPSK) – QPSK –Orthogonal QPSK-Minimum Shift Keying-Gaussian Minimum Shift Keying - Multicarrier modulation: Orthogonal Frequency Division Multiplexing (OFDM) -PAPR reduction –Windowed OFDM - Filtered OFDM		
UNIT – V	**WIRELESS NETWORKS**	**9 Periods**
Second Generation Cellular Standard: GSM - Third Generation Cellular standards: CDMA - WCDMA- Fourth Generation Cellular Standards: 4G LTE – LTE Advanced – 5G Network – Near Field Communication (NFC) systems – Wireless LAN technology – Hyper LAN – Bluetooth technology – Ultra Wideband (UWB) communication - Introduction to 60 GHz mmWave.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Theodore S. Rappaport, "Wireless communications", 2nd Edition, Pearson Education, 2010*
2	*Mischa Schwartz, "Mobile Wireless Communications", 1st Edition, Cambridge University Press, 2010*

REFERENCES:

1	*Suvra Sekhar Das and Ramjee Prasad, "Evolution of air interface towards 5G Radio Access Technology and Performance Analysis", River Publishers,2018*
2	*David Tse, Pramod Viswanath, "Fundamentals of Wireless Communication", 1st Edition, Cambridge University Press, 2006.*
3	*Andreas.F. Molisch, "Wireless Communications", 2nd Edition, Wiley, 2011.*
4	*Aditya K Jagannatham, "Principles of Modern Wireless Communication Systems Theory and Practice", 1st Edition, McGraw Hill Education (India) Private Limited, 2017*
5	*William Stallings, "Wireless Communications and networks", 2nd Edition, Pearson, 2009.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Interpret the concepts of radio propagation and fading channel models in wireless communication	K3
CO2	Interpret the functionalities of various cellular concepts and multiple access techniques and solve problems in channel assignment and traffic intensity in cellular system	K4
CO3	Explain various equalization and diversity combining techniques used in multipath propagation	K2
CO4	Discuss the need for digital and multicarrier modulation techniques used in modern cellular system	K2
CO5	Recall the functionalities of various wireless networks used in day-today life.	K2

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	2	1	1	-	-	-	-	-	-	-	1	3	-	1
CO2	3	2	1	1	-	-	-	-	-	-	-	1	3	-	1
CO3	3	2	1	1	-	-	-	-	-	-	-	1	3	-	1
CO4	3	2	1	1	-	-	-	-	-	-	-	1	3	-	1
CO5	3	2	1	1	-	-	-	-	-	-	-	1	3	-	1
22LOE$08	3	2	1	1	-	-	-	-	-	-	-	1	3	-	1
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.2,2.2.3,2.3.1,2.3.2,2.4.1,2.4.4,3.1.1,3.1.2, 3.3.1,4.1.1,4.2.1,4.3.3, 12.1.1,12.2.2														
CO2	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.2,2.2.3,2.3.1,2.3.2,2.4.1,2.4.4,3.1.1,3.1.2, 3.3.1,4.1.1,4.2.1,4.3.3, 12.1.1,12.2.2														
CO3	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.2,2.2.3,2.3.1,2.3.2,2.4.1,2.4.4,3.1.1,3.1.2, 3.3.1,4.1.1,4.2.1,4.3.3, 12.1.1,12.2.2														
CO4	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.2,2.2.3,2.3.1,2.3.2,2.4.1,2.4.4,3.1.1,3.1.2, 3.3.1,4.1.1,4.2.1,4.3.3,12.1.1,12.2.2														
CO5	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.2,2.2.3,2.3.1,2.3.2,2.4.1,2.4.4,3.1.1,3.1.2, 3.3.1,4.1.1,4.2.1,4.3.3,12.1.1,12.2.2														

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	40	20	20			100
CAT2	50	50					100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	40	20	20			100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	50	50					100
ESE	20	40	20	20			100

22POE$09	**RAPIDPROTOTYPING** *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objectives	To educate the students with fundamental and advanced knowledge in the field of Rapid Prototyping technology and associated Aerospace, Architecture, Art, Medical and Industrial applications.	
UNIT- I	**INTRODUCTION**	**(9 Periods)**
Overview - Need - Development of Rapid Prototyping (RP) Technology: Rapid Prototyping - Rapid Tooling - Rapid Manufacturing - Additive Manufacturing. RP Process Chain, Benefits, Applications: Building Printing, Bio Printing, Food Printing, Electronics Printing, Automobile, Aerospace, Healthcare.		
UNIT- II	**VAT POLYMERIZATION AND MATERIAL EXTRUSION**	**(9 Periods)**
Photo polymerization: Stereo lithography Apparatus (SLA) - Materials -Process - top down and bottom up approach - Advantages - Limitations - Applications. Digital Light Processing (DLP) - Process - Advantages - Applications. Material Extrusion: Fused Deposition Modelling (FDM) - Process-Materials -Applications and Limitations.		
UNIT- III	**POWDER BED FUSION AND BINDER JETTING**	**(9 Periods)**
Powder Bed Fusion: Selective Laser Sintering (SLS): Process - Powder Fusion Mechanism - Materials and Application. Selective Laser Melting (SLM), Electron Beam Melting (EBM): Materials - Process - Advantages and Applications. Binder Jetting: Three-Dimensional Printing - Materials - Process - Benefits - Limitations - Applications.		
UNIT- IV	**MATERIAL JETTING AND DIRECTED ENERGY DEPOSITION**	**(9 Periods)**
Material Jetting: Multi jet Modelling- Materials - Process - Benefits - Applications. Directed Energy Deposition: Laser Engineered Net Shaping (LENS) - Process - Material Delivery - Materials –Benefits -Applications.		
UNIT- V	**SHEET LAMINATION AND DIRECT WRITE TECHNOLOGY**	**(9 Periods)**
Sheet Lamination: Laminated Object Manufacturing (LOM)- Basic Principle- Mechanism: Gluing or Adhesive Bonding - Thermal Bonding - Materials - Application and Limitation. Ink-Based Direct Writing (DW): Nozzle Dispensing Processes, Inkjet Printing Processes, Aerosol DW - Applications of DW.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Ian Gibson, David Rosen, Brent Stucker, Mahyar Khorasani "**Additive manufacturing technologies".** 3rd edition Springer Cham, Switzerland, 2021.*
2	*Andreas Gebhardt and Jan-Steffen Hötter "**Additive Manufacturing: 3D Printing for Prototyping and Manufacturing**", Hanser publications, United States, 2015.*

REFERENCES:

1	*Andreas Gebhardt, **"Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing"**, Hanser Gardner Publication, Cincinnati., Ohio, 2011.*

2	*Milan Brandt, **"Laser Additive Manufacturing: Materials, Design, Technologies, and Applications"**, Woodhead Publishing., United Kingdom, 2016.*
3	*Amit Bandyopadhyay and Susmita Bose, **"Additive Manufacturing",** 1st Edition, CRC Press., United States, 2015.*
4	*Kamrani A.K. and Nasr E.A., **"Rapid Prototyping: Theory and practice",** Springer., United States ,2006.*
5	*Liou, L.W. and Liou, F.W., **"Rapid Prototyping and Engineering applications: A tool box for prototype development"**, CRC Press., United States, 2011.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Discuss the development of RP technology and how RP technology propagated into various businesses and developing opportunities.	K3
CO2	Demonstrate the Vat polymerization and material extrusion processes and its applications.	K3
CO3	Elaborate the process and applications of powder bed fusion and binder jetting.	K3
CO4	Evaluate the advantages, limitations, applications of material jetting and directed energy deposition processes.	K3
CO5	Describe the sheet lamination and direct write technology.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO 2	PSO 3
CO1	2	2	2	0	2	0	3	0	3	3	3	3	0	0	0
CO2	2	2	3	2	3	0	3	0	3	3	1	2	0	0	0
CO3	2	2	3	2	3	0	3	0	3	3	1	2	0	0	0
CO4	2	2	3	2	3	0	3	0	3	3	1	2	0	0	0
CO5	2	2	3	2	3	3	3	0	3	3	1	3	0	0	0
22POE$09	**2**	**2**	**3**	**2**	**3**	**1**	**3**	**0**	**3**	**3**	**2**	**3**	**0**	**0**	**0**

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.3, 5.2.2, 5.3.1, 5.3.2, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.1, 11.1.2, 11.2.1, 11.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.2, 12.3.1, 12.3.2.
CO2	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.2.1, 4.3.1, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.2, 12.2.2, 12.3.1, 12.3.2.
CO3	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.2.1, 4.3.1, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.2, 12.2.2, 12.3.1, 12.3.2.
CO4	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.2.1, 4.3.1, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.2, 12.2.2, 12.3.1, 12.3.2.
CO5	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.2.1, 4.3.1, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.1, 12.1.2, 12.2.2, 12.3.1, 12.3.2.

ASSESSMENT PATTERN– THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	15	52	33	-	-	-	100
CAT2	15	68	17	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	-	-	100	-	-	-	100
ESE	9	75	16	-	-	-	100

22POE$10	MANAGERIAL ECONOMICS *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objectives	*To introduce the fundamental economic principles necessary for production managers	
UNIT- I	**FUNDAMENTALS OF MANAGERIAL ECONOMICS**	**(9 Periods)**
Introduction to Economics - Scope of Managerial Economics - General Foundations of Managerial Economics: Economic Approach, Working of Economic System and Circular Flow of Activities - Economics and Business Decisions: Relationship between Economic Theory and Managerial Economics - Role of managerial Economics in Decision making - Concept of Economic Rationality - Opportunity Cost - Marginal and Incremental approach.		
UNIT- II	**DEMAND ANALYSIS**	**(9 Periods)**
Demand and Supply - Determinants of Demand - Demand Estimation and Forecasting - Price Elasticity of Demand - Price Elasticity- Factors Affecting Price Elasticity - Cross Price Elasticity - Income Elasticity of Demand - Advertisement or Promotional Elasticity - Elasticity of Supply.		
UNIT- III	**DEMAND THEORY**	**(9 Periods)**
Utility Analysis - Total and Marginal Utility - Law of Diminishing marginal utility - Indifference curve analysis - Consumer Equilibrium - Consumer Surplus - Price effect, Substitution Effect and Income Effect.		
UNIT- IV	**THEORY OF PRODUCTION AND COST**	**(9 Periods)**
The Production Function - Profit-Maximizing Input Usage - Isoquants and Isocosts – CostMinimization and Optimal Input Substitution - The Cost Function - Breakeven analysis,Contribution analysis - Long-run Costs and Economies of Scale - Multiple Cost Functions andEconomies of Scope - Learning curve.		
UNIT- V	**THEORY OF MARKET AND PRICING**	**(9 Periods)**
Forms of Markets: Meaning and Characteristics - Market Equilibrium: Practical Importance, Market Equilibrium and Changes in Market Equilibrium. Pricing Functions: Market Structures - Pricing and output decisions under different competitive conditions: Monopoly Monopolistic completion and Oligopoly.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Maheshwari.Y* ***"Managerial Economics",*** *Prentice Hall of India, 2012*
2	*Thomas and Maurice* ***"Managerial Economics: Concept and Applications",*** *McGrawHill, 2005*

REFERENCES:

