GOVERNMENT COLLEGE OF ENGINEERING

SALEM - 636 011

(An Autonomous Institution Affiliated to

Anna University, Chennai)

REGULATIONS 2022

CURRICULAM AND SYLLABUS

(For Candidates admitted from 2022 - 2023 onwards)

DEPARTMENT OF MECHANICAL ENGINEERING

(FULL TIME PROGRAMME)

Rough Draft

DEPARTMENT OF MECHANICAL ENGINEEERING - VISION & MISSION

A serene and tranquil 'MECH' atmosphere helps the dynamic professionals to kindle their innovative minds. The enduring efforts of faculties have enhanced the students with omnipotent skills, with considerable research work being done in the department.

VISION

The department of mechanical engineering is committed to blossom into a centre of excellence, dedicated and competent engineers by providing global quality interactive technical education to cater the needs of the industries and nation into a technologically, socially and culturally advanced one.

MISSION

- Constantly updating the departmental resources, faculty and other infrastructure by acquiring the state of the art equipments and by imparting constant in-service training to the faculty and supporting staff.
- Promoting skilled and employable graduates to meet the challenges in emerging fields of engineering.
- To prepare the students for prosperous career in entrepreneurship with leader ship qualities, ethics and human values.
- The department executes life-long learning skills and provides engineering services for sustainable development of the society.

PROGRAMME EDUCATIONAL OBJECTIVES

- **PEO 1**: To provide students with strong fundamental knowledge in mathematics, science and basic engineering to enable them to solve the mechanical engineering related problems.
- **PEO 2**: To develop expertise in core areas like design, analyze and synthesize data and technical concepts with software skills to create novel products and solutions for the real time problems.
- **PEO 3**: Graduates able to exhibit professionalism in their profession with effective communication, ethical attitude, entrepreneurship skills and the knowledge in global economy to meet the social challenges.
- **PEO 4**: To promote the students for continuous learning towards professional growth in contemporary areas of socio-technological issues like energy crisis, environmental pollution, industrial issues and natural disaster.

PROGRAMME OUTCOMES

- **PO1**: Apply the knowledge of mathematics, science and engineering specialization to solve complex engineering problems.
- **PO2**: Graduates will have the ability to identify, formulate, conduct experiment and analyze engineering problems
- **PO3**: Graduates will demonstrate the ability to design and evaluate a mechanical system (or) process with appropriate consideration for the socio - environmental conditions.
- **PO4**: Graduates will demonstrate the ability to design and conduct experiments, interpretation of data and synthesis of information to provide valid conclusions.
- **PO5**: Graduates will be familiar with modern engineering software tools and equipments to model and predict the Mechanical engineering problems
- **PO6**: Demonstrate knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to engineering practice
- **PO7**: Understand the impact of engineering solution in the environmental context and the need for sustainable development.
- **PO8**: Apply ethical principles and commitment to professional ethics and norms of the practice in the field of Mechanical engineering.
- **PO9**: Obtain the ability to function individually and also as a team member in multi-disciplinary activities.
- **PO10**: Able to communicate effectively in verbal, written and graphical forms.
- **PO11**: Recognize the need and ability to engage in independent and life-long learning in the broadest context of technological change.
- **PO12**: Graduates will have the ability to employ effective project management skills and financial principles to develop project plans in multi-disciplinary environments.

PROGRAMME SPECIFIC OUTCOMES

- **PSO 1**: Ability to identify, analyze and solve engineering problems in the domains of Design, Thermal and Manufacturing systems.
- **PSO 2**: Ability to apply their knowledge in principle of design and analysis, in execution of automation in mechanical system / processes.
- **PSO 3**: Ability to involve professionally in industries or as an entrepreneur by applying manufacturing and management practices.

GOVERNMENT COLLEGE OF ENGINEERING, SALEM – 636 011.

B.E – MECHANICAL ENGINEERING (FULL TIME) – R2022 CURRICULUM

SEMESTER I										
S. No.	Course Code	Course Title	Cat	Hours/Week				Max. Marks		
				L	T	P	C	CA	FE	Total
1	22MC101	Induction Program	MC	-	-	-	0	-	-	-
THEORY										
2	22MA101	Matrices, Calculus and Ordinary Differential Equation	BS	3	1	0	4	40	60	100
3	22CY101	Engineering Chemistry	BS	3	1	0	4	40	60	100
4	22EE101	Basics Electrical and Electronics Engineering	ES	3	1	0	4	40	60	100
5	22ME101	Engineering Graphics and Design	ES	1	0	4	3	40	60	100
6	22CS101	Problem Solving and C Programming	ES	3	0	0	3	40	60	100
7	22MC102	Heritage of Tamil / தமிழர்மரபு	HS MC	1	0	0	1	100	-	100
PRACTICAL										
8	22EN102	Professional Skills Laboratory	HS	0	0	2	1.0	60	40	100
9	22PH103	Physics Laboratory	BS	0	0	3	1.5	60	40	100
10	22CY102	Chemistry laboratory	BS	0	0	3	1.5	60	40	100
11	22EE102	Basics Electrical and Electronics Engineering Laboratory	ES	0	0	3	1.5	60	40	100
TOTAL							**24.5**			**1000**

SEMESTER II										
S. No.	Course Code	Course Title	Cat	Hours/Week			C	Max. Marks		
				L	T	P		CA	FE	Total
THEORY										
1	22EN101	Communicative English(Theory cum Practical)	HS	2	0	2	3	50	50	100
2	22MA201	Partial Differential Equation, Vector Calculus and Complex Variables	BS	3	1	0	4	40	60	100
3	22PH101	Engineering Physics	BS	3	1	0	4	40	60	100
4	22ES101	Engineering Mechanics	ES	3	0	0	3	40	60	100
5	22HS201	Universal Human Values	HS	2	1	0	3	40	60	100
6	22MCIN01	Engineering Sprints	EE	0	0	2	1	100	-	100
7	22MC201	Tamils and Technology / தமிழரும் தொழில்நுட்பமும்	HS MC	1	0	0	1	100	-	100
8	22NC201	NCC Course – I (only for NCC students)*	NC	3	0	0	3*	-	-	100*
PRACTICAL										
9	22CS102	Computer Practice and C Programming Laboratory	ES	0	0	3	1.5	60	40	100
10	22ME102	Workshop Manufacturing Practices	ES	0	0	4	2.0	60	40	100
TOTAL							**22.5**			**900**

SEMESTER III

***NCC credit course level I is offered for NCC students only. The grades earned by the students will be recorded in the Mark sheet, however the same shall not be considered for the computation of CGPA**

S. No.	Course Code	Course Title	Cat	Hours/Week				Max. Marks		
				L	T	P	C	CA	FE	Total
THEORY										
1	22MA305	Fourier Series, Boundary Value Problems and Transforms	BS	3	0	0	3	40	60	100
2	22ME301	Engineering Thermodynamics	PC	3	1	0	4	40	60	100
3	22ME302	Fluid Mechanics and Machinery	PC	3	1	0	4	40	60	100
4	22ME303	Manufacturing Processes	PC	3	0	0	3	40	60	100
5	22MT310	Materials Engineering	ES	3	0	0	3	40	60	100
6	22MCIN02	Innovation Sprints	EE	0	0	2	1	100	-	100
7	22NC301	NCC Course – II (only for NCC Students)*	NC	3	0	0	3*	-	-	100*
PRACTICAL										
8	22ME304	CAD Laboratory	PC	0	0	3	1.5	60	40	100
9	22CE308	Strength of Materials and Fluid Mechanics Laboratory	ES	0	0	3	1.5	60	40	100
TOTAL							**21**			**800**

SEMESTER IV

S. No.	Course Code	Course Title	Cat	Hours/Week				Max. Marks		
				L	T	P	C	CA	FE	Total
THEORY										
1	22ME401	Kinematics of Machinery	PC	3	1	0	4	40	60	100
2	22ME402	Thermal Engineering	PC	3	1	0	4	40	60	100
3	22ME403	Metal cutting and Machine Tools	PC	3	0	0	3	40	60	100
4	22ME404	Hydraulics and Pneumatics	PC	3	0	0	3	40	60	100
5	22CE409	Strength of Materials	ES	3	0	0	3	40	60	100
6	22MCIN03	Design Sprints	EE	0	0	2	1	100	-	100
7	22CYMC01	Environmental Science	MC	2	0	1	0	-	-	-
PRACTICAL										
9	22ME405	Thermal Engineering Laboratory	PC	0	0	3	1.5	60	40	100
10	22ME406	Manufacturing Technology Laboratory	PC	0	0	3	1.5	60	40	100
TOTAL							**21**			**800**

***NCC credit course level II is offered for NCC students only. The grades earned by the students will be recorded in the Mark sheet, however the same shall not be considered for the computation of CGPA**

SEMESTER V										
S. No.	Course Code	Course Title	Cat	Hours/Week				Max. Marks		
				L	T	P	C	CA	FE	Total
THEORY										
1	22ME501	Design of Machine Elements	PC	3	1	0	4	40	60	100
2	22ME502	Heat and Mass Transfer	PC	3	0	0	3	40	60	100
3	22ME503	Metrology and Quality Control	PC	3	0	0	3	40	60	100
4	22ME504	Dynamics of Machinery	PC	3	0	0	3	40	60	100
5	22ME505	Instrumentation and Control system	PC	3	0	0	3	40	60	100
6	22MCIN04	Ideation Sprints	EE	0	0	2	1	100	-	100
7	22MC301	Indian Constitution	MC	3	0	0	0	100	-	100
PRACTICAL										
8	22ME506	Dynamics and Metrology Laboratory	PC	0	0	3	1.5	60	40	100
9	22EN502	Placement and Career Training Laboratory	HS	0	0	4	1.5	60	40	100
10	22ME507	Heat Transfer and Refrigeration Laboratory	PC	0	0	3	1.5	60	40	100
TOTAL							**21.5**			**900**

SEMESTER VI (REGULAR STREAM)										
S. No.	Course Code	Course Title	Cat	Hours/Week				Max. Marks		
				L	T	P	C	CA	FE	Total
THEORY										
1	22MEPE1X	Professional Elective – I	PE	3	0	0	3	40	60	100
2	22MEPE2X	Professional Elective – II	PE	3	0	0	3	40	60	100
3	22MEPE3X	Professional Elective – III	PE	3	0	0	3	40	60	100
4	22MEOE1X	Open Elective –I	OE	3	0	0	3	40	60	100
5	22MEOE2X	Open Elective –II	OE	3	0	0	3	40	60	100
6	22MEOE3X	Open Elective-III	OE	3	0	0	3	40	60	100
PRACTICAL										
7	22ME601	Mini Project	EE	0	0	6	3	60	40	100
TOTAL							**21**			**700**

SEMESTER VI (PROTOSEM STREAM)										
S. No.	**Course Code**	**Course Title**	**Cat**	**Hours/Week**				**Max. Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1	22PSPE01	Computational Hardware	PE	3	0	0	3	100	0	100
2	22PSPE02	Coding for Innovators	PE	3	0	0	3	100	0	100
3	22PSPE03	Industrial Automation	PE	3	0	0	3	100	0	100
4	22PSOE01	Applied Design Thinking	OE	3	0	0	3	100	0	100
5	22PSOE02	Startup Fundamentals	OE	3	0	0	3	100	0	100
6	22PSOE03	Prototype Development	OE	3	0	0	3	100	0	100
PRACTICAL										
7	22MEPS17	Robotics	EE	3	0	0	3	100	0	100
TOTAL							**21**			**700**

SEMESTER VII										
S. No.	**Course Code**	**Course Title**	**Cat**	**Hours/Week**				**Max. Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1	22ME701	Mechatronics	PC	3	0	0	3	40	60	100
2	22ME702	Finite Element Analysis	PC	3	0	0	3	40	60	100
3	22HS701	Operations Research	HS	3	0	0	3	40	60	100
4	22MEPE4X	Professional Elective – IV	PE	3	0	0	3	40	60	100
PRACTICAL										
5	22ME703	Mechatronics Laboratory	PC	0	0	3	1.5	60	40	100
6	22ME704	Simulation Laboratory	PC	0	0	3	1.5	60	40	100
7	22ME705	CAM Laboratory	PC	0	0	3	1.5	60	40	100
8	22ME706	Project – I	EE	0	0	8	4	60	40	100
TOTAL							**20.5**			**800**

SEMESTER VIII										
S. No.	**Course Code**	**Course Title**	**Cat**	**Hours/Week**				**Max. Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1	22MEPE5X	Professional Elective – V	PE	3	0	0	3	40	60	100
2	22MEPE6X	Professional Elective – VI	PE	3	0	0	3	40	60	100
3	22MEOE4X	Open Elective –IV	OE	3	0	0	3	40	60	100
PRACTICAL										
4	22ME801	Project –II	EE	0	0	20	10	120	80	200
TOTAL							**19**			**500**
GRAND TOTAL							**167**			

SUMMARY FOR REGULAR STREAM

Course Component	Credits Per Semester								Total Credit
	I	II	III	IV	V	VI	VII	VIII	
Humanities and Social Sciences (HS)	1	6			1.5		3		**11.5**
Engineering Science (ES)	11.5	6.5	4.5	3					**25.5**
Basic Science (BS)	11	8	3						**22**
Professional Core (PC)			12.5	17	19		10.5		**59**
Professional Electives (PE)						9	3	3	**18**
Open Electives (OE)						9		3	**12**
Empl. Enhancement Courses (EE)		1	1	1	2	3	4	10	**19**
Mandatory Course (One Credit) (MC/HSMC)	1	1							**2**
	23.5	**21.5**	**21**	**21**	**22.5**	**21**	**20.5**	**16**	**169**

PROFESSIONAL ELECTIVE COURSES

Code No.	Course	Hours/Week				Maximum Marks		
PROFESSIONAL ELECTIVES - I (VI SEMESTER)								
		L	**T**	**P**	**C**	**CA**	**FE**	**Total**
22MEPE11	Automobile Engineering	3	0	0	3	40	60	100
22MEPE12	Composite Materials	3	0	0	3	40	60	100
22MEPE13	Computer Integrated Manufacturing	3	0	0	3	40	60	100
22MEPE14	Design of Transmission system	3	0	0	3	40	60	100
22MEPE15	Energy Conservation in Industries	3	0	0	3	40	60	100
22MEPE16	Gas Dynamics & Jet Propulsion	3	0	0	3	40	60	100
22MEPE17	Renewable Energy System	3	0	0	3	40	60	100
PROFESSIONAL ELECTIVES - II (VI SEMESTER)								
22MEPE21	Advanced Strength of Materials	3	0	0	3	40	60	100
22MEPE22	Energy Efficient Buildings Design	3	0	0	3	40	60	100
22MEPE23	Engineering System Analysis and Design	3	0	0	3	40	60	100
22MEPE24	Industrial Engineering and Management	3	0	0	3	40	60	100
22MEPE25	Internal Combustion Engines	3	0	0	3	40	60	100
22MEPE26	Machine Drawing	2	3	0	3	40	60	100
22MEPE27	Power plant Engineering	3	0	0	3	40	60	100
PROFESSIONAL ELECTIVES - III (VI SEMESTER)								
22MEPE31	Fuels and Combustion	3	0	0	3	40	60	100
22MEPE32	Maintenance Engineering	3	0	0	3	40	60	100
22MEPE33	Non-traditional Machining Process	3	0	0	3	40	60	100
22MEPE34	Professional Ethics and Human Values	3	0	0	3	40	60	100
22MEPE35	Rapid Product Development Technologies	3	0	0	3	40	60	100
22MEPE36	Refrigeration & Air Conditioning	3	0	0	3	40	60	100
22MEPE37	Solar Energy Technology	3	0	0	3	40	60	100
PROFESSIONAL ELECTIVES - IV (VII SEMESTER)								
22MEPE41	Advanced Decision Modelling Technique	3	0	0	3	40	60	100
22MEPE42	Automation in Manufacturing	3	0	0	3	40	60	100
22MEPE43	Cryogenic Engineering	3	0	0	3	40	60	100
22MEPE44	Fracture Mechanics and Failure Analysis	3	0	0	3	40	60	100
22MEPE45	Fundamentals of Tribology	3	0	0	3	40	60	100
22MEPE46	Metal Forming Processes	3	0	0	3	40	60	100
22MEPE47	Micro and Nano Machining	3	0	0	3	40	60	100

PROFESSIONAL ELECTIVES - V (VIII SEMESTER)								
22MEPE51	Analysis and Synthesis of Mechanism	3	0	0	3	40	60	100
22MEPE52	Design of Jigs, Fixtures and Press tools	3	0	0	3	40	60	100
22MEPE53	Heat Transfer Problems in Electronics and Instrumentation	3	0	0	3	40	60	100
22MEPE54	Nano Technology	3	0	0	3	40	60	100
22MEPE55	Nuclear Engineering	3	0	0	3	40	60	100
22MEPE56	Thermal Turbo Machines	3	0	0	3	40	60	100
22MEPE57	Total Quality Management	3	0	0	3	40	60	100
PROFESSIONAL ELECTIVES - VI (VIII SEMESTER)								
22MEPE61	Design of Production Tooling	3	0	0	3	40	60	100
22MEPE62	Engineering System Modelling and Simulation	3	0	0	3	40	60	100
22MEPE63	Entrepreneurship Development	3	0	0	3	40	60	100
22MEPE64	Industrial Safety	3	0	0	3	40	60	100
22MEPE65	Introduction to Computational Fluid Dynamics	3	0	0	3	40	60	100
22MEPE66	Marine Engineering	3	0	0	3	40	60	100
22MEPE67	Robotics	3	0	0	3	40	60	100

LIST OF OPEN ELECTIVE COURSES

S.No.	Course Code	Course	Cat	Hours/Week				Maximum Marks		
				L	T	P	C	CA	FE	Total
COURSES OFFERED BY THE DEPARTMENT OF MATHEMATICS										
1	22MAOE01	Sampling Theory	OE	3	0	0	3	40	60	100
2	22MAOE02	Numerical Methods	OE	3	0	0	3	40	60	100
3	22MAOE03	Probability and Queuing Theory	OE	3	0	0	3	40	60	100
COURSES OFFERED BY THE DEPARTMENT OF CIVIL ENGINEERING										
4	22CEOE01	Environmental Management	OE	3	0	0	3	40	60	100
5	22CEOE02	Disaster Mitigation and Management	OE	3	0	0	3	40	60	100
6	22CEOE03	Repair and Rehabilitation of Building Elements	OE	3	0	0	3	40	60	100
7	22CEOE04	Mechanics of Deformable bodies	OE	3	0	0	3	40	60	100
COURSES OFFERED BY THE DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING										
8	22CSOE01	Object Oriented Programming Using C++	OE	3	0	0	3	40	60	100
9	22CSOE02	Operating Systems	OE	3	0	0	3	40	60	100
10	22CSOE03	Computer Networks	OE	3	0	0	3	40	60	100
11	22CSOE04	Python Programming	OE	3	0	0	3	40	60	100
12	22CSOE05	Java Programming	OE	3	0	0	3	40	60	100
13	22CSOE06	Computer Organization and Architecture	OE	3	0	0	3	40	60	100
14	22CSOE07	Data Structures Using C++	OE	3	0	0	3	40	60	100
15	22CSOE08	Neural Networks	OE	3	0	0	3	40	60	100
16	22CSOE09	Soft Computing	OE	3	0	0	3	40	60	100
COURSES OFFERED BY THE DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING										
17	22ECOE01	Fundamentals of Electron Devices	OE	3	0	0	3	40	60	100
18	22ECOE02	Principles of Modern Communication Systems	OE	3	0	0	3	40	60	100
19	22ECOE03	Microcontrollers and its applications	OE	3	0	0	3	40	60	100
20	22ECOE04	Computer Networks	OE	3	0	0	3	40	60	100
21	22ECOE05	Basics of Embedded Systems	OE	3	0	0	3	40	60	100
22	22ECOE06	Basics of Internet of Things	OE	3	0	0	3	40	60	100
23	22ECOE07	Artificial Intelligence and Machine Learning	OE	3	0	0	3	40	60	100
COURSES OFFERED BY THE DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING										
24	22EEOE04	Renewable Energy Sources	OE	3	0	0	3	40	60	100
25	22EEOE05	Industrial Drives	OE	3	0	0	3	40	60	100
26	22EEOE06	Energy Conservation and Management	OE	3	0	0	3	40	60	100
27	22EEOE07	Electric Vehicles	OE	3	0	0	3	40	60	100

COURSES OFFERED BY THE DEPARTMENT OF MECHANICAL ENGINEERING										
28	22MEOE01	Design of Machine Elements and Machining	OE	3	0	0	3	40	60	100
29	22MEOE02	Industrial Engineering	OE	3	0	0	3	40	60	100
30	22MEOE03	Industrial Robotics	OE	3	0	0	3	40	60	100
31	22MEOE04	Power plant Engineering	OE	3	0	0	3	40	60	100
32	22MEOE05	Principles of Management	OE	3	0	0	3	40	60	100
33	22MEOE06	Professional Ethics in Engineering	OE	3	0	0	3	40	60	100
34	22MEOE07	Renewable Sources of Energy	OE	3	0	0	3	40	60	100
35	22MEOE08	Robotic Process Automation	OE	3	0	0	3	40	60	100
36	22MEOE09	Total Quality Management	OE	3	0	0	3	40	60	100
COURSES OFFERED BY THE DEPARTMENT OF METALLURGICAL ENGINEERING										
37	22MTOE01	Foundry and Welding Technology	OE	3	0	0	3	40	60	100
38	22MTOE02	Surface Engineering	OE	3	0	0	3	40	60	100
39	22MTOE03	Design and Selection of Materials	OE	3	0	0	3	40	60	100
40	22MTOE04	Nano Science and Technology	OE	3	0	0	3	40	60	100
41	22MTOE05	Materials for Automobile Components	OE	3	0	0	3	40	60	100

B.E – HONOURS

PROFESSIONAL ELECTIVE COURSES – VERTICALS

A student can also optionally register for additional courses (18 credits) and become eligible for the award of B.E. / B.Tech. (Honours) or Minor Degree. For B.E. / B. Tech. (Honours). A student shall register for the additional courses (18 credits) from semester V onwards. These courses shall be from the same vertical or a combination of different verticals of the same programme of study only. For minor degree, a student shall register for the additional courses (18 credits) from semester V onwards. All these courses have to be in a particular vertical from any one of the other programmes.

Vertical - I	**Vertical - II**	**Vertical - III**
Clean and Green Energy Technologies	**Computational Engineering**	**Product and Process Development**
22MEH101 Hydrogen and Fuel Cell Technologies	22MEH201 Numerical methods in Mechanical Engineering	22MEH301 Precision Engineering
22MEH102 Thermal Management of Electric Vehicle Battery Systems	22MEH202 Advanced Fluid Mechanics	22MEH302 Advanced Materials Technology
22MEH103 Electric and Hybrid Vehicle Technology	22MEH203 Fundamentals of Bio-Mechanics	22MEH303 Additive Manufacturing
22MEH104 Alternate Fuels for IC Engines	22MEH204 Introduction to Machine Learning	22MEH304 Non Destructive Testing and Failure Analysis
22MEH105 Advanced Energy Storage Technologies	22MEH205 Design Optimization and Design Theory	22MEH305 Product Life Cycle Management
22MEH106 Solar Power Plants	22MEH206 Advanced Finite Element Methods	22MEH306 Ergonomics in Design
22MEH107 Materials for Solar Devices	22MEH207 Advanced Computational Fluid Dynamics	22MEH307 Surface Engineering
22MEH108 Design of Solar and Wind Systems	22MEH208 Smart Materials and Structures	22MEH308 Industrial Layout Design and Safety
22MEH109 Fire Engineering and Explosion Control	22MEH209 Design of Pressure vessels	22MEH309 Digital Manufacturing and IOT
22MEH110 Energy Management and Environmental Benefits	22MEH210 Mechanical Vibrations	22MEH310 Smart Mobility and Intelligent vehicles

PROFESSIONAL ELECTIVE COURSES – VERTICALS

VERTICAL I - CLEAN AND GREEN ENERGY TECHNOLOGIES

S. No.	Code No.	Course Title	Hours/Week				Maximum Marks		
			L	T	P	C	CA	FE	Total
1.	22MEH101	Hydrogen and Fuel Cell Technologies	3	0	0	3	40	60	100
2.	22MEH102	Thermal Management of Electric Vehicle Battery Systems	3	0	0	3	40	60	100
3.	22MEH103	Electric and Hybrid Vehicle Technology	3	0	0	3	40	60	100
4.	22MEH104	Alternate Fuels for IC Engines	3	0	0	3	40	60	100
5.	22MEH105	Advanced Energy Storage Technologies	3	0	0	3	40	60	100
6.	22MEH106	Solar Power Plants	3	0	0	3	40	60	100
7.	22MEH107	Materials for Solar Devices	3	0	0	3	40	60	100
8.	22MEH108	Design of Solar and Wind Systems	3	0	0	3	40	60	100
9.	22MEH109	Fire Engineering and Explosion Control	3	0	0	3	40	60	100
10.	22MEH110	Energy Management and Environmental Benefits	3	0	0	3	40	60	100

VERTICAL II - COMPUTATIONAL ENGINEERING

S. No.	Code No.	Course Title	Hours/Week				Maximum Marks		
			L	T	P	C	CA	FE	Total
1.	22MEH201	Numerical methods in Mechanical Engineering	3	0	0	3	40	60	100
2.	22MEH202	Advanced Fluid Mechanics	3	0	0	3	40	60	100
3.	22MEH203	Fundamentals of Bio-Mechanics	3	0	0	3	40	60	100
4.	22MEH204	Introduction to Machine Learning	3	0	0	3	40	60	100
5.	22MEH205	Design Optimization and Design Theory	3	0	0	3	40	60	100
6.	22MEH206	Advanced Finite Element Methods	3	0	0	3	40	60	100
7.	22MEH207	Advanced Computational Fluid Dynamics	3	0	0	3	40	60	100
8.	22MEH208	Smart Materials and Structures	3	0	0	3	40	60	100
9.	22MEH209	Design of Pressure vessels	3	0	0	3	40	60	100
10.	22MEH210	Mechanical Vibrations	3	0	0	3	40	60	100

VERTICAL III - PRODUCT AND PROCESS DEVELOPMENT

S. No.	Code No.	Course Title	Hours/Week				Maximum Marks		
			L	T	P	C	CA	FE	Total
1.	22MEH301	Precision Engineering	3	0	0	3	40	60	100
2.	22MEH302	Advanced Materials Technology	3	0	0	3	40	60	100
3.	22MEH303	Additive Manufacturing	3	0	0	3	40	60	100
4.	22MEH304	Non Destructive Testing and Failure Analysis	3	0	0	3	40	60	100
5.	22MEH305	Product Life Cycle Management	3	0	0	3	40	60	100
6.	22MEH306	Ergonomics in Design	3	0	0	3	40	60	100
7.	22MEH307	Surface Engineering	3	0	0	3	40	60	100
8.	22MEH308	Industrial Layout Design and Safety	3	0	0	3	40	60	100
9.	22MEH309	Digital Manufacturing and IOT	3	0	0	3	40	60	100
10.	22MEH310	Smart Mobility and Intelligent vehicles	3	0	0	3	40	60	100

DEPARTMENT OF MECHANICAL ENGINEERING

MINOR DEGREE COURSES - VERTICALS

S. No.	Code No.	Course Title	Hours/Week				Maximum Marks		
			L	T	P	C	CA	FE	Total
1.	22MEM01	Engineering Thermodynamics	3	0	0	3	40	60	100
2.	22MEM02	Fluid Mechanics and Machinery	3	0	0	3	40	60	100
3.	22MEM03	Manufacturing Processes	3	0	0	3	40	60	100
4.	22MEM04	Materials Engineering	3	0	0	3	40	60	100
5.	22MEM05	Kinematics of Machinery	3	0	0	3	40	60	100
6.	22MEM06	Hydraulics and Pneumatics	3	0	0	3	40	60	100
7.	22MEM07	Design of Machine Elements	3	0	0	3	40	60	100
8.	22MEM08	Heat and Mass Transfer	3	0	0	3	40	60	100
9.	22MEM09	Metrology and Quality Control	3	0	0	3	40	60	100
10.	22MEM10	Dynamics of Machinery	3	0	0	3	40	60	100

B.E MECHANICAL ENGINEERING - FULL TIME

REGULATION 2022 – SYLLABUS

SEMESTER-I

<table>
<tr><td>22MC101</td><td colspan="2">INDUCTION PROGRAM</td><td colspan="4">SEMESTER I</td></tr>
<tr><td colspan="2">PRE-REQUISITE</td><td>Category</td><td>MC</td><td colspan="2">Credit</td><td>0</td></tr>
<tr><td colspan="2" rowspan="2"></td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td colspan="7">INDUCTION PROGRAM (MANDATORY) - 3 WEEKS DURATION</td></tr>
<tr><td colspan="7">LIST OF EXPERIMENTS
• Physical activity.
• Creative Arts.
• Universal Human Values.
• Literary.
• Proficiency Modules.
• Lectures by Eminent People.
• Visits to local Areas.
• Familiarization to Dept./Branch & Innovations.</td></tr>
<tr><td colspan="7">Total = 21Days</td></tr>
<tr><td colspan="7"></td></tr>
</table>

22MA101	MATRICES, CALCULUS AND ORDINARY DIFFERENTIAL EQUATION	SEMESTER I

PRE-REQUISITE:	Category	BS	Credit		4
Basic 12th level Matrices, Differential Calculus, Integral Calculus and ODE.	Hours/Week	L	T	P	TH
		3	1	0	4

Course Objectives:

1.	To know the use of matrix algebra needed by engineers for practical applications.
2.	To understand effectively both the limit definition and rules of differentiation.
3.	To familiarize in solving maxima and minima problems in two variables.
4.	To obtain the knowledge of multiple integrations and their related applications.
5.	To obtain the knowledge to solve second order differential equations with constant and variable coefficients

Unit I	MATRICES	9	3	0	12

System of linear equations – Characteristic equation of a Matrix – Eigen values and Eigen vectors – Properties – Cayley-Hamilton theorem (excluding proof) – Diagonalization of Matrices - Reduction of quadratic form to canonical form by orthogonal transformation.

Unit II	DIFFERENTIAL CALCULUS	9	3	0	12

Representation of functions - Limit of a function - Continuity - Derivatives - Differentiation rules - Maxima and Minima of the function of a single variable.

Unit III	FUNCTIONS OF SEVERAL VARIABLES	9	3	0	12

Partial derivatives – Euler's theorem for homogenous functions – Total Derivatives -Jacobians – Maxima, Minima and Saddle point- – Method of Lagrangian multipliers- Taylor's series.

Unit IV	MULTIPLE INTEGRALS	9	3	0	12

Multiple integrals- Double integrals – Change of order of integration in double integrals – Change of variables (Cartesian to Polar) – Application to Areas – Evaluation of Triple integrals – Application to volumes.

Unit V	ORDINARY DIFFERENTIAL EQUATIONS	9	3	0	12

Second-order linear differential equations with constant and variable coefficients –Cauchy-Euler equation and Cauchy-Legendre's linear equation - Method of variation of parameters –Simultaneous first order linear equations with constant coefficients.

Total (45L+15T) = 60 Periods

Text Books:

1.	Grewal. B.S, "Higher Engineering Mathematics", 43rd Edition, KhannaPublications, Delhi, 2015.
2.	Jain R.K. and Iyengar S.R.K., "Advanced Engineering Mathematics", 3rd Edition, Narosa Publications, New Delhi, 2007.

Reference Books:

1.	James Stewart, "Essential Calculus", 2nd Edition Cengage Learning, New Delhi, 2014.
2.	P. Kandasamy, K. Thilagavathy and K. Gunavathy," Engineering Mathematics (For I year B.E., B. Tech)", 9th Edition, S. Chand & Co. Ltd. New Delhi, 2010.
3.	Srimanta pal and Subath.C. Bhumia, "Engineering Mathematics", Oxford university publications, New Delhi, 2015
4.	Ewinkreyzig, "Advanced Engineering Mathematics", 9th edition, John Wiley & Sons, 2007.
5.	Siva RamakrishnaDas.P, Ruknmangadachari.E. "Engineering Mathematics", 2nd edition, Pearson, Chennai & Delhi, , 2013.

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Learn the fundamental knowledge of Matrix theory.	Understand
CO2	Use both the limit definition and rules of differentiation to differentiable functions.	Apply
CO3	Apply differentiation to solve maxima and minima problems.	Apply
CO4	Apply integration to compute multiple integrals, area, volume, integrals in polar coordinates, in addition to a change of order and change of variables.	Apply
CO5	Apply various techniques in solving differential equations.	Apply

COURSE ARTICULATION MATRIX

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

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22CY101	ENGINEERING CHEMISTRY		SEMESTER I			
PRE-REQUISITE:		**Category**	**BS**	**Credit**		**4**
Basic Chemistry		**Hours/Week**	**L**	**T**	**P**	**C**
			3	**1**	**0**	**4**

Course Objectives:

1. Basic Principles of Spectroscopy and their applications.
2. Knowledge of different methods for water analysis and purification & Nanomaterial and its application.
3. Various adsorption technics and basic knowledge of Phase equilibria.
4. Principles of electrochemistry, electrochemical cells, corrosion, and its control.
5. Basis of polymer preparations and applications and enhancement of the quantity and quality of fuels.

Unit I	SPECTROSCOPIC TECHNIQUES	9	3	0	12

Beer-Lambert's law (problem) -UV visible spectroscopy: Principle, Chromophores, auxochrome, electronic transitions and instrumentation (No applications). IR spectroscopy: Principles -instrumentation and applications of IR in H_2O, and CO_2.

Flame photometry -principle -instrumentation -estimation of sodium by flame photometer. Atomic absorption spectroscopy - principles -instrumentation -estimation of nickel by atomic absorption spectroscopy.

Unit II	WATER TECHNOLOGY AND NANO TECHNOLOGY	9	3	0	12

Hardness of water – types – expression of hardness – units – estimation of hardness of water by EDTA – boiler troubles (scale and sludge) – treatment of boiler feed water – Internal treatment (phosphate, colloidal, sodium aluminate and calgon conditioning) external treatment – Ion exchange process, zeolite process – desalination of brackish water – Reverse Osmosis.

Nano chemistry – preparations and properties of nanomaterials – nanorods – nanowires – nanotubes – carbon nano tubes and their application.