1	*D.N. Dwivedi,* ***"Managerial Economics",*** *Vikas Publishing house, 2015*
2	*Christopher R Thomas, S Charles Maurice,* ***"Managerial economics",*** *Mcgraw Hill, 2014*
3	*M. A. Beg, "****Managerial Economics****",Global Professional Publishing Ltd, 2010*
4	*K.C. Sankaranarayanan, "****Managerial Economics****", CBS, 2015*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain fundamentals of managerial economics	K2
CO2	Discuss the dynamics of Demand	K3
CO3	Explain about various theories of demand	K3

CO4	Discuss about the factors influencing production	K4
CO5	Describe about the theory of market and pricing method	K4

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO 2	PSO 3
CO1	1	2	1	3	1	3	3	0	1	3	3	3	0	1	2
CO2	1	3	2	3	1	3	3	0	1	3	3	3	0	1	2
CO3	1	3	2	3	1	3	3	0	1	3	3	3	0	1	2
CO4	1	3	2	3	1	3	3	0	1	3	3	3	1	1	2
CO5	1	3	2	3	1	3	3	0	1	3	3	3	0	1	2
22POE$10	**1**	**3**	**2**	**3**	**1**	**3**	**3**	**0**	**1**	**3**	**3**	**3**	**0**	**1**	**2**

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 2.1.2, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.4.4, 3.1.1, 3.1.3, 3.1.5, 3.2.3, 3.3.1, 3.4.1, 4.1.1, 4.1.2, 4.3.4, 5.2.1, 5.3.1, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.1, 11.2.1, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO2	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.3, 3.3.2, 3.4.1, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.3.1, 4.3.4, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.3.1, 10.1.1, 10.1.2, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.1, 11.2.1, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO3	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.3, 3.3.2, 3.4.1, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.3.1, 4.3.4, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.3.1, 10.1.1, 10.1.2, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.1, 11.2.1, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO4	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.3, 3.3.2, 3.4.1, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.3.1, 4.3.4, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.3.1, 10.1.1, 10.1.2, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.1, 11.2.1, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO5	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.3, 3.3.2, 3.4.1, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.3.1, 4.3.4, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.3.1, 10.1.1, 10.1.2, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.1, 11.2.1, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2

ASSESSMENT PATTERN– THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	50	50		-	-	-	100
CAT2	50	50		-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	33.33	33.33	33.33	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	33.33	33.33	33.33	-	-	-	100
ESE	42	42	16	-	-	-	100

22NOE$11	MEASUREMENT AND CONTROL *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

COURSE OBJECTIVE	To teach about the concepts of variable sensors for industrial parameter measurement and to impart knowledge on automatic control system	
UNIT - I	**INTRODUCTION TO MEASUREMENTS**	**9 Periods**
Elements of measurement system - Classification of Instruments – Static and dynamic characteristics of a measurement system - Errors in measurement - Calibration of instruments.		
UNIT - II	**STRAIN AND DISPLACEMENT MEASUREMENT**	**9 Periods**
Strain: Types of strain gauges, theory of operation, strain gauge materials, strain gauge circuits and applications. Displacement: Resistive potentiometer: Linear, circular and helical – LVDT - RVDT - Capacitance transducers – Piezoelectric transducers – Hall Effect devices - Proximity sensors.		
UNIT - III	**PRESSURE AND TEMPERATURE MEASUREMENT**	**9 Periods**
Pressure: Mechanical devices: Diaphragm, bellows, and bourdon tube - Electrical devices: Variable resistance, inductance and capacitance transducers. Temperature: Resistance type temperature sensors: RTD , Thermocouples, Thermopiles and Thermistor - Laws of thermocouple – Radiation methods for temperature measurement.		
UNIT - IV	**FLOW AND LEVEL MEASUREMENT**	**9 Periods**
Flow: Variable head type flow meters: Orifice plate, Venturi tube, Flow nozzle, Pitot tube - Variable area type: Rotameter - Turbine flow meter - Electromagnetic flow meter - Ultrasonic flow meter. Level: Resistive, inductive and capacitive techniques – Ultrasonic methods – Air purge system .		
UNIT - V	**AUTOMATIC CONTROL SYSTEM**	**9 Periods**
Elements of control system – Concept of open loop and closed loop systems – Mathematical modelling - Controllers – Brief idea of Proportional, Derivative and Integral Modes – Pneumatic Controller – Hydraulic Controller.		
Contact Periods: 45 Periods **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*A.K. Sawhney, Puneet Sawhney, **"A Course in Mechanical Measurements and Instrumentation & Control"** Dhanpat Rai & Co, 2012.*
2	*S. K. Singh, "**Industrial Instrumentation and Control**", McGraw Hill Publication, 3rd Edition, 2016.*

REFERENCES:

1	*William Bolton, "**Instrumentation and Control Systems**," Newnes, Publication, 3rd Edition, 2021.*
2	*E. D. Doeblin, **"Measurement Systems: Application and Design",** McGraw Hill Publication, 6th Edition, 2017.*
3	*E.W. Golding and F.C. Widdis, **"Electrical Measurements and Measuring Instruments"** A.H.Wheeler and Co., 5th Edition, 2011.*
4	*Alan S. Morris, **"Measurement and Instrumentation Principles",** Butterworth-Heinemann Publications, 3rd Edition, 2011.*

COURSE OUTCOMES Upon Completion of the course, the students will be able to		**Bloom's Taxonomy Mapped**
CO1	Describe the methods of measurement and classification of measuring	K2

	instruments.	
CO2	Suggest suitable sensor for the measurement of strain and displacement.	K2
CO3	Explain the construction and working of transducers for pressure and temperature measurement.	K2
CO4	Elucidate the characteristics of flow and level measuring instruments.	K2
CO5	Elaborate the concept of automatic control system.	K2

COURSE ARTICULATION MATRIX

a) CO/PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	-	-	-	-	-	-	-	-	-	3	2
CO2	3	2	2	2	-	-	-	-	-	-	-	-	-	3	2
CO3	3	2	2	2	-	-	-	-	-	-	-	-	-	3	2
CO4	3	2	2	2	-	-	-	-	-	-	-	-	-	3	2
CO5	3	3	3	2	-	-	-	-	-	-	-	-	-	3	3
22NOE$11	**3**	**3**	**3**	**2**	-	-	-	-	-	-	-	-	-	**3**	**2**

b) CO and Key Performance Indicators mapping

CO1	1.1.1, 1.1.2, 1.2.1,1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 3.2.1, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.2, 4.1.3, 4.1.4
CO2	1.1.1, 1.1.2, 1.2.1,1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.2,2.2.3, 2.3.1, 2.3.2, 3.1.6, 3.3.2, 3.4.1, 3.4.2, 4.1.2, 4.1.3, 4.1.4
CO3	1.1.1, 1.1.2, 1.2.1,1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 3.4.2, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2
CO4	1.1.1, 1.1.2, 1.2.1,1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.2,2.2.3, 2.2.4, 2.3.1, 2.3.2, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 3.4.2, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2
CO5	1.1.1, 1.1.2, 1.2.1,1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 3.1.5, 3.1.6, 3.2.1, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2

ASSESSMENT PATTERN - THEORY

Test/Bloom's Category	Remembering (K1)%	Understanding (K2) %	Applying (K3)%	Analyzing(K4)%	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	40	60					100
CAT2	40	60					100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	30	70					100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	70					100
ESE	40	60					100

22NOE$12	INDUSTRIAL AUTOMATION *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

COURSE OBJECTIVE	To elaborate on the basic concept of automation, including the necessary components and various automation controllers utilized in industrial automation.	
UNIT - I	**INTRODUCTION TO AUTOMATION**	**9 Periods**
Automation overview – Requirement of automation systems – Architecture of industrial automation system –Industrial bus systems: Modbus and Profibus.Introduction to Industry 4.0 and its evolution.		
UNIT - II	**AUTOMATION COMPONENTS**	**9 Periods**
Sensors for temperature – Pressure – Force – Displacement - Speed – Flow- level – Humidity and pH measurement. Actuators – Process control valves –Power electronic drives: DIAC- TRIAC –power MOSFET – IGBT. Introduction to DC and AC servo drives for motion control.		
UNIT - III	**PROGRAMMABLE LOGIC CONTROLLERS**	**9 Periods**
PLC Hardware – power supplies and isolators –Relays – Switches -Seal-in circuits – PLC programming – ladder diagram – sequential flow chart – PLC communication and networking – PLC selection – PLC installation – Advantages – Application of PLC to process control industries and Robotics.		
UNIT - IV	**DISTRIBUTED CONTROL SYSTEM**	**9 Periods**
Overview of DCS – DCS hardware – DCS software configuration – DCS communication – DCS supervisory computer tasks – DCS integration with PLC and Computers.		
UNIT - V	**SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEMS**	**9 Periods**
Introduction - Supervisory Control and Data Acquisition Systems – SCADA HMI Essentials – SCADA Components – SCADA Configuration and Software – HMI hardware and software.		
Contact Periods: 45 Periods **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Frank D. Petruzella, "**Programmable Logic Controllers**", 5th Edition, McGraw Hill, 2016.*
2	*S.K. Singh "**Industrial Instrumentation and Control**", 3rd Edition, McGraw Hill Companies, 2004.*

REFERENCES:

1	*Sudip Misra, Chandana Roy, Anandarup Mukherjee, **"Introduction to Industrial Internet of Things and Industry 4.0**", CRC Press, 1st edition, 2021*
2	*Bela G Liptak, "**Process software and digital networks – Volume 3**", 4th Edition, CRC press, 2012.*
3	*Romily Bowden, "**HART application guide and the OSI communication foundation**",1999.*
4	*John.W. Webb Ronald A Reis, "**Programmable Logic Controllers - Principles and Applications**", Prentice Hall Inc., 5th Edition, 2003.*
5	*M. P. Lukcas, "**Distributed Control Systems"**, Van Nostrand Reinhold Co., 1986.*

COURSE OUTCOMES Upon Completion of the course, the students will be able to		**Bloom's Taxonomy Mapped**
CO1	Elaborate the basic architecture of automation systems and Industry 4.0.	K2
CO2	Describe the various automation components and industrial bus system involved in industrial automation	K2
CO3	Construct ladder logic diagram using PLC basic functions, timer and counter functions for simple applications	K3
CO4	Illustrate the functionary components and supervisory control of DCS with relevant diagrams	K2

CO5	Describe the basics of SCADA technology.	K2

COURSE ARTICULATION MATRIX

a) CO/PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-	-	-	-	-	-	-	1	3	3
CO2	3	2	1	-	-	-	-	-	-	-	-	-	1	3	3
CO3	3	3	2	2	-	-	-	-	1	-	-	2	1	3	3
CO4	3	2	2	-	-	-	-	-	-	-	-	-	1	3	3
CO5	3	2	`1	-	-	-	-	-	-	-	-	-	1	3	3
22NOE$12	3	3	2	1	-	-	-	-	1	-	-	1	1	3	3

b) CO and Key Performance Indicators mapping

CO1	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.3.1, 2.4.3,3.1.1, 3.1.2, 3.1.3, 3.3.1,3.3.2.
CO2	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.3.1, 2.4.3,3.1.1, 3.1.2, 3.1.3, 3.3.1,3.3.2.
CO3	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.3.1, 2.4.3,3.1.1, 3.1.2, 3.1.3, 3.3.1,3.3.2, 4.1.1, 4.1.2, 4.2.1, 4.2.2, 9.1.1, 9.1.2, 10.1.1, 10.1.2, 10.1.3, 12.1.1, 12.1.2.
CO4	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.3.1, 2.4.3,3.1.1, 3.1.2, 3.1.3, 3.3.1,3.3.2.
CO5	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.3.1, 2.4.3,3.1.1, 3.1.2, 3.1.3, 3.3.1,3.3.2.

ASSESSMENT PATTERN - THEORY

Test/Bloom's Category	Remembering (K1)%	Understanding (K2) %	Applying (K3)%	Analyzing(K4)%	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	20	60	20				100
CAT2	20	60	20				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	60	20				100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	60	20				100
ESE	20	60	20				100

22SOE$13	**PROGRAMMING IN JAVA** *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objectives	The objective of this course is to provide students with the essential Java constructs necessary for developing an object-oriented program.	
UNIT – I	**FUNDAMENTALS OF JAVA PROGRAMMING**	**9 Periods**
History and Evolution of Java- Overview of java– Operators- Control Structures– Methods- Classes and Objects– Inheritance- Packages and Interfaces- Exception Handling.		
UNIT – II	**THREADS , I/O AND STRING HANDLING**	**9 Periods**
Multi threaded Programming– Enumeration- Auto boxing– Annotations- String Handling-Input/Output: Exploring java.io		
UNIT – III	**EVENT HANDLING**	**9 Periods**
Introducing the AWT: working with windows- graphics and text- Using AWT controls- Layout Manager - Menus - Introducing Swing		
UNIT – IV	**IMAGING AND DATABASE CONNECTIVITY**	**9 Periods**
Imaging: Creating- loading and displaying- Image observer- Double buffering- Media tracker- Image producer– consumer– filters– animation- Java Database Connectivity		
UNIT – V	**NETWORKING**	**9 Periods**
Networking – Remote Method Invocation – Java Beans –Java servlets		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS

1	*Herbert Schildt, "Java,* ***The Complete Reference*** *", Tata McGrawHill, 12th Edition, 2022*

REFERENCES

1	*Deitel .H.M and Deitel.P.J, "* ***Java: How to Program*** *", Pearson Education Asia, 9th Edition 2011*
2	*Lay.S&Horstmann Gary Cornell, "* ***Core Java Vol I*** *", The Sun Microsystems & press Java Series, 9th Edition, 2012*
3	*NPTEL Course : "****PROGRAMMING IN JAVA"*** ***https://archive.nptel.ac.in/courses/106/105/106105191/***

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Write simple java programs using fundamental concepts of java like control structures, inheritance, packages, interfaces and exception handling	K4
CO2	Write java program using multithreading and string handling	K3
CO3	Write java programs for managing events and to access database	K4
CO4	Write java programs to display and manipulation of graphical images	K3
CO5	Develop client server programs using RMI and servlets	K3

COURSE ARTICULATION MATRIX:

COs / POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PS O3
CO1	2	2	2	2	1	0	0	0	0	2	0	0	1	2	2
CO2	2	1	2	2	1	0	0	0	0	2	0	0		2	3
CO3	2	1	2	2	1	0	0	0	0	2	0	0	1	2	3
CO4	2	1	2	2	1	0	0	0	0	2	0	0	1	2	3
CO5	2	1	2	2	1	0	0	0	0	2	0	2	1	2	3
22SOE$13	2	2	2	2	1	0	0	0	0	2	0	1	1	2	3

b) CO and Key Performance Indicators Mapping	
CO1	1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.2.1, 2.2.3, 2.2.4, 2.4.3, 3.1.5, 3.1.6, 3.2.2, 3.3.1, 3.3.2, 4.1.1, 4.1.2, 4.1.3, 4.2.1, 4.3.1, 4.3.2, 5.2.2,10.1.1,10.1.2,10.1.3
CO2	1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.2.1, 2.2.3, 2.2.4, 2.4.3, 3.1.5, 3.1.6, 3.2.2, 3.3.1, 3.3.2, 4.1.1, 4.1.2, 4.1.3, 4.2.1, 4.3.1, 4.3.2, 5.2.2,10.1.1,10.1.2,10.1.3
CO3	1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.2.1, 2.2.3, 2.2.4, 2.4.3, 3.1.5, 3.1.6, 3.2.2, 3.3.1, 3.3.2, 4.1.1, 4.1.2, 4.1.3, 4.2.1, 4.3.1, 4.3.2, 5.2.2,10.1.1,10.1.2,10.1.3
CO4	1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.2.1, 2.2.3, 2.2.4, 2.4.3, 3.1.5, 3.1.6, 3.2.2, 3.3.1, 3.3.2, 4.1.1, 4.1.2, 4.1.3, 4.2.1, 4.3.1, 4.3.2, 5.2.2,10.1.1,10.1.2,10.1.3
CO5	1.3.1, 1.4.1, 2.1.1,2.1.2,2.4.3, 3.1.5, 3.1.6, 3.2.2, 3.3.2, 4.1.1, 4.1.2, 4.2.1, 4.3.1,4.3.2,5.1.1,5.2.2, 10.1.1,10.1.2,10.1.3,12.1.1,12.2.1,12.2.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1		30	40	30			100
CAT2	10	30	40	20			100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1			70	30			100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2			50	50			100
ESE		30	40	30			100

22SOE$14	NETWORK ESSENTIALS *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objectives	The objective of the course is to understand the basics of networking and able to configure and troubleshoot switches and routers.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Introduction to Computer Networks - Goals and advantages of Computer Networks - Network Topologies – Basic networking devices – Protocols – the need for a layered architecture - The OSI Model and the TCP/IP reference model – the Ethernet LAN – Home Networking – Assembling an office LAN – Testing and Troubleshooting a LAN – Physical layer cabling: Twisted pair and Fiber optics		
UNIT – II	**WIRELESS NETWORKING**	**9 Periods**
Importance of Wireless Networking – IEEE 802.11 Wireless LANs – Bluetooth- WIMAX – RFIDs – Securing the Wireless LANs – Configuring a Point to Multipoint Wireless LAN – Interconnecting network LANs – Switch, Bridges and Routers. Interconnecting LANs with the router, Configuring the network interface-Auto negotiation		
UNIT – III	**ADDRESSING AND ROUTING FUNDAMENTALS**	**9 Periods**
IPv4 and IPv6 addressing – Subnet masks – CIDR blocks – configuration of a router – Console port connection - user EXEC mode – Privileged EXEC mode - Configuration of a switch – Static VLAN configuration - Spanning Tree protocol – Network Management – Power over Ethernet		
UNIT – IV	**ROUTING PROTOCOLS**	**9 Periods**
Static Vs Dynamic Routing Protocols – Distance vector Routing – Link State Routing – Hybrid Routing – Configuring RIP - Network Services – DHCP, DNS - Analyzing Internet Traffic.		
UNIT – V	**TROUBLESHOOTING AND NETWORK SECURITY**	**9 Periods**
Analyzing Computer Networks – FTP data packets – Analyzing Campus Network data traffic – Troubleshooting the router and switch interface, Troubleshooting fiber optics – Intrusion – DOS – Security software and hardware.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK :

1	*Jeffrey S.Beasley Piyasat Nilkaew "**Network Essentials**" 3 rd Edition, Pearson, 2018*
2	*Larry L. Peterson and Bruce S. Davie "**Computer Networks, A Systems Approach**" 5 th edition, Morgan Kaufmann Publishers Inc, 2014.*

REFERENCES :

1	*Behrouz A. Forouzan, "**Data Communications and Networking with TCP/IP Protocol Suite**", Sixth Edition TMH, 2022.*
2	*James F. Kurose, Keith W. Ross, "**Computer Networking, A Top-Down Approach Featuring the Internet**", Eighth Edition, Pearson Education, 2021.*
3	*Ying-Dar Lin, Ren-Hung Hwang, Fred Baker, "**Computer Networks: An Open Source Approach**", McGraw Hill, 2012.*
4	*Nader F. Mir, "**Computer and Communication Networks",** Second Edition, Prentice Hall, 2014.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify topologies and types of Computer Networks and enumerate the layers of the OSI model and TCP/IP	K2
CO2	Explain the significance of wireless networks and configure a Wireless LAN	K3
CO3	Configure a switcher and a router	K3

CO4	Describe basic routing algorithms and network services	K3
CO5	Troubleshoot the router and switch interface	K3

a) CO and PO Mapping														
COs / POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO1	2	3				1							1	2	
CO2	2	3				1							1	2	
CO3	2	3		2	2	1							1	2	
CO4	2	3		2	2	1							1	2	
CO5	2	3		2	2	1							1	2	
22SOE$14	2	3		2	2	1							1	2	
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.3.1, 1.4.1, 2.1.2, 2.2.2, 2.4.4, , 4.1.2, 5.1.1, 5.1.2,5.2.1, 5.2.2, 5.3.2, 6.1.1, 6.1.2														
CO2	1.3.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3,2.2.4, 4.1.2, 5.1.1, 5.1.2,5.2.1, 5.2.2, 5.3.2, 6.1.1, 6.1.2														
CO3	1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3,2.2.4, 4.1.1, 4.1.2, 5.1.1, 5.1.2,5.2.1, 5.2.2, 5.3.2, 6.1.1, 6.1.2														
CO4	1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3,2.2.4, 4.1.1, 4.1.2, 5.1.1, 5.1.2,5.2.1, 5.2.2, 5.3.2, 6.1.1, 6.1.2														
CO5	1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3,2.2.4, 4.1.1, 4.1.2, 5.1.1, 5.1.2,5.2.1, 5.2.2, 5.3.2, 6.1.1, 6.1.2														

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	35	35				100
CAT2	10	45	45				100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1		50	50				100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2		50	50				100
ESE	10	40	50				100

22I0E$15	VIDEO CREATION AND EDITING *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objectives	Upon completion of the course the students will be familiar with the principles and techniques of video creation and editing, video production equipment and software, visual storytelling and video production, planning, executing, and editing video projects. also able to foster critical thinking and creativity in developing and executing video projects.	
UNIT – I	**INTRODUCTION TO VIDEO CREATION AND EDITING**	**9 Periods**
Overview of video creation and editing -Brief history of video and film production -Understanding visual storytelling: developing documentary and dramatic projects- introduction to digital and film systems		
UNIT – II	**PRE-PRODUCTION**	**9 Periods**
Developing a concept and idea - Scriptwriting and storytelling -The Digital image - Film systems and cameras -The film image - Case Study : Non linear editing system		
UNIT – III	**PRODUCTION**	**9 Periods**
Camera operation and techniques: The video camcorder- The Lens - Lighting and sound recording techniques - Directing actors and crew -Conducting interviews -Shooting the movie - Case Study : Professional video zoom lenses		
UNIT – IV	**POST-PRODUCTION**	**9 Periods**
Picture and Dialogue editing - Editing digital video -sound editing and mixing -Color grading and correction-Sound editing and mixing – working with film in post production Case Study : Digital Audio Recording		
UNIT – V	**DISTRIBUTION AND PROMOTION**	**9 Periods**
Presenting the project - funding sources - budgets- business arrangements- legal and copyright issues- distribution and marketing - publicity and the marketing campaigns-building and sustaining a career -Case Study : Creating a short movie.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK :

1	*Steven Ascher and Edward Pincus,The Filmmaker's Handbook: A Comprehensive Guide for the Digital Age,Fifth edition Penguin Publishing Group, 2012*

REFERENCES :