Unit III	SURFACE CHEMISTRY AND PHASE EQUILIBRIA	9	3	0	12

Adsorption: Types of adsorption – adsorption of gases on solids – adsorption of solute from solutions – adsorption isotherms – Freundlich‘s adsorption isotherm – Langmuir‘s adsorption isotherm.

Phase rule: Introduction, definition of terms with examples, one component system -water system – reduced phase rule – thermal analysis and cooling curves – two component systems – lead-silver system – Pattinson process.

Unit IV	ELECTROCHEMISTRY	9	3	0	12

Electrode Potential- Oxidation and Reduction Potentials - Electrochemical series – Significance and application - Electrochemical cell, Cell potential, derivation of Nernst equation for single electrode potential, numerical problems on E, E_0, and E_{cell} - numerical problems. Electrochemical theory of corrosion with respect to iron. Factors influencing the corrosion rate: physical state of the metal, nature of the metal, area effect, over voltage, pH, temperature, and nature of the corrosion product. Types of corrosion: galvanic series; (i) Differential aeration corrosion- oxygen concentration cell, (ii) Stress corrosion-explanation-caustic embrittlement. Corrosion control by i) Cathodic protection- sacrificial anode and impressed current methods i) Protective coatings-metal coatings- galvanizing and tinning.

Unit V	POLYMERS AND FUELS	9	3	0	12

Polymers – definition – polymerization – types – addition and condensation polymerization – free radical polymerization mechanism – plastics, classification – preparation, properties and uses of PVC, Teflon, polycarbonate, polyurethane, nylon-6,6, PET – Rubber- vulcanization of rubber, synthetic rubbers – butyl rubber, SBR – biopolymers – Nylon-2-Nylon-6 and PHBV

Fuels - classification with examples, calorific value-classification (HCV & LCV), and determination of calorific value of solid and liquid fuels using Bomb calorimeter- Petroleum cracking -fluidized bed catalytic cracking. Knocking in IC engine, its ill effects and prevention of knocking. Anti-knocking agent: Leaded and unleaded petrol.

Total (45L+15T) = 60 Periods

Text Books:	
1.	S. S. Dara and S. S. Umare, ―A Textbook of Engineering Chemistry | S. Chand & Company LTD, New Delhi, 2015
2.	P. C. Jain and Monika Jain, ―Engineering Chemistry | Dhanpat Rai Publishing Company (P) LTD, New Delhi, 2015
3.	S. Vairam, P. Kalyani and Suba Ramesh, ―Engineering Chemistry | Wiley India PVT, LTD, New Delhi, 2013.
Reference Books:	
1.	Friedrich Emich, ―Engineering Chemistry | Scientific International PVT, LTD, New Delhi, 2014.
2.	PrasantaRath, ―Engineering Chemistry | Cengage Learning India PVT, LTD, Delhi, 2015.
3.	ShikhaAgarwal, ― Engineering Chemistry-Fundamentals and Applications Cambridge University Press, Delhi, 2015.
E-References:	
1	www.onlinecourses.nptel.ac.in/
2	www.ePathshala.nic.in

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Recall the basic principles of spectroscopy and their applications	Remember
CO2	Paraphrase the different methods for water analysis & purification and Nanomaterial & its applications	Understand
CO3	Apply the various adsorption technics and basic knowledge of Phase equilibria	Apply
CO4	Integrate the principles of electrochemistry, electrochemical cells, corrosion, and its control	Create
CO5	Assess the basis of polymer preparations & applications and enhancement of the quantity & quality of fuels.	Evaluate

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	0	3	0	0	0	0	0	0	0	0	3	1	1
CO2	3	2	0	1	0	2	0	0	0	0	0	0	3	1	1
CO3	3	1	0	1	0	0	0	0	0	0	0	0	2	1	1
CO4	2	1	0	1	0	2	0	0	0	0	0	0	2	3	2
CO5	3	2	0	3	0	2	0	0	0	0	0	0	1	1	1
Avg	**2.8**	**1.8**	**0**	**1.8**	**0**	**1.2**	**0**	**0**	**0**	**0**	**0**	**0**	**2.2**	**1.4**	**1.2**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22EE101	BASIC ELECTRICAL AND ELECTRONICS ENGINEERING	SEMESTER I			
PRE-REQUISITE	Category	ES	Credit		4
	Hours/Week	L	T	P	C
		3	1	0	4

Course Objectives:

1.	To understand and analyze basic electric circuits.
2.	To study working principle of electrical machines and transformer.
3.	To study basics of electronic devices and operational amplifier.
4.	To understand the concepts of electrical installations.

UNIT I	DC CIRCUITS	9	3	0	12

Electrical circuit elements (R, L and C) - Voltage and current sources - Ohm's law and Kirchoff's laws- Series and parallel circuits - Analysis of simple electrical circuits with DC excitation using fundamental laws – Superposition theorem, Thevenin's and Norton's theorems.

UNIT II	AC CIRCUITS	9	3	0	12

Introduction to single phase AC circuits - Representation of sinusoidal waveforms, peak and RMS values, phasor representation- Analysis of single-phase ac circuits consisting of RL, RC, RLC combinations (series and parallel), real power, reactive power, apparent power, power factor. Three phase AC circuits, voltage and current relations in star and delta connections.

UNIT III	ELECTRICAL MACHINES AND TRANSFORMERS	9	3	0	12

DC Motor: Construction, operation, types and applications, Speed control of DC shunt motor - Construction and working of three-phase induction motors - Working of single-phase induction motor and its applications – Transformers: Ideal and practical transformer, Construction and working, losses and efficiency in transformers, Introduction to Three phase transformers

UNIT IV	BASICS ELECTRONICS SYSTEM	9	3	0	12

Introduction - Basic structure of semiconductors devices- PN junction diode, Zener diode and V-I characteristics- BJT – CE, CB, CC configuration and working principle. Operational Amplifier-principle of operation, Characteristics, Applications- Inverting Amplifier, Non inverting Amplifier, summing amplifier and differential amplifier.

UNIT V	ELECTRICAL INSTALLATIONS	9	3	0	12

Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB - Types of wires and cables – Earthing - Basics of house wiring tools and components, types of house wiring – Batteries: Principle Characteristics-Types and its applications - Introduction to UPS and SMPS.

Total (45L+15T) = 60 Periods

Text Books:

1.	Muthu Subramaniyam, R., Salivaganan, R., and Muralidharan, K. A., "Basic Electrical and Electronics Engineering", Second Edition, Tata McGraw Hill, 2010.
2.	Kothari, D. P., and Nagrath, I. J., "Basic Electrical Engineering", Tata McGraw Hill, 2010.
3.	Kulshreshtha, D.C., "Basic Electrical Engineering", Tata McGraw Hill, 2009.

Reference Books:

1.	Bobrow, L. S., "Fundamentals of Electrical Engineering", Oxford University Press, 2011.
2.	Hughes, E., "Electrical and Electronics Technology", Pearson, 2010.

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Analyze the DC circuits using fundamental laws and theorems.	Analyze
CO2	Analyze the single and three phase AC circuits.	Analyze
CO3	Recognize the working principle of electrical machines and transformers.	Understand
CO4	Recognize the fundamentals and characteristics of diode, BJT and operational amplifier.	Understand
CO5	Demonstrate the concept of electrical installations.	Apply

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	0	0	0	0	0	0	0	0	1	1	**0**	0	0
CO2	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0
CO3	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0
CO4	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0
CO5	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Avg	**1**	**0.4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**
3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)															

22ME101	ENGINEERING GRAPHICS AND DESIGN		SEMESTER I			
PRE-REQUISITE:		**Category**	**ES**	**Credit**		**3**
1. Students should know about the basics of drawings. 2. Students should be able to construct geometric shapes.		**Hours/Week**	**L**	**T**	**P**	**TH**
			1	**0**	**4**	**5**

Course Objectives:

1.	To impart knowledge on graphical skills for communications of concepts, ideas and design of engineering products and to provide exposure to design.
2.	To expose them to existing national standards related to technical drawings.
3.	To understand the basics of points, lines, planes and solids.
4.	To understand the basics of the surface of object.
5.	To expose them to isometric and perspective views of simple solids.

UNIT I	PROJECTION OF POINTS, LINES AND PLANE SURFACES	3	0	12	15

General principles of orthographic projection- Projection of points, located in all quadrants – Projection of straight lines located in the first quadrant – Determination of true lengths and true inclinations – Projection of polygonal surface and circular lamina inclined to both reference planes.

UNIT II	PROJECTION OF SOLIDS	3	0	12	15

Projection of simple solids like prisms, pyramids, cylinder and cone when the axis is perpendicular to one reference plane and also inclined to one reference plane by change of position method.

UNIT III	SECTION OF SOLIDS AND DEVELOPMENT OF SURFACES	3	0	12	15

Sectioning of above solids in a simple vertical position by cutting planes inclined to one reference plane and perpendicular to other – solids inclined position with cutting planes parallel to one reference plane- Obtaining true shape of the section.

Development of lateral surfaces of simple and truncated solids – Prisms, pyramids cylinders and cones- Development of lateral surfaces of solids with square and cylindrical cutouts, perpendicular to the axis.

UNIT IV	ORTHOGRAPHIC AND ISOMETRIC PROJECTION	3	0	12	15

Orthographic Projection - Visualization concepts and Freehand sketching - Visualization principles - Representation of three-dimensional objects - Layout of views - Freehand sketching of multiple views from pictorial views of object.

Principles of isometric projection – isometric scale - isometric projections of simple solids, truncated prisms, pyramids, cylinders and cones.

UNIT V	PERSPECTIVE PROJECTION	3	0	12	15

Perspective projection of prisms, pyramids and cylinders by visual ray and vanishing point methods.

Total (15L+60P) = 75 Periods

Text Books:

1.	Bhatt, N.D.,Panchal V M and Pramod R. Ingle, “Engineering Drawing”, Charotar Publishing House, 53rd Edition, 2014.
2.	Parthasarathy, N. S. and Vela Murali, “Engineering Drawing”, Oxford University Press, 2015

Reference Books:

1.	Agrawal, B. and Agrawal C.M., “Engineering Drawing”, Tata McGraw, N.Delhi, 2008.
2.	Gopalakrishna, K. R., “Engineering Drawing”,Subhas Stores, Bangalore, 2007.
3.	Natarajan, K. V., “A text book of Engineering Graphics”, 28thEd.,Dhanalakshmi Publishers, Chennai, 2015.
4.	Shah, M. B., and Rana, B. C., “Engineering Drawing”, Pearson, 2ndEd., 2009.
5.	Venugopal, K. and Prabhu Raja, V., “Engineering Graphics”, New Age,2008.

E-References:	
1.	https://nptel.ac.in/courses/112102304
2.	https://home.iitk.ac.in/~anupams/ME251/EDP.pdf
3.	https://static.sdcpublications.com/pdfsample/978-1-58503-610-3-1.pdf

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Familiarize with the fundamentals and standards of engineering graphics.	Understand
CO2	Ability to understand the fundamental concepts of projection of points, lines and planes.	Analyze
CO3	Project the solids and section of solids.	Analyze
CO4	Familiarize and develop the lateral surfaces of solids	Analyze
CO5	Visualize and project the orthographic, isometric and perspective sections of simple solids.	Analyze

COURSE ARTICULATION MATRIX

CO/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	0	0	0	0	0	0	0	0	0	0	3	1	0
CO2	3	1	0	0	0	0	0	0	0	0	0	0	3	1	0
CO3	3	1	0	0	0	0	0	0	0	0	0	0	3	1	0
CO4	3	1	0	0	0	0	0	0	0	0	0	0	3	1	0
CO5	3	1	0	0	0	0	0	0	0	0	0	0	3	1	0
Avg	**3**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**1**	**0**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22CS101	PROBLEM SOLVING AND C PROGRAMMING		SEMESTER I			
PRE-REQUISITE		Category	ES	Credit		3
		Hours/Week	L	T	P	C
			3	0	0	3

Course Objectives:

1.	To use general problem-solving techniques to device solutions to problems
2.	To understand the input-output relations of software involved in developing and converting a C program to an executable code.
3.	To provide complete knowledge about the programming concepts of C language.

UNIT I	SYSTEM SOFTWARE, PROBLEM SOLVING, AND C PROGRAMMING	9	0	0	9

High level programming language – Machine level language – role of system software (Editor, Compiler, Assembler, Linker, Loader, and Operating System) in developing and executing a C program

C Programming: Character set – Case sensitivity – Identifiers – Keywords –Literals – Data types – Declaration statement- Variables and their associated information – Formed and unformed console input-output statements – Type conversion – Operators – Precedence and Associativity – Pre-processor directives (#include and #define) – the main ( ) function

General problem-solving Techniques: Algorithm – Flow-chart – Pseudocode – Developing solution for problems involving only operators and writing their equivalent C programs.

UNIT II	CONTROL STATEMENTS	9	0	0	9

General problem-solving Techniques: Representing Decision making: if-else statement – switch-case statement – Looping statement: for loop, while loop and do-while loop – Branching statements: break and continue with Algorithm, Flow-chart, and Pseudocode

C programming: Decision Making: if-else statement – switch case statement - Looping statement: for loop, while loop and do-while loop – Branching statements: break and continue – Nesting

Developing solutions for problems involving control statements using General problem-solving techniques and their equivalent C programs

UNIT III	ARRAYS, POINTERS, AND STRINGS	9	0	0	9

One-dimensional and two-dimensional Arrays: Declaration– Initialization – Processing – Pointers:Declaration– Initialization - Processing – relation between pointers and arrays – Strings – String operation – C Library support for string handling

Developing solutions for problems involving arrays, pointers and strings using General problem-solving Techniques and their equivalent C programs.

UNIT IV	FUNCTIONS	9	0	0	9

Function – Library functions and user-defined functions – Function prototypes and function definitions – Parameter passing mechanisms – Recursion – Storage classes – Working with multiple source files

Developing solutions for problems involving functions using General problem-solving techniques and their equivalent C programs.

UNIT V	STRUCTURES, UNIONS AND FILE	9	0	0	9

Structure: declaration – definition - Structure within a structure – Passing structures to functions – Array of structures – Pointers to structures-Union - File operation: reading and writing/appending to binary and text files.

Total = 45 Periods

Text Books:	
1.	Balagurusamy E, “Programming in ANSI C”, Tata McGraw-Hill, 8th Edition, 2022.
2.	Yashvant P. Kanetkar, “Let Us C”, BPB Publications, 2016.
Reference Books:	
1.	Venugopal, “Mastering C”, Second Edition”, Tata McGraw-Hill. 2006
2.	R. G. Dromey, “How to solve it by computers”, Prentice Hall, 2007
3.	Greg Perry and Dean Miller, “C Programming Absolute Beginner’s Guide”, Third Edition, Que Publishing, 20123
4.	Brain W.Kernighan and Ritchie Dennis, “The C Programming Language”, Second Edition, Pearson, 1988.
E- Reference:	
1.	https://www.learn-c.org/
2.	https://www.programiz.com/c-programming

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom’s Taxonomy Mapped**
CO1	Explain the concepts of C Programming and roles of system software in programming	Remember & Understand
CO2	Use general problem-solving techniques to develop solution to problems	Apply
CO3	Apply the concepts of C Programming to develop solutions by writing C programs	Apply& Analyze

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	1	3	0	0	0	0	0	0	0	0	3	1	0	0
CO2	2	1	3	0	2	0	0	0	0	0	0	3	2	0	0
CO3	2	1	3	0	2	0	0	0	0	0	0	3	3	0	0
Avg	**2**	**1**	**3**	**0**	**1.3**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**2**	**0**	**0**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22MC102	தமிழர்மரபு	Semester I			
PREREQUISITES	Category	HSMC	Credit		1
Basics of Tamil	Hours/Week	L	T	P	TH
		1	0	0	1

அலகு I	மொழி மற்றும் இலக்கியம்	3	0	0	3

இந்திய மொழிக் குடும்பங்கள் – திராவிட மொழிகள் – தமிழ் ஒரு செம்மொழி – தமிழ் செவ்விலக்கியங்கள் – சங்க இலக்கியத்தின் சமயச்சார்பற்றதன்மை – சங்கஇலக்கியத்தில்பகிர்தல்அறம் – திருக்குறளில்மேலாண்மைக்கருத்துக்கள் – தமிழ்க்காப்பியங்கள், தமிழகத்தில்சமணபௌத்தசமயங்களின்தாக்கம்–பக்திஇலக்கியம், ஆழ்வார்கள்மற்றும்நாயன்மார்கள் – சிற்றிலக்கியங்கள் – தமிழில்நவீனஇலக்கியத்தின்வளர்ச்சி – தமிழ்இலக்கியவளர்ச்சியில்பாரதியார்மற்றும்பாரதிதாசன்ஆகியோரின்பங்களிப்பு.

அலகு II	மரபு – பாறைஓவியங்கள்முதல்நவீன ஓவியங்கள் வரைசிற்பக்கலை	3	0	0	3

நடுகல்முதல்நவீனசிற்பங்கள்வரை – ஐம்பொன்சிலைகள் – பழங்குடியினர்மற்றும்தயாரிக்கும்கைவினைப்பொருட்கள், பொம்மைகள் – தேர்செய்யும்கலை – சுடுமண்சிற்பங்கள் – நாட்டுப்புறத்தெய்வங்கள்- குமரிமுனையில்திருவள்ளுவர்சிலை- இசைக்கருவிகள் – மிருதங்கம், பறை, வீணை, யாழ், நாதஸ்வரம் – தமிழர்களின்சமூகபொருளாதாரவாழ்வில்கோவில்களின்பங்கு.

அலகு III	நாட்டுப்புறக்கலைகள்மற்றும்வீரவிளையாட்டுகள்	3	0	0	3

தெருக்கூத்து, கரகாட்டம், வில்லுப்பாட்டு, கணியான்கூத்து, ஒயிலாட்டம், தோல்பாவைக்கூத்து, சிலம்பாட்டம், வளரி, புலியாட்டம், தமிழர்களின்விளையாட்டுகள்.

அலகு IV	தமிழர்களின்திணைக்கோட்பாடுகள்	3	0	0	3

தமிழகத்தின்தாவரங்களும், விலங்குகளும் – தொல்காப்பியம்மற்றும்சங்கஇலக்கியத்தில்அகம்மற்றும்புறக்கோட்பாடுகள் – தமிழர்கள்போற்றியஅறக்கோட்பாடு – சங்ககாலத்தில்தமிழகத்தில்எழுத்தறிவும், கல்வியும் – சங்ககாலநகரங்களும்துறைமுகங்களும் – சங்ககாலத்தில்ஏற்றுமதிமற்றும்இறக்குமதி – கடல்கடந்தநாடுகளில்சோழர்களின்வெற்றி.

அலகு V	இந்தியதேசியஇயக்கம்மற்றும்இந்தியபண்பாட்டிற்குத்தமிழர்களின்பங்களிப்பு	3	0	0	3

இந்தியவிடுதலைப்போரில்தமிழர்களின்பங்கு – இந்தியாவின்பிறப்பகுதிகளில்தமிழ்ப்பண்பாட்டின்தாக்கம் – சுயமரியாதைஇயக்கம் – இந்தியமருத்துவத்தில், சித்தமருத்துவத்தின்பங்கு – கல்வெட்டுகள், கையெழுத்துப்படிகள் – தமிழ்ப்புத்தகங்களின்அச்சுவரலாறு.

Total= 15 Periods

Text Books / Reference Books:

1. தமிழகவரலாறு – மக்களும்பண்பாடும் – கே. கே. பிள்ளை (வெளியீடு :தமிழ்நாடுபாடநூல்மற்றும்கல்வியியல்பணிகள்கழகம்.
2. கணினித்தமிழ் – முனைவர்இல.சுந்தரம்.(விகடன்பிரசுரம்)

3	கீழடி – வைகைநதிக்கரையில்சங்ககாலநகரநாகரிகம்(தொல்லியல்துறைவெளியீடு)
4	பொருநை – ஆற்றங்கரைநாகரிகம்(தொல்லியல்துறைவெளியீடு)

22MC102	HERITAGE OF TAMILS		Semester I			
PREREQUISITES		Category	BS	Credit		1
Basics of Tamil		Hours/Week	L	T	P	TH
			1	0	0	1
Unit I	LANGUAGE AND LITERATURE		3	0	0	3
3 Language Families in India - Dravidian Languages – Tamil as a Classical Language - Classical Literature in Tamil – Secular Nature of Sangam Literature – Distributive Justice in Sangam Literature - Management Principles in Thirukural - Tamil Epics and Impact of Buddhism & Jainism in Tamil Land - Bakthi Literature Azhwars and Nayanmars - Forms of minor Poetry - Development of Modern literature in Tamil - Contribution of Bharathiyar and Bharathidhasan.						
Unit II	HERITAGE - ROCK ART PAINTINGS TO MODERN ART – SCULPTURE		3	0	0	3
Hero stone to modern sculpture - Bronze icons - Tribes and their handicrafts - Art of temple car making - - Massive Terracotta sculptures, Village deities, Thiruvalluvar Statue at Kanyakumari, Making of musical instruments - Mridhangam, Parai, Veenai, Yazh and Nadhaswaram - Role of Temples in Social and Economic Life of Tamils.						
Unit III	FOLK AND MARTIAL ARTS		3	0	0	3
Therukoothu, Karagattam, VilluPattu, KaniyanKoothu, Oyillattam, Leather puppetry, Silambattam, Valari, Tiger dance - Sports and Games of Tamils.						
Unit IV	THINAI CONCEPT OF TAMILS		3	0	0	3
Flora and Fauna of Tamils & Aham and Puram Concept from Tholkappiyam and Sangam Literature - Aram Concept of Tamils - Education and Literacy during Sangam Age - Ancient Cities and Ports of Sangam Age - Export and Import during Sangam Age - Overseas Conquest of Cholas.						
Unit V	CONTRIBUTION OF TAMILS TO INDIAN NATIONAL MOVEMENT AND INDIAN CULTURE		3	0	0	3
Contribution of Tamils to Indian Freedom Struggle - The Cultural Influence of Tamils over the other parts of India – Self-Respect Movement - Role of Siddha Medicine in Indigenous Systems of Medicine – Inscriptions & Manuscripts – Print History of Tamil Books.						
						Total = 15 Periods

Text Books:	
1	Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
2	Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
3	Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
4	The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies)

5	Keeladi - 'Sangam City Civilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology&TamilNadu Text Book and Educational Services Corporation, Tamil Nadu)
6	Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published by: The Author)
7	Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
8	Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL)

22EN102	PROFESSIONAL SKILLS LABORATORY		SEMESTER I			
PRE-REQUISITE		**Category**	**HS**	**Credit**		**1**
Basic language skills listening, speaking, reading and writing		**Hours/Week**	**L**	**T**	**P**	**TH**
			0	**0**	**2**	**2**

Course Objectives:

1.	To enable learners to improve their reading skills
2.	To make learners show variations while reading
3.	To assist learners to acquire speaking competency in English
4.	To enable learners to strengthen their fluency in speaking

UNIT I	**0**	**0**	**6**	**6**
Reading – Reading a short story – learning pronunciation, intonation, and splitting of sentences to form meaningful units. Speaking – Narrating a story without any help of handouts.				
UNIT II	**0**	**0**	**6**	**6**
Reading – Reading a poem – learning the skill of reciting, appreciate rhyme and music, change in tone as per the emotion of the poem. Speaking – Power-point presentation on a general topic.				
UNIT III	**0**	**0**	**6**	**6**
Reading – Reading newspaper article – learning vocabulary and language pattern of official communication. Speaking - Oral presentation on a topic from basic engineering pertained to their branch.				
UNIT IV	**0**	**0**	**6**	**6**
Reading – Reading dialogue scripts – learning expression, tone, stress and co-operative reading. Speaking –Proposing welcome address, vote of thanks and organizing events.				
UNIT V	**0**	**0**	**6**	**6**
Reading – Reading technical descriptions of gadgets – learning the different parts of devices. Speaking – Describing a process – everyday technical activities like taking printouts, purchasing equipment for a company, booking a hall for meetings etc.,				
Total = 30 Periods				

Text Books:

1.	Norman Whitby. Business Benchmark – Pre-Intermediate to Intermediate, Students book, Cambridge University Press, 2014.

Reference Books:

1.	Reading Fluency. Switzerland, MDPI AG, 2021.
2.	McJacobs, Wade. Dare to Read: Improving Your Reading Speed and skills. Australia, Friesen Press, 2021
3.	Hoge, A. J. Effortless English: Learn to Speak English Like a Native. United States, Effortless English LLC, 2014.

E-References:

1.	https://www.talkenglish.com/
2.	https://www.readingrockets.org/

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Read passages fluently with good pronunciation	Remember
CO2	Develop an expressive style of reading	Create

CO3	Make effective oral presentations in technical and general contexts	Create
CO4	Excel at professional oral communication	Evaluate

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	0	0	0	1	0	0	0	0	2	3	0	1	0	0	1
CO2	0	0	0	1	0	0	0	0	2	3	0	1	0	0	1
CO3	0	0	0	2	0	0	0	0	2	3	0	1	0	0	1
CO4	0	0	0	2	0	0	0	0	2	3	0	1	0	0	3
Avg	**0**	**0**	**0**	**1.5**	**0**	**0**	**0**	**0**	**2**	**3**	**0**	**1**	**0**	**0**	**1.5**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22PH103	PHYSICS LABORATORY	SEMESTER I

PRE-REQUISITE	Category	BS	Credit		1.5
NIL	Hours/Week	L	T	P	TH
		0	0	3	3

Course Objectives:

1.	To handle different measuring instruments.
2.	To understand the basic concepts of interference, diffraction, heat conduction and to measure the important parameters.

LIST OF EXPERIMENTS

1. Newton's rings – Determination of radius of curvature of a Plano convex lens.
2. Carey Foster's bridge – Determination of specific resistance of the material.
3. Poiseuille's flow – Determination of the Coefficient of viscosity of a liquid.
4. Spectrometer – Grating – Normal incidence – Determination of Wavelength of Mercury lines.
5. Lee's disc – Determination of thermal conductivity of a Bad conductor.
6. Ultrasonic interferometer – Determination of velocity of Ultrasonic Waves in Liquid.
7. Non-uniform bending – Determination of young's modulus of the wooden bar.
8. Determination of Band gap of a given semiconductor.
9. Determination of Wavelength of laser using grating and determination of particle size using Laser.
10. Determination of Acceptance angle and Numerical Aperture of fiber.

Total (45P) = 45 Periods

Text Books:

1.	C. S. Robinson, Dr. Ruby Das, 'A Textbook of Engineering Physics Practical', Laxmi Publication Pvt. Ltd., 2016.
2.	S. Panigrahi, 'Engineering Practical Physics', Cengage Learning India, 2015.

Reference Books:

1.	M.N. Srinivasan, 'Text Book of Practical Physics', Sultan Chand & Sons, 2013
2.	Singh Harman, 'B.Sc. Practical Physics', S Chand & Company Ltd, 2022.

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Handle different measuring instruments and to measure different parameters.	Apply
CO2	Calculate the important parameters and to arrive at the final result based on the experimental measurements.	Analyze

COURSE ARTICULATION MATRIX

CO/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	0	3	3	0	0	0	3	1	0	2	1	1	1
CO2	3	2	0	2	1	0	0	0	2	0	0	1	1	1	1
Avg	**3**	**2**	**0**	**2.5**	**2**	**0**	**0**	**0**	**2.5**	**0.5**	**0**	**1.5**	**1**	**1**	**1**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22CY102	CHEMISTRY LABORATORY	SEMESTER I

PRE-REQUISITE	Category	BS	Credit		1.5
	Hours/Week	L	T	P	C
		0	0	3	1.5

Course Objectives:

1. To gain practical knowledge by applying theoretical principles and performing the following experiments.

LIST OF EXPERIMENTS

1. Estimation of hardness of Water by EDTA
2. Estimation of Copper in brass by EDTA
3. Estimation of Alkalinity in water
4. Estimation of Chloride in water sample (Iodimetry)
5. Estimation of Iron content in the given salt by using external indicator
6. Conductometric titration of Strong Acid and Strong Base
7. Conductometric titration of Mixture of acids and Strong base
8. Determination of strength of Iron by Potentiometric method
9. Estimation of Iron by Spectrophotometry
10. Estimation of Copper by Colorimeter
11. Determination of molecular weight and degree of Polymerization by Viscometry
12. Determination of pKa of the given weak acid by pH meter
13. Estimation of the amount of given HCl using pH meter

Total = 45 Periods

E-References:

1. www.scuolab.com/en/chemistry/
2. www.onlinelabs.in/chemistry
3. www.virtuallabs.merlot.org/vl_chemistry

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Summarize the applicability of the practical skill gained in various fields.	Understand
CO2	Calculate the composition of brass quantitatively and the molecular weight of polymers.	Apply
CO3	Understand the principle and applications of conductometric and ph titrations, spectrometer, and potentiometric titrations.	Understand

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	0	3	0	0	0	0	0	0	0	0	2	0	0
CO2	1	2	0	3	0	0	0	0	0	0	0	0	2	0	0
CO3	2	2	0	3	0	0	0	0	0	0	0	0	2	0	0
Avg	**1.3**	**1.7**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22EE102	BASIC ELECTRICAL AND ELECTRONICS ENGINEERING LABORATORY	SEMESTER I

PRE-REQUISITE	Category	ES	Credit		1.5
	Hours/Week	L	T	P	TH
		0	0	3	3

Course Objectives:

1. To impart hands on experience in use of measuring instruments, testing in transformers, and house wiring practices

LIST OF EXPERIMENTS

1. Verification of Kirchhoff's laws.
2. Verification of Superposition theorem.
3. Measurement of three-phase power in three-phase circuits.
4. Determination losses in single phase Transformer.
5. Demonstration of cut-out sections of machines: induction machine (squirrel cage rotor), and single-phase induction motor.
6. Speed control of DC shunt motor.
7. Study of basic safety precautions, measuring instruments – voltmeter, ammeter, multi-meter, and Electrical components.
8. VI Characteristics of PN Junction diode.
9. Staircase wiring.
10. Wiring for fluorescent lamp.

Total (45 P) = 45 Periods

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Analyse DC and AC circuits.	Analyze
CO2	Calculate various losses in transformer.	Analyze
CO3	Recognise the parts of single-phase and three phase induction motors.	Understand
CO4	Demonstrate the characteristics of electron devices.	Understand
CO5	Practice electrical connections by wires of appropriate ratings.	Apply

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0
CO2	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0
CO3	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0
CO4	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0
CO5	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Avg	**1**	**0.4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

SEMESTER-II

22EN101	COMMUNICATIVE ENGLISH		SEMESTER II			
PRE-REQUISITE		**Category**	**HS**	**Credit**		**3**
Basic language skills listening, speaking, reading and writing		**Hours/Week**	**L**	**T**	**P**	**TH**
			2	**0**	**2**	**4**

Course Objectives:

1.	To develop the communicative skills of learners by engaging them in reading, writing and grammar learning activities
2.	To inculcate learners' ability to read texts, summaries, articles and user manuals
3.	To assist learners to acquire writing skills for academic, social and professional purposes
4.	To improve learners' vocabulary and grammar to supplement their language use at different contexts

UNIT I		**6**	**0**	**6**	**12**

Listening – Interview with personal assistant, an interview with a business consultant, describing changes in a company, Describing dimensions of products.

Speaking - Self-introduction, name, home background, study details, area of interest, hobbies, strengths and weaknesses, etc.

Reading - Reading for detailed comprehension, specific information, Understanding notices, messages, timetables, graphs relevant to technical contexts.

Writing – Dialogue writing in a business context.

Grammar - Parts of speech, Tenses, Voices, Common errors in English, Subject-Verb agreement, Noun-Pronoun agreement, Prepositions and Articles.

UNIT II		**6**	**0**	**6**	**12**

Listening – An interview about a production process, Telephone conversations, Making and changing appointments, Description of how a product is advertised.

Speaking - Personal interview, dress code, body language, required skills, corporate culture and mock interview.

Reading - Reading technical texts from journals, newspapers and technical blogs.

Writing - Writing checklists, Recommendations.

Grammar - Prefix and suffix, Synonyms, Antonyms, Verb forms - Auxiliary verbs, Modal verbs, Phrasal verbs, Pronouns, Adverbs and Adjectives.

UNIT III		**6**	**0**	**6**	**12**

Listening - Conversation between two employees, Interview about change in job and corporate gift giving, Creating good teams: a presentation.

Speaking - Role play - examiner and candidate, customer and sales manager, team leader and team member, interviewer and applicant, industrialist and candidate.

Reading - Reading advertisements, gadget reviews, user manuals.

Writing - Providing instruction, Writing E-mails - Attending workshops, Paper submission for seminars and conferences, Arranging and cancelling a meeting.

Grammar - Conditional statements, Redundancies, Collocations and Meanings of individual words.

UNIT IV		**6**	**0**	**6**	**12**

Listening – Working in an international team, Statistical information, Interview with investor relations, Radio interviews.

Speaking – Giving a speech, describing given data, discussing company information, Summarizing an article.

Reading - Reading longer technical texts, cause and effect essays, newspaper articles, company profiles.

Writing - Essay writing on social topics, Technical Report Writing – Status reports on projects, Feasibility reports and event reports on seminars, conferences, meeting.

Grammar - Compound words, Conjunctions, Sentence completion, Negation in statements and questions.

UNIT V		**6**	**0**	**6**	**12**

Listening – An interview with career advisor and recruitment agent, Feedbacks, Meeting extracts.

Speaking – Qualities required for employability, Improving employee productivity, presentation on problem-solving skills, teamwork, creativity and leadership quality.