1	*Walter Murch,**In the Blink of an Eye: A Perspective on Film Editing**", Silman-James Press,2001*
2	*Karel Reisz and Gavin Millar,**The Technique of Film Editing**",second edition ,Taylor and Francis Group 2017*
3	*Ken Dancyger, **The technique of film and video editing** , fifth edition , Elsevier 2011.*
4	*Chris Kenworthy,Digital video production cookbook, OReillyMedia ,2006*
5	*Mark Brindle, The Digital Filmmaking Handbook ,Quercus Publishing, 2014*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Demonstrate an understanding of the history and evolution of video production and editing.	2
CO2	Develop and execute a concept, script, and storyboard for a video project	3
CO3	Plan and prepare for a video shoot, including casting, location scouting, and budgeting.	3
CO4	Edit and assemble video footage using basic and advanced editing techniques.	2
CO5	Promote and distribute the final video on various platforms.	1

Course Articulation Matrix

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	1	1	1	0	0	0	0	0	0	0	0	1	1
CO2	1	2	3	2	3	0	0	0	0	0	0	0	1	1
CO3	1	2	1	3	3	0	1	0	3	1	2	0	1	1
CO4	1	2	2	2	3	3	0	0	3	1	2	0	1	1
CO5	1	2	2	2	3	3	1	3	3	3	2	0	1	1
22IOE$15	1	2	2	2	2	1	1	1	2	1	1	0	1	1

1– Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO	Key Performance Indicators
CO1	1.1.1,1.2.1,1.31,2.1.1,2.1.2,2.2.4,2.4.1,3.1.4,3.4.1,4.1.3,
CO2	1.1.1,2.1.1,2.1.2,2.1.3,2.2.1,2.2.2,2.4.3,3.1.1,3.1.2,3.1.3,3.1.6,3.2.1,3.2.2,3.2.3,3.3.1,3.4.1,3.4.2,4.1.1,4.1.3,4.2.1,4.3.1,4.3.2,4.3.4,5.1.1,5.1.2,5.2.1,5.2.2,5.3.1,5.3.2,
CO3	1.1.1,2.1.1,2.1.3,2.1.3,2.2.1,2.2.2,2.2.3,2.2.4,2.3.2,2.4.3,3.2.1,3.2.2,3.3.1,3.4.2,4.1.1,4.1.3,4.1.4,4.2.2,4.3.1,4.3.2,4.3.3,,5.1.1,5.1.2,5.2.1,5.2.2,5.3.2,7.1.1,9.1.1,9.1.2,9.2.1,9.2.2,9.2.3,10.1.1,11.2.1,11.3.1,11.3.2
CO4	1.1.1,2.1.1,2.1.3,2.1.3,2.2.1,2.2.2,2.2.3,2.2.4,2.3.2,2.4.3,3.2.1,3.2.2,3.3.1,,3.3.2,3.4.2,4.1.1,4.1.3,4.2.1, ,4.3.1,4.3.2,5.1.1,5.1.2,5.2.1,5.2.2,5.3.2,6.1.1,6.1.2,,9.1.1,9.1.2,9.2.1,9.2.2,9.2.3,10.1.1,11.3.1,11.3.2
CO5	1.1.1 , 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4 2.3.2, 2.4.3, 3.2.1, 3.2.3, 3.3.1, 3.3.2, 3.4.2, 4.1.1, 4.1.3, 4.3.1, 4.3.2, 4.3.3, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.12, 8.1.1, 8.2.1,8.2.2, , 9.1.1, 9.1.2, 9.2.1,9.2.2, 9.2.3,9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3,10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.1, 11.1.2, 11.2.1

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	30	40				100
CAT2	30	30	40				100
Assignment 1	30	30	40				100
Assignment 2	30	30	40				100
Other mode of internal assessments, if any	--	--	--	--	--	--	--
ESE	30	30	40				100

22IOE$16	**DIGITAL MARKETING** *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objectives	To give insight on the framework to analyze, strategies and plan digital marketing and communication activities for typical marketing situations. Familiarize with the key tools and techniques of digital marketing that are popularly used by professionals in the real world of digital marketing and help them develop the ability to formulate and analyze key metrics to evaluate the performance of typical digital marketing efforts.

UNIT – I	**INTRODUCTION TO DIGITAL MARKETING**	**9 Periods**
Basics of Digital Marketing - online marketplace analysis: digital marketing environment - consumer choice and digital influence online consumer behavior-competitors -suppliers- new channel structures - rate of environment change - economic force-political force -legal force - social force- cultural force.		
UNIT – II	**DIGITAL MARKETING STRATEGY DEVELOPMENT**	**9 Periods**
Digital marketing strategy - The impact of digital media and technology on the marketing mix: product- price-place-promotion -people, process and physical evidence - relationship marketing using digital platforms: the challenge of customer engagement - customer lifecycle management		
UNIT – III	**DIGITAL MARKETING IMPLEMENTATION AND PRACTICE**	**9 Periods**
Delivering the online customer experience: planning website design and redesign projects - initiation of the website project - defining site or app requirement - designing the user experience - development and testing of content - site promotion or traffic building - campaign planning for digital media		
UNIT – IV	**MARKETING COMMUNICATIONS USING DIGITAL MEDIA CHANNELS**	**9 Periods**
Search engine marketing - online public relations - affiliated marketing - interactive display advertising -email marketing and mobile text messaging- social media and viral marketing - offline promotion techniques		
UNIT – V	**EVALUATION OF DIGITAL CHANNEL PERFORMANCE**	**9 Periods**
Create a performance management system - performance metric framework - tools and techniques for collecting metrics -customer experience and content management - online consumer behavior- online retailing - customer acquisition in B2B marketing -online inter-organizational trading		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK :

1	*Dave Chaffey Fiona Ellis-Chadwick, Digital Marketing,sixth edition, 2016*

REFERENCES :

1	*Puneet singh Bhatia, Fundamentals of Digital Marketing , Pearson India Education services,2017*
2	*Mathur, Vibha, Arora, Saloni,"DigitalMarketing",PHI Learning Pvt. Ltd.,2020*
3	*Ian Dodson, The Art of Digital Marketing: The Definitive Guide to Creating Strategic, Targeted, and Measurable Online Compaigns, Wiley 2016*
4	*Dr.Shakti Kundu, Digital Marketing Trends and Prospects:Develop an effective Digital Marketing strategy with SEO, SEM, PPC, Digital Display Ads & Email Marketing techniques,BPB PUBN,2021*
5	*Seema Gupta , Digital Marketing,Third Edition, McGraw Hill 2022*

6.	*Simon Kingsnorth, Digital Marketing Strategy:An Integrated Approach to Online Marketing, Kogan page,2022*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Explain the role and importance of digital marketing in a rapidly changing business landscape	K1
CO2	Discuss the key elements of a digital marketing strategy	K2
CO3	Demonstrate advanced practical skills in common digital marketing tools such as Social media and Blogs	K2
CO4	Demonstrate advanced practical skills in common digital marketing tools such as SEM	K2
CO5	understand online consumer behavior and influence the extent to which individuals are likely to engage with the digital marketplace	K2

Course Articulation Matrix

COs / POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	1	1	2	2									2	2
CO2	1	1	2	2									2	2
CO3	1	1	2	2	3								2	2
CO4	1	1	2	2	3	2	3	3	3	3	3	3	2	2
CO5	1	1	2	2	1		3	3	3	3	3	3	2	2
22IOE$16	1	1	2	2	1	1	1	1	1	1	1	1	2	2

1– Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO	Key Performance Indicators
CO1	1.1.1,2.1.1,2.1.2,3.1.1,3.1.6,3.2.1,3.2.2,3.2.3,3.3.1,4.1.1,4.1.3,4.2.1,4.3.3,
CO2	1.1.1,2.1.1,2.1.2,3.1.1,3.1.6,3.2.1,3.2.2,3.2.3,3.3.1,4.1.1,4.1.3,4.2.1,4.3.3,
CO3	1.1.1,2.1.1,2.1.2,3.1.1,3.1.6,3.2.1,3.2.2,3.2.3,3.3.1,4.1.1,4.1.3,4.2.1,4.3.3,5.1.1,5.1.2,5.2.1,5.2.2,5.3.1,5.3.2
CO4	1.1.1,2.1.1,2.1.2,3.1.1,3.1.6,3.2.1,3.2.2,3.2.3,3.3.1,4.1.1,4.1.3,4.2.1,4.3.3, 5.1.1,5.1.2,5.2.1, 5.2.2,5.3.1,5.3.2,6.1.1,7.1.1,7.1.2,7.2.1,7.2.2,8.1.1,8.2.1,8.2.2,9.1.1,9.1.2,9.2.1,9.2.2,9.2.3,9.2.4,9.3.1, 10.1.1, 10.1.2,10.1.3,10.2.1,10.2.2,10.3.1,10.3.2, 11.1.1,11.1.2,11.2.1,11.3.1,11.3.2,12.1.1,12.1.2, 12.2.1,12.2.2,12.3.1,12.3.2
CO5	1.1.1,2.1.1,2.1.2,3.1.1,3.1.6,3.2.1,3.2.2,3.2.3,3.3.1,4.1.1,4.1.3,4.2.1,4.3.3, 5.1.1,5.1.2,5.2.1, 7.1.1,7.1.2,7.2.1,7.2.2,8.1.1,8.2.1,8.2.2,9.1.1,9.1.2,9.2.1,9.2.2,9.2.3,9.2.4,9.3.1, 10.1.1,10.1.2,10.1.3, 10.2.1,10.2.2,10.3.1,10.3.2,11.1.1,11.1.2,11.2.1,11.3.1,11.3.2,12.1.1,12.1.2,12.2.1,12.2.2,12.3.1,12.3.2

ASSESSMENT PATTERN – THEORY (Times New Roman, Size 11)

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	30	30	40				100
CAT2	30	30	40				100
Assignment 1	30	30	40				100
Assignment 2	30	30	40				100
Other mode of internal assessments, if any	--	--	--	--	--	--	--
ESE	30	30	40				100

22BOE$17	PRINCIPLES OF FOOD TECHNOLOGY *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objectives	To learn about the various food constituents and its additives. To learn about various microbes associated with food. To learn about different food processing and preservation techniques.	
UNIT – I	**FOOD AND ENERGY**	**9 Periods**
Constituents of food – carbohydrates, lipids, proteins, water, vitamins and minerals, dietary sources, role and functional properties in food, contribution to organoleptic and textural characteristics.		
UNIT – II	**FOOD BORNE DISEASES**	**9 Periods**
Classification – food infections – bacterial and other types; food intoxications and poisonings– bacterial and non-bacterial; food spoilage – factors responsible for spoilage, spoilage of vegetable, fruit, meat, poultry, beverage and other food products.		
UNIT – III	**FOOD ADDITIVES**	**9 Periods**
Classification, intentional and non-intentional additives, functional role in food processing and preservation; food colourants – natural and artificial; food flavours; enzymes as food processing aids.		
UNIT – IV	**FOOD PRESERVATION**	**9 Periods**
Principles involved in the use of sterilization, pasteurization and blanching, thermal death curves of microorganisms, canning; frozen storage-freezing characteristics of foods, microbial activity at low temperatures, factors affecting quality of foods in frozen storage; irradiation preservation of foods.		
UNIT – V	**FOOD PACKAGING**	**9 Periods**
Types of packaging material and containers; Interactions between packaging and foods; Packing - meat, dairy, fresh fruits and vegetables, beverages and confectionaries; Food packaging closure and sealing system; Nutrition labelling and legislative requirements.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	*T.P. Coultate , **Food – The Chemistry Of Its Components**, 6th Edn. Royal Society,London, 2015.*
2	*W.C. Frazier And D.C. Westhoff , **Food Microbiology**, 4th Ed., Mcgraw-Hill Book Co., NewYork 2013.*