Reading - Reading brochures, telephone messages, social media messages relevant to technical contexts. Writing - Letter Writing – Formal Letters and Informal Letters - cover letter with resume, Mind maps, Charts - interpreting statistical data, charts, graphs and tables. Grammar - One word substitution, Abbreviations and acronyms in technical contexts and technical vocabulary, Idioms.
Total (30L + 30P) = 60 Periods

Reference Books:	
1.	Meenakshi Raman and Sangeeta Sharma. Professional English. Oxford University Press, New Delhi, 2019.
2.	Krishna Mohan, MeeraBannerji. Developing Communication Skills. Macmillan India Ltd, Delhi, 1990.
3.	Sanjay Kumar, PushpaLata. English Language and Communication Skills for Engineers. Oxford University Press, 2018.
E-References:	
1.	https://learnenglish.britishcouncil.org/
2.	https://www.bbc.co.uk/learningenglish

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Comprehend the main ideas, key details and inferred meanings of technical texts	Understand
CO2	Use language effectively at technical and professional contexts	Apply
CO3	Apply the academic and functional writing skills in formal and informal communicative contexts	Apply
CO4	Interpret pictorial representation of statistical data and charts	Apply

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	0	0	0	1	0	0	0	0	1	3	0	1	0	0	1
CO2	0	0	0	1	0	0	0	0	1	3	0	2	0	0	2
CO3	0	0	0	2	0	0	0	0	1	3	0	1	0	0	1
CO4	0	0	0	3	0	0	0	0	1	3	0	1	0	0	1
Avg	**0**	**0**	**0**	**1.75**	**0**	**0**	**0**	**0**	**1**	**3**	**0**	**1.25**	**0**	**0**	**1.25**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22MA201	PARTIAL DIFFERENTIAL EQUATIONS, VECTOR CALCULUS AND COMPLEX VARIABLES	SEMESTER II

PRE-REQUISITE:	Category	BS	Credit		4
Basic 12th level knowledge of Partial Derivatives, Vector algebra and Complex Numbers.	Hours/Week	L	T	P	TH
		3	1	0	4

Course Objectives:

1.	To familiarize with the formation and solutions of first-order partial differential equation.
2.	To familiarize with the solutions of higher-order partial differential equations.
3.	To acquire knowledge of vector differentiation and integration and its applications.
4.	To know about analytic functions with properties, construction of analytic functions and conformal transformations.
5.	To obtain the knowledge of Cauchy's integral theorems, calculus of residues and complex integration around unit circle and semi-circle.

UNIT I	PARTIAL DIFFERENTIAL EQUATIONS – FIRST ORDER	9	3	0	12

Formation of partial differential equations by elimination of arbitrary constants and functions – Solutions to first order partial differential equations - Standard types of first order linear and non-linear PDE- Lagrange's linear PDE.

UNIT II	PARTIAL DIFFERENTIAL EQUATIONS – HIGHER ORDER	9	3	0	12

Solution to homogeneous and non-homogeneous linear partial differential equations of second and higher-order by complementary function and particular integral method - Separation of variables method: simple problems in Cartesian coordinates, Laplace equation in Cartesian and polar coordinates, one-dimensional diffusion equation, one-dimensional wave equation.

UNIT III	VECTOR CALCULUS	9	3	0	12

Vector differentiation- Gradient- Directional derivative - Divergence - Curl, Vector integration- Line integration- work done – Surface and Volume integrals - Green's theorem, Gauss divergence and Stokes theorem (without proof) – Simple applications involving cubes and rectangular parallelepipeds.

UNIT IV	COMPLEX DIFFERENTIATION	9	3	0	12

Functions of a complex variable – Analytic functions – Cauchy – Riemann equation and sufficient conditions (excluding proof) – Harmonic and orthogonal properties of analytic function – Construction of analytic functions – Conformal mappings: w= z+c, cz, 1/z, $z^2$and Bilinear transformations.

UNIT V	COMPLEX INTEGRATION	9	3	0	12

Cauchy's integral theorem - Cauchy's integral formula – Taylor's and Laurent's theorems (Statements only) and expansions – Poles and Residues – Cauchy's Residue theorem – Contour integration: Circular and semi-circle contours with no poles on the real axis.

Total (45L+15T) = 60 Periods

Text Books:

1.	Grewal. B.S, "Higher Engineering Mathematics", 43rd Edition, Khanna Publications, Delhi, 2015.
2.	Jain R.K. and Iyengar S.R.K., "Advanced Engineering Mathematics",3rd Edition, Narosa Publications, New Delhi, 2007.

Reference Books:

1.	James Stewart, "Essential Calculus", 2nd edition Cengage Learning, New Delhi, 2014.
2.	P. Kandasamy, K. Thilagavathy and K. Gunavathy," Engineering Mathematics (For I year B.E., B. Tech)", 9thEdition, S. Chand & Co. Ltd. New Delhi, 2010.
3.	Srimanta pal and Subath C. Bhumia, "Engineering Mathematics", Oxford university publications, New Delhi, 2015
4.	Ewinkreyzig, "Advanced Engineering Mathematics", 9th Edition, John Wiley & Sons, 2007.

5.	Siva RamakrishnaDas.P, Ruknmangadachari.E. "Engineering Mathematics", 2nd edition Pearson, Chennai & Delhi, 2013.

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Understand how to solve the given standard partial differential equations.	Understand
CO2	Solve higher order partial differential equations.	Apply
CO3	Use Gauss, Stokes and Green's theorems for the verification of line, surface and volume integrals.	Apply
CO4	Familiar with the concept of Conformal and Bilinear transformations.	Understand
CO5	Acquire the knowledge of Contour integration over unit circle and semi-circle.	Apply

COURSE ARTICULATION MATRIX

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

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22PH101	ENGINEERING PHYSICS		SEMESTER II			
PRE-REQUISITE:		**Category**	**BS**	**Credit**		**4**
Basic theoretical knowledge in Physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**1**	**0**	**4**

Course Objectives:

1.	To understand Principles of ultrasonic production, its applications and acoustics of buildings.
2.	To understand Principle, working and industrial applications of LASER and optical fiber
3.	To gain knowledge in mode of transmission of heat by conduction mechanism with experimental illustrations
4.	To obtain knowledge in basic concepts of quantum physics and matter waves
5.	To acquire knowledge in basics of crystal structure, types of crystal and its defects and crystal growth techniques

UNIT I	ULTRASONICS AND ACOUSTICS	9	3	0	12

ULTRASONICS: Introduction – Production - Magnetostriction effect – Magnetostriction generator – Piezoelectric effect – Piezoelectric generator –Detection of ultrasonic waves - Properties – Acoustical grating– Velocity measurement–Industrial applications - Drilling, welding, soldering and cleaning –SONAR – Medical applications (Qualitative).

ACOUSTICS OF BUILDINGS: Introduction – Reverberation and reverberation time –Factors affecting acoustics of buildings and their remedies – Absorption co-efficient – Basic requirements for the acoustically good auditorium.

UNIT II	LASER AND FIBRE OPTICS	9	3	0	12

LASER: Stimulated absorption, spontaneous emission and stimulated emission – Population inversion – Pumping methods – Types of laser-Nd–YAG,CO_2 laser – Industrial and medical applications (Qualitative)

FIBER OPTICS: Principle of optical fiber – Structure and classification of optical fiber – Critical angle - Numerical aperture – Acceptance angle – Fiber optic communication (Block diagram).

UNIT III	THERMAL PHYSICS	9	3	0	12

Modes of Transmission of heat - Conduction – Convection – Radiation – Thermal conductivity – Coefficient of thermal conductivity and its unit –Thermal conduction through compound media in series – Determination of thermal conductivity - Searle's method for good conductors, Lee's disc method for Bad conductors – Thermal insulating materials – Thermal insulation in buildings.

UNIT IV	QUANTUM PHYSICS	9	3	0	12

Matter waves – experimental evidence: Davisson and Germer experiment – Schroedinger's wave equation - Time independent and dependent equations – Physical significance of wave function – Particle in a one-dimensional box – Electron Microscope (Qualitative).

UNIT V	CRYSTAL PHYSICS	9	3	0	12

Lattice – Unit cell – Bravais lattice – Number of atoms per unit cell, atomic radius, coordination number, and packing factor– Crystal growth techniques: Bridgman, Czochralski techniques. Crystal imperfections - Point defects – Schottky defect, Frenkel defect – Line defects – Edge dislocation, Screw dislocation – Planar defects – Grain boundaries, Twin boundaries.

Total (45L+15T) = 60 Periods

Text Books:

1.	Arumugam M, 'Engineering Physics', Anuradha publishers, 2019.
2.	Rajendran V. and Marikani A, 'Engineering Physics', PHI Learning Pvt., India, 2018.
3.	Palanisamy P.K, 'Engineering Physics', SCITECH Publications, 2018.
4.	Ragavan V, 'Material science and engineering', Prentice Hall of India Pvt Ltd, NewDelhi, 2004.
5.	Introduction to crystal growth, Principles and Practice, H.L. Bhat, Taylor and Francis, 2015 edition.

Reference Books:	
1.	Gaur R.K. and Gupta S.L, 'Engineering Physics', DhanpatRai publishers, 2012.
2.	Arthur Beiser, 'Concepts of Modern Physics', Tata McGraw Hill Publishing Co. Ltd, sixth Edition, 2019.
3.	Gerdkeiser, 'Optical fiber communications', Tata McGraw Hill Publishing Co. Ltd, 5th Edition, 2017.
4.	OrazioSvelto. David C. Hanna, 'Principles of Lasers', Springer Science &Business Media, LLC, 2010.

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Understand the principle, production of ultrasonic wave and acoustics of buildings.	Understand
CO2	Understand the principle and applications of laser and optical fiber.	Understand
CO3	Analyze various modes involved in heat transmission	Analyze
CO4	Gain knowledge in basic concept of quantum physics.	Remember
CO5	Recognize crystal structure, crystal defects and crystal growth techniques.	Evaluate

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	0	0	0	0	0	2	2	1	0
CO2	2	3	1	1	2	1	0	0	0	0	0	2	1	1	0
CO3	3	2	1	1	0	0	0	0	0	0	0	1	2	0	0
CO4	3	2	1	1	2	0	1	0	0	0	0	1	1	0	0
CO5	2	2	1	1	2	0	0	0	0	0	0	1	0	1	1
Avg	**2.6**	**2.2**	**1**	**1**	**1.4**	**0.4**	**0.2**	**0**	**0**	**0**	**0**	**1.4**	**1.2**	**0.6**	**0.2**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22ES101	ENGINEERING MECHANICS		SEMESTER II			
PRE-REQUISITE:		**Category**	**ES**	**Credit**		**3**
1. Engineering Physics. **2. Engineering Mathematics.**		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To develop the capacity to predict the effect of force and motion in the course of carrying out the design functions of engineering.
2.	To analyze the force systems and friction.
3.	To study the dynamics of particles, impulse and momentum

UNIT I	STATICS OF PARTICLES	9	0	0	9

Fundamental Concepts and Principles, Systems of Units, Method of Problem Solutions, Statics of Particles -Forces in a Plane, Resultant of Forces, Resolution of a Force into Components, Rectangular Components of a Force, Unit Vectors. Equilibrium of a Particle- Newton's First Law of Motion, Space and Free-Body Diagrams, Forces in Space, Equilibrium of a Particle in Space.

UNIT II	EQUILIBRIUM OF RIGID BODIES	9	0	0	9

Principle of Transmissibility, Equivalent Forces, Vector Product of Two Vectors, Moment of a Force about a Point, Varignon's Theorem, Rectangular Components of the Moment of a Force, Scalar Product of Two Vectors, Mixed Triple Product of Three Vectors, Moment of a Force about an Axis, Couple - Moment of a Couple, Equivalent Couples, Addition of Couples, Resolution of a Given Force into a Force -Couple system, Further Reduction of a System of Forces, Equilibrium in Two and Three Dimensions - Reactions at Supports and Connections.

UNIT III	PROPERTIES OF SURFACES AND SOLIDS	9	0	0	9

Centroid of simple figures from first principle, centroid of composite sections; Centre of Gravity and its implications; Area moment of inertia- Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections and composite sections; Theorems of Pappus-Guldinus.

UNIT IV	FRICTION	9	0	0	9

The laws of dry friction. Coefficients of friction, Angles of friction, Wedges, Wheel friction. Rolling resistance, Ladder friction.

UNIT V	DYNAMICS OF PARTICLES	9	0	0	9

Kinematics - Rectilinear Motion and Curvilinear Motion of Particles. Kinetics- Newton's Second Law of Motion -Equations of Motions, Dynamic Equilibrium, Energy and Momentum Methods - Work of a Force , Kinetic Energy of a Particle, Principle of Work and Energy, Principle of Impulse and Momentum, Impact of elastic bodies.

Total = 45 Periods

Text Books:

1.	A Textbook of Engineering Mechanics, R.K. Bansal, Laxmi Publications, 2010.
2.	Rajasekaran S and Sankarasubramanian G., "Fundamentals of Engineering Mechanics", Vikas Publishing House Pvt. Ltd., 2013.

Reference Books:

1.	Beer Ferdinand P, Russel Johnston Jr., David F Mazurek, Philip J Cornwell, SanjeevSanghi, Vector Mechanics for Engineers: Statics and Dynamics, McGraw Higher Education. 11thEdition, 2017.
2.	Timoshenko S, Young D H, Rao J V and SukumarPati, Engineering Mechanics, 5thEdition, McGraw Hill Higher Education, 2013.
3.	Hibbeller, R.C., Engineering Mechanics: Statics, and Engineering Mechanics: Dynamics, 13th edition, Prentice Hall, 2013.

4.	Palanichamy M.S. and Nagam S., "Engineering Mechanics – Statics & Dynamics", Tata McGraw-Hill, 2001
5.	Engineering Mechanics, D.S. Bedi, Khanna Book Publishing Co. (P) Ltd, 2019.
E-References:	
1.	https://nptel.ac.in/courses/122104014
2.	https://nptel.ac.in/courses/112106286

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Apply the various methods to determine the resultant forces and its equilibrium acting on a particle in 2D and 3D	Create
CO2	Apply the concept of reaction forces (non-concurrent coplanar and noncoplanar forces) and moment of various support systems with rigid bodies in 2D and 3D.	Evaluate
CO3	Evaluate area moments of inertia for various sections by applying the concepts of centroids.	Evaluate
CO4	Apply the concepts of frictional forces at the contact surfaces of various engineering systems.	Apply
CO5	Apply the various methods for evaluating dynamic parameters of the particles subjected to concurrent coplanar forces.	Apply

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	1	0	0	0	0	0	0	0	1	3	1	0
CO2	3	2	2	1	0	0	0	0	0	0	0	1	3	1	0
CO3	3	2	2	1	0	0	0	0	0	0	0	2	3	2	0
CO4	3	1	2	1	0	0	0	0	0	0	0	1	3	2	0
CO5	3	1	2	1	0	0	0	0	0	0	0	1	3	2	0
Avg	**3**	**1.6**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1.2**	**3**	**1.6**	**0**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22HS201	UNIVERSAL HUMAN VALUES		SEMESTER II			
PRE-REQUISITE:		Category	HS	Credit		3
		Hours/Week	L	T	P	TH
			2	1	0	3

Course Objectives:

1.	Development of a holistic perspective based on self-exploration about themselves (human being), family, society and nature/existence.
2.	Understanding (or developing clarity) of the harmony in the human being, family, society and nature/existence.
3.	Strengthening of self-reflection.
4.	Development of commitment and courage to act.

UNIT I		6	3	0	9

Course Introduction - Need, Basic Guidelines, Content and Process for Value Education. Purpose and motivation for the course, recapitulation from Universal Human Values-I. Self-Exploration–what is it? - Its content and process; 'Natural Acceptance' and Experiential Validation- as the process for self-exploration Continuous Happiness and Prosperity- A look at basic Human Aspirations. Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority. Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario Method to fulfil the above human aspirations- understanding and living in harmony at various levels.

UNIT II		6	3	0	9

Understanding Harmony in the Human Being - Harmony in Myself! Understanding human being as a co-existence of the sentient 'I' and the material 'Body' Understanding the needs of Self ('I') and 'Body' - happiness and physical facility. Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer) Understanding the characteristics and activities of 'I' and harmony in 'I' Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail Programs to ensure Sanyam and Health.

UNIT III		6	3	0	9

Understanding Harmony in the Family and Society- Harmony in Human- Human Relationship Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship. Understanding the meaning of Trust; Difference between intention and competence. Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship. Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals. Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family.

UNIT IV		6	3	0	9

Understanding Harmony in the Nature and Existence - Whole existence as Coexistence. Understanding the harmony in the Nature. Interconnectedness and mutual fulfilment among the four orders of nature- recyclability and self-regulation in nature. Understanding Existence as Co-existence of mutually interacting units in all- pervasive space. Holistic perception of harmony at all levels of existence.

UNIT V		6	3	0	9

Implications of the above Holistic Understanding of Harmony on Professional Ethics. Natural acceptance of human values. Definitiveness of Ethical Human Conduct. Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order. Competence in professional ethics, Strategy for transition from the present state to Universal Human Order.

Total (30L + 15T) = 45 Periods

Reference Books:	
1.	Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 2010
Reference Books:	
1.	JeevanVidya: EkParichaya, A Nagaraj, JeevanVidyaPrakashan, Amarkantak, 1999.
2.	Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3.	The Story of Stuff (Book)
4.	The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi
5.	Small is Beautiful - E. F Schumacher.
6.	Slow is Beautiful - Cecile Andrews
7.	Economy of Permanence - J C Kumarappa
8.	Bharat Mein Angreji Raj - PanditSunderlal
9.	Rediscovering India - by Dharampal
10.	Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
11.	India Wins Freedom - Maulana Abdul Kalam Azad
12.	Vivekananda - Romain Rolland (English)
13.	Gandhi - Romain Rolland (English)

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Become more aware of themselves, and their surroundings (family, society, nature) and become more responsible in life	Evaluate
CO2	Handle problems with sustainable solutions, while keeping human relationships and human nature in mind	Apply
CO3	Become sensitive to their commitment towards what they have understood (human values, human relationship and human society)	Evaluate
CO4	Apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.	Apply

COURSE ARTICULATION MATRIX

CO/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	0	0	1	0	0	1	0	2	0	1	0	3	2	0	1
CO2	0	0	1	0	0	3	0	1	0	1	0	3	1	0	1
CO3	0	0	1	0	0	2	0	1	0	1	0	3	1	0	2
CO4	0	0	2	0	0	1	0	1	0	1	0	3	1	0	1
Avg	**0**	**0**	**1.25**	**0**	**0**	**1.75**	**0**	**1.25**	**0**	**1**	**0**	**3**	**1.25**	**0**	**1.25**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22MCIN01	ENGINEERING SPRINTS		SEMESTER II			
PRE-REQUISITE:		Category	EE	Credit		1
		Hours/Week	L	T	P	TH
			0	0	2	2

Course Objectives:

1.	To strengthen conceptual understanding of fundamental engineering concepts.
2.	To spark curiosity in students' Minds.
3.	To focus on teaching through a problem-solving approach using Street Fight Engineering principles pioneered.
4.	To foster the growth of functional independence and self-driven learning habits
5.	To maximize the interest levels toward learning - as students aspire to create meaningful changes in the world.

UNIT I	STREET FIGHTING ENGINEERING	0	0	6	6

Why Street fight engineering - How to street fight engineering - Decode real-world problems - Observe key patterns - Relationship study - Derive actionable inferences - Perform data driven insights- Generate concepts and case studies

UNIT II	PROGRAMMING PARADIGM	0	0	6	6

Need for programming - Outside box thinking to solve problems - Need for algorithms and data structures -Flowcharts & Algorithms - Memory Allocation - Conditions and loops - Creating effective functions - Case studies - Visual Programming - Types of programming languages& paradigms - Getting started with development - Build & test an algorithm - best practices

UNIT III	BRAINS OF MACHINES	0	0	6	6

Key Innovations in Tesla Electric car - Case study - Brains of Electric cars - Transdisciplinary systems - Adapting Transdisciplinary systems to Accelerate innovation - Idea Hexagon - Exercise to think new innovations using Idea Hexagon - Brains of Digital camera

UNIT IV	MACHINES THAT MAKE-UP THE WORLD	0	0	6	6

Basic of Electronics Passive Components -Need for sensors & Actuators - Analyzing & Understanding electronic circuits - How to Build a Basic Custom Hardware - Bootloader& its purpose

UNIT V	ENGINEERING THE REAL WORLD	0	0	6	6

Real-world as systems - Introduction to Systems Thinking - Stock and Flow Diagrams - System Traps - Intervening in System - Living in a World of Systems

Total = 30 Periods

Text Books:

1.	SanjoyMahajan - Street Fighting Mathematics
2.	Donald Knuth - The Art of Computer Programming
3.	Think like a programmer: An introduction to creative problem solving
4.	Thinking in Systems: A Primer

Reference Books:

1.	Learning to code: How to think like a programmer
2.	How to find innovative ideas: Ramesh Raskar's note
3.	Case study: How Tesla changed the auto industry
4.	Ultimate Guide: How to develop a new electronic hardware product

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Apply street fight engineering concepts to solve problems	Apply
CO2	Construct flowcharts & block diagrams for algorithms	Apply
CO3	Apply the Idea Hexagon Tool to learn innovation models	Apply
CO4	Understand basic electronics for building hardware	Apply
CO5	Examine real-world problems with a system view	Analyze

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	3	0	0	0	0	0	0	2	0	2	0	0	0	2
CO2	2	0	0	3	0	0	0	0	2	0	0	0	0	0	2
CO3	2	2	0	3	0	0	0	0	2	0	2	0	0	0	2
CO4	2	2	0	3	0	0	0	1	2	0	2	0	0	0	2
CO5	0	3	0	0	0	1	2	0	2	1	2	0	0	0	2
Avg	**1.6**	**2**	**0**	**1.8**	**0**	**0.2**	**0.4**	**0.2**	**2**	**0.2**	**1.6**	**0**	**0**	**0**	**2**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22MC201	TAMILS AND TECHNOLOGY		SEMESTER II			
PREREQUISITES		Category	HS MS	Credit		1
		Hours/Week	L	T	P	TH
			1	0	0	1

Course Learning Objectives

1	
2	
3	
4	
5	

Unit I	**WEAVING AND CERAMIC TECHNOLOGY**	**3**	**0**	**0**	**3**

Weaving Industry during Sangam Age – Ceramic technology – Black and Red Ware Potteries (BRW) – Graffiti on Potteries.

Unit II	**DESIGN AND CONSTRUCTION TECHNOLOGY**	**3**	**0**	**0**	**3**

Designing and Structural construction House & Designs in household materials during Sangam Age - Building materials and Hero stones of Sangam age – Details of Stage Constructions in Silappathikaram - Sculptures and Temples of Mamallapuram - Great Temples of Cholas and other worship places - Temples of Nayaka Period - Type study (Madurai Meenakshi Temple)- ThirumalaiNayakar Mahal - Chetti Nadu Houses, Indo - Saracenic architecture at Madras during British Period.

Unit III	**MANUFACTURING TECHNOLOGY**	**3**	**0**	**0**	**3**

Art of Ship Building - Metallurgical studies - Iron industry - Iron smelting,steel -Copper and goldCoins as source of history - Minting of Coins – Beads making-industries Stone beads -Glass beads - Terracotta beads -Shell beads/ bone beats - Archeological evidences - Gem stone types described in Silappathikaram.

Unit IV	**AGRICULTURE AND IRRIGATION TECHNOLOGY**	**3**	**0**	**0**	**3**

Dam, Tank, ponds, Sluice, Significance of KumizhiThoompu of Chola Period, Animal Husbandry - Wells designed for cattle use - Agriculture and Agro Processing - Knowledge of Sea - Fisheries – Pearl - Conche diving - Ancient Knowledge of Ocean - Knowledge Specific Society.

Unit V	**SCIENTIFIC TAMIL & TAMIL COMPUTING**	**3**	**0**	**0**	**3**

Development of Scientific Tamil - Tamil computing – Digitalization of Tamil Books – Development of Tamil Software – Tamil Virtual Academy – Tamil Digital Library – Online Tamil Dictionaries – Sorkuvai Project.

Total = 15 Periods

Text Books:

1	Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
2	Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
3	Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
4	The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies)

5	Keeladi - ‘Sangam City Civilization on the banks of river Vaigai’ (Jointly Published by: Department ofArchaeology&TamilNadu Text Book and Educational Services Corporation, Tamil Nadu)
6	Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published by: The Author)
7	Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
8	Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL)

22NC201	NCC COURSE-I(Only for NCC Students)		Semester II			
PREREQUISITES		**Category**	**NC**	**Credit**		**3**
NIL		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To maintain the unity and disciplines to the students

Unit I	**NCC GENERAL & NATIONAL INTEGRATION AND AWARENESS**	**9**	**0**	**0**	**9**

Aims, Objectives and Org of NCC – Incentives to NCC cadets – Duties of NCC Cadets – NCC Camps: Types & Conduct; National Integration: Importance and Necessity – Factors affecting National Integration – Unity in Diversity – Threats to National Security.

Unit II	**PERSONALITY DEVELOPMENT & LEADERSHIP DEVELOPMENT**	**9**	**0**	**0**	**9**

Personality Development Capsule -Self Awareness Empathy, Creative& Creative Thinking, Decision Making - Communication Skills - Group Discussion - Stress emotions, Change Your Mindset, Inter Personal Relations& Team work, Time Managements, Civil Sense - Career Counselling, SSB Procedures & Interview Skills; Leadership Capsule - Traits, Indicators, Motivation, Ethics &Honour code - Case Studies-Shivaji, APG Abdul Kalam & Deepa Malik, MaharanaPratap, Ratan Tata, KiranMajumdar, Jhansi Ki Rani, Narayan Murty, PrakashPadukone, Tipu Sultan, Rabindranath Tagore.

Unit III	**DISASTER MANAGEMENT AND HEALTH & HYGIENE**	**9**	**0**	**0**	**9**

Disaster Management Capsule- SochVichar, Types - Organisation, Capability & Role of NCC Cadets – Fire Service & Fire Fighting – Initiative Training, Organisation Skills, Do's and Don'ts – Natural Disasters, Man Made Disasters; Health & Sanitation – First aid in Common Medical Emergencies, Treatment & Care of Wounds – Introduction to Yoga & Exercises.

Unit IV	**PRINCIPLES OF FLIGHT & GENERAL SERVICE KNOWLEDGE**	**9**	**0**	**0**	**9**

Laws of Motion – Glossary Terms – Bernoulli's Principle – Aerofoil – Forces acting on Aircraft – Lift & Drag – Flaps & Slats – Stall – Thrust; Armed Forces & IAF Capsule – Modes of Entry in IAF, Civil Aviation – Aircraft Recognition – Latest Trends & Acquisitions.

Unit V	**NAVIGATION, AEROENGINES, AIRCOMPAIGNS & AIRMANSHIP**	**9**	**0**	**0**	**9**

Requirements of Navigation – Glossary terms – Maps – Map Reading; Basic Theory – Types of Engines – Piston Engines – Jet Engines – Turbo Prop Engines; Indo Pak war 1971 – Operation Safed Sagar – Famous Air Heroes; Airmanship – Airfield Layout – Rules of the Air – Circuit Procedures – ATC RT Procedures – Aviation Medicine - Survival.

Total = 45 Periods

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Acquired knowledge about the history of NCC, its organization, incentives of NCC, duties, different NCC camps	Analyze
CO2	Understand the concept of national integration and its importance	Understand
CO3	Understand the importance disaster management and health and hygiene.	Understand

CO4	Understand the importance principal of Flight and knowledge about armed services.	Understand
CO5	Understand and learn the importance of navigation, Aero engines & Airmanship work.	Understand

22CS102	COMPUTER PRACTICE AND C PROGRAMMING LABORATORY	SEMESTER II

PREREQUISITES	Category	ES	Credit		1.5
	Hours/Week	L	T	P	TH
		0	0	3	3

Course Learning Objectives

1	To provide basic knowledge to work with word processing applications
2	To provide basic knowledge to work with spread sheet applications
3	To promote the programming ability to develop C applications

EXPERIMENTS

A. Word Processing

1. Creating and formatting documents.
2. Creating Tables and Manipulation
3. Using Equation Editor
4. Inserting Pictures, Shapes and Charts
5. Using Mail merge

B. Spread Sheet

6. Creating sheets, using built in function and use-defined formulae
7. Creating different types of charts from data

C. Simple C Programming

8. Program using different operators.
9. Program using Control statements.
10. Program using Loops, Array and Strings.
11. Program using Functions and pointers.
12. Program using Structures and Files.

For programming exercises Algorithm, Flow chart and pseudo code are essential

Total (45+15) = 60 Periods

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Demonstrate the usage of features supported by word processing applications.	Understand andApply
CO2	Demonstrate the usage of features supported by spread sheet applications.	Understand andApply
CO3	Apply general programming techniques to develop digital solution to problems	Understand andApply
CO4	Implement solutions develop with general programming techniques in C programming language	Understand andApply

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	0	0	0	0	0	0	0	0	3	0	0	1	0	0
CO2	2	3	0	0	0	0	0	0	0	0	0	0	1	0	0
CO3	2	3	3	0	0	0	0	0	0	0	0	3	2	0	0
CO4	1	1	1	0	0	0	0	0	0	0	0	3	3	0	0
Avg	**1.6**	**2.3**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**3**	**1.7**	**0**	**0**
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

22ME102	WORKSHOP MANUFACTURING PRACTICES	SEMESTER II			
PREREQUISITES		Category	ES	Credit	2
		Hours/Week	L	T	P	TH
			0	0	4	4

Course Learning Objectives

1	To understand the basics of safety measures taken in the laboratory.
2	To provide exposure to the students with hands-on experience on various basic engineering practices in Civil and Mechanical Engineering.
3	To know about the various fitting joints and lathe operation.
4	To gain knowledge in welding and fitting operation.
5	To understand the fabrication of various models using sheet metals.

LIST OF EXPERIMENTS

1. Introduction to Safety measures and First aid.
2. Study of Lathe, drilling machine -Welding methods and equipment- Casting process and tools- Sheet metal and fitting tools- Carpentry tools and joints.
3. Fitting: V-fitting, square fitting, Curve fitting.
4. Lathe: Facing, turning, taper turning and knurling.
5. Welding: BUTT, LAP and T- joints.
6. Foundry: Greensand preparation- mould making practice.
7. Sheet metal: Cone, tray, cylinder.
8. Carpentry: CROSS, T and DOVETAIL joints.
9. Drilling: simple exercises.

Total = 30 Periods

Reference Books:

1	Bawa, H.S, "Workshop Practice", Tata McGraw Hill Publishing Company Limited, 2007.
2	Jeyachandran, K, Natarajan, K and Balasubramanian, S, "A Primer on Engineering Practices Laboratory", Anuradha Publications, 2007.
3	Jeyapoovan, T, SaravanaPandian, M and Pranitha, S, "Engineering Practices Lab Manual", Vikas Publishing House Pvt. Ltd, 2006.
4	Dr. P.kannan, Mr. T, Satheeskumar&Mr .K .Rajasekar, "Engineering practices laboratory" manual first edition 2017
5	Dr. V. Rameshbabu "Engineering practices laboratory" VRB publication pvt ld.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Familiarize the working of various equipment and safety measures.	Understand
CO2	Prepare fitting of metal and wooden pieces using simple fitting and carpentry tools manually.	Apply
CO3	Fabrication of components using welding, lathe and drilling machine.	Analyze
CO4	Make the model using sheet metal works.	Analyze

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
CO2	0	3	0	2	1	0	0	0	0	0	0	0	0	0	2
CO3	0	3	0	2	1	0	0	0	0	0	0	0	0	0	2
CO4	0	3	0	2	1	0	0	0	0	0	0	0	0	0	2
CO5	0	3	0	2	1	0	0	0	0	0	0	0	0	0	2
Avg	**0**	**2.4**	**0**	**1.6**	**0.8**	**0.6**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1.6**
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

SEMESTER-III

22MA305	FOURIER SERIES, BOUNDARY VALUES PROBLEMS AND TRANSFORMS		SEMESTER III			
PRE-REQUISITE:		**Category**	**BS**	**Credit**		**3**
Basic 12th level knowledge of Taylor series, ODE and integration.		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To introduce the concept of the Fourier series.
2.	To understand the application of Fourier analysis in solving boundary value problems.
3.	To obtain the knowledge of solving second order ODE using Laplace transform techniques and inverse Laplace transform using convolution theorem.
4.	To familiarize with Fourier, transform of a function and its sine and cosine transforms.
5.	To gain the skills to form difference equations and find its solution by using the Z-transform method.

UNIT I	**FOURIER SERIES**	**9**	**0**	**0**	**9**

Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series – Half range cosine series – Parseval's Identity.

UNIT II	**BOUNDARY VALUE PROBLEMS**	**9**	**0**	**0**	**9**

Classification of second-order quasi-linear partial differential equations – Solutions of one-dimensional wave equation – One-dimensional heat equation – Steady-state solution of two-dimensional heat equation (Insulated edges excluded) – Fourier series solutions in Cartesian coordinates.

UNIT III	**LAPLACE TRANSFORM**	**9**	**0**	**0**	**9**

Laplace Transform- Conditions for existence – Transform of elementary functions – Basic Properties –Initial and Final value theorems- Transform of periodic Functions – Inverse Laplace Transform- statement and application of convolution theorem.

UNIT IV	**FOURIER TRANSFORM**	**9**	**0**	**0**	**9**

Statement of Fourier integral theorem – Fourier transforms pair – Sine and Cosine transforms – Properties – Transforms of simple functions – Convolution theorem - Parseval's Identity.

UNIT V	**Z -TRANSFORM AND DIFFERENCE EQUATIONS**	**9**	**0**	**0**	**9**

Z-transform of simple functions and properties – Inverse Z – transform –initial and final value theorems- Convolution theorem - Formation of difference equations.

Total = 45 Periods

Text Books:

1.	Veerarajan T, "Engineering Mathematics (For Semester III)", 3rd Edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2009.
2.	P. Kandasamy, K. Thilagavathy and K. Gunavathy, "Engineering Mathematics, Volume III", S. Chand & Company ltd., New Delhi, 1996.

Reference Books:

1.	Grewal, B.S., "Higher Engineering Mathematics", 43rd Edition, Khanna Publishers, Delhi, 2014.
2.	Wylie C. Ray and Barrett Louis, C., "Advanced Engineering Mathematics", 6th Edition, McGraw-Hill, Inc., New York, 1995.
3.	Andrews, L.A., and Shivamoggi B.K., "Integral Transforms for Engineers and Applied Mathematics", MacMillan, New York, 1988.
4.	Narayanan, S., Manicavachagom Pillai, T.K. and Ramaniah, G., "Advanced Mathematics for Engineering Students",

	Volumes II and III, S. Viswanathan (Printers and Publishers) Pvt. Ltd. Chennai, 2002.

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Acquire knowledge about the Fourier series.	Understand
CO2	Appreciate the physical significance of Fourier series techniques in solving one and two-dimensional heat flow problems and one-dimensional wave equations.	Understand
CO3	Apply the knowledge of the Laplace transforms.	Understand
CO4	Apply the knowledge of Fourier transform in engineering problems.	Apply
CO5	Apply the knowledge of Z-transform in engineering problems.	Apply

COURSE ARTICULATION MATRIX

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

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22ME301	ENGINEERING THERMODYNAMICS *(Use of standard thermodynamic tables, Mollier diagram are permitted)*		SEMESTER III			
PRE-REQUISITE:		**Category**	**PC**	**Credit**		**4**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**1**	**0**	**4**

Course Objectives:

1.	To impart the knowledge on concepts of zeroth and first law of thermodynamics.
2.	To make the learners to understand the third law of thermodynamics and analyze the various work and heat interactions in closed and open systems.
3.	To teach properties of pure substance.
4.	To impart knowledge on the concepts of steam power cycle.
5.	To derive thermodynamic relations for ideal and real gases.

UNIT I	BASIC CONCEPT AND FIRST LAW	9	3	0	12

Role of Thermodynamics in Engineering and Science - Applications of Thermodynamics. Basic concepts - concept of continuum, macroscopic approach, thermodynamic systems. Property, state, path and processes, quasi-static process, Thermodynamic equilibrium, Displacement work, P-V diagram. Zeroth law of thermodynamics – concept of temperature and heat. First law of thermodynamics – application to closed and open systems, internal energy, specific heat capacities, enthalpy, steady flow process with reference to various thermal equipment.

UNIT II	SECOND LAW AND ENTROPY	9	3	0	12

Heat engine – Refrigerator – Heat Pump, Second law of thermodynamics – Kelvin's and Clausius statements- Equivalence of these statements their corollaries. Reversibility and irreversibility. Carnot cycle, reversed Carnot cycle. Clausius inequality, Concept of entropy, principle of increase of entropy, T-s diagram, T-ds equations.

UNIT III	PROPERTIES OF PURE SUBSTANCES	9	3	0	12

Steam - formation and its thermodynamic properties - p-v, p-T, T-v, T-s, h-s diagrams. PVT surface. Determination of dryness fraction. Calculation of work done and heat transfer in non-flow and flow processes using Steam Table and Mollier Chart.

UNIT IV	STEAM POWER CYCLE	9	3	0	12

Standard Rankine cycle, Performance Improvement - Reheat cycle, regenerative cycle and their combination cycles.

UNIT V	IDEAL AND REAL GASES AND THERMO DYNAMIC RELATIONS	9	3	0	12

Properties of ideal and real gases, equation of state of ideal and real gases, Avogadro's law, Vander Waal's equation of states, Principle of corresponding states, reduced properties and compressibility chart. Exact differentials, Maxwell relations, Specific heat equations, T-ds relations, Clausius Clapeyron equations and Joule Thomson Coefficient.

Total (45L+15T)= 60 Periods

Text Books:

1.	Nag. P.K, "Engineering Thermodynamics", Tata McGraw-Hill, New Delhi, 2017.
2.	Sonntag, R.E., Borgnakke, C., and Van Wylen, G.J., Fundamentals of Thermodynamics, 6th ed., John Wiley, 2003.
3.	Arora C.P, "Thermodynamics", Tata McGraw Hill, New Delhi, 2003.
4.	Venwylen and Sontag, "Classical Thermodynamics", Wiley Eastern, 1987.

Reference Books:

1.	Cengel, "Thermodynamics- An Engineering Approach", 3rd Edition, Tata McGraw Hill,2015.

2.	Merala C, Pother, Craig W and Somerton, “Thermodynamics for Engineers”, Schaum Outline Series, Tata McGraw-Hill, New Delhi, 2004.

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom’s Taxonomy Mapped**
CO1	Understand the concepts of zeroth, first and second law of thermodynamics.	Remember
CO2	Analyze the various work and heat interactions for different types of processes for closed and open systems	Evaluate
CO3	Evaluate the different properties of pure substances using steam tables and Mollier chart	Evaluate
CO4	Analyze the performance of steam power cycle.	Analyze
CO5	Derive thermodynamic relations for ideal and real gases.	Analyze

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	2	0	0	1	0	0	0	0	1	3	1	1
CO2	3	3	2	2	0	0	1	0	0	0	0	1	3	1	1
CO3	3	3	3	2	0	1	1	0	0	0	0	1	3	1	1
CO4	2	3	2	2	0	1	1	0	0	0	0	1	3	1	1
CO5	3	3	2	2	0	1	0	0	0	0	0	1	3	1	1
Avg	**2.8**	**3**	**2.2**	**2**	**0**	**0.6**	**0.8**	**0**	**0**	**0**	**0**	**1**	**3**	**1**	**1**
3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)															

22ME302	FLUID MECHANICS AND MACHINERY	SEMESTER III

PRE-REQUISITE:	Category	PC	Credit		4
1. Engineering Physics 2.Engineering Chemistry 3.Engineering Mathematics	Hours/Week	L	T	P	TH
		3	1	0	4

Course Objectives:

1.	To understand the basic concepts and properties of fluids
2.	To analyze the kinematic and dynamic concepts of fluid flow
3.	To understand the various incompressible fluid flow through pipes and between parallel plates
4.	To apply the principles of fluid mechanics to design and operation of hydraulic turbines
5.	To apply the principles of fluid mechanics to design and operation of hydraulic pumps

UNIT I	INTRODUCTION AND FLUID STATICS	9	3	0	12

Basic concepts and units of measurement of physical quantities- Classification of fluids - Properties of fluids – density, relative density, vapour pressure, surface tension, Capillarity and viscosity. Fluid statics- hydrostatic pressure, buoyancy and Archimedes' principle.

UNIT II	FLUID KINEMATICS AND DYNAMICS	9	3	0	12

Classification of fluid flow - system and control volume - Lagrangian and Eulerian description for fluid flow - flow patterns- streamline, path line, streak line and timeline. Velocity potential function and Stream function - continuity equation and its applications. Fluid dynamics - Bernoulli's equation and its applications. Dimensional analysis – Buckingham's theorem, dimensional homogeneity, similarity-laws and models.

UNIT III	FLOW THROUGH PIPES AND PLATES	9	3	0	12

Incompressible fluid flow-Laminar flow- Hagen-Poiseuille equation, shear stress, pressure gradient relationship - flow through pipes and flow between parallel plates. Turbulent flow – flow through pipes, friction factors in turbulent flow - total energy line, hydraulic gradient line, flow through pipes in series and parallel- Moody's friction factor chart. Power transmission-Boundary layer flows - Boundary layer thickness, momentum thickness, energy thickness-boundary layer separation.

UNIT IV	HYDRAULIC TURBINES	9	3	0	12

Hydraulic turbines classification-impulse and reaction turbines-Working principle, Velocity triangle, work done-efficiency and performance curves for Pelton, Francis and Kaplan turbines. Comparison between impulse and reaction turbine- specific speed degree of reaction -draft tubes.

UNIT V	HYDRAULIC PUMPS	9	3	0	12

Classification of hydraulic pumps-Centrifugal pumps - working principle, velocity triangle, specific speed, performance curves and priming. Reciprocating pumps - classification, working principle, indicator diagram, air vessels and performance curves. Cavitation in pumps. Working principles of gear and vane pumps.

Total (45L+15T) = 60 Periods

Text Books:

1.	Bansal, R.K., "A Textbook of Fluid Mechanics and Hydraulic Machines, 9th Ed", Laxmi Publication Pvt Ltd, 2010.
2.	Rajput, R.K., "A Textbook of Fluid Mechanics and Hydraulic Mechanics", S.Chand and Company Ltd, 2011.
3.	Subramanya. K., "Fluid Mechanics and Hydraulic Machines", Tata McGraw Hill Publishing Company Ltd, 2011.

Reference Books:

1.	White, "Fluid Mechanics, 8 Ed", McGraw Hill India, 2017.
2.	Munson, Young and Okiishi, "Fundamentals of Fluid Mechanics 8 th Edition", Wiley, 2016.
3.	Yunuscengel, John. M.cimbala, "Fluid Mechanics Fundamentals and Applications", McGraw Hill, 2017.

4.	Som, S.K, Biswas.G and SumanChakraborty, “Introduction to Fluid Mechanics and Fluid Machines”, Tata McGraw Hill India, 2011.
5.	Dr.P.N.Modi, Dr.S.M.Seth, “Hydraulics and Fluid Mechanics including Hydraulic Machines”, Standard book house, 2018.
E-References:	
1.	NPTEL courses: http://nptel.iitm.ac.in/courses.php - web and video sources on fluid mechanics.

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom’s Taxonomy Mapped**
CO1	Understand the basic concepts and properties of fluids	Remember
CO2	Analyze the kinematic and dynamic concepts of fluid flow	Analyze
CO3	Understand the various incompressible fluid flow through pipes and between parallel plates	Understand
CO4	Apply the principles of fluid mechanics to design and operation of hydraulic turbines	Apply
CO5	Apply the principles of fluid mechanics to design and operation of hydraulic pumps	Apply

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	1	0	0	0	2	0	0	0	1	0	2	2	1
CO2	3	3	1	0	2	0	0	0	0	0	0	0	2	2	1
CO3	2	3	2	2	1	0	0	0	0	0	0	0	2	2	1
CO4	3	3	3	2	1	2	1	0	0	0	0	0	2	2	1
CO5	3	3	3	2	1	2	1	0	0	0	0	0	2	2	1
Avg	**2.8**	**2.6**	**2**	**1.2**	**1**	**0.8**	**0.8**	**0**	**0**	**0**	**0.2**	**0**	**2**	**2**	**1**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22ME303	MANUFACTURING PROCESSES		SEMESTER III			
PRE-REQUISITE:		**Category**	**PC**	**Credit**		**3**
1. Basic science, Engineering mathematics, Engineering Physics 2. Engineering Materials		**Hours/Week**	**L**	**T**	**P**	**C**
			3	**0**	**0**	**3**

Course Objectives:

1.	To make the students familiarize with various manufacturing processes and fabrication techniques of metals and design of casting.
2.	To develop design concepts of various manufacturing processes.
3.	Gain knowledge to select appropriate manufacturing processes for various parts.
4.	To develop an entrepreneur skill among the students.
5.	To evaluate and select plastic deformation processes for various parts.

UNIT I	**CASTING**	**9**	**0**	**0**	**9**

Concepts of Manufacturing Process -Sand casting -Patterns – Design of Pattern, mould and cores- gate and riser design, solidification time calculation - Moulding machines - Core making. Special moulding processes – CO_2 moulding; shell moulding, investment moulding, pressure die casting, centrifugal casting, casting defects.

UNIT II	**WELDING**	**9**	**0**	**0**	**9**

Classification of welding processes. Principles of Oxy-acetylene gas welding. Metal arc welding, resistance welding, submerged arc welding, tungsten inert gas welding, metal inert gas welding, plasma arc welding, thermit welding, electron beam welding, laser beam welding, defects in welding, Soldering and Brazing, Adhesive Bonding.

UNIT III	**METAL FORMING**	**10**	**0**	**0**	**10**

Metallurgical aspects of metal forming, slip, twinning mechanics of plastic deformation, load estimation of bulk deformation processes, Hot working and cold working of metals, Forging processes – open, closed and impression die forging – forging operations. Rolling of metals– Types of Rolling mill – Flat strip rolling – shape rolling operations – Defects in rolled parts. Principle of rod and wire drawing – Tube drawing – Principles of Extrusion – Types.

UNIT IV	**SHAPING OF PLASTICS**	**8**	**0**	**0**	**8**

Types of plastics - Characteristics of the forming and shaping processes – Moulding of Thermoplastics – Working principles and typical applications of - Injection moulding – Plunger and screw machines – Blow moulding – Rotational moulding – Film blowing – Extrusion - Typical industrial applications – Thermoforming – Processing of Thermosets – Working principles and typical applications - Compression moulding – Transfer moulding.

UNIT V	**SHEET METAL FORMING AND POWDER METALLURGY**	**9**	**0**	**0**	**9**

Formability of Sheet Metal, load estimation of sheet metal processes - Shearing, Deep drawing, Bending operations- types of presses used, Super Plastic forming; Introduction to Powder Metallurgy– Principal steps involved – sintering and compacting techniques, Advantages, limitations and applications of powder metallurgy.

Total = 45 Periods

Text Books:

1.	HajraChoudhury, "Elements of Workshop Technology", Vol. I and II, Media Promoters and Publishers Pvt., Ltd., Mumbai, 2005.
2.	NagendraParashar B.S. and Mittal R.K., "Elements of Manufacturing Processes", Prentice-Hall of India Private Limited, 2007.

Reference Books:

1.	SeropeKalpajian, Steven R.Schmid, "Manufacturing Processes for Engineering Materials",4/e, Pearson Education, Inc. 2007.

2.	Jain. R.K., and S.C. Gupta, "Production Technology", 16th Edition, Khanna Publishers, 2001.
3.	"H.M.T. "Production Technology – Handbook", Tata McGraw-Hill, 2000.
4.	Roy. A. Linberg, "Process and Materials of Manufacture", PHI, 2000.
5.	Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems.
E-References:	
1.	https://fdocuments.in/document/production-technology-55844cac00bfc.html?page=40

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Describe the operational features of various casting processes, design of gate, riser and discover various defects in casting.	Understand
CO2	Explain various metal joining processes and compare them.	Understand
CO3	Summarize several types of metal forming processes and select suitable method for different applications.	Analyze
CO4	Analyze various manufacturing methods for plastics and their needs in industry.	Analyze
CO5	Describe various sheet metal forming processes, load estimation calculation and principles of powder metallurgy	Understand

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	1	2	1	0	0	0	0	0	1	0	0	1	2	1
CO2	2	1	2	1	0	1	0	0	1	1	0	0	1	2	1
CO3	1	1	1	1	0	0	0	0	0	1	0	0	1	1	1
CO4	1	1	1	0	1	0	0	0	0	1	0	0	1	1	1
CO5	0	1	0	0	0	0	0	0	1	1	0	0	1	0	1
Avg	**1.2**	**1**	**1.2**	**0.6**	**0.2**	**0.2**	**0**	**0**	**0.4**	**1**	**0**	**0**	**1**	**1.2**	**1**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22MT310	MATERIALS ENGINEERING		SEMESTER III			
PRE-REQUISITE:		**Category**	**ES**	**Credit**		**3**
1. Engineering Physics 2.Engineering Chemistry		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To impart concept on reactions, treatment, microstructure and mechanical behavior of engineering materials at different temperature.
2.	To learn basic principles in metallurgy and materials engineering.
3.	To identity and select suitable engineering materials based on their applications

UNIT I	PHASE DIAGRAMS	9	0	0	9

Crystal structures, Phases, solid solution types, compounds, Hume- Rothery rules; Gibb's phase rule; Binary isomorphous alloy systems – Eutectic, Eutectoid, Peritectic systems. Lever rule, Equilibrium and non-equilibrium cooling, Fe-C Equilibrium diagram - effects of alloying elements – Ferrite and Austenite Stabilizers, TTT and CCT diagrams.

UNIT II	HEAT TREATMENT	9	0	0	9

Definition – Full annealing, stress relief, recrystallisation and spheroidizing –normalizing, hardening and tempering of steel. Isothermal transformation diagrams – cooling curves superimposed on I.T. diagram CCR - Hardenability, Jominy end quench test – Austempering, martempering – case hardening, carburising, nitriding, cyaniding, carbo-nitriding – Flame and Induction hardening. Heat treatment of non-ferrous alloys - precipitation hardening. Heat treatment of HSS tools, gears, springs and gauges.

UNIT III	FERROUS AND NON-FERROUS METALS	9	0	0	9

Plain carbon steels – Tool steels - maraging steels – HSLA steels. Stainless steels- ferritic and Austenitic, martensitic, duplex and precipitation hardened stainless steels. Types of Cast Irons- Gray cast iron, white cast iron, malleable cast iron, S.G. Iron. Copper alloys – Brass, Bronze and Cupronickel, Aluminium alloys, Bearing alloys.

UNIT IV	MECHANICAL PROPERTIES AND TESTING	9	0	0	9

Mechanical properties of engineering materials - Mechanisms of plastic deformation, slip and twinning – Creep, Fatigue and Fracture - Types of fracture – Testing of materials - tension, compression and shear loads - fatigue and creep tests – hardness and its effects – testing for hardness (Brinell, Vickers and Rockwell) - Impact test - Izod and Charpy.

UNIT V	NON-DESTRUCTIVE TESTING AND SURFACE ENGINEERING	9	0	0	9

Non-Destructive Testing: Basic principles, Testing method - Radiographic Testing, Ultrasonic testing, Magnetic particle inspection and Liquid penetrant inspections. Introduction to surface engineering– Definition, diffusion techniques, deposition methods, high and low energy beam methods, surface engineering charts, elastic contact mechanics.

Total = 45 Periods

Text Books:

1.	Kenneth G. Budinski and Michael K. Buinski, "Engineering Materials", Prentice Hall of India Ltd, 2002.
2.	Raghavan, V, "Materials Science and Engineering", Prentice Hall of India (P) Ltd., 1999.
3.	Aswani.K.G, "A Text Book of Material Science", S.Chand and Co. Ltd., New Delhi, 2001.
4.	Khanna O.P., "A Text Book of Materials Science and Metallurgy", DhanpatRai Sons, 2004.

Reference Books:

1.	William. D.Callsber, "Material Science and Engineering", John Wiley and Sons, 1997.
2.	Sydney.H.Avner, "Introduction to Physical Metallurgy" Mc Graw Hill Book Company, 1994.

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Understand the formation of materials and their classification based on atomic structure.	Understand
CO2	Understand the principles of various heat treatment processes in fabrication industry.	Understand
CO3	Describe properties, applications and types of various ferrous and non-ferrous metals used in fabrication industry	Understand
CO4	Describe various types of failure and select methods for destructive testing	Understand
CO5	Select methods for Non-destructive testing	Evaluate

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	2	2	1	1	1	0	0	0	0	0	2	3	1
CO2	1	0	2	1	1	2	1	0	0	0	0	0	2	3	1
CO3	0	1	1	1	1	0	1	0	0	0	0	0	3	2	1
CO4	0	2	2	1	1	1	1	0	0	0	0	0	2	3	1
CO5	0	2	2	2	1	0	1	0	0	0	0	0	2	2	1
Avg	**0.4**	**1.2**	**1.8**	**1.4**	**1.0**	**0.8**	**1**	**0**	**0**	**0**	**0**	**0**	**2.2**	**2.6**	**1.0**
3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)															

22MCIN02	INNOVATION SPRINTS				SEMESTER III	
PRE-REQUISITE:		Category	EE	Credit		1
		Hours/Week	L	T	P	TH
			0	0	2	2

Course Objectives:

1.	To understand the fundamentals of Design thinking & apply in ideating solutions for real-world problems.
2.	To solve challenges through problem curation, problem validation and customer discovery problems.

UNIT I	CHALLENGE CURATION	3	0	0	3

Introduction: Design Thinking Principles - Design Thinking Values - Design Thinking Methods - Challenge impact setting - Framing the design challenge.

UNIT II	CUSTOMER-CENTRIC INNOVATION	3	0	0	3

Understanding Customer needs - Empathy building techniques - gap analysis - adoption barriers - observations and insights - Translating Insights into Innovation Opportunities

UNIT III	IDEA GENERATION	3	0	0	3

Identifying pains & gains - crafting value proposition - Ideation - Divergent Thinking - Ideation methods- Rules of brainstorming - Managing risks - Concept of minimum usable prototypes - Generating solution concepts

UNIT IV	PROTOTYPING	3	0	0	3

Prototyping concepts -- Palm Pilot Experiment - Fake it before make it - Prototyping - The Law of Failure - Building a Prototype - Testing the Prototypes

UNIT V	PITCH & PRESENTATION	3	0	0	3

Science of Storytelling - the blueprint for storytelling - Pitch Script - Pitch Presentations - Best practices to creating a compelling pitch - communication fundamentals

Total = 15 Periods

Text Books:

1.	Tim Brown (2019), “Change by Design: How design thinking transforms organizations and inspires innovation”
2.	Jan Chipchase& Simon Steinhardt (2013), “Hidden in Plain Sight: How to Create extraordinary Products for Tomorrow’s Customers”, Harper Business 2013
3.	Christian Madsbjerg&Mikkel B. Rasmussen (2014), “The Moment of Clarity”, Harvard Business Review Press
4.	IdrisMootee(2013), Design Thinking for Strategic Innovation,Willey
5.	Alexander Osterwalder, Value Proposition Design: How to Create Products and Services Customers Want (Strategyzer) John Wiley & Sons, 2014

Reference Books:

1.	Avoia. Alberto, 2009 The Pretotyping Manifesto -
2.	https://sites.google.com/a/pretotyping.org/www/the-pretotyping-manifesto
3.	Jazz Factory, All about Presentations - http://blog.jazzfactory.in/
4.	Pretotyping Methodology - https://www.pretotyping.org/methodology.html

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Identify real-world problems	Understand
CO2	Apply the challenge curation techniques to real-world problems.	Apply
CO3	Analyze the problems and generate solutions to address the challenges	Analyze
CO4	Build solutions using prototyping tools & techniques	Apply
CO5	Develop an innovation pitch to effectively communicate the idea to solve the identified problem	Analyze

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	0	3	0	0	0	2	1	0	2	0	0	0	0	0	2
CO2	0	3	0	2	0	0	0	0	2	0	0	0	0	0	2
CO3	0	0	3	2	0	0	0	0	2	0	0	0	0	0	2
CO4	2	0	3	0	0	0	0	1	2	0	0	0	0	0	2
CO5	0	0	0	0	0	0	0	0	2	3	0	0	0	0	2
Avg	**0.4**	**1.2**	**1.2**	**0.8**	**0**	**0.4**	**0.2**	**0.2**	**2**	**0.6**	**0**	**0**	**0**	**0**	**2**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22NC301	NCC COURSE-II (Only for NCC Students)		SEMESTER III			
PRE-REQUISITE:		**Category**	**NC**	**Credit**		**0**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1. To maintain the unity and disciplines to the students

UNIT I	SOCIAL SERVICE & COMMUNITY DEVELOPMENT	9	0	0	9

Basic of social service and it's need - Rural Development Program – NGOs Roles & Contribution – Drug abuse and Trafficking – Civic Responsibilities – Causes & prevention of AIDS/HIV – Counter Terrorism – Corruption – Social Evil – RTI & RTE – Traffic Control Organization – Anti Drunken Driving.

UNIT II	GENERAL AWARENESS & ADVENTURE	9	0	0	9

General Knowledge – Logical & Analytical Reasoning - Modes of Entry to Army, CAPF, Police – SSB Procedure; Para Sailing – Slithering – Rock climbing – Cycling and Trekking.

UNIT III	AEROENGINES & NAVIGATION	9	0	0	9

Introduction to aero engines and its type – Components of aero engines – Principles of Propulsion – Basic Terminology – Jet engines – Brayton Cycle – Turbo prop engines and its types; Requirements of Navigation - Lines on Earth – Maps and its types - Symbols used in map – Scales of map – Map reading procedure and its aids.

UNIT IV	AIRFRAME & METEOROLOGY	9	0	0	9

Aircraft Control – Primary and Secondary –Fuselage – Main Plain and Tail Plain – Ailerons, Elevators& Rudders –Landing Gear; Importance of METT in Aviation – Atmosphere – Clouds and Precipitation – Flying Hazards.

UNIT V	FLIGHT INSTRUMENTS & AEROMODELLING	9	0	0	9

Airspeed Indicator – Altimeter – Artificial Horizon – Radar and Its Type – Instruments Battery Test, Compass; History of Aero Modeling – Basic Materials & Tools – Types of Aero Modelling – Flying/Building of Aero Models – General Safety Procedure.

Total = 45 Periods

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Acquired knowledge about social and legal responsibilities.	Understand
CO2	Understand the adventure activities and verbal training on defense examinations.	Remember and Understand
CO3	Understand the technical knowledge on aero engines and map reading.	Understand
CO4	Understand the structure and control of an aircraft.	Understand
CO5	Understand and learn the importance of avionic instruments on aircraft control.	Remember and Understand

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	0	0	0	0	0	0	0	0	0	0	3	1	1
CO2	3	3	2	3	0	0	0	0	0	0	0	0	3	2	1
CO3	3	2	3	1	0	2	0	0	0	0	0	0	3	2	1
CO4	3	2	2	2	0	0	0	0	0	0	0	0	3	2	1
CO5	3	0	0	0	0	1	0	0	0	0	0	0	3	3	1
Avg	**3**	**1.6**	**1.4**	**1.2**	**0**	**0.6**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**2**	**1**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22ME304	CAD LABORATORY	SEMESTER III

PRE-REQUISITE:	Category	PC	Credit		1.5
1. Engineering Drawing 2. Machine Drawing	Hours/Week	L	T	P	TH
		0	0	3	1.5

Course Objectives:

1.	Understand the Code of drawing practice as per BIS conventions for mechanical elements using CAD software.
2.	Practice the methods for sectioning and drawing the joints, couplings, bearings, and keys.
3.	Prepare assembly drawings, sectional views and bill of materials for selected assemblies.

CAD EXPERIMENTS

The students will be required to carry out the following exercises using software packages (e.g. 3D modeling package / Pro Engineer/ CATIA /I-Deas/ Solid Edge/Solid Works etc.)

- Introduction to advanced modeling software
- Part Modeling of Screw Jack
- Part Modeling of Flange Coupling
- Part Modeling of Plummer Block
- Part Modeling of Knuckle Joint
- Creation of 3D assembly model of universal joint
- Creation of 3D assembly model of connecting rod
- Creation of 3D assembly model of crankshaft
- Creation of 3D assembly model of Lathe Tailstock
- Creation of 3D assembly model of Piston.
- Creation of 3D assembly model of Safety valve.
- Detailing of Lathe Tailstock

Total = 45 Periods

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Describe how CAD technology can be leveraged in the design process and the basic and advanced features available with CAD software	Understand
CO2	Design a part or assembly of parts using Computer-Aided Design software.	Create
CO3	Design a detailed view of part or assembly of parts using Computer-Aided Design software.	Create

COURSE ARTICULATION MATRIX

CO/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	2	3	0	1	0	0	0	2	0	2	2	1
CO2	1	1	1	1	3	0	1	0	0	0	0	0	2	2	1
CO3	2	2	2	1	2	0	1	0	0	0	1	0	2	2	1
Avg	**1.6**	**1.6**	**1.33**	**1.33**	**2.6**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**2**	**2**	**1**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22CE308	STRENGTH OF MATERIALS AND FLUID MECHANICS LABORATORY	SEMESTER III

PRE-REQUISITE:	Category	ES	Credit		1.5
Strength of Materials Fluid Mechanics	Hours/Week	L	T	P	TH
		0	0	3	3

Course Objectives:

1.	To analyze structural members subjected to tension, compression and bending using the fundamental concepts of stress, strain and elastic behavior of materials.
2.	To Study about Pump and Turbine.

STRENGTH OF MATERIAL LABORATORY EXERCISES

1. Double shear test on mild steel rod
2. Tension Test on mild steel rod
3. Test of springs (Open coil and closed coil)
4. Impact test on a metallic specimen (Izod and Charpy Impact test)
5. Hardness tests on metallic specimen (Brinell / Rockwell)
6. Bending deflection test on beams

FLUID MECHANICS LABORATORY EXERCISES

1. Determination of Friction factor of pipes
2. Performance characteristics of Kaplan Turbine
3. Determination of the coefficient of discharge of orifice meter
4. Determination of the coefficient of discharge of venturi meter
5. Conducting experiments and drawing the characteristics curves of centrifugal pump
6. Conducting experiments and drawing the characteristics curves of reciprocating pump
7. Conducting experiments and drawing the characteristics curves of gear pump

Total = 30 Periods

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Learn the various techniques of testing methods for materials	Understand
CO2	Perform test and identify the different characteristics of materials.	Evaluate
CO3	Perform experiments on hydraulic machines to draw the performance characteristics.	Evaluate

COURSE ARTICULATION MATRIX

CO/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	1	1	0	0	0	0	1	0	0	0	1	1	3
CO2	1	2	1	1	0	0	0	0	1	0	0	0	2	1	2
CO3	1	2	2	2	0	0	0	0	1	0	0	0	2	1	3
Avg	**1**	**2**	**1.33**	**1.33**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1.66**	**1**	**2.6**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

SEMESTER-IV

22ME401	KINEMATICS OF MACHINERY		SEMESTER IV			
PRE-REQUISITE:		**Category**	**PC**	**Credit**		**4**
1. Engineering Graphics. 2.Engineering Mechanics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**1**	**0**	**4**

Course Objectives:

1.	To understand the basic components and layout of linkages in the assembly of a system/ machine.
2.	To understand the principles in analyzing the assembly with respect to the displacement, velocity, and acceleration at any point in a link of a mechanism.
3.	To understand basics of cam profile and its displacement.
4.	To understand the basic concepts of toothed gearing and kinematics of gear trains.
5.	Illustrate the effects of friction drives in transmission system.

UNIT I	BASICS OF MECHANISMS	9	3	0	12

Classification of mechanisms- Basic kinematic concepts and definitions- Degree of freedom, mobility- Grashof's law, Kinematic inversions of four bar chain and slider-crank chains Limit positions- Mechanical advantage - Transmission angle- Description of some common mechanisms- Quick return mechanism, straight-line generators- Universal Joint- Rocker Mechanisms.

UNIT II	KINEMATIC ANALYSIS	9	3	0	12

Displacement, velocity and acceleration analysis of simple mechanisms - graphical velocity analysis using instantaneous centres - velocity and acceleration analysis using loop closure equations- kinematic analysis of simple mechanisms- slider-crank mechanism, dynamics, Coincident points- Coriolis component of acceleration. Introduction to linkage synthesis - three Position graphical synthesis for motion and path generation.

UNIT III	KINEMATICS OF CAM	9	3	0	12

Classification of cams and followers- Terminology and definitions- Displacement diagrams Uniform velocity, parabolic, simple harmonic and cycloidal motions- derivatives of follower motions- specified contour cams circular and tangent cams- pressure angle and undercutting, sizing of cams, graphical and analytical disc cam profile synthesis for roller and flat face Followers.

UNIT IV	GEARS AND GEAR TRAINS	9	3	0	12

Involute and cycloidal gear profiles, gear parameters, fundamental law of gearing and conjugate action, spur gear contact ratio and interference/undercutting- helical, bevel, worm, rack & pinion gears, epicyclic and regular gear train kinematics.

UNIT V	FRICTION IN MACHINE ELEMENTS	9	3	0	12

Surface contacts- sliding and rolling friction- friction drives- friction in screw threads – bearings and lubrication- friction Clutches- belt and rope drives- friction in brakes.

Total (45L+15T) = 60 Periods

Text Books:

1.	Rattan S.S, "Theory of Machines", Tata McGraw Hill Publishing Company Ltd., New Delhi, 1998.
2.	Ghosh, A and Mallick, A.K, "Theory of Mechanisms and Machines", East-West Pvt. Ltd., New Delhi, 1988.

Reference Books:

1.	Thomas Bevan, "Theory of Machines", CBS Publishers and Distributors, 1984.
2.	Rao J.S and Dukkipati R.V, "Mechanism and Machine Theory", Wiley- Eastern Ltd., New Delhi, 1992.
3.	Erdman AG and Sandor G N, "Mechanism Design, Analysis and Synthesis", Vol.I, PHI Inc., 1997.
4.	Ambekar A.G, "Mechanism and Machine Theory" Prentice Hall of India, New Delhi, 2007.
5.	John Hannah and Stephens R C, "Mechanisms of Machines", Viva Low Price Student Edition, New Delhi, 1999.

E-References:	
1.	https://archive.nptel.ac.in/courses/112/104/112104121/
2.	https://nptel.ac.in/courses/112106270
3.	http://velhightech.com/Documents/ME8492 Kinematics of Machinery.pdf

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Demonstrate and understand the concepts of various mechanisms and pairs.	Apply
CO2	Analyze the velocity and acceleration of simple mechanisms.	Analyze
CO3	Construct the cam profile for various motion.	Create
CO4	Solve problems on gears and gear trains.	Evaluate
CO5	Evaluate the friction in transmission system	Evaluate

COURSE ARTICULATION MATRIX

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

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22ME402	THERMAL ENGINEERING *(Use of standard thermodynamic tables, Mollier diagram, Psychometric chart and Refrigerant property tables are permitted in the examination)*	SEMESTER IV

PRE-REQUISITE:	Category	PC	Credit		4
	Hours/Week	L	T	P	TH
		3	1	0	4

Course Objectives:

1.	To teach the construction and working of IC engine and basics on gas power cycles.
2.	To acquaint the concepts of nozzle, turbine and draw velocity triangle for a turbine, calculate work done and efficiency.
3.	To understand the construction and working of all types compressor and calculate the work done and efficiency of a reciprocating compressor.
4.	To provide knowledge concept of psychrometry and its processes.
5.	To acquaint knowledge of refrigeration cycles and calculation of COP and RE

UNIT I	INTERNAL COMBUSTION ENGINES AND GAS POWER CYCLES	9	3	0	12

Classification of IC engine, IC engine components and functions. Valve timing diagram and port timing diagram. Comparison of two stroke and four stroke engines, Actual and theoretical P-V diagram of two and four stroke engines, Performance calculation. Otto, Diesel, Dual, Brayton cycles, Calculation of mean effective pressure and air standard efficiency.

UNIT II	STEAM NOZZLES AND TURBINES	9	3	0	12

Flow of steam through nozzles, shapes of nozzles, effect of friction, critical pressure ratio, supersaturated flow. Principles of Impulse and Reaction Turbines, Compounding of Impulse Turbines. Velocity Diagrams, work done and efficiency for simple turbines.

UNIT III	AIR COMPRESSOR	9	3	0	12

Classification and comparison, working principle, work of compression - with and without clearance, Volumetric efficiency, Isothermal efficiency and Isentropic efficiency. Multistage air compressor with Intercooling. Working principle and comparison of Rotary compressors with reciprocating air compressors.

UNIT IV	PSYCHROMETRY	9	3	0	12

Psychrometric properties – Property calculations using Psychrometric chart and expressions. Psychrometric processes using Psychrometric chart – adiabatic saturation, sensible heating and cooling, humidification, dehumidification, evaporative cooling and adiabatic mixing.

UNIT V	REFRIGERATION SYSTEMS	9	3	0	12

Vapour compression Refrigeration cycle – Effect of suction and delivery pressures, super heat and sub cooling, performance calculations. Working principle of vapour absorption system. Comparison between vapour compression and absorption systems.