REFERENCES

1	*Srinivasan Damodaran and Kirk L. Parkin., "Fennema's Food Chemistry", CRC Press, 5 thedition. 2017.*
2	*Fellows P.J, "Food Processing Technology: Principles and Practices", Woodhead Publishing 4 th edition,2016·*
3	*B. Sivasanker , Food Processing And Preservation, Prentice-Hall Of India Pvt. Ltd. New Delhi 2002.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	learn different constituents present in food and microorganism involved in processing of food.	K1
CO2	learn principles and different preservations techniques of food can also be known.	K1
CO3	learn techniques involved in modern food processing and impact of the process on food quality.	K2
CO4	Explain various preservation and packaging techniques for food product	K2
CO5	Describe the relationship between food and microorganism that basis for fermentation and preservation	K2

a) Course Articulation Matrix														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	-	-	1	-	-	-	-	2	3	-	-	1	3
CO2	1	-	-	-	-	-	-	-	-	3	-	-	1	3
CO3	1	-	-	2	-	2	-	-	-	3	-	-	1	3
CO4	1	-	1	-	-	-	-	-	-	3	-	-	1	3
CO5	1	-	2	-	-	-	-	-	-	3	-	-	1	3
22BOE$17	1	-	1	1	-	2	-	-	2	3	-	-	1	3
1 – Slight, 2 – Moderate, 3 – Substantial														
b) CO and Key Performance Indicators Mapping														
CO1	1.4.2, 2.1.3													
CO2	1.4.1, 3.1.3													
CO3	1.4.4, 2.1.4													
CO4	1.4.1, 2.1.3,3.4.2													
CO5	1.4.1,2.2.1													

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	50	50	-	-	-	-	100
CAT2	60	40	-	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	50	50	-	-	-	-	100
ESE	50	50	-	-	-	-	100

22BOE$18	BIOLOGY FOR ENGINEERS *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objectives	1. Understand and interpret commonly reported statistical measures published in healthcare research 2. Analyze the different type of data using appropriate statistical software 3. Demonstrate a good understanding of descriptive statistics and graphical tools 4. Explain fundamental concepts of estimation and hypothesis testing and be confident when interpreting P values and confidence intervals	
UNIT – I	**BASICS OF CELL BIOLOGY**	**9 periods**
An overview of cells – origin and evolution of cells-cell theory-classification of cells – prokaryotic cells and eukaryotic cells; Structure of prokaryotic and eukaryotic cells and their organelles comparison of prokaryotic and eukaryotic cells; Transport across membranes – diffusion - active and passive diffusion.		
UNIT – II	**BASICS OF MICROBIOLOGY**	**9 periods**
Classification of microorganism-microscopic examination of microorganisms; Structural organization and multiplication of bacteria-viruses-algae and fungi; Microorganism used for the production of penicillin-alcohol and vitamin B-12.		
UNIT – III	**HUMAN ANATOMY AND PHYSIOLOGY**	**9 periods**
Basics of human anatomy-tissues of the human body-epithelial-connective-nervous and muscular; Nervous system-Respiratory System-Circulatory system and Digestive system.		
UNIT – IV	**BIO MOLECULES AND IMMUNE SYSTEM**	**9 periods**
Introduction to Biochemistry-classification-structure and properties of carbohydrates- proteins-lipids and nucleic acids; Innate and acquired immunity; Types of immune responses.		
UNIT-V	**APPLIED BIOLOGY FOR ENGINEERS**	**9 periods**
Overview of biosensors - glucometer applications-medicine; Microarray analysis to diagnose the cancer; Microbial production of biofuels; Applications of stem cells.		
Contact Periods: **45** **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	*Darnell J, Lodish H, Baltimore D. **"Molecular Cell Biology"**, W.H.Freeman; 8th Edition, 2016.*
2	*Pelczar MJ, Chan ECS and Krein NR, **"Microbiology",** Tata McGraw Hill, 5thEdition, New Delhi.2001.*
3	*Wulf Cruger and Anneliese Cruger, **"A Textbook of Industrial Microbiology",** Panima Publishing Corporation, 2nd Edition, 2000.*

REFERENCES

1	*David L. Nelson and Michael M Cox, **"Lehninger's Principles of Biochemistry",** Macmillan Worth Publisher, 4th edition, 2004.*
2	*Brain R.Eggins , **"Chemical Sensors and Biosensors",** John Wiley & Sons, 2002.*
3	*Anton Moser, **"Bioprocess Technology, Kinetics and Reactors",** Springer, Berlin (Verlag),1st edition, 1998*
4	*Kuby J, **"Immunology",** WH Freeman & Co., 7th edition, 2013.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the functions of cell and their structural organization	K1
CO2	Describe the mechanisms and role of cell in immune system	K1
CO3	Get familiarized biomolecules and human anatomy system	K2
CO4	Illustrate the applications of microbes in industrial process	K3
CO5	Apply the engineering concepts in biology	K3

a) Course Articulation Matrix

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	-	1	-	-	-	2	2	2	-	-	1	2	2	2
CO2	1	-	-	1	1	-	-	2	3	3	2	2	1	3
CO3	1	1	-	-	-	-	-	1	1	-	-	-	1	3
CO4	-	-	-	-	1	-	-	2	3	3	1	1	1	3
CO5	-	2	-	1	3	-	-	-	-	-	-	-	2	2
22BOE$18	1	1	-	1	2	2	2	2	3	3	2	2	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	2.2.2,6.1.1,7.1.2,8.1.1,11.1.1,12.1.2
CO2	1.1.1,4.2.1,5.2.1,8.1.1,9.1.1,9.2.1,10.1.1,10.1.2,11.1.1,12.1.2
CO3	1.1.1,2.1.1,8.1.1,9.1.1
CO4	5.2.1,8.1.1,9.1.1,9.2.1,10.1.1,10.1.2,11.1.1,12.1.2
CO5	1.1.1,2.2.2,4.2.1,5.2.1,6.1.1,7.1.2,8.1.1,9.1.1,9.2.1,10.1.1,10.1.2,11.1.1,12.1.2

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	50	10	10	10	10	10	100
CAT2	50	10	10	10	10	10	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	20	20	20	10	10	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	20	20	20	10	10	100
ESE	50	10	10	10	10	10	100

22MVA$07	YOGA AND ART OF LIVING

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EE	1	0	0	1

Course Objectives	To create awareness and the benefits of yoga and meditation to develop the successful and healthy life.	
UNIT – I	**SELF AWARNESS AND PHYSICAL EXERCISES**	**(5 Periods)**
Purpose of life, philosophy of life, Importance of physical exercise, Rules and regulation of simplified physical exercises, hand exercise, leg exercise, breathing exercise, eye exercise, body massage, acupressure, body relaxation.		
UNIT – II	**YOGASANAS**	**(5 Periods)**
Introduction about Yoga - Rules & Regulations – asana, pranayama, mudra, maharasana, Kundalini yoga: Arginai, Santhi, thuriam, thuriyatheetham. – Applications of Yoga.		
UNIT – III	**MEDITATION FOR MIND CONTROL**	**(5 Periods)**
Introduction about Bio magnetism & mind - eight essential factors of living beings - Mental frequency and ten stages of mind - benefits of meditation.		
Contact Periods: **Lecture: 15 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 15 Periods**		

TEXT BOOK:

1	*Vethathiri Maharashi – "**Yoga for Modern Age**"*
2	*Vethathiri Maharashi "**Mind**"*

REFERENCES:

1	*Jennifer Smith, "**Yoga for Beginners: Easy Yoga Exercises to Calm Your Mind, Lose Weight and Strengthen Your Body**", April 2020.*
2	*Lois D. Robinson, "**Practical Meditation for Beginners**", March 2021.*
3	*B. K. S. Iyengar "**Light on Yoga**",2006*
4	*Noomi Anand, "**Yoga: A Manual for Life**", 2019*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Knowledge of proper physical exercises which need to maintain the physical fitness for healthy and peaceful life.	K3
CO2	Practice proper Yoga as per proper steps to maintain physical fitness along with mental fitness.	K3
CO3	Do meditation practices, which strengthen the mind and increases the concentration, creativity and ultimately to transform the mind to achieve self-realization.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	0	0	0	0	3	1	0	2	0	0	2	1		
CO2	1	1	1	1	0	3	3	0	2	0	1	2	1		
CO3	1	2	1	2	1	3	3	1	3	3	2	3	1		
22MVA$07	1	1	1	1	1	3	2	1	2	1	1	2	1		
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.1.1, 2.1.1, 3.1.1, 4.1.1
CO2	1.1.1, 1.2.1, 2.1.1, 2.2.1, 3.1.1, 3.3.1, 3.3.2, 3.4.1
CO3	1.1.1, 1.2.1, 2.1.1, 2.2.1, 3.1.1, 3.3.1, 3.3.2, 3.4.1

22MVA$08	GEOMETRIC DIMENSIONING AND TOLERANCING

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EE	1	0	0	1

Course Objectives	To enable to create precise, manufacturable, and functional designs that meet industry standards as per Geometric Dimensioning and Tolerancing standards.	
UNIT – I	**DIMENSIONING AND TOLERANCING**	**(5 Periods)**
Dimensioning Units- Fundamental Dimensioning Rules, - Definitions Related to Tolerancing. Tolerancing Fundamentals- Single Limits-Maximum Material Condition (MMC)- Least Material Condition (LMC)- Basic Fits of Mating Parts.- Clearance Fit-Allowance-Clearance-Force fit- Chain Dimensioning- Baseline Dimensioning- Direct Dimensioning-, Alternate Dimensioning Practices- Geometric Dimensioning and Tolerancing for CADD/CAM.		
UNIT – II	**INTRODUCTION TO SYMBOLS AND TERMS**	**(5 Periods)**
Dimensioning Symbols-Dimensioning and Tolerancing Templates- Datum Feature Symbols- Datum Target Symbols- Geometric Characteristic Symbols- Material Condition and Material Boundary Symbols- Feature Control Frame-Basic dimensions- Additional Symbols.		
UNIT – III	**FORM TOLERANCES AND ORIENTATION TOLERANCES**	**(5 Periods)**
Straightness Tolerance - Flatness Tolerance - Circularity Tolerance- Free State Variation - Cylindricity Tolerance- Orientation Tolerances- Parallelism Tolerance- Perpendicularity Tolerance- Combination of Parallelism and Perpendicularity Tolerances- Angularity Tolerance.		
Contact Periods: **Lecture: 15 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 15 Periods**		

TEXT BOOKs:

1	*Alex Krulikowski, "**Fundamentals of Geometric Dimensioning and Tolerancing2018: Using Critical Thonking Skills" SAE International**, 2018.*
2	*P.S.Gill, "**Geometric Dimensioning and Tolerancing**",S.K.Kataria& sons, 2013*

REFERENCES:

1	*Bruce A.Wilson,"**GD&T- Application and Interpretation**",Goodeheart-Willcox, 2019*
2	*James D Meadows,"**Geometric Dimensioning and Tolerancing Handbook**", JamesD. Meadows & Associates, 2009.*
3	*David A. Madsen,**" Geometric Dimensioning and Tolerancing"**, The Goodheart-Willcox Company, Inc. Tinley Park, Illinois ,2013*
4	*Gene R. Cogorno, "**Geometric Dimensioning and Tolerancing for Mechanical Design**", 3E (Mechanical Engineering),Mc Graw Hill,2020*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Gain knowledge on principles of dimensioning, limits, tolerances and fits.	K2
CO2	To understand the 321 principle of datum features and rules of GD&T	K2
CO3	Know the various types of form tolerances and orientation tolerances.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	1	-	-	-	1	-	-	2	-	-	-	1	-	-
CO2	2	1	-	-	-	-	-	-	-	-	-	-	1	1	-
CO3	2	1	-	-	-	-	-	-	-	-	-	-	1	1	-
22MVA$08	2	1	-	-	-	1	-	-	1	-	-	-	1	1	1
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.3.1, 2.1.2, 6.1.1
CO2	1.3.1, 2.1.2
CO3	1.3.1, 2.1.3, 6.1.1, 9.1.2

22MVA$09	CONCEPTS OF METALLOGRAPHY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EE	1	0	0	1

Course Objectives	To learn the techniques of material preparation, characterization, analysis to identify behavior of materials in engineering.	
UNIT – I	**MATERIAL PREPARATION AND CHARACTERIZATION**	**(5 Periods)**
Preparation of specimen – Metallographic techniques - Microstructural characteristics – Composition of alloys – Material properties - Material behaviour – Material defects		
UNIT – II	**MATERIAL ANALYSIS**	**(5 Periods)**
Corrosion analysis – Failure analysis – Grain structure analysis – Heat treatment analysis – Phase identification – Weld analysis		
UNIT – III	**MICROSCOPIC TECHNIQUES**	**(5 Periods)**
Optical metallography – Scanning electron metallography – X-ray diffraction metallography		
Contact Periods: **Lecture: 15 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 15 Periods**		

TEXT BOOKS:

1	*Albert Sauver,* ***"Metallography and Heat treatment of Iron and Steel"****, University press.*
2	*Cornelius A Johnson,* ***"Metallography Principles and Procedures"****, Leco Corporation.*

REFERENCES:

1	*T.Scheper, J.Rietdorf "****Microscopy Techniques****", Springer,2005*
2	*W.F. Smith, Tata Mc-Graw Hill, 2008. "****Principles of Materials Science and Engineering: An Introduction****".*
3	*V. Raghavan, "****Introduction to Materials Science and Engineering a First Course****" PHI, Delhi, 2015.*
4	*K. G. Budinski, "****Engineering Materials – Properties and selection****", Prentince Hall India, 2009*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the material preparation, characterization of materials.	K1
CO2	Analyse the grain structure of various materials	K2
CO3	Gain knowledge on Microscopic techniques.	K2

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	0	1	3	0	0	0	0	0	0	0	3	1	2
CO2	3	3	0	1	2	0	0	0	0	0	0	0	3	2	2
CO3	3	3	0	0	3	0	0	0	0	0	0	0	3	1	2
22MVA$09	3	2	0	1	3	0	0	0	0	0	0	0	3	1	2
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.3, 2.2.1, 2.2.3, 2.2.4, 2.4.4, 4.3.4, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2
CO2	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 4.1.4, 5.1.2, 5.2.1, 5.3.1, 5.3.2
CO3	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2

22MVA$10	MICROMACHINING

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EE	1	0	0	1

Course Objectives	To facilitate the students with the principles, basic machine tools, and developments in the micro machining processes and impart basic knowledge on nano-finishing techniques.	
UNIT – I	**INTRODUCTION**	**(5 Periods)**
Introduction to micro-manufacturing – Definition – Importance – Applications – Size effect – Classification of micro-manufacturing processes – Molecular dynamics at atomistic scale – Diamond micro-machining and grinding.		
UNIT – II	**MACHINING TECHNIQUES**	**(5 Periods)**
Water Jet Micro Machining – Abrasive Jet Micromachining – Ultrasonic Micromachining – Electrochemical Micromachining – Laser beam micro-machining – Electron beam micro-machining – Ion-beam techniques.		
UNIT – III	**FINISHING TECHNIQUES**	**(5 Periods)**
Abrasive Flow Nanofinishing – Magnetic Abrasive Nanofinishing – Magneto rheological finishing – Magneto Rheological abrasive flow finishing – Magnetic Float polishing – Elastic Emission Machining – Chemo-mechanical Polishing.		
Contact Periods: **Lecture: 15 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 15 Periods**		

TEXT BOOK:

1	*Jain V. K., **"Micro Manufacturing Processes"** CRC Press, Taylor & Francis Group, 2012.*
2	*Mcgeough. J.A., **"Micromachining of Engineering Materials"**, CRC press 2001.*

REFERENCES:

1	*Jackson M.J, **"Microfabrication and Nanomanufacturing",** Taylor & Francis, CRC Press, 2005.*
2	*Johnstone R.W, **"Introduction to Surface micromachining"**, Kluwer Academic, 2014.*
3	*Raichoudhury,P,**"Handbook of Microlithography, Micromachining and Microfabrication"**, 1997.*
4	*Ehmann, K.F, **"Micromanufacturing: International Assessment of Research and Development"**, Springer, 2007.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Gain knowledge on principles of various micromachining techniques.	K2
CO2	Apply the various micromachining techniques for specific applications and to develop new methods for micromachining	K3
CO3	Apply the various nano finishing techniques for industrial applications.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	1	1	-	-	-	-	1	-	-	-	-	-	-	-	-
CO2	1	0	-	-	-	-	2	-	-	-	-	-	-	-	-
CO3	1	1	-	-	-	-	1	-	-	-	1	-	2	-	-
22MVA$10	3	2	-	-	1	1	3	-	1	-	2	1	2	1	1
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.3.1, 2.3.1, 7.2.2														
CO2	1.3.1, 7.1.1, 7.1.2														
CO3	1.3.1, 2.3.1, 7.2.2, 11.1.1														

22MVA$11	WIND ENERGY MANAGEMENT

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EE	1	0	0	1

Course Objectives	To understand the fundamentals of wind energy and its conversion system for the generation of wind energy and then the wind energy economics and its application.	
UNIT – I	**WIND ENERGY**	**(5 Periods)**
History - Dutch Windmill, Farm Windmill, Wind Chargers, Generation of Electricity for Utilities, Wind Farms, Small Systems, Advantages / Disadvantages.		
UNIT – II	**AERODYNAMICS THEORY**	**(5 Periods)**
Wind Characteristics - Extractable Limits of Wind Power, Power in wind, wind shear, wind Direction. Wind Turbines- aerodynamics, Drag Device- Lift Device- Orientation of the Rotor Axis- Description of the System.		
UNIT –III	**PERFORMANCE AND APPLICATION**	**(5 Periods)**
Blade Performance, measures of performance- Applications- utility Scale, Small Wind Turbines, Distributed Systems- Factors Affecting Economics- Life Cycle Costs.		
Lecture: 15 Periods Tutorial: 0 Periods Practical: 0 Periods Total:15 Periods		

TEXT BOOK:

1	*Nelson, Vaughn; Starcher, Kenneth "**Wind energy : renewable energy and the environment**"- CRC Press Publications - 2019*
2	*Paritosh Bhattacharya., **"Wind Energy Management",** InTech publisher, 2016*

REFERENCES

1	*Mario Garcia –Sanz, Constantine H. Houpis, **"Wind Energy Systems**", CRC Press 2012*
2	*Spera, D.A., **"Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering**", ASME Press, 1994.*
3	*John D Sorensen and Jens N Sorensen, "**Wind Energy Systems**", Woodhead Publishing Ltd, 2011*
4	*A.R. Jha "**Wind Turbine Technology**" CRC Press publisher, 2011.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify the wind mill for the power generation and usage.	K3
CO2	Apply aerodynamics concept to wind turbine components and their construction.	K3
CO3	Analyse the wind turbine and costs involved in the production.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	3	0	2	2	0	1	1	3	2	3	2	2
CO2	3	1	2	3	1	2	1	1	0	1	2	2	3	1	2
CO3	3	1	2	3	2	2	1	3	2	2	2	2	3	1	2
22MVA$11	3	1	2	3	1	2	1	1	1	1	2	2	3	1	2
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.1.1, 1.1.2, 1.2.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.2, 2.2.3, 3.1.2, 3.1.4, 3.2.1, 3.3.2, 3.4.2, 4.1.2, 4.1.3, 4.2.1, 4.3.2, 4.3.3, 4.3.4, 6.2.1, 7.1.1, 7.1.2, 9.2.1, 10.1.2, 11.1.1, 11.1.2, 11.2.1, 11.3.2, 12.1.1, 12.3.2														
CO2	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.2, 2.4.1, 3.1.1, 3.1.3, 3.1.5, 3.2.2, 3.2.3, 3.3.1, 3.4.1, 4.1.2, 4.1.3, 4.1.4, 4.3.1, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 6.2.1, 7.1.2, 8.2.2, 10.3.1, 11.1.1, 11.2.1, 12.1.2, 12.2.2, 12.3.1														
CO3	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.2, 2.4.1, 3.1.1, 3.1.3, 3.1.5, 3.2.2, 3.2.3, 3.3.1, 3.4.1, 4.1.2, 4.1.3, 4.1.4, 4.3.1, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.3.2, 6.2.1, 7.1.2, 8.1.1, 8.2.1, 8.2.2, 9.1.2, 9.2.3, 9.2.4, 10.1.1, 10.1.2, 10.1.3, 10.3.1, 11.1.1, 11.2.1, 11.3.2, 12.1.2, 12.2.2, 12.3.1														

22MVA$12	APPLICATIONS OF MATLAB IN MECHANICAL ENGINEERING

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EE	1	0	0	1

Course Objectives	To understand and appreciate the applications of MATLAB in solving problems in Mechanical Engineering.	
UNIT – I	**INTRODUCTION TO PROGRAMMING FOR MECHANICAL ENGINEERS**	**(5 Periods)**
Introduction to computer languages and computer hardware, MATLAB programming environment, Number Systems, MATLAB data types, MATLAB graphics, Functions, Inputs / Outputs, Char variable type, and text processing function library, Plotting functions, Reading a writing data files, Case Studies using different Matlab Toolboxes.		
UNIT – II	**MATLAB IN ROBOTICS**	**(5 Periods)**
Manipulator motion, Simulation of a 2R robotic arm manipulator, Creating a movie clip with the spatial motions of a robotic arm, For loop in programming, Working of the hold on command, Arrays and linspace commands.		
UNIT – III	**MATLAB IN THERMAL AND AUTOMOTIVE SYSTEMS**	**(5 Periods)**
Thermodynamics based applications in automotive, aerospace and industrial control-Thermolib And Simulink environment - calculation of real gas behavior using MATLAB-Modeling of Kinetics, Kinematics and complete dynamic system of Automotive suspensions:		
Contact Periods: **Lecture: 15 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 15 Periods**		

TEXT BOOKS:

1	*Andre Knoesen and Rajeevan Amirtharajah," **Introduction to MATLAB with Zylabs**", 1st Edition, Zybooks, 2023*
2	*Amos Gilat, "**MATLAB, an introduction with Applications**",, WILEY, 3rd Edition. ISBN 978-0-470-10877-2.*

REFERENCES:

1	*William J. Palm III, "**MATLAB for Engineering Applications**", 4th Edition, McGraw-Hill Education, 2018.*
2	*Rao V Dukkipati, "**MATLAB for Mechanical Engineers**", Fairfield University New Age Science Limited, 2009*
3	*K.Viswanath Allamraju,"**Getting started with MATLAB for Mechanical Engineers**", Mahi Publicaton, 2021*
4	*Shailendra Jain, **"Modeling and Simulation using MATLAB - Simulink",** 2nd Edition, Wiley Press, 2015.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the capability of MATLAB in solving Engineering problems.	K2
CO2	Design, model and interpret the solutions to kinematic problems in robotics.	K2,K6
CO3	Develop solutions to problems in Thermal and Automotive systems in MATLAB Environment.	K3,K6

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping														
COs/POs	**PO 1**	**PO 2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	2	2	-	-	-	-	1	-	-	3	3	-
CO2	3	3	3	2	2	-	-	-	-	1	-	-	3	3	-
CO3	3	3	3	3	2	-	-	-	-	1	-	-	2	3	-
22MVA$12	3	3	3	2	2	-	-	-	-	1	-	-	3	3	-
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.1.1,2.1.1,2.1.2,2.1,.3,2.2.1,2.2.2,2.2.3,2.2.4,2.3.1,2.3.2,3.1.1,3.2.1,4.1.2,4.3.1,5.1.1,5.1.2,10.1.1,
CO2	1.1.1, 2.4.1,3.1.1,3.2.2,4.1.2,4.3.2, 5.1.1,5.1.2,10.1.1
CO3	1.1.1, 2.4.2,2.4.3,3.1.1,3.2.3,4.1.4,4.3.3, 5.1.1,5.1.2,10.1.1

22MVA$13	DESIGN OF E-VEHICLE	SEMESTER $

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EE	1	0	0	1

Course Objectives	To familiarize with the basic electric components configuration for the Electric Propulsion unit, utilization of different Energy storage system and Hybridization and to inculcate knowledge on resolving issues in Energy Management system.	
UNIT – I	**INTRODUCTION TO ELECTRIC VEHICLE DYNAMICS**	**(5 Periods)**
Electric Propulsion unit-Introduction to electric components used in electric vehicles-Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, Switch Reluctance Motor drives- Drive system efficiency.		
UNIT – II	**ENERGY STORAGE**	**(5 Periods)**
Introduction to Energy Storage Requirements in Electric Vehicles- Mode of energy storage and its analysis- Battery based, Fuel Cell based, Super Capacitor based, Flywheel based-Hybridization of different energy storage devices.		
UNIT – III	**ENERGY MANAGEMENT STRATEGIES**	**(5 Periods)**
Introduction to energy management strategies used in hybrid and electric vehicles-Classification of different energy management strategies- comparison of different energy management strategies -Implementation issues of energy management strategies-Maintenance and recycling of battery.		
Contact Periods: **Lecture: 15 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 15 Periods**		

TEXT BOOK:

1	*Iqbal Hussein, "**Electric and Hybrid Vehicles: Design Fundamentals**", CRC Press, 2021.*
2	*James Larminie, John Lowry, **"Electric Vehicle Technology"** Wiley, Second ediion.2012.*

REFERENCES

1	***"Vehicles: Fundamentals, Theory and Design**", CRC Press, Third edition, 2021.*
2	*Sandeep Dhameja, **"Electric Vehicle Battery Systems",** Newnes, 2011.*
3	*Ali Emadi, **"Advanced Electric Drive Vehicles"**, 1st Edition, CRC Press, 2017.*
4	*Mehrdad Ehsani, Yimin Gao, Stefano Longo, Kambiz Ebrahimi**, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles"**, 3rd Edition, CRC Press, 2018.*
5	*https://onlinecourses.nptel.ac.in/noc24_ee30*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand and apply the controls of different motors for drive system efficiency.	K2, K3
CO2	Understand various Energy storage devices including the Hybridization.	K2
CO3	Apply Energy management system strategies to solve problems.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping														
COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	2	1	2	2	2	-	-	-	-	-	3	2	3
CO2	3	2	2	1	3	3	2	-	-	-	-	-	3	3	2
CO3	2	3	2	1	3	3	1	-	-	-	-	-	3	2	2
22MVA$12	3	2	2	1	3	3	2	-	-	-	-	-	3	2	2
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.3.1,1.4.1,2.2.2,2.3.1,3.1.3,4.1.1,5.1.1,5.1.2,6.1.1,7.1.1														
CO2	1.3.1,1.4.1,2.2.4,3.2.1,4.1.3,5.2.1,5.2.2,6.1.1,7.2.1														
CO3	1.3.1,1.4.1,2.2.3,2.4.2,3.4.2,4.3.4,5.3.1,5.3.2,6.1.1,7.2.2,														

22MVA$14	**DESIGN OF PUMPS** *(Use of Approved Design Data Book is permitted)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EE	1	0	0	1

Course Objectives	To expose students to design, test and maintenance of various types of pumps in industrial and general applications.	
UNIT – I	**PUMPS AND GENERAL CONSIDERATIONS**	**(5 Periods)**
Introduction to pumps – characteristics working fluids - fluid mechanics concepts and governing laws of fluid flow - various components of pumps and their functions - classification of pumping systems –applications and working fluids.		
UNIT – II	**DESIGN OF PUMPS**	**(5 Periods)**
Design of pumps – data required for the design of pump and design calculations - selection of the drive – types of drives, their behavior and advantages, selection of the pumps – types of pumps - selection of piping and other components - development of a schematic layout of the piping system.		
UNIT – III	**TESTING AND MAINTENANCE OF PUMPS**	**(5 Periods)**
Operation and maintenance – installation of pumping system - testing of the pumping systems – various methods based on the working fluid, drive and pump - maintenance of the pumps – prediction and correction methods - factors affecting the maintenance and their evaluation.		
Contact Periods: **Lecture: 15 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 15 Periods**		

TEXT BOOKS:

1	*G. K. Sahu., **"Rotodynamic and Positive Displacement Types: Theory, Design and Applications"**, New Age International Pvt Ltd, 3rd, edition 2011.*
2	*R. K. Turton., **"Rotodynamic Pump Design"**, Cambridge University Press, 2005.*

REFERENCES:

1	*Stepanoff, A. J., **"Centrifugal and Axial Flow Pumps: Theory, Design and Application"**, John Wiley & Sons, 2nd Edition, 1966.*
2	*Sacile Goorah, **"Centrifugal Pumps: Design and Application"**, Horizon Press, 2024.*
3	*Igor Karassik, Joseph Messina, Paul Cooper and Charles Heald, **"Pump Handbook"**, McGraw-Hill Education, 4th Edition, 2008.*
4	*Noah D.Manring, **"Fluid Power Pumps and Motors: Analysis, Design and Control"**, McGraw Hill Education Publishers, 2013.*
5	*Phillip Ellenberger, **"Piping Systems & Pipeline"** McGraw-Hill Education Publishers, 2005.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the various classifications of pumps.	K2
CO2	Design and analyze the pump geometry based on their behavior.	K4
CO3	Acquire knowledge on various method of testing the pump systems.	K4

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	2	-	3	2	-	-	-	-	1	1	1	1
CO2	3	3	2	3	3	2	3	-	-	-	-	1	2	2	3
CO3	3	3	2	2	1	3	3	-	-	-	-	1	2	2	2
22MVA$13	3	3	2	2	1	3	3	-	-	-	-	1	2	2	2
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.1.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 3.1.1, 3.1.2, 4.1.1, 4.1.2, 5.1.1, 5.1.2, 6.1.1, 6.2.1, 7.1.1, 12.1.1, 12.1.2
CO2	1.1.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 3.1.1, 3.1.2, 3.2.1, 3.2.2, 4.1.1, 4.1.2, 5.1.1, 5.1.2, 6.1.1, 6.2.1, 7.1.1, 12.1.1, 12.1.2
CO3	1.1.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 3.1.1, 3.1.2, 4.1.1, 4.1.2, 5.1.1, 5.1.2, 6.1.1, 6.2.1, 7.1.1, 12.1.1, 12.1.2

22MVA$15	DESIGN OF EXPERIMENTS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EE	1	0	0	1

Course Objectives	To introduce the concepts of design of Experiments and to know how to plan, design, conduct experiments efficiently and effectively, and analyze the resulting data to obtain objective conclusions.	
UNIT – I	**INTRODUCTION AND BASIC STATISTICAL CONCEPTS**	**(5 Periods)**
Strategy of Experimentation- applications, principles, guidelines. Concepts of random variable, probability, density function cumulative distribution function-Sample and population, Measures of Central tendency and Variability, Concept of confidence level. Statistical Distributions-Hypothesis testing, Probability plots- choice of sample size. Illustration through Numerical examples.		
UNIT – II	**EXPERIMENTAL DESIGN**	**(5 Periods)**
Classical Experiments: Factorial Experiments: Terminology: factors, levels, interactions, treatment combination, randomization, Factor effects, Factor interactions, Fractional factorial design, Saturated Designs, Response surface methodology, Taguchi's Orthogonal Arrays-selection, Dummy level Technique, Compound factor method, Modification of linear graphs. Illustration through Numerical examples.		
UNIT – III	**QUALITY BY EXPERIMENTAL DESIGN**	**(5 Periods)**
Ranking method, Column effect method & Plotting method, Analysis of variance (ANOVA) in Factorial Experiments: YATE's algorithm for ANOVA, Regression analysis, Mathematical models from experimental data. Illustration through Numerical examples. Evaluation of sensitivity to noise. Signal to Noise ratios for static problems: Smaller-the-better type, Nominal-the –better-type, Larger-the-better type. Signal to Noise ratios for Dynamic problems. Illustration through Numerical examples.		
Contact Periods: **Lecture: 15 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 15 Periods**		

TEXT BOOK:

1	*Montgomery, D.C., "**Design and Analysis of Experiments**", 5 Ed., John Wiley and Sons Inc., New York, 2nd edition, 2006.*
2	*Angela Dean,Daniel Voss, Danel Draguljic,**"Design and Analysis of Experiments"**, Springer press, 2017.*

REFERENCES

1	*Alan S.Gerber, Donald P.Green, "**Field Experiments-Design, Analysis, and Interpretation**",W.W. Norton and Company,2012.*
2	*Mark J.Anderson, Patrick J.Whitcomb **"RSM Simplified: Optimizing Processes Using Response Surface Methods for Design of Experiments",** Second Edition, Infotech Standards India Pvt Ltd, 2016.*
3	*George. E. P. Box, J. Stuart Hunter, William G. Hunter, "**Statistics for Experimenters: Design, Innovation, and Discovery**", 2nd Edition, Wiley, 2005*
4	*Kai YangBasem S. El-Haik, **"Design for Six Sigma: A Roadmap for Product Development",** 2nd Edition,The McGraw-Hill Companies, Inc.,2009.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Given a number of factors which affects the experiment, understand and determine the most important factor.	K2
CO2	Learn the factorial design of experiments and design a regression model for an experiment and construct confidence intervals for each parameter.	K2,K6
CO3	Assess the importance of curvature in regression and construct response surface.	K3,K6

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping														
COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	3	3	2	2	-	-	-	-	1	-	-	3	3	-
CO2	3	3	3	2	2	-	-	-	-	1	-	-	3	3	-
CO3	3	3	3	3	2	-	-	-	-	1	-	-	2	3	-
22MVA$14	3	3	3	2	2	-	-	-	-	1	-	-	3	3	-
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	1.1.1,2.1.1,2.1.2,2.1,.3,2.2.1,2.2.2,2.2.3,2.2.4,2.3.1,2.3.2,3.1.1,3.2.1,4.1.2,4.3.1,5.1.1,5.1.2,10.1.1,														
CO2	1.1.1, 2.4.1,3.1.1,3.2.2,4.1.2,4.3.2, 5.1.1,5.1.2,10.1.1														
CO3	1.1.1, 2.4.2,2.4.3,3.1.1,3.2.3,4.1.4,4.3.3, 5.1.1,5.1.2,10.1.1														