Total (45L+15T) = 60 Periods

Text Books:

1.	Rajput, R.K, “Thermal Engineering”, S. Chand Publishers, 2000.
2.	Rudramoorthy, R, “Thermal Engineering”, Tata McGraw Hill, New Delhi, 2003.
3.	Kothandaraman, C.P., Domkundwar,S. and Domkundwar , A.V, “A course in Thermal Engineering”, DhanpatRai and Sons, 5th Edition, 2002.
4.	Sarkar B.K, “Thermal Engineering”, Tata McGraw Hill, 1998

Reference Books:

1.	Holman. J.P., “Thermodynamics”, McGraw Hill, 1985.

2.	Arora.C.P, “Refrigeration and Air Conditioning”, TMH, 1994.

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom’s Taxonomy Mapped**
CO1	Analyze the performance parameters in IC engines and air standard cycles.	Analyze
CO2	Analyze the performance of steam nozzle and turbines and understand the concepts of compounding.	Analyze
CO3	Evaluate the performance parameters of an air compressor.	Evaluate
CO4	Apply the principles of Psychrometry for air-conditioning processes.	Apply
CO5	Analyze the vapour compression refrigeration cycle and evaluate COP and refrigerating effect.	Analyze

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	0	0	0	0	0	0	0	0	0	0	3	1	1
CO2	3	3	2	3	0	0	0	0	0	0	0	0	3	2	1
CO3	3	2	3	1	0	2	0	0	0	0	0	0	3	2	1
CO4	3	2	2	2	0	0	0	0	0	0	0	0	3	2	1
CO5	3	0	0	0	0	1	0	0	0	0	0	0	3	3	1
Avg	**3**	**1.6**	**1.4**	**1.2**	**0**	**0.6**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**2**	**1**
3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)															

22ME403	METAL CUTTING AND MACHINE TOOLS	SEMESTER IV

PRE-REQUISITE:	Category	PC	Credit		3
Introduction to Materials, force analysis Heat treatment processes and Engineering physics.	Hours/Week	L	T	P	TH
		3	0	0	3

Course Objectives:

1.	To provide knowledge on basic mechanics of metal cutting.
2.	Summarize the constructional and operational features of machine tools for manufacturing various components.
3.	Explain the machine tools for hole making grinding and broaching.
4.	To analyze various unconventional machining processes and their needs in industries
5.	Describe the necessity of additive manufacturing techniques and ready to interpret with industries requirements

UNIT I	THEORY OF METAL CUTTING	9	0	0	9

Mechanics of chip formation, single-point cutting tool, forces in machining, Types of chips, cutting tools– nomenclature, orthogonal metal cutting, thermal aspects, cutting tool materials, tool wear, tool life, surface finish, cutting fluids and Machinability.

UNIT II	AUTOMATS, SHAPING AND PLANING MACHINES	9	0	0	9

Capstan and turret lathes – construction - indexing mechanism - operations - working principle of single and multi-spindle automats – shaping and planning machines – types – construction - mechanism – principle of operation – different shaping operations.

UNIT III	DRILLING, BROACHING AND GRINDING MACHINES	9	0	0	9

Drilling machines – specifications, types - feed mechanism, operations – drill tool nomenclature – broaching – specifications, types, tool nomenclature, broaching operations – grinding – types of grinding machines – grinding wheels, specifications – bonds – mounting and reconditioning of grinding wheels.

UNIT IV	MILLING AND GEAR GENERATING MACHINES	9	0	0	9

Milling – specifications – types - cutter nomenclature – types of cutters – milling processes – indexing – gear forming in milling – gear generation - gear shaping and gear hobbing – specifications - cutters –coated tools & inserts- cutting spur and helical gears - bevel gear generators – gear finishing methods

UNIT V	ADVANCES IN MACHINING	9	0	0	9

Unconventional machining processes - principles, process parameters, MRR, process capabilities and tooling for Abrasive Jet Machining (AJM), Electrochemical Machining (ECM). Electric Discharge Machining (EDM), Laser Beam Machining (LBM). Additive manufacturing processes - Fundamentals of Additive Manufacturing (AM)-Product Development-Materials for AM Stereo lithography apparatus - STL file - Fused Deposition Modeling- Laminated Object Manufacturing- Selective Laser sintering- 3D Printer – Tooling.

Total = 45 Periods

Text Books:

1.	Kalpakjian and Schmid, “Manufacturing processes for Engineering Materials” (5th Edition)- Pearson India, 2014.
2.	Rao. P.N “Manufacturing Technology - Metal Cutting and Machine Tools", 3rd Edition, Tata McGraw-Hill, New Delhi, 2013

Reference Books:

1.	HajraChoudhury, "Elements of Workshop Technology", Vol.II., Media Promoters 2014
2.	"H.M.T. "Production Technology – Handbook", Tata McGraw-Hill, 2000.
3.	Roy. A. Linberg, "Process and Materials of Manufacture", PHI, 2000.

4.	Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems.
5.	Jain. R.K., and S.C. Gupta, "Production Technology", 16th Edition, Khanna Publishers, 2001

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Explain the mechanism of material removal processes.	Understand
CO2	Describe the constructional and operational features of special-purpose lathes, shaper and planner.	Understand
CO3	Gain working exposure to hole-making operations, grinding and broaching machines utilized in industries.	Evaluate
CO4	Study of special-purpose machine tools, operations and its uses in industries.	Understand
CO5	Summarize unconventional machining processes and additive manufacturing processes and their applications.	Remember

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	1	0	1	0	0	0	0	0	1	1	0	2	0	1
CO2	0	1	1	1	0	0	0	0	0	1	1	1	1	2	3
CO3	0	1	1	0	0	0	0	0	0	1	1	1	1	2	2
CO4	0	1	1	0	0	0	0	0	0	1	1	1	1	2	2
CO5	0	1	0	0	2	0	2	0	2	1	1	1	1	2	2
Avg	**0.4**	**1**	**0.6**	**0.4**	**0.1**	**0**	**0.1**	**0**	**0.1**	**1**	**1**	**0.8**	**1.2**	**1.6**	**2**
3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)															

22ME404	HYDRAULICS AND PNEUMATICS		SEMESTER IV			
PRE-REQUISITE:		Category	PC	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	To enable the students, understand the basics of hydraulics and pneumatics
2.	Applying the working principles of hydraulic actuators and control components.
3.	Designing and develop hydraulic circuits and systems.
4.	Applying the working principles of pneumatic power system and its components.
5.	Solving problems and troubles in fluid power systems.

UNIT I	FLUID POWER PRINICIPLES AND HYDRAULIC PUMPS	9	0	0	9

Introduction to Fluid power – Advantages and Applications – Fluid power systems – Types of fluids - Properties of fluids and selection – Basics of Hydraulics – Pascal's Law – Principles of flow - Friction loss – Work, Power and Torque - Problems, Sources of Hydraulic power; Pumping Theory – Pump Classification – Construction, Working, Design, Advantages, Disadvantages, Performance, Selection criteria of pumps – Fixed and Variable displacement pumps – Problems.

UNIT II	HYDRAULIC ACTUATORS AND CONTROL COMPONENTS	9	0	0	9

Hydraulic Actuators: Cylinders – Types and construction, Application, Hydraulic cushioning – Rotary actuators - Hydraulic motors - Control Components: Direction Control, Flow control and pressure control valves – Types, Construction and Operation – Accessories; Reservoirs, Pressure Switches – Filters – types and selection - Applications – Fluid Power ANSI Symbols – Problems.

UNIT III	HYDRAULIC CIRCUITS AND SYSTEMS	9	0	0	9

Accumulators, Intensifiers, Industrial hydraulic circuits – Regenerative, Pump Unloading, Double - Pump, Pressure Intensifier, Air-over oil, Sequence, Reciprocation, Synchronization, Fail - Safe, Speed Control, Deceleration circuits, Sizing of hydraulic systems, Hydrostatic transmission, Electro hydraulic circuits – Servo and Proportional valves – Applications - Mechanical, hydraulic servo systems.

UNIT IV	PNEUMATIC AND ELECTRO PNEUMATIC SYSTEMS	9	0	0	9

Properties of air – Air preparation and distribution – Filters, Regulator, Lubricator, Muffler, Air control valves, Quick exhaust valves, Pneumatic actuators, Design of Pneumatic circuit – classification - single cylinder and multi cylinder circuits - Cascade method – Integration of fringe circuits, Electro pneumatic system – Elements – Ladder diagram – timer circuits problems, Introduction to fluidics and pneumatic logic circuits.

UNIT V	DESIGN OF FLUID POWER CIRCUITS AND TROUBLESHOOTING	9	0	0	9

Servo systems, Hydro mechanical servo systems, electro hydraulic servo systems and proportional Valves, Introduction to electro hydraulic pneumatic logic circuits, ladder diagrams, PLC applications in fluid power control. Fluid power circuits, failure and troubleshooting. Design of Pneumatic circuits for metal working, handling, clamping counter and timer circuits. – Low-cost Automation – Hydraulic and Pneumatic power packs. Case studies: A simple sequence, synchronize circuits using hydraulic and pneumatics components.

Total = 45 Periods

Text Books:

1.	Manjumdar S.R, "Oil Hydraulics", Tata McGraw-Hill, December 2002.
2.	Anthony Esposito, "Fluid Power with Applications", Pearson Education 2013.

Reference Books:	
1.	Andrew Parr, “Hydraulic and Pneumatics”, Jaico Publications House, 2005.
2.	Bolton W. “Pneumatic and hydraulic system”, Butterworth-Heinemann 1997
3.	Majumdar S.R., “Pneumatic systems – Principles and maintenance”, Tata McGraw Hill, 2010
4.	Shanmugasundaram. K, “Hydraulic and Pneumatic controls”, Chand & Co, 2006
5.	Srinivasan.R. “Hydraulic and Pneumatic Controls”, Vijay Nicole Imprints, 2008.
E-References:	
1.	http://www.fluidpowerjournal.com
2.	http://14.139.160.15/courses/112102011/2
3.	https://www.nfpa.com/home.htm

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom’s Taxonomy Mapped**
CO1	Select the components as per the application	Evaluate
CO2	Apply the working principles of hydraulic actuators and control components.	Apply
CO3	Design and develop hydraulic circuits and systems.	Create
CO4	Apply the working principles of pneumatic power system and its components.	Apply
CO5	Solve problems and troubles in fluid power systems.	Evaluate

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	1	1	0	0	0	0	0	0	0	0	0	1	1	1
CO2	0	2	2	1	0	0	0	0	0	0	0	0	1	1	1
CO3	1	2	3	0	0	1	0	0	0	0	0	0	1	2	1
CO4	1	1	3	2	2	0	0	0	0	0	0	0	2	1	1
CO5	1	1	2	0	0	0	0	0	0	0	0	0	1	1	1
Avg	**1**	**1.4**	**2.2**	**0.6**	**0.4**	**0.2**	**0**	**0**	**0**	**0**	**0**	**0**	**1.2**	**1.2**	**1**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22CE409	STRENGTH OF MATERIALS		SEMESTER IV			
PRE-REQUISITE:		**Category**	**ES**	**Credit**		**3**
Differentiation, Partial Differential Equations Engineering Mechanics.		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the nature of stresses developed in simple geometries such as bars, cantilevers, beams, shafts, cylinders and spheres for various types of simple loads
2.	To calculate the shear force and bending moment of various beams transverse loading
3.	To estimate the slope and the deflection of beams and strengths of the columns
4.	To evaluate the axial and hoop stresses in thin and thick shells for the applied internal and external pressures.
5.	To learn about the torsion behavior of shafts and coil springs

UNIT I	**STRESS, STRAIN AND DEFORMATION OF SOLIDS**	**9**	**0**	**0**	**9**

Deformation in solids- Hooke's law, stress and strain- tension, compression and shear stresses-elastic constants and their relations- volumetric, linear and shear strains- principal stresses and principal planes- Mohr's circle. Deformation of simple compound bars-Relation between elastic constants-Thermal stresses.

UNIT II	**TRANSVERSE LOADING ON BEAMS AND STRESSES IN BEAMS**	**9**	**0**	**0**	**9**

Beams and types of transverse loading on beams- shear force and bending moment diagrams Types of beam supports, simply supported and over-hanging beams, cantilevers. Theory of bending of beams, bending stress distribution and neutral axis, shear stress distribution, point and distributed loads. Shear stress distribution of simple beams- circular, rectangular, "I" section, "T" section and channel sections.

UNIT III	**DEFLECTION OF BEAMS AND COLUMNS**	**9**	**0**	**0**	**9**

Moment of inertia about an axis and polar moment of inertia, deflection of a beam using double integration method, computation of slopes and deflection in beams, Macaulay's method – Area moment method - Conjugate beam and strain energy – Maxwell's reciprocal theorems. Columns: End Conditions-Equivalent length of a column-Euler's equation Slenderness ratio - Rankine's formula for columns.

UNIT IV	**THIN CYLINDERS, SPHERES AND THICK CYLINDERS**	**9**	**0**	**0**	**9**

Axial and hoop stresses in cylinders subjected to internal pressure, deformation of thick and thin cylinders, deformation in spherical shells subjected to internal pressure – Lame's theorem.

UNIT V	**TORSION AND SPRINGS**	**9**	**0**	**0**	**9**

Torsion, stresses and deformation in circular and hollow shafts, stepped shafts, deflection of shafts fixed at both ends. Torsion on springs-Wahl's factor of spring Stresses in helical springs under torsion loads-Stiffness and deflection of springs under axial load.

Total = 45 Periods

Text Books:

1.	Rajput, R.K, "Strength of Materials", S.Chand and Co, 3rd Edition, 2003.
2.	Bansal, R.K., "Strength of Materials", Laxmi Publications (P) Ltd., 2016.

Reference Books:

1.	Strength of Materials, D.S. Bedi, Khanna Publishing House
2.	Subramanian R., "Strength of Materials", Oxford University Press, Oxford Higher Education Series, 2010.
3.	Mechanics of Materials, Punmia, Jain and Jain, Laxmi Publications
4.	Strength of Materials (Mechanics of Solid), R.S. Khurmi, S.Chand Publications

5.	Strength of Materials, Jindal U.C., Asian Books Pvt. Ltd., New Delhi, 2009
E-References:	
1.	NPTEL Videos/Tutorials

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Evaluate the stress, strain and strain energy of simple bars	Evaluate
CO2	Familiarize the load transferring mechanism in beams and stress distribution due to shearing force and bending moment	Understand
CO3	Evaluate the slope and the deflection of beams and strengths of the columns	Evaluate
CO4	Analyze and design thin and thick shells for the applied internal and external pressures.	Analyze
CO5	Analyze the torsion behavior of shafts and coil springs	Analyze

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
CO2	2	2	1	1	0	0	0	0	0	0	0	0	1	2	0
CO3	3	2	1	1	0	0	0	0	0	0	0	0	2	2	0
CO4	3	2	2	2	0	0	0	0	0	0	0	0	2	0	1
CO5	2	2	2	2	0	0	0	0	0	0	0	0	2	0	1
Avg	**2.4**	**1.8**	**1.4**	**1.2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1.4**	**0.8**	**0.4**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22MCIN03	DESIGN SPRINTS		SEMESTER IV			
PRE-REQUISITE:		Category	EE	Credit		1
		Hours/Week	L	T	P	TH
			0	0	2	2

Course Objectives:

1.	Develop key skill areas essential for a product designer from the perspective of design, its inherent complexity and supports them with tools & techniques to prototype rapidly.
2.	To enable the participants to visualize the experience for a user.
3.	To learn the roles & responsibilities of a designer in creating and shaping experiences for the user.
4.	The participants shall learn through the lenses of system thinking of how existing products work.
5.	Learn to select & apply various practice tools to aid them in rapid prototyping

UNIT I	DESIGN FUNDAMENTALS	0	0	6	6

Introduction to Visual Design, History and Modernism, Design Thinking methodology, seven elements of design, principles of design, principles of good design, designing a product and a service

UNIT II	SYSTEM THINKING AND REVERSE ENGINEERING	0	0	6	6

System Thinking for Engineering Problem Solving, Understanding Systems, Examples and understandings, Complex Systems, Reverse Engineering Methodology, Identify building blocks/Components - Re-Engineering a complex system

UNIT III	USER INTERFACE & USER EXPERIENCE	0	0	6	6

Introduction to UI/UX, Human-Computer interface, user-centered Design Principles, User research techniques, UX Design workflow, Information Architecture, UI Components, need for UI prototyping, Wireframes

UNIT IV	MECHANICAL PROTOTYPING	0	0	6	6

Need for prototyping - Domains in prototyping - Difference between actual manufacturing and prototyping - Rapid prototyping methods - Tools used in different domains - Introduction - Working with Fusion 360 - 3D Modeling - 3D Printing and classification - Laser Cutting and engraving - RD Works - Additive manufacturing

UNIT V	ELECTRONIC & SOFTWARE PROTOTYPING	0	0	6	6

Introduction to Lumped Circuits - Electronic Prototyping - Tinker CAD - Designing in KI CAD - PCB design - Source code management and version control - GitHub - GitHub Actions - GitBash - Continuous Integration - Platform as service - Heroku - Build Packs

Total = 30 Periods

Text Books:

1.	Thinking in systems - Donella Meadows, 2015
2.	Rapid Prototyping And Engineering Applications: A Toolbox For Prototype Development - Frank W.Liou, 2007
3.	Rapid Prototyping Technology: Selection and application - COOPER K. G, 2001

Reference Books:

1.	https://thesystemsthinker.com/wp-content/uploads/2016/03/Introduction-to Systems-Thinking-IMS013Epk.pdf
2.	https://formlabs.com/blog/ultimate-guide-to-prototyping-tools-for-hardware-and product-design/
3.	https://docs.kicad-pcb.org/
4.	https://www.tinkercad.com/learn/circuits
5.	https://docs.github.com/en/free-pro- team@latest/actions/guides

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Understand the elements and principles of product and service design	Apply
CO2	Apply system thinking concepts in reverse engineering	Apply
CO3	Apply user research techniques to meet the UX needs of a customer and design a visual prototype	Apply
CO4	Develop prototyping models using the tools from mechanical prototyping models	Apply
CO5	Develop prototyping models using the tools from electrical and software prototyping methods	Apply

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	0	1	0	0	0	0	0	2	0	0	0	0	0	2
CO2	2	3	0	0	0	0	0	0	2	0	0	0	0	0	2
CO3	3	0	1	0	0	0	0	1	2	0	0	0	0	0	2
CO4	0	0	3	2	3	0	0	0	2	0	0	0	0	0	2
CO5	2	0	2	0	1	0	0	0	2	0	0	0	0	0	2
Avg	**2**	**0.6**	**1.4**	**0.4**	**0.8**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**2**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22CYMC01	ENVIRONMENTAL SCIENCE	SEMESTER IV

PRE-REQUISITE:	Category	MC	Credit		0
	Hours/Week	L	T	P	C
		2	0	1	3

Course Objectives:

1.	To learn the concept of non-conventional energy systems.
2.	To explore the environmental impact assessment and to learn about the consequence of different types of pollutants.
3.	To have an ancient wisdom drawn from Vedas.
4.	To acquire activity-based knowledge to preserve environment.
5.	To learn about conservation of water and its optimization.

ENVIRONMENTAL AWARENESS	30	0	0	30

Various types of traditional power Plant --Advantage and Disadvantage of conventional Power Definition of non-conventional energy sources Plants – Conventional vs. Non-conventional power generation. – types of non-conventional energy sources - India's current energy resources and their long-term viability – India’s Energy requirement and management

Solar Energy Basics- Solar Thermal Energy- Solar Photovoltaic Energy- Benefits and Drawbacks -Effects on the environment and safety. Wind turbine power and energy- India's wind energy potential- Wind turbine types. Environmental benefits and impacts of offshore wind energy.Air pollution- Sources, effects, control, air quality standards, air pollution act, air pollution measurement. Water Pollution-Sources and its remedy, Soil Pollution-Sources and its remedy, disposal of solid waste. Greenhouse gases – effect, acid rain. Noise pollution reduction. Aspects of pollution from various power plants.

ENVIRONMENTAL ACTIVITIES	0	0	15	15

Group activity on water management – Group discussion on recycle of waste (4R’s)- Slogan making contest – Poster making event – Expert lecture on environmental awareness – Imparting knowledge on reduction of electricity usage.

Identification and segregation of biodegradable and non-biodegradable waste – Campus cleaning activity – Plantation of trees in the college campus and local waste lands – Identification of varieties of plants and their usage – Shutting down the fans and ACs of the campus for an hour.

Total (30L + 15P) = 45 Periods

Text Books:

1.	Elements of Environmental science and Engineering, P.Meenakshi, Prentice Hall of India, New Delhi, 2009.
2.	A Textbook of Environmental Chemistry and Pollution Control: (With Energy, Ecology, Ethics and Society), Revised Edition, Dr. S.S. Dara, D.D. Mishra Published by S. Chand & Company Ltd, 20 14.

Reference Books:

1.	Introduction to Environmental Engineering and Science, Gilbert M. Masters; Wendell P. Ela Publisher: Prentice-Hall India, 3rd Edition, 2008.
2.	Environmental Science, Fldren D. Enger, Bredley F.Smith, WCD McGraw Hill 14"Edition 2015.

E-Reference

1	www.onlinecourses.nptel.ac.in/
2	www.ePathshala.nic.in

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Identify about the major renewable energy systems and will investigate the environmental impact of various energy sources as well as the consequences of various pollutants.	Understand & Analyze
CO2	Predict the methods to conserve energy and ways to make optimal use of the energy for the future.	Apply

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	0	1	3	0	0	3	1	1	0	0	0	1	2	0	1
CO2	0	1	3	0	0	3	1	1	0	0	0	1	2	0	1
Avg	**0**	**1**	**3**	**0**	**0**	**3**	**1**	**1**	**0**	**0**	**0**	**1**	**2**	**0**	**1**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22ME405	THERMAL ENGINEERING LABORATORY	SEMESTER IV

PRE-REQUISITE:	Category	PC	Credit		1.5
	Hours/Week	L	T	P	TH
		0	0	3	3

Course Objectives:

1.	The components of IC engine and boiler, mountings and accessories and procedure of steam generation.
2.	Constructing port and valve timing diagram and determine the flash and fire point of fuel oil.
3.	Analyzing the petrol and diesel engine performance by conducting load test.
4.	Analyzing the diesel engine performance by retardation test.
5.	Characteristics of heat release in diesel engine and to study the p-θ diagram.

LIST OF EXPERIMENTS

1. Dismantling and assembling of a single cylinder petrol and diesel engine.
2. Demonstration of generating steam using boiler.
3. Determination of Viscosity, Flash and Fire point.
4. Construction of Valve Timing and Port Timing Diagrams.
5. Performance analysis of a four-stroke Diesel Engine.
6. Performance analysis of a four-stroke Petrol Engine.
7. Construction of a Heat Balance Test on four-stroke Diesel Engine.
8. Morse Test on Multi cylinder Diesel Engine.
9. Retardation Test to find Frictional Power of a Diesel Engine.
10. Determination of p-θ diagram and heat release characteristics of an IC engine.

Total = 45 Periods

COURSE OUTCOMES: **Upon completion of the course, the students will be able:**		**Bloom's Taxonomy Mapped**
CO1	To identify the components of IC engine and boiler, mountings and accessories and procedure of steam generation.	Understand
CO2	To construct port and valve timing diagram and determine the flash and fire point of fuel oil.	Create
CO3	To analyze the petrol and diesel engine performance by conducting load test.	Analyze
CO4	To analyze the diesel engine performance by retardation test.	Analyze
CO5	To study the characteristics of heat release in diesel engine and to study the p-θ diagram.	Remember

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	1	1	0	0	0	0	0	1	1	2
CO2	1	2	1	1	1	2	1	0	0	0	0	0	2	1	1
CO3	2	1	3	1	1	2	1	0	0	0	0	0	3	1	3
CO4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Avg	**1.2**	**1**	**1**	**0.6**	**1**	**1**	**0.6**	**0**	**0**	**0**	**0**	**0**	**1.2**	**0.6**	**1.2**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22ME406	MANUFACTURING TECHNOLOGY LABORATORY	SEMESTER IV

PRE-REQUISITE:	Category	PC	Credit		1.5
1. Constructional and operational features of conventional machine tools 2. Theory of metal cutting and machinability of various engineering materials.	Hours/Week	L	T	P	TH
		0	0	3	3

Course Objectives:

1.	To study different types of machine tools like lathe, drilling machine, shaper and grinding machine.
2.	To acquire the necessary skills to operate different machinery.
3.	To calculate metal removal rate and machining time of metal cutting processes
4.	To analyze and select an appropriate machining process for different components.
5.	To study safety measures while machining.

LIST OF EXPERIMENTS

1. Eccentric turning
2. Multi starts thread cutting
3. Drilling and grooving
4. Counter boring
5. Counter sinking
6. Shaping the sides of a cubical blank
7. Groove cutting and V-cutting
8. Dovetail cutting
9. T –slot cutting
10. Spur gear cutting in milling machine
11. Helical Gear Cutting in milling machine
12. Contour milling using vertical milling machine
13. Surface Grinding of cubical block
14. Cylindrical Grinding of circular shaft

Total = 45 Periods

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Operate machines tools for various assembly and fabrication tasks.	Understand
CO2	Set up machines like lathe shaper, grinding and milling machine for various applications	Create
CO3	Perform machining time calculation in machining jobs.	Analyze
CO4	Evaluate the accuracy & tolerance of components produced	Analyze
CO5	Prepare gears using forming and generating methods of gear manufacturing	Remember

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	0	0	0	1	0	1	0	0	1	0	1	0	1	0
CO2	0	2	0	0	2	2	1	1	0	0	0	2	0	2	0
CO3	3	1	0	1	0	0	2	0	1	1	0	1	2	1	3
CO4	3	3	0	0	2	0	0	2	0	0	0	0	0	2	0
CO5	0	1	0	0	0	0	0	0	1	2	0	0	3	0	1
Avg	**1.6**	**1.4**	**0**	**0.2**	**1**	**0.4**	**0.8**	**0.6**	**0.4**	**0.8**	**0**	**0.8**	**1**	**1.2**	**0.8**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

SEMESTER-V

22ME501	DESIGN OF MACHINE ELEMENTS		SEMESTERV			
PREREQUISITES		**Category**	**PC**	**Credit**		**4**
1. Student should study engineering mechanics. 2. Student should study kinematic of machinery.		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**1**	**0**	**4**

COURSE OBJECTIVES

1.	Understanding of background in mechanics of materials and design of machine components.
2.	An understanding of the origins, nature and applicability of empirical design principles, based on safety considerations
3.	An understanding the design of shafts, couplings and joints.
4.	Familiarize the design of energy storing elements and engine components.
5.	An appreciation of the relationships between component level design and overall machine system design and performance

UNIT-I	**STEADY STRESSES AND VARIABLE STRESSES IN MACHINE MEMBERS**	**9**	**3**	**0**	**12**

Introduction to the design process – Product development cycle- factors influencing machine design, selection of materials based on mechanical properties - Preferred numbers– Direct, Bending and Torsional stress – Impact and shock loading – Calculation of principle stresses for various load combinations, eccentric loading – Design of curved beams – crane hook and 'C' frame - Factor of safety -theories of failure – stress concentration – design for variable loading – Soderberg, Goodman and Gerber relations .

UNIT-II	**DESIGN OF SHAFTS, COUPLINGS AND PIN JOINTS**	**9**	**3**	**0**	**12**

Design of solid and hollow shafts based on strength, rigidity and critical speed – Design of keys and key ways - Design of rigid and flexible couplings – Design of pin joints like cotter and knuckle joints.

UNIT-III	**DESIGN OF THREADED FASTENERS, RIVETED AND WELDED JOINTS**	**9**	**3**	**0**	**12**

Threaded fasteners - Design of bolted joints including eccentric loading – Design of riveted and welded joints for pressure vessels and structures- theory of bonded joints.

UNIT-IV	**DESIGN OF ENERGY STORING ELEMENTS AND ENGINE COMPONENTS**	**9**	**3**	**0**	**12**

Various types of springs, optimization of helical springs - rubber springs - Flywheels considering stresses in rims and arms for engines and punching machines- Connecting Rods and crank shafts. Heat engines- Brief details about external combustion and internal combustion engines, Design of I.C engine cylinder, piston, connecting rod, crankshaft and flywheel.

UNIT-V	**DESIGN OF BEARINGS, LEVERS, PRESSURE VESSELS AND PIPES**	**9**	**3**	**0**	**12**

Sliding contact and rolling contact bearings - Hydrodynamic journal bearings, Sommerfeld Number - Selection of Rolling Contact bearings. Design of Levers - Design of pressure vessels and pipes

Total(45L+15T) = 60 Periods

Text Books:

1	Bhandari V.B, "Design of Machine Elements", Tata McGraw Hill Book Co, 2020
2	Md.Jalaludeen.S, "A text book of Machine Design", Anuradha Publications, 2006

Reference Books:

1	Shigley, J.E. and Mischke, C.R., Mechanical Engineering Design, Fifth Edition, McGraw-Hill International; 1989.
2	Deutschman, D., Michels, W.J. and Wilson, C.E., Machine Design Theory and Practice, Macmillan, 1992.

3	Juvinal, R.C., Fundamentals of Machine Component Design, John Wiley, 1994.
4	PSG Tech, "Design Data Handbook", M/s.DPV Printers, Coimbatore, 2009
E –References:	
1	https://nptel.ac.in/courses/112105124
2	Design of Machine Elements - V. B. Bhandari - Google Books
3	A Textbook of Machine Design by R.S.Khurmi And J.K.Gupta [tortuka]_1490186411865.pdf | DocDroid

COURSE OUTCOMES: **On completion of the course the student will be able to**		**Bloom's Taxonomy Mapped**
CO1	Explain the influence of steady and variable stresses in machine component design.	Understand
CO2	Apply the concepts of design to shafts, keys and couplings.	Apply
CO3	Familiarize the design of temporary and permanent joints	Understand
CO4	Design the various energy storing elements and engine components.	Analyze
CO5	Familiarize the design of various types of bearings and pressure vessels.	Understand

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	1	2	0	1	1	0	0	0	1	0	3	2	1
CO2	2	2	1	2	0	1	1	0	0	0	1	0	3	2	1
CO3	2	2	1	2	0	1	1	0	0	0	1	0	3	2	1
CO4	2	2	1	2	0	1	1	0	0	0	1	0	3	2	1
CO5	2	2	1	2	0	1	1	0	0	0	1	0	3	2	1
Avg	**2.0**	**2.0**	**1.0**	**2.0**	**0.0**	**1.0**	**1.0**	**0.0**	**0.0**	**0.0**	**1.0**	**0.0**	**3.0**	**2.0**	**1.0**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

22ME502	HEAT AND MASS TRANSFER		SEMESTER V			
PREREQUISITES:		**Category**	**PC**	**Credit**		**3**
1.The laws and basic concepts of thermodynamics 2. The concept of energy transfers and their conversion principles		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives

1.	Understanding the science behind conduction heat transfer and its applications
2.	Differentiating the concepts of forced and natural convection heat transfer
3.	Describing the laws and concepts of radiation heat transfer
4.	Understanding phase change processes and analyzing heat exchangers
5.	Studying the concept of mass transfer process and its modes

UNIT-I	**CONDUCTION HEAT TRANSFER**	**9**	**0**	**0**	**9**

General Differential equation – Cartesian (derivation of General Differential Equation), Cylindrical (derivation of General Differential Equation) and Spherical Coordinates– One Dimensional Steady State Heat-Concepts of electrical analogy, Conduction — plane and Composite Systems – Conduction with Internal Heat Generation., Critical thickness of insulation.

Extended Surfaces – Unsteady Heat Conduction – Lumped Analysis – Semi Infinite and Infinite Solids –Use of Heisler's charts.

UNIT-II	**CONVECTION HEAT TRANSFER**	**9**	**0**	**0**	**9**

Conservation equations, boundary layer concept – Forced convection: external flow – flow over plates, cylinders, spheres and bank of tubes. Internal flow – entrance effects. Free convection –flow over vertical plate, horizontal plate, inclined plate, cylinders and spheres.

UNIT-III	**BOILING, CONDENSATION AND HEAT EXCHANGERS**	**9**	**0**	**0**	**9**

Regimes of Pool boiling and Flow boiling, Nusselt's theory of condensation- correlations in boiling and condensation. Heat Exchanger Types - Overall Heat Transfer Coefficient – Fouling Factors. LMTD and NTU methods.

UNIT-IV	**RADIATION HEAT TRANSFER**	**9**	**0**	**0**	**9**

Radiation laws, Black Body and Gray body Radiation. Shape Factor. Electrical Analogy. Radiation Shields.

UNIT-V	**MASS TRANSFER**	**9**	**0**	**0**	**9**

Basic Concepts – Diffusion Mass Transfer – Fick's Law of Diffusion – Steady state Molecular Diffusion - Equimolal counter diffusion. Basic Convective Mass Transfer Problems.

Total = 45 Periods

Text Books:

1	R.C. Sachdeva, "Fundamentals of Engineering Heat & Mass transfer", New Age International Publishers, 2017
2	Frank P. Incropera and David P. Dewitt, "Fundamentals of Heat and Mass Transfer", John Wiley & Sons, 7th Edition, 2014.

Reference Books:

1	Yunus A. Cengel, "Heat Transfer A Practical Approach" – Tata McGraw Hill, 5 th Edition - 2013
2	Holman, J.P., "Heat and Mass Transfer", Tata McGraw Hill, 2017
3	Kothandaraman, C.P., "Fundamentals of Heat and Mass Transfer", New Age International, New Delhi, 2012
4	Ozisik, M.N., "Heat Transfer", McGraw Hill Book Co., 1994.

COURSE OUTCOMES: **On completion of the course the student will be able to**		**Bloom's Taxonomy Mapped**
CO1	Analyze the mechanism of heat conduction under steady and transient conditions.	Apply
CO2	Develop solutions to problems involving convective heat transfer	Create
CO3	Design a heat exchanger for any specific application	Understand
CO4	Adopt the concept of radiation heat transfer in real time systems	Understand
CO5	Develop solutions to problems involving combined heat and mass transfer	Apply

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	3	2	0	1	0	0	0	0	0	3	3	1
CO2	3	3	3	3	2	0	1	0	0	0	0	0	3	3	1
CO3	3	3	3	3	2	0	1	0	0	0	0	0	3	3	1
CO4	3	3	3	3	2	0	1	0	0	0	0	0	3	2	1
CO5	2	2	2	2	1	0	1	0	0	0	0	0	3	1	0
Avg	**2.8**	**2.8**	**2.8**	**2.8**	**1.8**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**3**	**2.4**	**0.8**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22ME503	METROLOGY AND QUALITY CONTROL		SEMESTER V			
PREREQUISITES		Category	PC	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	Explaining the importance of measurements in engineering and the factors affecting measurements and to compute measurement uncertainty
2.	Applying the applications of linear and angular measuring instruments
3.	Interpretation of various tolerance symbols.
4.	Applying the SQC methods in manufacturing
5.	Applying the advances in measurements for quality control

UNIT I	BASICS OF MEASUREMENT SYSTEM AND DEVICES	9	0	0	9

Definition of metrology, accuracy, precision and sensitivity, Abbe‘s principle. Three stages of generalizedmeasurementsystem-mechanicalloading-staticcharacteristicsofinstruments-factorsconsideredinselection of instruments - commonly used terms, error analysis and classification - sources of error. Measurement uncertainty

UNIT II	CALIBRATION OF INSTRUMENTS AND QUALITY STANDARDS	9	0	0	9

Calibration of measuring instruments - principles of calibration, Calibration of Instruments - Vernier caliper, Micrometer, feeler gauges, dial indicator, surface plates, slip gauges, care of gauge blocks. General cares and rules in measurement, ISO 9000 quality standards. Comparators - mechanical, electrical, optical and pneumatic.