22MVA$16	INDUSTRY 4.0

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EE	1	0	0	1

Course Objectives	To acquire the concepts of industry 4.0 and its physical structure and to learn the obstacles and applications of IoT in Industry 4.0.	
UNIT – I	**INTRODUCTION**	**(5 Periods)**
Introduction, industry 1.0, 2.0, 3.0 and 4.0, Industry 4.0 production system, current state of industry 4.0, Technologies, Need, State of Art, SupportiveTechnologies.		
UNIT – II	**COMPONENTS OF INDUSTRY 4.0**	**(5 Periods)**
Cloud computing, Big Data and Analytics, Simulation and Virtualization, Additive Manufacturing, Machine learning, and Block chain technology. Robots- Advanced Sensor Technologies, Internet of Robotic Things, Cognitive Architecture for Cyber security - AR Hardware and Software Technology, Industrial Applications of AR.		
UNIT – III	**OBSTACLES IN INDUSTRY 4.0 AND APPLICATIONS**	**(5 Periods)**
Lack of A Digital Strategy alongside Resource Scarcity, Lack of standards and poor data security, Financing conditions, comprehensive broadband infra- structure, legal framework, protection of corporate data, handling personal data -The Role of the Internet of Things - Industry 4.0 in Car Manufacturing – Electronics Manufacturing – IoT Based Building Automation - Agricultural Automation.		
Contact Periods: **Lecture: 15 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 15 Periods**		

TEXT BOOKS

1	*Alasdair Gilchrist, **"Industry 4.0: The Industrial Internet of Things"**, APress, 2016.*
2	*Alp Ustundag and Emre Cevikcan,**"Industry 4.0: Managing the Digital Transformation".***

REFERENCES

1	*Duato J, Yalamanchili S, and Lionel Ni, **"Interconnection Networks: An Engineering Approach",** Morgan Kaufmann Publishers, 2004.*
2	*Fayez Gebali, Haytham Elmiligi, Mohamed Wathed and El -Kharashi **"Networks- on chips: Theory and Practice"**, CRC Press, Taylor and Francis Group, 2009.*
3	*Giovanni De Micheli and Luca Benini, "**Networks on Chips: Technology and Tools**", Morgan Kaufmann, 2006*
4	*Kiran Kumar Pabbathi, "**Quick Start Guide to Industry 4.0: One-Stop Reference Guide for Industry 4.0**", Create space Independent Publishing Platform, 2018*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify the recent technologies used in industries.	K3
CO2	Apply the concepts of Industry 4.0 in industries.	K3
CO3	Evaluate obstacles in implementing Industry 4.0.	K5

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping															
COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	2	3	3	3	2	3				2	2	2	3	2
CO2	2	2	3	3	3	2	3				2	2	2	3	2
CO3	2	2	3	3	3	2	3				2	2	2	3	2
22MVA$15	2	2	3	3	3	2	3				2	2	2	3	2
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping (Times New Roman, Size 11)	
CO1	1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 6.1.1, 7.1.1,7.1.2, 7.2.2, 11.1.1, 11.3.1, 11.3.2, 12.2.2, 12.3.1, 12.3.2
CO2	1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 6.1.1, 7.1.1,7.1.2, 7.2.2, 11.1.1, 11.3.1, 11.3.2, 12.3.1, 12.3.2
CO3	1.1.2, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2,3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1,4.2.2, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.1, 5.2.2, 6.1.1, 7.1.1,7.1.2, 7.2.2, 11.1.1, 11.3.1, 11.3.2, 12.2.2, 12.3.1, 12.3.2

22MVA$17	NON DESTRUCTIVE TESTING

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EE	1	0	0	1

Course Objectives	To enrich the students with different non-destructive testing techniques and their applications.	
UNIT – I	**DYE PENETRANT AND MAGNETIC PARTICLE TESTING**	**(5 Periods)**
Fundamentals non-destructive testing (NDT) – Scope and limitations of NDT – Visual examination methods and aids – Penetrant testing materials – Fluorescent penetrant testing method – Magnetizing technique – Fluorescent magnetic particle testing method.		
UNIT – II	**ULTRASONIC AND RADIOGRAPHIC TESTING**	**(5 Periods)**
Principle of ultrasonic testing (UT) – Methods of UT – Defects in welded products by UT – Thickness determination by UT – X-ray and Gamma-Ray radiography – Industrial radiography techniques (RT) – Inspection techniques – Interpretation of radiographs – Safety in industrial radiography.		
UNIT – III	**LEAK AND EDDY CURRENT TESTING**	**(5 Periods)**
Definition of leak and types – Principle and various methods of pressure and leak testing – Application and limitation – Eddy current testing – Principle, instrument and techniques – Sensitivity – Application and limitations – Thermal methods of NDT.		
Contact Periods: **Lecture: 15 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 15 Periods**		

TEXT BOOK:

1	*Prasad J, Nair C. G. K.,* ***Non-Destructive Test and Evaluation of Materials****, Tata McGraw-Hill Education, 2nd Edition, 2011.*
2	*Raj, B, Jayakumar T, Thavasimuthu M,* ***Practical Non Destructive Testing****, Alpha Science International Limited, 4th Edition, 2012.*

REFERENCES:

1	*Hellier C,* ***Handbook of NonDestructive Evluation****, McGraw-Hill Professional, 1st Edition, 2001.*
2	*Thomas Schmidt J, Skeie K, Maclntire P,* ***ASNT Non Destructive Testing Handbook: Magnetic Particle Testing****, American Society for Nondestructive Testing, American Society for Metals, 2nd Edition, 1989.*
3	*Rao,B.P.C,* ***Practical Eddy Current Testing****, Alpha Science International Limited, 2006.*
4	*Tracy N. A, Moore P. O,* ***Non-Destructive Testing Handbook: Liquid Penetrant Testing****, Vol. 2, American Society for Nondestructive Testing, 3rd Edition, 1999.*
5	*Krautkramer J and Krautkramer H,* ***Ultrasonic Testing of Materials****, Springer, 4th Edition, 1990.*
6	*Halmshaw R,* ***Industrial Radiography: Theory and Practice****, Springer, 2nd Edition, 1995.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the dye penetrant and magnetic particle testing methods which enable to carry out various inspection in accordance with the established procedures.	K2
CO2	Apply the ultrasonic and radiography testing methods to perform inspection on applications.	K3
CO3	Apply the leak and pressure testing and eddy current testing techniques for applications.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping														
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	-	-	-	2	1	2	3	1	-	-	-	-	-	-	1
CO2	-	-	-	2	1	2	3	1	-	-	-	-	-	-	1
CO3	-	-	-	2	1	2	3	1	-	-	-	-	-	-	1
22MVA$16	-	-	-	3	3	3	3	3	-	-	-	-	-	-	3
1 – Slight, 2 – Moderate, 3 – Substantial															
b) CO and Key Performance Indicators Mapping															
CO1	4.1.1,4.1.2,4.1.3,4.1.4,5.2.1,5.3.2,7.1.1,7.1.2,7.2.2,8.2.2														
CO2	4.1.1,4.1.2,4.1.3,4.1.4,5.2.1,5.3.2,7.1.1,7.1.2,7.2.2,8.2.2														
CO3	4.1.1,4.1.2,4.1.3,4.1.4,5.2.1,5.3.2,7.1.1,7.1.2,7.2.2,8.2.2														

22MVA$18	ENTERPRISE RESOURCE PLANNING

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	EE	1	0	0	1

Course Objectives	To understand about ERP systems, Technologies and implementation	
UNIT – I	**INTRODUCTION**	**(5 Periods)**
Enterprise—An Overview, Introduction to ERP, Basic Concepts of ERP, Risks and Benefits of ERP		
UNIT – II	**ERP AND RELATED TECHNOLOGIES**	**(5 Periods)**
Business Intelligence (BI) and Business Analytics (BA), Product Life Cycle Management (PLM), Supply Chain Management (SCM), Customer Relationship Management (CRM), Advanced Technology and ERP Security		
UNIT – III	**ERP IMPLEMENTATION**	**(5 Periods)**
ERP Implementation Life Cycle, Implementation Methodologies, ERP (Implementation) Transition Strategies		
Contact Periods: **Lecture: 15 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 15 Periods**		

TEXT BOOKS

1	*Alexis Leon, "**ERP Demystified**", Third Edition Tata McGraw-Hill, 2008*
2	*Jagan Nathan Vaman, "**ERP in Practice**", Tata McGraw-Hill, 2008*

REFERENCES

1	*Alexis Leon, "**Enterprise Resource Planning**", Fourth edition, Tata McGraw-Hill, 2019*
2	*Mahadeo Jaiswal and Ganesh Vanapalli, "**ERP**" Macmillan India, 2009.*
3	*Vinod Kumar Grag and N.K. Venkitakrishnan, "**ERP- Concepts and Practice**", Prentice Hall of India, 2nd edition, 2006.*
4	*Summer, "**ERP**", Pearson Education, 2008.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the Concepts of ERP	K2
CO2	Familiarize the Technologies related to ERP	K2
CO3	Develop the ERP implementation strategies	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping														
COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	1	1	1	2		1				1	1	1	1	1	1
CO2	1	2	1	2		1				2	2	1	1	1	1
CO3	1	2	1	2		1				2	2	1	1	1	1
22MVA$17	1	2	1	2		1				2	2	1	1	1	1
1 – Slight, 2 – Moderate, 3 – Substantial															

b) CO and Key Performance Indicators Mapping	
CO1	1.1.2,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.1,2.2.2,2.2.3,2.2.4,2.3.2,2.4.3,2.4.4,3.1.1,3.1.2,3.1.3,3.1.5,3.1.6,3.2.1, 3.2.2,3.2.3,3.3.1,3.3.2,4.1.1,4.1.2,4.1.3,4.3.1,4.3.2,4.3.3,4.3.4,6.1.1,6.2.1,10.1.1,10.1.2,10.3.1,10.3.2,11.1. 1,11.1.2,11.2.1,11.3.2,12.1.1,12.2.2
CO2	1.1.2,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.1,2.2.2,2.2.3,2.2.4,2.3.2,2.4.3,2.4.4,3.1.1,3.1.2,3.1.3,3.1.5,3.1.6,3.2.1, 3.2.2,3.2.3,3.3.1,3.3.2,4.1.1,4.1.2,4.1.3,4.3.1,4.3.2,4.3.3,4.3.4,6.1.1,6.2.1,10.1.1,10.1.2,10.3.1,10.3.2,11.1. 1,11.1.2,11.2.1,11.3.2,12.1.1,12.2.2
CO3	1.1.2,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.1,2.2.2,2.2.3,2.2.4,2.3.2,2.4.3,2.4.4,3.1.1,3.1.2,3.1.3,3.1.5,3.1.6,3.2.1, 3.2.2,3.2.3,3.3.1,3.3.2,4.1.1,4.1.2,4.1.3,4.3.1,4.3.2,4.3.3,4.3.4,6.1.1,6.2.1,10.1.1,10.1.2,10.3.1,10.3.2,11.1. 1,11.1.2,11.2.1,11.3.2,12.1.1,12.2.2