UNIT III	GEOMETRICAL MEASUREMENT AND MACHINE ELEMENTS	9	0	0	9

Angular measurement - optical protractors, sine bar, roundness measurement, limit gauge, design of plug gauge, Taylor ‘s principle, three basic types of limit gauges, Tomlinson surface meter, computer controlled CMM. ISO metric thread, measurement of major, minor and effective diameters. Gear terminology; spur gear measurement, checking of composite errors, base pitch measurement. Principle of interferometry, laser interferometer, Machine vision, Fundamental of GD and T. Inspection of straightness, flatness, roundness deviations.

UNIT IV	STATISTICAL QUALITY CONTROL	9	0	0	9

Surfacefinish-terminologyandmeasurements-Opticalmeasuringinstruments-AcceptancetestformachinesStatisticalQuality Control-Control charts-Sampling plans

UNIT V	SIX SIGMA	9	0	0	9

Sixsigma:definemeasure,analyse,improveandcontrolphases.Analyzephasetools:CommonTools:Histogram,BoxPlot,Controlchart,Scatterchart,Causeandeffectdiagram,Paretoanalysis,interrelationsdiagram. Special Tools: Regression Analysis, Hypothesis Testing, ANOVA, Multi variate analysis.

Total = 45 Periods

Text Books:

1.	Gupta.I.C, ―A text book of Engineering Metrology, Dhanpat Rai publications, New Delhi, 2018
2.	Beckwith.T.G,Roy D. Marangoni, John H. Lienhard, - Mechanical Measurements‖, Prentice Hall, 2006

Reference Books:

1.	Jain.R.K, ―Mechanical and Industrial Measurements‖, Khanna Publishers, Delhi, 1999.
2.	Holmen.J.P, ―Experimental Methods for Engineers‖, Tata McGraw Hill Publications Co Limited, 2017.
3.	Grant, E.L., Statistical Quality Control, Mc Graw-Hill, 2004. 3. Doeblin E.O., Measurement Systems, Mc Graw-Hill, 2004.

4.	Alan S Morris, ―Measurement and Instrumentation Principles‖, Butterworth, 2006.
5.	De Feo J A and Barnard W W, ―Six Sigma: Break trough and BeyondG, Tata McGraw-Hill, New Delhi, 2005.
E-References:	
1.	https://nitsri.ac.in/Department/Mechanical%20Engineering/MEC_405_Book_2,_for_Unit_2B.pdf
2.	https://www.nist.gov/system/files/documents/srm/NIST-SRM-RM-Articlefinal.pdf
3.	https://www.researchgate.net/publication/319587859_Computer-Aided_Metrology-CAM

COURSE OUTCOMES: **On completion of the course the student will be able to**		**Bloom's Taxonomy Mapped**
CO1	Explain the importance of measurements in engineering and the factors affecting measurements and to compute measurement uncertainty	Understand
CO2	Apply the working principle and the applications of linear and angular measuring instruments	Apply
CO3	Interpret of various tolerance symbols.	Apply
CO4	Apply the SQC methods in manufacturing.	Apply
CO5	Apply the advances in measurements for quality control in manufacturing industries.	Apply

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	0	0	0	0	0	0	2	1	2	0	0	0	2	1	0
CO2	0	0	0	0	0	0	3	1	2	0	0	0	1	2	0
CO3	0	0	0	0	0	0	2	1	0	0	0	0	2	1	0
CO4	0	0	0	3	0	0	2	0	1	0	0	0	1	2	0
CO5	0	0	0	2	0	0	0	3	1	0	0	0	2	1	0
Avg	**0.0**	**0.0**	**0.0**	**1.0**	**0.0**	**0.0**	**1.8**	**1.2**	**1.2**	**0.0**	**0.0**	**0.0**	**1.6**	**1.4**	**0.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22ME504	DYNAMICS OF MACHINERY		SEMESTER V			
PREREQUISITES		**Category**	**PC**	**Credit**		**3**
Engineering Mechanics, Kinematics of Machinery, Strength of Materials		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To impart students with the knowledge about motion, masses and forces in machines and the Principle of Virtual Work
2.	To facilitate students to understand the concept of balancing of rotating and reciprocating masses
3.	To teach concepts of free vibration analyses of one and two degree-of-freedom rigid body systems
4.	To teach concepts of forced vibrations analyses of rigid body systems and to give awareness to students on the phenomenon of vibration and its effects
5.	To learn about the concept of various types of governors

UNIT I	**FORCE ANALYSIS**	**9**	**0**	**0**	**9**

Static force analysis, Free body diagrams, Conditions of two, three and four force members. Inertia forces and D'Alembert's Principle – Inertia force analysis in reciprocating engines – Crank shaft torque. Flywheels – Turning moment diagrams and fluctuation of energy of reciprocating engine mechanisms, Coefficient of fluctuation of energy and speed, Weight of flywheel required.

UNIT II	**BALANCING**	**9**	**0**	**0**	**9**

Static and dynamic balancing - Balancing of rotating masses - Balancing a single cylinder Engine - Balancing Multi-cylinder Engines - Partial balancing in locomotive Engines - Balancing linkages - balancing machines

UNIT III	**FREE VIBRATION**	**9**	**0**	**0**	**9**

Basic features of vibratory systems – Types – Single degree of freedom system – Transverse vibration of beams – Natural frequency by energy method, Dunkerly's method - Critical speed - Damped free vibration of single degree freedom system - Types of damping – Free vibration with viscous damping, Critically damped system, Under damped system. Torsional Systems: Natural frequency of two and three rotor systems.

UNIT IV	**FORCED VIBRATION**	**9**	**0**	**0**	**9**

Response to periodic Force – Harmonic force – Force caused by unbalance – Support motion - Logarithmic Decrement- Magnification factor – Vibration isolation and transmissibility.

UNIT V	**GOVERNORS**	**9**	**0**	**0**	**9**

Governors - Types - Centrifugal governors - Gravity controlled and spring controlled centrifugal governors –Characteristics - Effect of friction - Controlling Force - other Governor mechanisms.

Total = 45 Periods

Text Books:

1.	Design of Machinery, Fourth Edition, by R.L. Norton, McGraw Hill, 2007
2.	Mechanical Vibration, V.P.Singh, Dhanpatrai, Delhi

Reference Books:

1.	Ballaney, P.L., "Theory of Machines and Mechanisms", Khanna Publishers, New Delhi, 2002.
2.	Shigley, J.E. and Uicker, J.J., "Theory of Machines and Mechanisms", TMH ND, 1998.
3.	Amithabha Ghosh, and Ashok Kumar Malik., "Theory of Mechanisms and Machines", 2nd Ed., Affiliated East and West Press Limited, 1998.
4.	Prof.Nakara, IIT-Delhi Reference Books

E-References:

1.	www.university.youth4work.com/IIT_Kharagpur_Indian-Institute-of-Technology/study/1653-dynamics-of- machinery-ebook
2.	http://nptel.ac.in/courses/112104114/

COURSE OUTCOMES: **On completion of the course the student will be able to**		**Bloom's Taxonomy Mapped**
CO1	Apply basic principles of mechanisms in mechanical system	Apply
CO2	Familiarize the static and dynamic analysis of simple mechanisms	Understand
CO3	Analyze the mechanical systems subjected to free vibration	Analyze
CO4	Analyze mechanical systems subjected to forced vibration	Analyze
CO5	Analyze the various types of governors and its speed control mechanism	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	3	3	1	0	0	0	0	1	0	3	2	1	2
CO2	2	2	3	2	1	0	0	0	0	1	0	3	2	1	2
CO3	2	2	3	2	0	0	0	0	0	1	0	3	2	1	2
CO4	2	2	3	2	1	0	0	0	0	1	0	3	2	1	2
CO5	1	2	3	2	0	0	0	0	0	1	0	3	2	1	1
Avg	**1.8**	**2.0**	**3.0**	**2.2**	**1.2**	**0.0**	**0.0**	**0.0**	**0.0**	**1.0**	**0.0**	**3.0**	**2.0**	**1.0**	**1.8**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22ME505	INSTRUMENTATION AND CONTROL SYSTEM		SEMESTER V			
PREREQUISITE:		**Category**	**PC**	**Credit**		**3**
Basics of measurements		**Hours/Week**	**L**	**0**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To make the students aware of the modern sensors and advanced measurement systems
2.	To select the correct system of instrumentation and sensing as per the industrial requirements
3.	To understand statistical signal processing
4.	To provide adequate knowledge in the time response of systems and steady state error analysis
5.	To introduce stability analysis and design of compensators

UNIT I	GENERAL CONCEPTS OF MEASUREMENT	9	0	0	9

Measurement systems- Sensors and transducers– Classifications of Transducers -Static and Dynamic Characteristics –Sensors for displacement, position and proximity; velocity, motion, force, fluid pressure, liquid flow, liquid level, temperature, light sensors– Selection of sensors

UNIT II	SIGNAL CONDITIONING	9	0	0	9

Amplifier characteristics, wheat's stone bridge- Instrumentation sensor – integration and differentiation - sampling, A/D and D/A conversion, choppers, voltage to time conversion, voltage to freq. Conversion concept and methods.

UNIT III	DATA ACQUISITION	9	0	0	9

Real-time interfacing – Introduction - Elements of data acquisition and control - Overview of I/O process, Digital I/O, counters and timers, DMA, Software and hardware installation, Data acquisition interface requirements, -General configuration-single channel and multichannel data acquisition – Data Logging – Data conversion – Introduction to Digital Transmission system.

UNIT IV	TIME RESPONSE ANALYSIS	9	0	0	9

Response of systems for different time-based input, Classification of feedback control system according to type; static error coefficients- generalized steady state errors steady state errors due to impulse, step, ramp and parabolic inputs.

UNIT V	FREQUENCY DOMAIN ANALYSIS	9	0	0	9

Frequency response–Bode plot –Polar plot –Determination of closed loop response, open loop response-Correlation between frequency domain and time domain specifications-Effect of Lag, lead and lag-lead compensation on frequency response-Analysis

Total = 45 Periods

Text Books:

1.	John G. Webster, "Measurement, Instrumentation, and Sensors Handbook", CRC Press. 1998.
2.	Murthy, D.V.S., Transducers and Instrumentation, 2nd Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2010

Reference Books:

1.	Patranabis, D, "Sensors and Transducers", Wheeler Publishing Co, Ltd., New Delhi, 1997.
2.	M.Gopal, 'Control Systems, Principles and Design', 4th Edition, Tata McGraw Hill, New Delhi, 2012
3.	K.Ogata, Modern Control Engineering, 4th Edition, Prentice Hall, 2002

COURSE OUTCOMES: **On completion of the course the student will be able to**		**Bloom's Taxonomy Mapped**
CO1	Apply common measurement characteristics and terms to select sensors to meet control and monitoring requirements	Apply
CO2	Design, build and test sensor interface circuits including amplifiers to process the measured variable into a useful signal in the presence of noise and environmental variations	Create
CO3	Select and design appropriate signal processing to its instrumentation and control and their measurement	Create
CO4	Understand and apply basic science, theory control theory and apply them to control engineering problems.	Understand
CO5	Analyse the performance of systems and components through the use of analytical techniques	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	2	2	3	0	0	0	1	0	0	3	1	0	0
CO2	0	0	2	2	0	0	0	0	0	0	0	0	2	1	0
CO3	1	2	2	2	2	2	1	0	2	0	1	1	0	2	1
CO4	0	1	2	3	1	0	2	0	0	0	0	2	0	0	0
CO5	0	2	3	3	1	0	0	1	2	1	0	3	0	0	2
Avg	**0.4**	**1.2**	**2.2**	**2.4**	**1.4**	**0.4**	**0.6**	**0.2**	**1.0**	**0.2**	**0.2**	**1.8**	**0.6**	**0.6**	**0.6**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

22MCIN04	IDEATION SPRINTS		SEMESTER V			
PRE-REQUISITE:		Category	EE	Credit		1
		Hours/Week	L	T	P	TH
			0	0	2	2

Course Objectives:

1.	To offer a systematic and structured process to hack a solution using available tools & resources
2.	To identify the challenge/opportunity, derive insights from the customer/user interviews, & build a solution and validate the technical feasibility of the solution
3.	To build the PoC for proposed solution & pitch to user/customer for validation.

UNIT I	**INNOVATION 101**	**0**	**0**	**6**	**6**

Difference between a startup and a small business enterprise - Idea worth prototyping -Risk of innovations - Defining &validating hypothesis through Product Innovation Hypothesis (PIH) & Forge Innovation Rubric (FIR)

UNIT II	**PROBLEM VALIDATION & CUSTOMER DISCOVERY**	**0**	**0**	**6**	**6**

Tools and techniques of the managed innovation process (iTOOLS - innovation toolkit) -Customer-Centric Innovation: Customer-centric design thinking and validate the problem scenario, its significance, severity, and incidence - Discover & identify the right buyer beneficiary/Customer - rigorous Gap analysis of the existing solution - Adoption barriers of the solutions.

UNIT III	**DESIGNING & CRAFTING VALUE PROPOSITION**	**0**	**0**	**6**	**6**

Understand Customer Jobs, Pains & gains - Design Product/Service - Define & quantify Value Proposition -Build a compelling value proposition.

UNIT IV	**MUP SOLUTION CONCEPT EXPLORATION & DESIGN GENERATION**	**0**	**0**	**6**	**6**

Solution: Concept Generation, Concept Assessment, Solution, Capability, Usability, and Feasibility- MUP Design and Technology Block Diagrams- Bill of Materials Generation - BoM Optimization

UNIT V	**PROOF OF CONCEPT DEVELOPMENT & DEMONSTRATION**	**0**	**0**	**6**	**6**

Proof-of-Concept design - hack to build PoC with critical features -Test PoC for technical feasibility test deliver of Value proposition - Innovation Brief documentation (Proposal) - Demonstrate a PoC;

Total = 30 Periods

Text Books:

1.	Tim Brown, Change by Design:How design thinking transforms organizations and inspires innovation – HarperCollins e-books, 2009
2.	Alexander Osterwalder, Value Proposition Design: How to Create Products and Services Customers Want (Strategyzer) - John Wiley & Sons, 2014
3.	Ulrich Karl and Eppinger Steven D, Product Design and Development - McGraw Hill, 5th edition, 2020
4.	Blank Steve, Four Steps to Epiphany: Successful strategies for products that win, KS Ranch, 5th edition, 2013

Reference Books:

1.	Everything you need about value proposition: https://blog.forgeforward.in/everything-you-need-to-know-about-value-proposition-7247493c940c
2.	Test your Value Proposition:http://businessmodelalchemist.com/2012/09/test-your-value-proposition-supercharge-lean-startup-and-custdev-principles.html
3.	Valuation Risk versus Validation Risk in Product Innovations:https://blog.forgeforward.in/valuation-risk-versus-validation-risk-in-product-innovations-49f253ca8624
4.	User Guide for Product Innovation Rubric:https://blog.forgeforward.in/user-guide-for-product-innovation-rubric-

	857181b253dd
5.	Innovation Risk Diagnostic - Product Innovation Rubric:https://blog.forgeforward.in/product-innovation-rubric-adf5ebdfd356
6.	Evaluating Product Innovations - proof, potential, & progress:https://blog.forgeforward.in/evaluating-product-innovations-e8178e58b86e

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Apply a scientific method to understand the inherent risks of product innovation	Apply
CO2	Apply innovation tools & techniques to validate the problem scenario and to assess the market potential of product innovation;	Apply
CO3	Design solution concept based on the proposed value by exploring various alternate solutions to achieve value-price fit;	Design
CO4	Demonstrate technical skills by applying technology to build and demonstrate proof of concept for the solution proposed;	Develop
CO5	Develop skills to articulate the solution concept into a proposal for grants.	Develop

22MC301	INDIAN CONSTITUTION		SEMESTER V			
PREREQUISITE:		**Category**	**MC**	**Credit**		**0**
		Hours/Week	**L**	**0**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	Learn the salient features of the Indian Constitution.
2.	To study the List the Fundamental Rights and Fundamental Duties.
3.	To study the Present a systematic analysis of all dimensions of Indian Political System.
4.	To study the Understand the power and functions of the Parliament, the Legislature and the Judiciary.

UNIT I		**9**	**0**	**0**	**9**
Union and its Territory – Citizenship–Fundamental Rights–Directive Principles of State Policy–Fundamental Duties					
UNIT II		**9**	**0**	**0**	**9**
The Union–The States–The Union Territories–The Panchayats–The Municipalities					
UNIT III		**9**	**0**	**0**	**9**
The Co-operative Societies–The scheduled and Tribal Areas–Relations between the Union and the States–Finance, Property, Contracts and Suits–Trade and Commerce within the territory of India					
UNIT IV		**9**	**0**	**0**	**9**
Services under the Union, the States – Tribunals – Elections– Special Provisions –Relating to certain Classes					
UNIT V		**9**	**0**	**0**	**9**
Languages–Emergency Provisions – Miscellaneous–Amendment of the Constitution					

Total = 45 Periods

Reference Books:

1.	Subhash C. Kashyap, Our Constitution, National Book Trust, 2017
2.	Durga Das Basu, Introduction to the Constitution of India, Lexis Nexis, 2015
3.	Granville Austin, The Indian Constitution: Cornerstone of a Nation, Oxford University Press, 1999.
4.	M.V. Pylee, Constitutional History of India, S.Chand publishing, 2010

COURSE OUTCOMES: **On completion of the course the student will be able to**		**Bloom's Taxonomy Mapped**
CO1	Understand the emergence and evolution of the Indian Constitution	Understand
CO2	Explain the key concepts of Indian Political System	Understand
CO3	Describe the role of constitution in a democratic society.	Understand
CO4	Present the structure and functions of the Central and State Governments, the Legislature and the Judiciary	Apply

22ME506	DYNAMICS AND METROLOGY LABORATORY	SEMESTER V

PREREQUISITE:	Category	PC	Credit		1.5
	Hours/Week	L	T	P	TH
		0	0	3	3

Course Objectives:

1.	To be familiar with different measuring equipment.
2.	Use of the instruments in industry for quality inspection
3.	To know the need of accuracy in industry To know about balancing of rotating system
4.	To be familiar with different measuring equipment.

LIST OF EXPERIMENTS

1. Governors- Determination of sensitivity, effort, etc.for Watt, Porter, Proell, Hartnell governors
2. Cam- Study of jump phenomenon and drawing profile of the cam.
3. Motorized Gyroscope-Verification of laws –Determination of gyroscopic couple.
4. Whirling of shaft-Determination of critical speed of shaft with concentrated loads.
5. Determination of moment of inertia by oscillation method for connecting rod and flywheel.
6. Vibrating system- Spring mass system-Determination of damping co-efficient of single degree of freedom system.
7. Determination of transmissibility ratio-vibrating table.
8. Determination of torsional frequencies for compound pendulum and fly wheel system with Lumped Moment of inertia.
9. Transverse vibration of Beam. Determination of natural frequency and deflection of beam.
10. Calibration of Vernier /Micrometer/ Dial Gauge
11. Checking Dimensions of part using lip gauges
12. Measurements of Gear Tooth Dimensions.
13. Measurement of Taper Angle using sine bar/tool makers microscope.
14. Measurement of thread parameters
15. Checking the limits of dimensional tolerances using comparators (Mechanical/Pneumatic/Electrical)

Total = 45 Periods

COURSE OUTCOMES: **On completion of the course the student will be able to**		**Bloom's Taxonomy Mapped**
CO1	Handle different measurement tools	Understand
CO2	Perform measurements with accuracy.	Evaluate
CO3	Avoid errors in measurement	Analyze
CO4	Understand balancing of equipment	Understand

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3	2	2	3	0	0	0	0	0	0	0	3	1	2
CO2	0	2	0	3	1	1	0	0	0	0	0	0	1	2	3
CO3	3	1	0	0	0	2	0	0	0	0	0	0	2	3	1
CO4	2	3	0	1	3	1	0	0	0	0	0	0	3	2	1
Avg	**1.5**	**2**	**0.5**	**1.2**	**1.7**	**1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**2.2**	**2.0**	**1.7**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22EN502	PLACEMENT AND CAREER TRAINING LABORATORY		SEMESTER V			
PRE-REQUISITE:		**Category**	**HS**	**Credit**		**1.5**
1. Basic knowledge in reading skill and writing skill 2. Basic ability in listening skill and speaking skill		**Hours/Week**	**L**	**T**	**P**	**TH**
			0	**0**	**4**	**4**

Course Objectives:

1.	To develop the students' confidence and help them to attend interviews successfully
2.	To express opinions, illustrate with examples and conclude in group discussions
3.	To acquire knowledge to write error free letters and prepare reports
4.	To enhance the employability and soft skills of students

UNIT I	**WRITING SKILLS**	**0**	**0**	**10**	**10**
Letter of invitation, Resume and cover letter, Job application, E-mail writing, Report writing, progress in project work					
UNIT II	**SPEAKING SKILLS**	**0**	**0**	**10**	**10**
Welcome address and vote of thanks, Power point presentation, Presenting the visuals effectively, Group discussion, participating in group discussions, understanding group dynamics, Brain-storming the topics					
UNIT III	**CAREER SKILLS**	**0**	**0**	**10**	**10**
Employability and career skills, Self-introduction, introducing oneself to the audience, introducing the topic, Interview skills, Interview etiquette, Dress code, Body language, Attending job interviews					
UNIT IV	**VERBAL ABILITIES**	**0**	**0**	**10**	**10**
Error Spotting, Listening Comprehension, reading comprehension, Rearranging Jumbled sentences, Vocabulary					
UNIT V	**REASONING ABILITIES**	**0**	**0**	**5**	**5**
Series completion, Analogy, Classification, Coding-Decoding, Blood relations, Seating Arrangements, Directional Sense, Logical reasoning					

Total = 45 Periods

Reference Books:

1.	Campus Recruitment Complete Reference, Praxis Groups (5th edition), Hyderabad, 2017.
2.	John Seely, The Oxford Guide to Writing and Speaking, Oxford University Press, New Delhi, 2004.
3.	R.S. Aggarwal. A Modern Approach to Verbal & Non-Verbal Reasoning. 2018 S Chand Publication, 2018

E-References:

1.	https://prepinsta.com/
2.	https://www.indiabix.com/

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Participate in group discussion and interview confidently	Evaluate
CO2	Develop adequate soft skills and career skills required for the workplace	Create
CO3	Make effective presentations on given topics	Create
CO4	Apply their verbal ability and reasoning ability in campus interviews	Apply

COURSE ARTICULATION MATRIX

CO/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	0	0	0	1	0	0	0	0	2	3	0	1	0	0	1
CO2	0	0	0	2	0	0	0	0	2	3	0	1	0	0	2
CO3	0	0	0	2	0	0	0	0	1	3	0	1	0	0	1
CO4	0	0	0	1	0	0	0	0	2	3	0	1	0	0	2
Avg	**0**	**0**	**0**	**1.5**	**0**	**0**	**0**	**0**	**1.75**	**3.0**	**0**	**1.0**	**0**	**0**	**1.5**

3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)

22ME507	HEAT TRANSFER AND REFRIGERATION LABORATORY	SEMESTER V

PREREQUISITES:	Category	PC	Credit		1.5
1.Basic knowledge about the modes of heat transfer	Hours/Week	L	T	P	C
2.Concept of psychrometry and refrigeration and air conditioning systems		0	0	3	1.5

Course Objectives:

1.	Applying the concepts and laws of conduction heat transfer in real equipment
2.	Practicing to estimate the heat transfer coefficient values of various fluids.
3.	Experimenting and analyzing the heat transfer phenomena in boiling and condensation heat exchangers
4.	Determining the radiation heat transfer parameters for black and grey surfaces and calibration of thermocouples
5.	Studying the performance analysis of the refrigeration and air-conditioning systems and cooling towers.

LIST OF EXPERIMENTS:

1. Thermal conductivity measurement of pipe insulation using lagged pipe apparatus.
2. Determination of thermal conductivity of a composite wall, insulating powder.
3. Determination of heat transfer coefficient of air under natural convection and forced convection.
4. Heat transfer from pin-fin under forced convection heat transfer.
5. Determination of heat flux under pool boiling and flow boiling in various regimes.
6. Determination of heat transfer coefficient in film-wise and drop-wise condensation.
7. Determination of friction factor, heat transfer coefficient of cold/hot fluids and effectiveness oftube-in-tube heat exchanger.
8. Determination of Stefan – Boltzmann constant.
9. Determination of emissivity of a grey surface.
10. Calibration of thermocouples / RTDs at standard reference temperatures.
11. Determination of Coefficient of Performance of a vapor compression refrigeration system
12. Determination of Coefficient of Performance of an Air-Conditioning system.
13. Determination of effectiveness of a cooling tower.

Total = 45 Periods

COURSE OUTCOMES: On completion of the course the student will be able to		Bloom's Taxonomy Mapped
CO1	Calculate the thermal conductivity of various conducting and non-conducting materials	Evaluate
CO2	Estimate the heat transfer coefficient in free and forced convections for various geometries.	Evaluate
CO3	Evaluate the heat flux and the heat transfer coefficient in various types of heat exchangers	Evaluate
CO4	Obtain the radiation parameters such as emissivity, wave length and surface temperatures	Analyze
CO5	Test the performance of the refrigeration and air-conditioning systems and cooling towers.	Analyze

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3	0	2	0	0	0	0	0	0	0	0	3	1	2
CO2	1	2	1	1	0	0	0	0	0	0	0	0	2	1	1
CO3	1	3	1	0	0	0	0	0	0	0	0	0	3	0	2
CO4	1	2	1	1	0	0	0	0	0	0	0	0	2	0	1
CO5	1	2	0	1	0	0	0	0	0	0	0	0	1	1	1
Avg	**1**	**2.4**	**0.6**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2.2**	**0.6**	**1.4**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22ME601	MINI PROJECT	SEMESTER VI			
PREREQUISITE:	**Category**	**EE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		0	**0**	**6**	**6**

Course Objectives:

1.	Opportunity to design and develop small working models.
2.	Develop experimental or simulation solutions to small industrial problems.
3.	Facilitate problem identification, formulation and solution.
4.	Work collaboratively in small groups.

The students may be grouped into groups of about 2 to 4 members per group and work under a project supervisor. The device / system / component(s) to be designed/ fabricated / investigated / analyzed may be decided in consultation with the 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.

FABRICATION PROJECT GUIDELINES

a. Mechanical Assembly and Dismantling Models
b. Day-life Usage Project
c. New Scientific Invention
d. Implementation of Mechanical Principle

Total = 90 Periods

COURSE OUTCOMES: **On completion of the course the student will be able to**		**Bloom's Taxonomy Mapped**
CO1	Initiate the students to come out with innovative ideas for various applications.	Create
CO2	Create an environment to convert the ideas into design of prototype for useful industrial, agricultural and social applications.	Create
CO3	Familiarize the feasibility study and manage activities to complete task in specified duration.	Understand
CO4	Assign and undertake tasks in a team as per team discussion.	Evaluate
CO5	Do presentation and write technical reports for effective communication within and outside the team.	Create

COURSE ARTICULATION MATRIX

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	0	2	0	3	3	3
CO2	3	3	3	3	2	3	3	0	3	0	1	0	3	3	0
CO3	2	2	2	2	2	1	1	1	3	1	2	3	3	3	0
CO4	3	2	2	1	1	1	2	3	3	3	0	3	3	3	0
CO5	0	0	0	0	2	2	0	1	3	3	0	2	3	0	3
Avg	**2.2**	**2.0**	**2.0**	**1.8**	**1.8**	**2.0**	**1.8**	**1.2**	**3.0**	**1.4**	**2.0**	**1.6**	**3.0**	**2.4**	**1.2**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

SEMESTER - VII

22ME701	MECHATRONICS	SEMESTER VII			
PREREQUISITE:	**Category**	**PC**	**Credit**		**3**
Basics of electronics and electrical engineering Knowledge in instrumentation and sensors Basics of Hydraulic and pneumatic systems	**Hours/Week**	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To impart knowledge about the elements and techniques involved in Mechatronics systems which are very much essential to understand the emerging field of automation.
2.	To acquire adequate knowledge to model and simulate the physical systems.
3.	To understand issues of implementation of different actuation systems in a Mechatronics system,
4.	To gain practical experience in interfacing input and output devices to PLCs
5.	To gain practical experience in applying knowledge in the real word systems.

UNIT I	**INTRODUCTION TO MECHATRONICS**	**9**	**0**	**0**	**9**

Definition, Introduction to Mechatronic Systems- Mechatronic Products and their functioning- Advanced applications in Mechatronics -Measurement systems- Control Systems- sequential controllers.

UNIT II	**PHYSICAL SYSTEM MODELING**	**9**	**0**	**0**	**9**

General System Models- zero order-first order- second order-mechanical systems, electrical systems, thermal systems, electromechanical systems, hydro-mechanical systems, pneumatic systems-Basis of analogies in physical system models.

UNIT III	**ACTUATION SYSTEMS**	**9**	**0**	**0**	**9**

Electric motors - Solenoids - Solid state switches - Stepper motors- Servo motors- Mechanical actuators- Hydraulic motors - Piezo actuators– Control systems - PID Controllers - Artificial intelligence in mechatronics – Adaptive and nonlinear control design- Neural networks and fuzzy systems.

UNIT IV	**PROGRAMMING LOGIC CONTROLLERS**	**9**	**0**	**0**	**9**

Introduction to Programmable Logic Controllers – Basic Structure – Input / Output processing – Ladder logic programming – Mnemonics –relays and counters – Shift registers – Master and Jump controls – Data handling – Analog Input / Output – Case studies on PLC.

UNIT V	**MECHATRONICS SYSTEMS DESIGN**	**9**	**0**	**0**	**9**

Stages in designing of Mechatronics systems – Traditional and Mechatronic design - Possible design solutions. Case studies: Data acquisition and control - Pick and place robot – automatic car park barrier systems – Engine management systems- Mechatronic control in automated manufacturing.

Total = 45 Periods

Text Books:

1. Bolton, W, Mechatronics, Pearson Education, 6th Edition, 2015.
2. Ganesh S.Hegde, Mechatronics, Jones & Bartlett publishers, 1st Edition, 2010.

Reference Books:

1. Michael B. Histand and David G. Alciatore, Introduction to Mechatronics and Measurement Systems, McGraw Hill International Editions, 3rd Edition, 2007
2. Bradley D. A., Dawson D., Buru N.C. and. Loader A.J, Mechatronics, Chapman and Hall, 1st Edition, 1993.

3.	Dan Necsulesu, Mechatronics, Pearson Education Asia, 1st Edition, 2002
4.	Brian Morriss, Automated Manufacturing Systems - Actuators, Controls, Sensors and Robotics, McGraw Hill International Edition, 1995
5.	Devadas Shetty, Richard A.Kolkm, Mechatronics system design, PWS publishing company, 2009
E-References:	
1.	https://onlinecourses.nptel.ac.in/noc21_me12

COURSE OUTCOMES: **On completion of the course the student will be able to**		**Bloom's Taxonomy Mapped**
CO1	Understand the basic elements underlying mechatronics systems and integrate them in the design of mechatronics systems.	Understand
CO2	Develop a simulation model for simple physical systems and illustrate mechatronics design process.	Analyze
CO3	Design, interface and understand issues of implementation of different actuation in a mechatronics system for a set of specifications.	Analyze
CO4	Interface electromechanical systems to PLCs.	Apply
CO5	Attain practical experience in applying knowledge gained in the course through a hands-on project.	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	2	0	2	0	0	0	0	0	0	0	1	1	0	2
CO2	2	2	3	3	1	0	0	0	0	0	0	2	2	2	0
CO3	0	0	2	2	0	0	2	0	2	0	0	2	0	0	0
CO4	0	2	3	3	3	0	0	0	3	0	3	2	0	2	1
CO5	1	2	2	3	3	2	2	1	3	2	1	3	0	0	3
Avg	**2.0**	**1.6**	**2.0**	**2.6**	**1.4**	**0.4**	**0.8**	**0.2**	**1.6**	**0.4**	**0.8**	**2.0**	**0.6**	**0.8**	**1.2**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22ME702	FINITE ELEMENT ANALYSIS	SEMESTER VII

PREREQUISITE:	Category	PC	Credit		3
Basic knowledge in mathematics with differentiation, integration, matrix operations and numerical methods. Basic knowledge in solid mechanics.	Hours/Week	L	T	P	TH
		3	0	0	3

COURSE OBJECTIVES:

1.	To make the students to formulate the physical design problems into FEA including domain discretization, polynomial interpolation, application of boundary conditions, assembly of global arrays, and solution of the resulting algebraic systems.
2.	To make the students to apply FEM concept for developing FE equations for solving 1-D problems with bar, truss and beam elements.
3.	To make the students to apply FEM concept for developing FE equations for solving 2-D problems with CST elements for plane stress, plane strain and axisymmetric problems.
4.	To equip the students about iso-parametric formulations for quadrilateral element and apply the gauss quadrature for numerical integration.
5.	To familiarize the students, apply FE equations for solving thermal and fluid flow problems.

UNIT I	INTRODUCTION	9	0	0	9

Historical Background – Mathematical Modeling of field problems in Engineering –Governing Equations – Discrete and continuous models – Boundary, Initial and Eigen Value problems– Weighted Residual Methods – Variational Formulation of Boundary Value Problems – Ritz Technique – Basic concepts of the Finite Element Method.

UNIT II	ONE DIMENSIONAL FEA	9	0	0	9

One Dimensional Second Order Equations – Discretization – Element types- Linear and Higher order Elements – Derivation of Shape functions and Stiffness matrices and force vectors-Assembly of Matrices - Solution of problems from solid mechanics including thermal stresses.

UNIT III	TWO DIMENSIONAL FEA	9	0	0	9

Second Order 2D Equations involving Scalar Variable Functions – Variational formulation –Finite Element formulation – Triangular elements and Quadrilateral elements- Shape functions and element matrices and vectors- Equations of elasticity – Plane stress, plane strain and axisymmetric problems – Constitutive matrices and Strain displacement matrices – Stiffness matrix – Stress calculations.

UNIT IV	ISOPARAMETRIC FORMULATION AND NUMERICAL INTEGRATION	9	0	0	9

Natural co-ordinate systems – Iso-parametric elements – Shape functions for iso-parametric elements – One and two dimensions – Serendipity elements – Numerical integration-Lagrange's interpolation- Higher order one dimensional elements - Quadratic and cubic element - Applying numerical integration: 1, 2 and 3gauge point for 1D and 2D cases - example problems.

UNIT V	FEA APPLICATION TO HEAT TRANSFER AND FLUID MECHANICS	9	0	0	9

Steady state heat transfer, 1D heat conduction governing Equations -Functional approach for heat conduction- Galerkin's approach for heat conduction - application to one-dimensional heat transfer problems- 1D heat transfer in thin fins problems Governing Equations of Fluid Mechanics – Solid structure interaction - Inviscid and Incompressible Flow – Potential Formulations- simple problems.

Total = 45 Periods

Text Books:

1.	Tirupathi R. Chandrupatla and Ashok D. Belegundu, "Introduction to Finite Elements in Engineering", International Edition, Pearson Education Limited, 2014.
2.	Seshu.P, "Text Book of Finite Element Analysis", PHI Learning Pvt. Ltd., New Delhi, 2012

Reference Books:	
1.	Rao, S.S., "The Finite Element Method in Engineering", 6th Edition, Butterworth-Heinemann, 2018
2.	Reddy,J.N. "Introduction to the Finite Element Method", 4thEdition, Tata McGrawHill,2018
3.	Dhanaraj. R and Prabhakaran Nair. K, "Finite Element Analysis", Oxford Publications, 2015.
4.	David Hutton, "Fundamentals of Finite Element Analysis", Tata Mc Graw Hill, 2005
5.	Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt, "Concepts and Applications of Finite Element Analysis", 4th Edition, Wiley Student Edition, 2004.
E-References:	
1.	https://soaneemrana.com/onewebmedia/TEXT%20BOOKOF%20FINITE%20ELEMENT%20ANALYSIS%20BY%20P.%20SESHU%20.pdf
2.	https://nptel.ac.in/courses/112104193
3.	https://www.engr.uvic.ca/~mech410/lectures/FEA_Theory.pdf

COURSE OUTCOMES: **On completion of the course the student will be able to**		**Bloom's Taxonomy Mapped**
CO1	Formulate the physical design problems into FEA including domain discretization, polynomial interpolation, application of boundary conditions, assembly of global arrays, and solution of the resulting algebraic systems.	Analyze
CO2	Apply FEM concept for developing FE equations for solving 1-D problems with bar, truss and beam elements.	Apply
CO3	Apply FEM concept for developing FE equations for solving 2-D problems with CST elements for plane stress, plane strain and axisymmetric problems.	Apply
CO4	Derive iso-parametric formulations for quadrilateral element and apply the gauss quadrature for numerical integration.	Apply
CO5	Apply the concepts of FEA for solving 1-D heat transfer and fluid flow problems under the given boundary conditions.	Apply

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	1	0	0	0	0	0	0	0	3	1	0
CO2	3	3	2	1	1	0	0	0	0	0	0	0	3	1	0
CO3	3	3	2	1	1	0	0	0	0	0	0	0	3	1	0
CO4	3	3	2	1	1	0	0	0	0	0	0	0	3	1	0
CO5	3	3	2	1	1	0	0	0	0	0	0	0	3	1	0
Avg	**3.0**	**3.0**	**2.0**	**1.0**	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**3.0**	**1.0**	**0.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22ME703	MECHATRONICS LABORATORY	SEMESTER VII

PREREQUISITE:	Category	PC	Credit		1.5
1. Basics of electronics and electrical engineering 2. Knowledge in instrumentation and sensors 3. Basics of Hydraulic and pneumatic systems	Hours/Week	L	T	P	TH
		0	0	3	3

Course Objectives:

1.	To provide automation concepts where students could perform experimental study regarding fundamental sequence control by utilising various hydraulic and pneumatic components.
2.	To provide knowledge to assist the students in the development of "handson" skills with an emphasis on actuators and multidisciplinary systems.
3.	To provide software knowledge to the engineering students to apply hardware and programming basics and absorb Mechatronics concepts.
4.	To equip students with mechatronics knowledge and also gather knowledge of virtual instrumentation systems for mechanical engineering applications/
5.	To promote interdisciplinary research and industry driven innovation in the cutting-edge areas of mechatronics.

LIST OF EXPERIMENTS

1. Design and testing of fluid power circuits to control
   (i) velocity (ii) direction and (iii) force of single and double acting cylinders
2. Design and testing of cylinder sequences A+B+A-B- and A+B+B-A- of pneumatic circuits.
3. Design of Electro pneumatic circuits with logic sequence using Electro pneumatic trainer kits.
4. Design of Electro hydraulic circuits with logic sequence using Electro hydraulic trainer kits.
5. Simulation of basic Hydraulic, Pneumatic and Electro-hydraulic, Electro-pneumatic circuits using simulation software.
6. Design and simulation of Electro pneumatic circuits with PLC programming using simulation software.
7. Study the performance of DC motor.
8. Experiment on servo controller interfacing for closed loop control.
9. Stepper motor interfacing with 8051 Micro controller
   (i)full step resolution (ii) half step resolution
10. Maintain constant pressure of a process in a process station using PID controller in Virtual Instrumentation software.
11. Maintain constant temperature of a process in a shell and tube heat exchanger using PID controller in Virtual Instrumentation software.
12. Maintain constant flow rate of a process in a process station using PID controller in Virtual Instrumentation software.
13. Study the performance of 6- axis robot.

Total = 45 Periods

COURSE OUTCOMES: On completion of the course the student will be able to		Bloom's Taxonomy Mapped
CO1	Select various control valves and use them in hydraulic and pneumatic circuit development	Understand
CO2	Get adequate knowledge to simulate the basic electric, hydraulic and pneumatic system using simulation software.	Understand
CO3	Get adequate knowledge about the characteristics of various actuators and methods of tuning of controller in a Mechatronic system.	Understand
CO4	Understand how to interface electromechanical systems to PLCs.	Understand
CO5	Gain practical experience in data acquisition system and develop and evaluate alternate solutions to real world problems.	Understand

COURSE OUTCOMES: **On completion of the course the student will be able to**		**Bloom's Taxonomy Mapped**
CO1	Select various control valves and use them in hydraulic and pneumatic circuit development	Understand
CO2	Get adequate knowledge to simulate the basic electric, hydraulic and pneumatic system using simulation software.	Understand
CO3	Get adequate knowledge about the characteristics of various actuators and methods of tuning of controller in a Mechatronic system.	Understand
CO4	Understand how to interface electromechanical systems to PLCs.	Understand
CO5	Gain practical experience in data acquisition system and develop and evaluate alternate solutions to real world problems.	Understand

COURSE ARTICULATION MATRIX

Cos/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	3	0	0	0	0	0	0	0	0	0	0	1	1	1
CO2	0	0	1	2	0	0	0	0	0	0	0	0	1	2	2
CO3	0	0	1	0	0	0	1	2	0	0	0	0	2	1	3
CO4	0	0	0	3	0	0	0	0	0	0	2	3	2	1	3
CO5	0	0	3	0	0	0	0	0	2	1	2	0	2	2	3
Avg	**0.2**	**0.6**	**1**	**1**	**0**	**0**	**0.2**	**0.4**	**0.4**	**0.2**	**0.8**	**0.6**	**1.6**	**1.4**	**2.4**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

22ME704	SIMULATION LABORATORY		SEMESTER VII			
PREREQUISITE:		**CATEGORY**	**PC**	**Credit**		**1.5**
1. Basic knowledge in any modeling software. 2. Fundamental knowledge in FEA.		**Hours/Week**	**L**	**T**	**P**	**TH**
			0	**0**	**3**	**3**

COURSE OBJECTIVES:

1.	To make the students analyze the structural components for deflection, stress and reaction forces.
2.	To make the students analyze the force, stress, deflection in mechanical components.
3.	To make the students analyze thermal stress and heat transfer in mechanical components.
4.	To make the students analyze the vibration of mechanical components.
5.	To make the students analyze the modal, harmonic, transient and spectrum concepts in mechanical components.

LIST OF EXPERIMENTS

Analysis of Mechanical Components – Use of FEA packages, like ANSYS/ NASTRON etc., Excesses shell include FEA analysis of

1. Force and Stress analysis using link elements in Trusses.
2. Force and stress analysis using link elements in axially loaded bars.
3. Stress and deflection analysis in beams with different support conditions.
4. Stress analysis of flat plates.
5. Stress analysis of axis–symmetric components.
6. Thermal stress and heat transfer analysis of plates.
7. Thermal stress analysis of cylindrical shells.
8. Vibration analysis of spring-mass systems.
9. Modal analysis of Beams.
10. Harmonic, transient and spectrum analysis of simple systems

E-REFERENCES:

1.	https://www.ansys.com/
2.	https://bmsce.ac.in/Content/ME/MFELAB_manual_Jan2019_Updated_28_1_2019.pdf
3.	https://confluence.cornell.edu/display/SIMULATION/ANSYS+Learning+Modules

COURSE OUTCOMES: **On completion of the course the student will be able to**		**Bloom's Taxonomy Mapped**
CO1	Analyze the structural components for deflection, stress and reaction forces.	Analyze
CO2	Analyze the force, stress, deflection in mechanical components.	Analyze
CO3	Analyze thermal stress and heat transfer in mechanical components.	Analyze
CO4	Analyze the vibration of mechanical components.	Analyze
CO5	Analyze the modal, harmonic, transient and spectrum concepts in mechanical components.	Analyze

COURSE ARTICULATION MATRIX															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	0	0	3	0	0	1	0	0	0	1	1	0	0
CO2	2	2	0	0	3	0	0	1	0	0	0	1	1	0	0
CO3	2	2	0	0	3	0	0	1	0	0	0	1	2	0	0
CO4	2	2	0	0	3	0	0	1	0	0	0	1	2	0	0
CO5	2	2	0	0	3	0	0	1	0	0	0	1	2	0	0
Avg	**2.0**	**2.0**	**0.0**	**0.0**	**3.0**	**0.0**	**0.0**	**1.0**	**0.0**	**0.0**	**0.0**	**1.0**	**1.6**	**0.0**	**0.0**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

22ME705	CAM LABAROTARY		SEMESTER VII			
PREREQUISITE:		**CATEGORY**	**PC**	**Credit**		**1.5**
		Hours/Week	**L**	**T**	**P**	**TH**
			0	**0**	**3**	**3**

COURSE OBJECTIVES:

1.	To equip the students for implement CNC programs for milling and turning machining operations.
2.	To create a computer aided manufacturing (CAM) model and generate the machining codes automatically using the CAM system.
3.	Understand different operations that are to be executed to get a final product which include drilling and reaming operations.
4.	Understand CNC machining and uses, and applications of CNC program.
5.	Remember the purpose of other alphabetical commands used in programming operations of a CNC machine.

CAM EXPERIMENTS

Tool path generation, Part programming, G & M codes development for machining operations, Physical interpretation of machining features and tool geometries

Manual part programming

- CNC Turning Centre Facing, Turning, Chamfering, Taper turning, Thread cutting
- CNC Turning Centre Facing, Turning, Chamfering, Taper turning, Grooving, Threading using canned cycles
- CNC Milling Linear and circular Profile, Pocket, Drill, Peck-Drill, Bore, Tap- Using canned cycles.
- Part Program generation and tool path simulation for turning &milling for Fanuc Control System using CAM software.
- Demonstration on CNC Turning & Milling Machines

Total (45P) = 45 Periods

COURSE OUTCOMES: **On completion of the course the student will be able to**		**Bloom's Taxonomy Mapped**
CO1	Understand the features and specifications of CNC machines	Understand
CO2	Develop the process planning sheets and tool layouts.	Apply
CO3	Understand the CAM software and its programming.	Understand
CO4	Use the CAM software and prepare CNC part programs.	Apply
CO5	Execute the part program and machine the component as per the production drawing.	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	1	2	2	2	1	0	0	2	0	2	0	2	2	1
CO2	1	1	1	1	0	0	0	0	0	0	3	0	1	1	1
CO3	1	2	1	2	2	3	0	0	0	0	3	0	2	2	1
CO4	1	2	1	1	1	3	0	0	0	0	3	0	2	2	1
CO5	1	2	1	1	1	3	0	0	0	0	3	0	2	2	1
Avg	**1.2**	**1.6**	**1.2**	**1.4**	**1.2**	**2.0**	**0.0**	**0.0**	**0.4**	**0.0**	**2.8**	**0.0**	**1.8**	**1.8**	**1.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22ME706	PROJECT – I	SEMESTER VII			
PREREQUISITE:	**CATEGORY**	**EE**	**Credit**		**4**
	Hours/Week	**L**	**T**	**P**	**TH**
		0	**0**	**8**	**8**

COURSE OBJECTIVES:

1.	The main objective is to give an opportunity to the student to get hands on training in the fabrication of one or more components of a complete working model, which is designed by them.
2.	It is intended to start the project work early in the seventh semester and carry out both design and fabrication of a mechanical device whose working can be demonstrated. The design is expected to be completed in the seventh semester and the fabrication and demonstration will be carried out in the eighth semester

GUIDELINE FOR REVIEW AND EVALUATION

1.	The students may be grouped into 2 to 4 and work under a project supervisor. The device/system/component(s) to be fabricated may be decided in consultation with the supervisor and if possible, with an industry. A project report to be submitted by the group and the fabricated model, which will be reviewed and evaluated for internal assessment by a committee constituted by the Head of the Department. At the end of the semester examination the project work is evaluated based on oral presentation and the project report jointly by external and internal examiners (Supervisors) constituted by the Head of the Department

Total (75P) =75 Periods

COURSE OUTCOMES: **On completion of the course the student will be able to**		**Bloom's Taxonomy Mapped**
CO1	Initiate and motivate the students to come out with innovative ideas for different applications.	Create
CO2	Create an environment to convert the ideas into design of prototype for useful industrial, agricultural and social applications.	Create
CO3	Create an environment to convert the design into manufacturing of prototype for useful industrial, agricultural and social applications.	Create
CO4	Assign and undertake tasks in a team as per team discussion.	Understand
CO5	Do presentation and write technical reports for effective communication within and outside the team.	Understand

COURSE ARTICULATION MATRIX

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	0	2	0	3	3	3
CO2	3	3	3	3	2	3	3	0	3	0	1	0	3	3	0
CO3	2	2	2	2	2	1	1	1	3	1	2	3	3	3	0
CO4	3	2	2	1	1	1	2	3	3	3	0	3	3	3	0
CO5	0	0	0	0	2	2	0	1	3	3	0	2	3	0	3
Avg	**2.2**	**2.0**	**2.0**	**1.8**	**1.8**	**2.0**	**1.8**	**1.2**	**3.0**	**1.4**	**1.0**	**1.6**	**3.0**	**2.4**	**1.2**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

SEMESTER-VIII

22ME801	PROJECT – II				SEMESTER VII
PREREQUISITE:		CATEGORY	EE	Credit	10
		Hours/Week	L	T	P	TH
			0	0	20	10

COURSE OBJECTIVES:

1.	The main objective is to give an opportunity to the student to get hands on training in the fabrication of one or more components of a complete working model, which is designed by them.
2.	It is intended to start the project work early in the seventh semester and carry out both design and fabrication of a mechanical device whose working can be demonstrated. The design is expected to be completed in the seventh semester and the fabrication and demonstration will be carried out in the eighth semester

GUIDELINE FOR REVIEW AND EVALUATION

1.	The students may be grouped into 2 to 4 and work under a project supervisor. The device/system/component(s) to be fabricated may be decided in consultation with the supervisor and if possible, with an industry. A project report to be submitted by the group and the fabricated model, which will be reviewed and evaluated for internal assessment by a committee constituted by the Head of the Department. At the end of the semester examination the project work is evaluated based on oral presentation and the project report jointly by external and internal examiners (Supervisors) constituted by the Head of the Department.

Total (90P) =90 Periods

COURSE OUTCOMES: **On completion of the course the student will be able to**		**Bloom's Taxonomy Mapped**
CO1	Initiate and motivate the students to come out with innovative ideas for different applications.	Create
CO2	Create an environment to convert the ideas into design of prototype for useful industrial, agricultural and social applications.	Create
CO3	Create an environment to convert the design into manufacturing of prototype for useful industrial, agricultural and social applications.	Create
CO4	Assign and undertake tasks in a team as per team discussion.	Understand
CO5	Do presentation and write technical reports for effective communication within and outside the team.	Understand

COURSE ARTICULATION MATRIX

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	0	2	0	3	3	3
CO2	3	3	3	3	2	3	3	0	3	0	1	0	3	3	0
CO3	2	2	2	2	2	1	1	1	3	1	2	3	3	3	0
CO4	3	2	2	1	1	1	2	3	3	3	0	3	3	3	0
CO5	0	0	0	0	2	2	0	1	3	3	0	2	3	0	3
Avg	**2.2**	**2.0**	**2.0**	**1.8**	**1.8**	**2.0**	**1.8**	**1.2**	**3.0**	**1.4**	**1.0**	**1.6**	**3.0**	**2.4**	**1.2**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

PROFESSIONAL ELECTIVES – I

22MEPE11	AUTOMOBILE ENGINEERING				SEMESTER VI
PREREQUISITES	**CATEGORY**	**PE**	**Credit**		**3**
1. Engineering Mechanics	**Hours/Week**	**L**	**T**	**P**	**TH**
2. Thermodynamics and Thermal Engineering		**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To broaden the understanding of students in the structure of vehicle chassis and engines
2.	To teach students about the importance of alternate fuels and modifying the engine suitably
3.	Analyze the working principles and operations details of transmission and suspension systems
4.	Evaluate the operational details and design principles of breaking and steering systems
5.	To introduce students to engine auxiliary systems like heating, ventilation and air-conditioning

UNIT I	**AUTOMOBILE VEHICLE STRUCTURE AND PERFORMANCE**	**9**	**0**	**0**	**9**

Automotive components, subsystems and their positions- Chassis, frame and body, front, rear and four-wheel drives, Operation and performance, Traction force and traction resistance, Power required for automobile - Rolling, air and gradient resistance. Introduction to MV Act, Pollution Norms

UNIT II	**POWERTRAIN AND FUEL MANAGEMENT SYSTEMS**	**9**	**0**	**0**	**9**

Reciprocating Engine systems, Hybrid systems. Pollutant emissions and their control; Catalytic converter systems, Electronic Engine Management systems for SI and CI engines. Liquid and gaseous alternate fuels - Alcohol, LPG, CNG, and Hydrogen.

UNIT III	**TRANSMISSION AND SUSPENSIONS SYSTEMS**	**9**	**0**	**0**	**9**

Transmission system: Clutches - principle, types - single plate clutch, multiplate clutch, magnetic and centrifugal clutches, fluid fly wheel. Gear boxes, types, constant mesh, synchromesh gear boxes, epicyclic gear box, auto transmission, continuous variable transmission, propeller shaft, Hotch-Kiss drive, Torque tube drive, universal joint, differential, rear axles types, wheels and tyres; Suspension system: Objects of suspension systems, rigid axle suspension system, torsion bar, shock absorber, independent suspension system

UNIT IV	**BRAKING AND STEERING SYSTEMS**	**9**	**0**	**0**	**9**

Forces on vehicles, tyre grip, load transfer, braking distribution between axles, stopping distance, Types of brakes - Mechanical, Hydraulic, Air brakes, Disc & Drum brakes, Engine brakes anti-lock braking system. Types of steering systems - Ackermann principle, Davis steering gear, steering gear boxes, steering linkages, power steering, wheel geometry-caster, camber toe-in, toe out etc., wheel Alignment and balancing.

UNIT V	**ELECTRICAL AND ELECTRONICS SYSTEMS**	**9**	**0**	**0**	**9**

General electrical circuits. Battery, Starting motor, DC generator, Alternator, Ignition circuit, Dash board instrumentation, Lighting system. Passenger comfort - Safety and security - HVAC - Seat belts - Air bags - Automotive Electronics - Electronic Control Unit (ECU) - Variable Valve Timing (VVT) - Active Suspension System (ASS) - Electronic Brake Distribution (EBD) – Electronic Stability Program (ESP) Traction Control System (TCS) - Global Positioning System (GPS) - Electric - Hybrid vehicle.

Total (45L) = 45Periods

TEXT BOOKS:

1.	William. H. Crouse, Donald L Anglin, Automotive Mechanics, 10th Edition, McGraw-Hill, 2017
2.	Jack Erjavek, “Automotive Technology – A Systems Approach”, Thomson Learning, 3rd Edition, 1999.

REFERENCES:

1	Bosch Automotive Hand Book, 8th Edition, Bentley Publishers, 2011.
2	Kirpal Singh, Automobile Engineering, Vol.1 &2, Standard Publishers, 2012.

3	N. K. Giri, Automobile Mechanics, 5 th Edition, Khanna Publishers, 2014.
4	Kumar D.S., "Automobile Engineering", S.K.Kataria and Sons, 2nd Edition, 2017.
5	Robert Bosch GmbH, "Automotive Handbook", Robert Bosch, 2004.
E-REFERENCES:	
1.	http:// www.engineeringstudymaterial.net/tag/automotive-engineering-books
2.	https://www.studynama.com/.../299-Automobile-engineering-lecture-notes-ebook-pdf
3.	https://onlinecourses.nptel.ac.in/noc21_de02/preview

COURSE OUTCOMES: **Upon completion of this course, the students will be able to:**		**Bloom Taxonomy Mapped**
CO1	Describe the fundamental concepts of automobile **e**ngineering	Understand
CO2	Analyze the various types of power train and fuel supply and management systems**.**	Analyze
CO3	Analyze the various types of automatic transmission and steering systems for a vehicle**.**	Analyze
CO4	Discuss various types of braking and suspension system**.**	Understand
CO5	Troubleshoot the electrical and electronics instrumentation system in the automobiles.	Understand

COURSE ARTICULATION MATRIX

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

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE12	COMPOSITE MATERIALS		SEMESTER VI			
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**C**
1. Engineering Physics		**Hours/Week**	**L**	**T**	**P**	**TH**
2. Engineering Chemistry			**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To provide knowledge on the advantages of use of different types of composites.
2.	To introduce the advantages of the use of different types of composites, their manufacturing, properties and applications
3.	To make them aware the manufacturing and testing methods of composites

UNIT I	**INTRODUCTION TO COMPOSITES**	**9**	**0**	**0**	**9**

Fundamentals of composites - need for composites – Enhancement of properties - classification of composites – Matrix and their role- Metal matrix composites (MMC), Ceramic matrix composites (CMC), Polymer matrix composites (PMC)- Reinforcement – Particle reinforced composites-Fibre reinforced composites- Rule of mixtures- Applications of various types of composites.

UNIT II	**METAL MATRIX COMPOSITES**	**9**	**0**	**0**	**9**

Metal Matrix, Reinforcements – particles – fibres, Effect of reinforcement - Volume fraction. Various types of Metal Matrix Composites, Characteristics of MMC, Alloy vs. MMC, Advantages and limitations of MMC –Processing of MMC – Powder metallurgy process - diffusion bonding – stir casting – squeeze casting

UNIT III	**CERAMIC MATRIX COMPOSITES**	**9**	**0**	**0**	**9**

Engineering ceramic materials – Properties – Advantages – Limitations – Monolithic ceramics - Need for CMCs – Ceramic matrix - Various types of Ceramic Matrix composites- oxide ceramics – Non oxide Ceramics – Aluminium oxide – Silicon nitride – Reinforcements – particles- fibres- whiskers. Sintering - Hot pressing – Cold Isostatic Pressing (CIP) – Hot Isostatic Pressing (HIP).

UNIT IV	**POLYMER MATRIX COMPOSITES**	**9**	**0**	**0**	**9**

Polymer matrix resins – Thermosetting resins, thermoplastic resins – Reinforcement fibres – Rovings – Woven fabrics – non-woven random mats – Various types of fibres. Methods for producing PMC - Hand layup processes – Spray up processes – Compression moulding – Reinforced reaction injection moulding - Resin transfer moulding – Pultrusion – Filament winding – Injection moulding. Fibre Reinforced Plastics (FRP), Glass fibre Reinforced Plastics (GRP).

UNIT V	**TESTING OF COMPOSITES AND INTRODUCTION OF NANO COMPOSITES**	**9**	**0**	**0**	**9**

Raw material testing, Property evaluation at laminate level, NDT techniques. Nano particle dispersion in polymer matrix, Polymer- nano clay composites and polymer-carbon nanotubes composites.

Total (45L) = 45Periods

Text Books:

1.	R.M. Jones, Mechanics of Composites, 2nd ed., Taylor & Francis, 1999
2.	Mathews F.L. and Rawlings R.D., “Composite materials: Engineering and Science”, Chapman and Hall, London, England, 2006

References:

1.	Chawla K.K., “Compositematerials”, Springer –Verlag, 2012...
2.	Clyne T.W. and Withers P.J., “Introduction to Metal Matrix Composites”, Cambridge University Press, 2003.
3.	Strong A.B., “Fundamentals of Composite Manufacturing”, SME, 2008...
4	P.M. Ajayan, L. Schadler, P.V. Braun “Nano Composite Science and Technology”, Wiley VCH, 2003.
5	C. Seferis, L. Nicolais, (Eds.) The Role of the Polymeric Matrix in the Processing and Structural Properties of Composite Materials, Plenum Press, New York 1983.

E-References:	
1.	NPTEL Courses.

COURSE OUTCOMES: **Upon completion of this course, the students will be able to:**		**Bloom Taxonomy Mapped**
CO1	Identify the various matrices, reinforcements and their combinations in composite materials and select composite materials for suitable applications.	Remember
CO2	Develop suitable Metal Matrix Composites.	Apply
CO3	Identify perfect Ceramic Matrix Composites for high temperature applications.	Remember
CO4	Choose various combinations of fibres and resins and select an appropriate manufacturing technique for composite materials.	Understand
CO5	Predict the appropriate characterization testing methods for different classes of composites and manufacturing process, application polymer nano composites.	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	2	1	0	2	0	1	0	0	1	0	2	2	1
CO2	2	1	1	1	0	0	1	0	0	0	1	0	2	1	0
CO3	2	1	1	1	0	0	1	0	0	0	1	0	2	1	0
CO4	2	1	1	1	0	1	1	1	0	0	1	0	2	1	0
CO5	2	2	1	1	0	1	1	1	0	0	1	0	2	2	1
Avg	**2.0**	**1.4**	**1.2**	**1.0**	**0.0**	**0.8**	**0.8**	**0.6**	**0.0**	**0.0**	**5.0**	**0.0**	**2.0**	**1.4**	**0.4**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

22MEPE13	COMPUTER INTEGRATED MANUFACTURING		SEMESTER VI			
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
1. Computer Aided Design, Process planning		**Hours/Week**	**L**	**T**	**P**	**TH**
2. Computer Aided Manufacturing, integration software			**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To gain knowledge on how computers are integrated at various levels of planning and manufacturing.
2.	To apply knowledge about Computer Aided Quality control and Process Planning Control.
3.	To understand the flexible manufacturing system and to handle the product data and various software used for manufacturing
4.	To design flexible manufacturing cell after carrying out group technology
5.	To develop and manage databases for CIM

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

The meaning and origin of CIM- the changing manufacturing and management scene - External communication - islands of automation and software-dedicated and open systems-manufacturing automation protocol - product related activities of a company- marketing engineering - production planning - plant operations - physical distribution- business and financial management.

UNIT II	**GROUP TECHNOLOGY AND COMPUTER AIDED PROCESS PLANNING**	**9**	**0**	**0**	**9**

History of group technology- role of G.T. in CAD/CAM integration - part families - classification and coding – DCLASS and MICLASS and OPITZ coding systems-facility design using G.T. -benefits of G.T. - cellular manufacturing. Process planning - role of process planning in CAD/CAM integration - approaches to computer aided process planning -variant approach and generative approaches - CAPP and CMPP process planning systems.

UNIT III	**SHOP FLOOR CONTROL AND INTRODUCTION OF FMS**	**9**	**0**	**0**	**9**

Shop floor control-phases -factory data collection system -automatic identification methods- Bar code technology- automated data collection system. FMS-components of FMS - types -FMS workstation -material handling and storage systems- FMS layout -computer control systems-application and benefits.

UNIT IV	**CIM IMPLEMENTATION AND DATA COMMUNICATION**	**9**	**0**	**0**	**9**

CIM and company strategy - system modeling tools -IDEF models - activity cycle diagram - CIM Open System Architecture (CIMOSA) - manufacturing enterprise wheel-CIM architecture - Product data management-CIM implementation software. Communication fundamentals- local area networks -topology - LAN implementations - network management and installations.

UNIT V	**OPEN SYSTEM AND DATABASE FOR CIM**	**9**	**0**	**0**	**9**

Open systems-open system inter connection - manufacturing automations protocol and technical office protocol (MAP /TOP). Development of databases -database terminology- architecture of database systems-data modeling and data associations -relational data bases - database operators - advantages of data base and relational database.

Total(45L) = 45Periods

TEXT BOOKS:

1.	Mikell.P.Groover, “Automation, Production Systems and Computer Integrated Manufacturing”, Pearson Education, 2008.
2.	Roger Hanman, “Computer Integrated Manufacturing”, Addison –Wesley, 1997

REFERENCES:

1.	Ranky and Paul G., “Computer Integrated Manufacturing”, Prentice Hall International 1986
2.	David D.Bedworth, Mark R.Hendersan and Phillip M.Wolfe, “Computer Integrated Design and Manufacturing”, McGraw Hill Inc, 1998.

3.	Kant Vajpayee S, “Principles of Computer Integrated Manufacturing”, Prentice Hall India,2003
4.	Mikell. P.Groover and Emory ZimmersJr, “CAD/CAM”, Prentice Hall of India Pvt. Ltd, 1998
5.	Yoremkoren, “Computer Integrated Manufacturing system”, McGraw-Hill, 1983.

COURSE OUTCOMES: **Upon completion of this course, the students will be able to:**		**Bloom Taxonomy Mapped**
CO1	Recognize the manufacturing activities interrelated with computers.	Understand
CO2	Understand the concept of group technology and the various approaches of computer aided process planning	Understand
CO3	Explain the phases of shop floor control activities.	Understand
CO4	Apply the system modeling tools in CIM.	Apply
CO5	Explain the applications of database and system protocol	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	0	0	0	0	0	0	0	0	1	0	1	1	1	2	3
CO2	0	0	0	0	0	0	0	0	1	0	1	0	1	2	2
CO3	0	0	1	0	0	0	0	0	1	0	1	0	1	2	2
CO4	0	1	1	1	3	0	0	0	3	2	1	0	1	1	3
CO5	0	0	1	3	2	0	0	0	2	2	1	1	1	2	2
Avg	**0.0**	**0.2**	**0.6**	**0.8**	**1.0**	**0.0**	**0.0**	**0.0**	**1.6**	**0.8**	**1.0**	**0.4**	**1.0**	**1.8**	**2.4**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE14	DESIGN OF TRANSMISSION SYSTEM				SEMESTER VI
PREREQUISITES		**CATEGORY**	**PE**	**Credit**	**3**
1.Student should study kinematic of machinery		**Horus/Week**	**L**	**T**	**P**	**TH**
2. Student should study Design of machine elements.			**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To gain knowledge on the principles and procedures for the design of mechanical power transmission components.
2.	To understand the standard procedures available for design of transmission elements.
3.	To solve the problems for the real time applications of the systems
4.	Designing multi speed gear box for machine tool and automotive applications.
5.	Designing clutch and brake systems for engineering applications.

UNIT I	**DESIGN OF FLEXIBLE ELEMENTS**	**9**	**0**	**0**	**9**

Motor power capacity for various applications - Design of Flat belts and pulleys - Selection of V belts and sheaves – Selection of wire ropes and pulleys – Design of Transmission chains and Sprockets.

UNIT II	**SPUR AND HELICAL GEARS**	**9**	**0**	**0**	**9**

Gear materials - Design of straight tooth spur & helical gears based on speed ratios, number of teeth, Fatigue strength, Factor of safety, strength and wear considerations. Force analysis -Tooth stresses - Dynamic effects - Helical gears – Module - normal and transverse, Equivalent number of teeth - forces.

UNIT III	**BEVEL AND WORM GEARS**	**9**	**0**	**0**	**9**

Straight bevel gear: Gear materials - Tooth terminology, tooth forces and stresses, equivalent number of teeth, estimation of dimensions of straight bevel gears. Worm Gear: Gear materials - Tooth terminology, Thermal capacity, forces and stresses, efficiency, estimation of dimensions of worm gear pair.

UNIT IV	**GEAR BOXES**	**9**	**0**	**0**	**9**

Need - Design of sliding and constant mesh gear boxes: Speed selection - Geometric progression - Standard step ratio - Ray diagram, kinematic layout – Determination of number of teeth. Design of multi speed gear box for machine tool applications, Variable speed gear box, Fluid Couplings, Torque Converters for automotive applications.

UNIT V	**CLUTCHES, BRAKES AND CAMS**	**9**	**0**	**0**	**9**

Design of single and multi-plate clutches, cone clutches, internal expanding rim clutches and Electromagnetic clutches. Design of brakes: External shoe brakes - Single and Double Shoe, Internal expanding shoe brakes and Band brakes. Design of Cams: Types- Pressure angle and under cutting, determination of base circle - forces and surface stresses.

Total (45L) = 45Periods

TEXT BOOKS:

1.	Joseph Shigley,CharlesMischke, Richard Budynas and Keith Nisbett “Mechanical Engineering Design”, 10th Edition, Tata McGraw-Hill, 2014.
2.	Sundararajamoorthy T. V and Shanmugam. N, “Machine Design”, 9th edition, Anuradha Publications, Chennai, 2003.

REFERENCES:

1	Bhandari V, “Design of Machine Elements”, 15th Reprint, Tata McGraw-Hill Book Co, 2014.
2	Prabhu. T.J., “Design of Transmission Elements”, Mani Offset, Chennai, 2003. Md. Jalaludeen, Machine Design, Volume II, Design of Transmission Systems, 4th edition, Anuradha Publications, 2014.
3	GitinMaitra,L. Prasad “Handbook of Mechanical Design”, 2nd Edition, Tata McGraw-Hill,2001.
4	C.S.Sharma, KamleshPurohit, “Design of Machine Elements”, Prentice Hall of IndiaPvt. Ltd., 2003.

5	Bernard Hamrock, Steven Schmid, Bo Jacobson, "Fundamentals of Machine Elements",2nd Edition, Tata McGraw Hill, 2006.
E-REFERENCES:	
1.	https://archive.nptel.ac.in/courses/112/101/112101304/
2.	http://www.velhightech.com/Documents/ME8651 Design of Transmission Systems.pdf
3.	https://civildatas.com/download/design-of-transmission-elements-by-t-j-prabhu

COURSE OUTCOMES: **Upon completion of this course, the students will be able to:**		**Bloom Taxonomy Mapped**
CO1	Appreciate the functions of various transmission elements and their assemblies	Understand
CO2	Design different transmission components according to the requirement as per standards using data books.	Analyze
CO3	Apply the appropriate calculation procedures for the various systems designing	Apply
CO4	Design multi speed gear box for machine tool and automotive applications.	Analyze
CO5	Design clutch and brake systems for engineering applications.	Analyze

COURSE ARTICULATION MATRIX

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

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE15	ENERGY CONVERSION IN INDUSTRIES				SEMESTER VI
PREREQUISITES		**CATEGORY**	**PE**	**Credit**	**3**
1.Thermal Engineering		**Hours/Week**	**L**	**T**	**P**	**TH**
2.Thermal storage system			**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	Analyzing the thermodynamic cycles used in power generation
2.	Evaluating the merits of direct thermal energy conversion systems compared to conventional techniques
3.	Analyzing the performance of fuel cells
4.	Selecting the best energy storage mechanism for any given application
5.	Developing a mechanism for total energy recovery from a system adopting CHCP concept

UNIT I	**ENERGY CONVERSION CYCLES**	**9**	**0**	**0**	**9**

Bell Coleman, Scuderi, Stirling, Ericsson, Lenoir, Atkinson, Stoddard and Kalina cycle – Comparison with Rankine and Brayton cycles.

UNIT II	**DIRECT CONVERSION OF THERMAL TO ELECTRICAL ENERGY**	**9**	**0**	**0**	**9**

MHD - Thermoelectric Converters – Thermoelectric refrigerator – Thermoelectric Generator – Thermionic converters – Ferro electric converter – Nernst Effect Generator – Thermo Magnetic Converter

UNIT III	**DIRECT CONVERSION OF CHEMICAL TO ELECTRICAL ENERGY**	**9**	**0**	**0**	**9**

Fuel Cell: Basics – working advantages and drawbacks – types – comparative analysis – thermodynamics and kinetics of fuel cell process – performance of fuel cell – applications

UNIT IV	**ENERGY STORAGE SYSTEMS**	**9**	**0**	**0**	**9**

Batteries – types – working – performance governing parameters – hydrogen energy – solar cells. Energy storage devices for Mechanical Energy, Electrical Energy, Chemical Energy, Thermal Energy.

UNIT V	**COMBINED HEAT, COOLING AND POWER PRODUCTION (CHCP)**	**9**	**0**	**0**	**9**

Cogeneration - types - Configuration and thermodynamic performance of steam turbine cogeneration systems – gas turbine cogeneration systems – reciprocating IC engines cogeneration systems – concept of polygeneration

Total (45L) = 45Periods

TEXT BOOKS:

1.	Archie.W.Culp, Principles of Energy Conversion, 2nd Edition, McGraw-Hill Inc., 1991, New York
2.	Kordesch Karl, and Günter R. Simader, Fuel Cell and Their Applications, Wiley 2006

REFERENCES:

1	Bent Sorensen, Renewable Energy Conversion, Transmission, and Storage Technology & Engineering, Academic Press, 2007.
2	Charles R. Russell, Elements of Energy Conversion, Permagon Press, 1967
3	Hart A.B. and Womack, G.J., Fuel Cells: Theory and Application, Prentice Hall, 1989
4	Kettari, M.A., Direct Energy Conversion, Addison-Wesley, 1997
5	Yogi Goswami, D. and Frank Kreith, Energy Conversion, Second Edition, Science, 2017.

E-REFERENCES:

1.	https://energyeducation.ca/encyclopedia/Energy_conversion_technology
2.	https://ioe.iitm.ac.in/program/energy-systems/
3.	https://www.industrytap.com/industrial-energy-conversion-transfer-efficiencies-trending/39616

COURSE OUTCOMES: **Upon completion of this course, the students will be able to:**		**Bloom Taxonomy Mapped**
CO1	Analyze the thermodynamic cycles used in power generation	Analyze
CO2	Evaluate the merits of direct thermal energy conversion systems compared to conventional techniques	Apply
CO3	Analyze the performance of fuel cells	Analyze
CO4	Select the best energy storage mechanism for any given application	Understand
CO5	Develop a mechanism for total energy recovery from a system adopting CHCP concept	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	1	1	0	1	0	0	0	0	0	2	1	1
CO2	3	2	2	1	1	1	0	0	0	0	0	0	2	1	1
CO3	3	3	3	1	1	1	1	0	0	0	0	0	2	1	1
CO4	2	2	3	1	1	1	1	0	0	0	0	0	2	1	1
CO5	2	2	2	2	1	1	1	0	0	0	0	0	2	1	1
Avg	**2.6**	**2.2**	**2.4**	**1.2**	**1.0**	**0.8**	**0.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**2**	**1**	**1**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE16	GAS DYNAMICS AND JET PROPULSION		SEMESTER VI			
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**C**
1.Basic knowledge in laws and principles of thermodynamics		**Hours/Week**	**L**	**T**	**P**	**TH**
2.Fundamental concepts about turbo machines and compressible flow			**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	Studying the basic concepts of compressible fluid flow and isentropic flow
2.	Learning about the flow through ducts and various flow parameters
3.	Discussing various flow parameters of normal and oblique shocks
4.	Understanding the concept of jet propulsion and its performance analysis
5.	Studying about space propulsion concept and evaluating its performance parameters

UNIT I	**BASIC CONCEPTS OF FLUID FLOW**	**9**	**0**	**0**	**9**

Energy and momentum equations of compressible fluid flows – Stagnation states – Mach waves and Mach cone – Effect of Mach number on compressibility. Isentropic flows: Isentropic flow through variable area ducts

UNIT II	**ISENTROPIC FLOW**	**9**	**0**	**0**	**9**

Nozzles, Diffusers, compressors and turbines – Use of Gas tables. Flow through ducts: Flow through constant area ducts with heat transfer (Rayleigh flow) and Friction (Fanno flow) – Variation of flow properties – Use of tables and charts – Generalized gas dynamics.

UNIT III	**NORMAL AND OBLIQUE SHOCKS**	**9**	**0**	**0**	**9**

Governing equations – Variation of flow parameters across the normal and oblique shocks – Prandtl Meyer relations – Expansion of supersonic flow, Use of table and charts – Applications

UNIT IV	**JET PROPULSION**	**9**	**0**	**0**	**9**

Theory of jet propulsion – Thrust equation – Thrust power and propulsive efficiency – Operation principle – cycle analysis and use of stagnation state performance of ram jet, turbojet, turbofan and turbo-prop engines – Aircraft combustors

UNIT V	**SPACE PROPULSION**	**9**	**0**	**0**	**9**

Types of rocket engines – Propellants – Ignition and combustion – Theory of rocket propulsion – Performance study – Staging – Terminal and characteristic velocity – Applications – Space flights

TOTAL (45L) = 45PERIODS

TEXT BOOKS:

1.	John D. Anderson Jr. – 'Modern Compressible Flow with historical perspective' – McGraw Hill Publishing company – International Edition – 1990 – 2nd Edition
2.	Yahya S. M. – 'Compressible Flow' – Tata McGraw Hill India – 2009

REFERENCES:

1	Balachandran P. – 'Fundamentals of Compressible Fluid Dynamics' – PHI Learning India Private Ltd. – 2009
2	Cohen H., Rogers G. E. and Saravanamuttoo – 'Gas Turbine Theory' – Longman – 1980
3	Sutton G. P. – 'Rocket Propulsion Elements' – John Wiley, New York – 1986
4	Shapiro A. H. – 'Dynamics and Thermodynamics of Compressible Fluid Flow – Vol.I' – John Wiley, New York – 1953
5	Radhakrishnan E. – 'Gas Dynamics' – Prentice-Hall of India Pvt. Ltd – 2004

E-REFERENCES:

1.	https://nptel.ac.in/courses

COURSE OUTCOMES: **Upon completion of this course, the students will be able to:**		**Bloom Taxonomy Mapped**
CO1	Describe the compressible fluid flow and isentropic flow through various ducts	Understand
CO2	Calculate the flow properties of isentropic flow using gas tables and charts	Analyze
CO3	Differentiate normal and oblique shocks and determine their performance parameters	Understand
CO4	Explain the theory of jet propulsion and calculate the operating parameters of various jet engines	Understand
CO5	Illustrate the theory of rocket engines and determine their performance indicators	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	0	0	1	1	0	1	1	0	0	1	0	0	0	0	0
CO2	1	1	0	0	1	0	0	1	0	0	0	0	1	1	1
CO3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO4	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
CO5	0	0	1	1	0	1	1	0	0	0	0	1	0	0	0
Avg	**0.2**	**0.2**	**0.6**	**0.6**	**0.2**	**0.4**	**0.4**	**0.2**	**0.0**	**0.2**	**0.0**	**0.2**	**0.2**	**0.2**	**0.2**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE17	RENEWABLE ENERGY SYSTEM				SEMESTER VI
PREREQUISITES		**CATEGORY**	**PE**	**Credit**	**TH**
Basic idea about solar radiation and other renewable energy that exists.		**Hours/Week**	**L**	**T**	**P**	**C**
Understanding about various chemical reactions occur in the process			**3**	**0**	**0**	**3**

Course Objectives:

1.	To recognize the consciousness of energy conservation in scholars
2.	To identify the employ of renewable energy sources for electrical power generation
3.	To collect different energy storage methods
4.	To detect about environmental effects of energy conversion

UNIT I	SOLAR ENERGY	9	0	0	9

Devices for thermal collectors and storage: Thermal energy, Chemical Energy and Electromagnetic energy storage; - Thermal Applications-Solar thermal power plant-Solar Photo voltaic Conversion-Solar cell-PV application: Solar water heating, Space heating and cooling, Solar distillation, Solar pumping, Solar furnace, Solar cooking.

UNIT II	WIND ENERGY	9	0	0	9

Principles of wind Energy Conversion-Site Selection Considerations-Wind Energy Conversion System-Advantages and Disadvantages of WECS-Wind Energy Collectors Interconnected System Environmental Aspects.

UNIT III	BIO ENERGY	9	0	0	9

Biomass Conversion Technologies- Direct combustion – Thermo-chemical – Biochemical methods; Types of Bio gas plants-Bio gas from plant wastes-Site selection Problems related to Bio gas plants- factors affecting bio-generation or generation of gas - Alternative liquid fuels -Advantages and Disadvantages of Biological Conversion of Solar Energy.

UNIT IV	ENERGY FROM THE OCEANS	9	0	0	9

Ocean thermal Electric Conversion- Open and Closed cycle; Energy fromTides-Layout of Tidal power house-Components of Tidal power plants- operation methods of utilization of tidal power-Single and Double basin Arrangement; wave-Energy Conversion Devices-Hybrid System.

UNIT V	GEOTHERMAL ENERGY AND FUEL CELLS	9	0	0	9

Geothermal sources – hydrothermal geothermal resources, geopressurised resources, hot dry rock resources of Petro thermal systems, Magma resources – Comparison of flashed steam and total flow concept - Advantages and Disadvantages-Applications of Geothermal Energy; Design and principle operation of a Fuel cells, classification of fuel cells, types of fuel cells, Advantages, disadvantages and applications of fuel cells.

Total (45L) = 45Periods

Text Books:

1.	G.D. Rai, “Non-Conventional Energy Sources”, Khanna publishers, 2017
2.	Suhas P. Sukhatme, “Solar Energy”, Tata McGraw Hill Publishing Company Ltd., 2007.
3.	Sunil S. Rao, B. B. Parulekar, “Energy Technology (Non-Conventional, Renewable And Conventional)”, Khanna publishers 2002.

References:

1	Twidell, J.W. & Weir, A., "Renewable Energy Resources", EFN Spon Ltd., UK, 2005.
2	Tiwari, G.N., "Solar Energy -Fundamentals Design, Modelling and applications", Alpha Science Intl Ltd, 2015.
3	Khan, B.H., "Non-Conventional Energy Resources”, The McGraw Hill Companies, 2009.
4	Godfrey Boyle, “Renewable Energy”, Power for a Sustainable future, Oxford University Press,1996.
5	Johnson Gavy L, “Wind Energy Systems”, Prentice Hall, 1985.

E-References:	
1.	https://www.sciencedirect.com/book/9780128200049/renewable-energy-systems
2.	https://en.wikipedia.org/wiki/Renewable_energy
3.	Ellabban, Omar; Abu-Rub, Haitham; Blaabjerg, Frede (2014). "Renewable energy resources: Current status, future prospects and their enabling technology". Renewable and Sustainable Energy Reviews. 39: 748–764 [749]

COURSE OUTCOMES: **Upon completion of this course, the students will be able to:**		**Bloom Taxonomy Mapped**
CO1	Impart knowledge about solar energy harvesting techniques and its storage system	Understand
CO2	Enhance insight into different wind energy methods to generate electricity.	Understand
CO3	Enrich the scholars to inculcate paramount energy conversion technologies and problems related to bio gas plants	Understand
CO4	Reveals the notion of obtaining abundant energy from the oceans	Understand
CO5	Impart knowledge about geothermal energy and fuel cells	Understand

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	3	2	1	0	2	2	3	1	1	2	2	1	3
CO2	1	2	3	2	1	0	2	2	3	1	1	2	2	1	3
CO3	0	2	3	2	1	0	2	2	3	1	1	2	2	1	3
CO4	1	2	3	2	0	0	2	2	3	1	1	2	2	1	3
CO5	1	2	3	2	1	0	2	2	3	1	1	2	2	1	3
Avg	**0.8**	**2.0**	**3.0**	**2.0**	**0.8**	**0.0**	**2.0**	**2.0**	**3.0**	**1.0**	**1.0**	**2.0**	**2.0**	**1.0**	**3.0**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

PROFESSIONAL ELECTIVES - II

22MEPE21	ADVANCED STRENGTH OF MATERIALS				SEMESTER VI
PREREQUISITES	**CATEGORY**	**PE**	**Credit**		**3**
		L	**T**	**P**	**TH**
Engineering Mechanics and Strength of Materials	**Hours/Week**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To provide basic knowledge in mechanics of materials to solve real engineering problems and design engineering systems
2.	To determine the mechanical behavior of the body by determining the stresses, strains produced by the application of load.
3.	To learn about radial and tangential stresses in thick cylinders and rotating disks
4.	To study about torsion of non-circular sections
5.	To determine the stresses in circular and rectangular plates due to various types of loading and end conditions

UNIT I	**ELASTICITY**	**9**	**0**	**0**	**9**

Stress – Strain relation and General equation of elasticity in cartesian- polar and spherical coordinates- differential equation of equilibrium – compact ability –boundary conditions- representations of three dimensional stress of a tension –generalized Hooke's law – St.Vennant's principle – Plane strain- plane stress – Airy's stress function. Shear Centre- Location of shear center for various sections – shear flow.

UNIT II	**UNSYMMETRICAL BENDING**	**9**	**0**	**0**	**9**

Stresses and deflection in beams subjected to unsymmetrical loading – Kern of a section. Curved flexural members - circumferential and radial stresses – deflection and radial curved beam with re-strained ends – closed ring subjected to concentrated load and uniform load – chain link and crane hooks.

UNIT III	**THICK CYLINDERS AND ROTATING DISKS**	**9**	**0**	**0**	**9**

Thick-walled cylinder subjected to internal and external pressures – Shrink fit joints – Stresses due to rotation – Radial and tangential stresses in solid disc and ring of uniform thickness and varying thickness – allowable speed. – Rotating shafts and cylinders.

UNIT IV	**TORSION OF NON-CIRCULAR SECTIONS**	**9**	**0**	**0**	**9**

Torsion of rectangular cross section – St.Vennant Theory – elastic membrane analogy – Prandtl's stress function – Torsional stresses in hollow thin walled tubes.

UNIT V	**STRESSES IN FLAT PLATES**	**9**	**0**	**0**	**9**

Stresses in circular and rectangular plates due to various types of loading and end conditions – Buckling of plates. Theory of contact stresses – methods of computing contact stresses – deflection of bodies in point and line contact – applications.

Total (45L) = 45 Periods

Text Books:

1.	Arthur P.Boresi and Richard J.Schmidt, "Advanced Mechanics of Materials", 6th Edition, John Wiley &Sons-Inc., 2009.
2.	Arthur P.Boresi and Omar M.Siseborttom- "Advanced Mechanics of Materials", John Wiley International Education, 1985.

References:

1	Robert D.Cook and Wareen.C.Yound, "Advanced Mechanics of Materials", 2nd Edition,Macmilon Publishers Company, 1985
2	Srinath.L.S, "Advanced Mechanics of Solids", Tata McGraw Hill PublishingCompany Limited, 2003

3	KrishnaRaju- N and Gururaja-D.R., "Advanced Mechanics of Solids and Structures", Narosa Publishing House, 1997.
4	U.C.Jindal, "Advanced Topics of Strength of materials", Galgotia Publications, 1st Edition, 1997
E-References:	
1.	NPTEL Videos/Tutorials

COURSE OUTCOMES: **Upon completion of this course, the students will be able to:**		**Bloom Taxonomy Mapped**
CO1	Familiarize the concepts of stress and strain at a point as well as the stress-strain relationships for homogenous, isotropic materials.	Understand
CO2	Evaluate the stresses and strains in axially-loaded members, circular torsion members, and members subject to flexural loadings.	Analyze
CO3	Evaluate the stresses and strains associated with thick-wall spherical and cylindrical pressure vessels.	Analyze
CO4	Evaluate the stresses in non-circular sections	Analyze
CO5	Evaluate the stresses in circular and rectangular plates due to various types of loading and end conditions	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	1	0	0	0	1	0	0	0	0	3	2	1
CO2	2	3	3	1	0	0	0	0	0	0	0	0	3	2	1
CO3	2	3	3	2	0	0	0	1	0	0	0	0	2	3	1
CO4	2	2	2	2	2	0	1	1	0	0	1	0	3	2	1
CO5	2	2	2	2	2	0	0	1	0	0	0	0	3	2	1
Avg	**2.2**	**2.4**	**2.2**	**1.6**	**0.8**	**0.0**	**0.2**	**0.8**	**0.0**	**0.0**	**0.2**	**0.0**	**2.8**	**2.2**	**1.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE22	ENERGY EFFICIENT BUILDINGS DESIGN				SEMESTER VI	
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
1.Basic knowledge about energy efficient technologies		**Hours/Week**	**L**	**T**	**P**	**TH**
2.Concepts of psychometry and renewable energy technologies			**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	Explaining the future building aspects and need for comfort human living.
2.	Designing an energy efficient landscape system for pleasant living environment.
3.	Developing novel solutions for storage integration in buildings and will evolve passive building strategies.
4.	Performing building load estimates and applying them real time procedure.
5.	Explaining the importance of renewable energy integration in buildings.

UNIT I	**INTRODUCTION TO ENERGY EFFICIENT BUILDING CONCEPTS**	**9**	**0**	**0**	**9**

Conventional versus energy efficient buildings – Historical perspective – Water – Energy – IAQ requirement analysis – Future building design aspects – Effective use of resources and needs of modern living – Building assessment and green building processes - Energy conservation building codes.

UNIT II	**LANDSCAPE AND BUILDING ENVELOPES**	**9**	**0**	**0**	**9**

Energy efficient landscape design – Micro climates – various methods – Shading, water bodies –Building envelope: Building materials, Envelope heat loss and heat gain and its evaluation, paints, insulation, Design methods and tools.

UNIT III	**HEATING, VENTILATION AND AIR CONDITIONING**	**9**	**0**	**0**	**9**

Natural Ventilation, Passive cooling and heating: Thermal mass effects – Application of wind, water and earth for cooling, evaporative cooling, radiant cooling – Hybrid methods – energy conservation measures, thermal storage integration in buildings.

UNIT IV	**HEAT TRANSMISSION IN BUILDINGS**	**9**	**0**	**0**	**9**

Surface co-efficient: air cavity, internal and external surfaces, overall thermal transmittance, wall and windows; heat transfer due to infiltration, internal heat transfer; solar temperature; decrement factor; phase lag. Design of day lighting; estimation of building loads: steady state method, network method, numerical method, correlations; computer packages for carrying out thermal design of buildings and predicting performance. Thermal load estimation: Heat balance method. Degree day method for seasonal energy consumption.

UNIT V	**BUILDING COOLING AND RENEWABLE ENERGY IN BUILDINGS**	**9**	**0**	**0**	**9**

Passive cooling concepts, Application of wind, water and earth cooling; shading, paints and cavity walls for cooling; roof radiation traps, Earth air tunnel. Solar sorption cooling and solar vapour compression cooling for buildings – Solar water heating systems in buildings – Small wind turbines, standalone PV, Hybrid systems for residential buildings with economics.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Krieder. J., and Rabi. A., Heating and cooling of buildings: design for efficiency, McGraw Hill, 2016.
2.	Charles. J. Kibert, Sustainable Construction: Green Building Design and Deliver, John Wiley & Sons, 2016.

REFERENCES:

1	Duffie, A and Beckmann, W. A., Solar Engineering of Thermal Processes, John Wiley, 1991.
2	Sukhatme, S.P., Solar Energy, Tata McGraw Hill, 1984.
3	Michael Bauer, Peter Mosle and Michael Schwarz, Green Building - Guidebook for Sustainable Architecture, 2009.
4	Velraj.R, 'Sensible heat Storage for solar heating and cooling systems' in the book titled "Advances in Solar

	Heating and Cooling" – Pages 399 - 428 Elsevier Publication, 2016.
E-REFERENCES:	
1.	https://nptel.ac.in/courses
2.	UrsalaEicker, "Solar Technologies for buildings", Wiley Publications, 2003.3 Guide book for national certification examination for energy managers and energy auditors (downloaded from www.energymanagertraining.com).

COURSE OUTCOMES: **Upon completion of this course, the students will be able to:**		**Bloom Taxonomy Mapped**
CO1	Apply the modern building aspects and the need of indoor air quality for comfort living.	Apply
CO2	Design an energy efficient landscape and evaluate the heat loss or gain through building components.	Analyze
CO3	Develop novel solutions for storage integration in buildings and evolve passive building strategies.	Understand
CO4	Estimate the actual and accurate thermal load for various types of buildings.	Analyze
CO5	Explain the importance of integrating various renewable energy resources in buildings.	Understand

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1	1	0	2	0	0	0	0	0	0	2	1	1
CO2	0	0	3	2	0	0	1	0	0	0	0	0	1	1	0
CO3	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0
CO4	1	1	1	1	0	0	1	1	0	0	0	0	1	1	1
CO5	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0
Avg	**0.6**	**0.4**	**1.2**	**1.0**	**0.0**	**0.6**	**0.8**	**0.2**	**0.2**	**0.2**	**0.0**	**0.0**	**0.8**	**0.6**	**0.4**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE23	ENGINEERING SYSTEM ANALYSIS AND DESIGN				SEMESTER VI
PREREQUISITES		**CATEGORY**	**PE**	**Credit**	**3**
1.Engineering Mechanics & Product design development		**Hours/Week**	**L**	**T**	**P**	**TH**
2.Design of Machine Element			**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	Analyze the asymptotic performance of Manual and automated systems.
2.	Ability to understand the principles of systems documentation.
3.	Demonstrate a familiarity with Systems flowcharts and structured charts.
4.	Apply important Planning considerations for advance development.
5.	Understand the basic concepts and implement the Object-orientedanalysis and design.

UNIT I	**SYSTEM DEFINITION AND CONCEPTS**	**9**	**0**	**0**	**9**

Characteristics and types of system, Manual and automated systems Real - life Business sub - systems: Production, Marketing, Personal, Material and Finance. Systems models types of models: Systems environment and boundaries, Real - time and distributed systems, Basic principles of successful systems

UNIT II	**SYSTEMS ANALYST**	**9**	**0**	**0**	**9**

Role and need of systems analyst, Qualifications and responsibilities, Systems Analyst and agent of change, Introduction to systems development life cycle (SDLC), Various phases of development: Analysis, Design, Development, Implementation, Maintenance Systems documentation considerations: Principles of systems documentation, Types of documentation and their importance, Enforcing documentation discipline in an organization.

UNIT III	**SYSTEMS DESIGN AND PROCESS MODELING**	**9**	**0**	**0**	**9**

Logical and physical design, Design representation, Systems flowcharts and structured charts, Data flow diagrams, Common diagramming conventions and guidelines using DFD and ERD diagrams. Data Modeling and systems analysis, Designing the internals: Program and Process design, Designing Distributed Systems

UNIT IV	**SYSTEM IMPLEMENTATION AND MAINTENANCE**	**9**	**0**	**0**	**9**

Planning considerations, Conversion methods, producers and controls, System acceptance Criteria, System evaluation and performance, Testing and validation, Systems quality Control and assurance, Maintenance activities and issues. Threat to computer system and control measures, Disaster recovery and contingency planning

UNIT V	**OBJECT ORIENTED ANALYSIS AND DESIGN**	**9**	**0**	**0**	**9**

Introduction to Object Oriented Analysis and design life cycle, object modeling: Class Diagrams, Dynamic modeling: state diagram, Dynamic modeling: sequence diagramming.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Analysis and design of information systems – James A.Senn, McGraw-Hill Education, 2008
2.	System analysis and design –Perry Edwards, McGraw-Hill Companies, 1993

REFERENCES:

1	System Analysis and Design Methods, Whitten, Bentaly and Barlow, Galgotia Publication
2	System Analysis and Design Elias M. Award, Galgotia Publication
3	Modern System Analysis and Design, Jeffrey A. Hofer Joey F. George Joseph S. Valacich Addison Weseley.

E-REFERENCES:

1.	https://archive.nptel.ac.in/courses/106/108/106108103/
2.	https://www.tutorialspoint.com/system_analysis_and_design/system_analysis_and_design_overview.htm
3.	https://nios.ac.in/media/documents/vocational/cca/cca1.pdf

COURSE OUTCOMES: **Upon completion of this course, the students will be able to:**		**Bloom Taxonomy Mapped**
CO1	Understand the requirements of a system	Understand
CO2	Design system components and environments.	Analyze
CO3	Build general and detailed models that assist programmers in implementing a system.	Apply
CO4	Design a database for storing data and a user interface for data input and output, as well as controls to protect the system and its data.	Apply
CO5	Understand the concepts of object modeling and dynamics modeling.	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	2	2	1	2	0	0	0	0	0	0	0	2	1	0
CO2	0	1	3	2	1	0	0	0	0	0	0	0	2	3	0
CO3	1	2	2	1	1	0	0	0	0	0	0	0	2	3	0
CO4	1	2	3	2	1	0	0	0	0	0	0	0	1	3	0
CO5	0	2	2	2	0	0	0	0	0	0	0	0	0	2	0
Avg	**0.6**	**1.8**	**2.4**	**1.6**	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.4**	**2.4**	**0.0**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

22MEPE24	INDUSTRIAL ENGINEERING AND MANAGEMENT	SEMESTER VI

PREREQUISITES	CATEGORY	PE	Credit		
1. Basic knowledge of mathematics, science, and engineering.	Hours/Week	L	T	P	TH
2. Basic knowledge about management principles.		3	0	0	3

COURSE OBJECTIVES:

1.	To equip them for applying knowledge of mathematics, science and engineering in the direction to improve the productivity of industries.
2.	To provide the knowledge on engineering economic analysis for effective utilization of available facilities.
3.	To provide the knowledge on supply chain management for efficient use of available resources with aggregate planning.
4.	To make the students familiarize the concept of JIT and modern manufacturing principles.
5.	To familiarize the modern concepts and marketing in management for applying them in professional organization

UNIT I	FORECASTING AND INVENTORY	9	0	0	9

Characteristics and Principles, Qualitative methods - Delphi technique, Market Research, Intrinsic method - Time-series analysis, Moving averages, Exponential smoothing - The Bon Jenkins method, Extrinsic methods - Regression models, Measurement of forecast errors. Inventory models - Classification of inventory systems – EOQ models and purchase discounts - ABC and other classification methods - Applications

UNIT II	FACILITIES PLANNING	9	0	0	9

Facilities planning - An overview, Facilities planning and engineering economic analysis - Facilities location problems – Types of layouts - Computerized layout planning - Warehouse management, Value added management, Management system audit - Role of KAIZEN, TQM, QC and POKA YOKE in facilities planning.

UNIT III	AGGREGATE PLANNING AND SUPPLY CHAIN MANAGEMENT	9	0	0	9

Approaches to aggregate planning - Development of master production schedule - Capacity planning - Materials requirements planning (MRP-I), Manufacturing resources planning (MRP-II), Enterprises resources planning (ERP) - Supply chain management (SCM) – Supply chain and “Keiretsu”.

UNIT IV	JIT AND MODERN MANUFACTURING PRINCIPLES	9	0	0	9

Introduction - Elements of Just in Time (JIT), Pull versus Push method, Kanban system - Single Minute Exchange of Die (SMED) - Continuous improvement - Optimized production technology - Business process reengineering (BPR), Lean manufacturing concepts – Implementation of Six Sigma concepts - Cellular manufacturing - Concurrent engineering - Agile manufacturing - Rapid manufacturing.

UNIT V	MODERN MANAGEMENT CONCEPTS AND MARKETING	9	0	0	9

Concept, features, merits and demerits of: SWOT Analysis; Business Process Re-engineering (BPR); Supply Chain Management (SCM) – Marketing: Concept; Functions; Importance; Segmentation; Mix; Problems of Marketing in Small Enterprise; Competitive Analysis and Advantage – E-marketing.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Dilworth B. James, “Operations Management Design, Planning and control for Manufacturing and Services”, McGraw Hill Inc., New York, 1996.
2.	Samson Eilon, “Elements of Production Planning and Control”, Universal Book Corpn.1984.

REFERENCES:

1	Vollman T.E, “Manufacturing Planning and Control systems”, Galgotia Publications, 2002.
2	Tomkins, J.A and White, J.A, “Facilities Planning”, John Wiley and Sons, 1984.
3	Elwood S. Buffa, and Rakesh K.Sarin, “Modern Production and Operations Management”, 8th Edition. John Wiley and Sons, 2000.

4	Saxena, P.K., Principles of Management: A Modern Approach, Global India Publications, 2009.
5	M. Govindarajan, Marketing Management, Prentice Hall of India, New Delhi, 2010.
E-REFERENCES:	
1.	https://nptel.ac.in/courses/112107292
2.	https://cscmp.org/
3.	https://cdn.websiteeditor.net/25dd89c80efb48d88c2c233155dfc479/files/uploaded/Kotler_keller_marketing_management_14th_edition.pdf

COURSE OUTCOMES: **Upon completion of this course, the students will be able to:**		**Bloom Taxonomy Mapped**
CO1	Apply the knowledge in mathematics, science, and engineering in the direction to improve the productivity of industries.	Apply
CO2	Explain the concepts in engineering economic analysis for effective utilization and management of available facilities.	Understand
CO3	Explain the concepts of supply chain management for efficient use of available resources with aggregate planning.	Understand
CO4	Apply the concept of JIT and modern manufacturing principles in professional organization.	Apply
CO5	Identify modern concepts and marketing in management for applying them in professional organization	Remember

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	1	0	0	0	0	0	0	0	0	2	2	0
CO2	1	2	3	1	0	0	0	0	0	0	0	0	1	2	1
CO3	0	2	2	0	3	1	0	0	0	0	0	0	1	2	3
CO4	0	0	0	0	0	0	0	0	3	0	0	1	0	0	2
CO5	0	0	0	0	0	2	0	2	0	0	1	1	2	0	0
Avg	**0.8**	**1.2**	**1.2**	**0.4**	**0.6**	**0.6**	**0**	**0.4**	**0.6**	**0.0**	**0.2**	**0.4**	**1.2**	**1.2**	**1.2**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE25	INTERNAL COMBUSTION ENGINES				SEMESTER VI
PREREQUISITES		**CATEGORY**	**PE**	**Credit**	**3**
1. Engineering Thermodynamics		**Hours/Week**	**L**	**T**	**P**	**TH**
2. Thermal Engineering			**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To acquire knowledge of basic concepts of IC engine.
2.	To give a comprehensive insight into the engine fuel supply system.
3.	To make the students understand the combustion phenomenon of SI and CI engines.
4.	To study engine management and exhaust emission control techniques.
5.	To impart knowledge on recent trends in IC engines.

UNIT I	**INTRODUCTION OF IC ENGINES**	**9**	**0**	**0**	**9**

Introduction, Types of IC engines, Constructional details in IC engine, working principles - Two-stroke and Four-stroke engines, Actual Indicator diagram for four-stroke and two-stroke engines, General fuel properties, Ignition properties - Octane and cetane rating, Materials for engine components.

UNIT II	**FUEL SUPPLY SYSTEMS**	**9**	**0**	**0**	**9**

Fuel supply systems in SI engine - Introduction - Carburetion - Mixture requirements - Simple carburetor, compensation devices, High altitude fuel supply device - CI engine – Injection systems - Mechanical and electronic.

UNIT III	**COMBUSTION IN IC ENGINE**	**9**	**0**	**0**	**9**

Combustion phenomenon in SI and CI engines - Ignition - Stages of combustion - Normal and abnormal combustion - Factors affecting knock - Combustion chambers - Fuel spray behavior - Spray structure, Spray penetration, and evaporation - Air motion - Factors affecting combustion.

UNIT IV	**ENGINE MANAGEMENT SYSTEM**	**9**	**0**	**0**	**9**

Combined ignition and fuel management systems, Digital control techniques, Complete engine control systems, Artificial intelligence with engine management - Exhaust emission control techniques in SI and CI Engines.

UNIT V	**RECENT TRENDS IN IC ENGINE**	**9**	**0**	**0**	**9**

HCCI engines – construction and working, CRDI injection system, GDI Technology, E - Turbocharger, Variable compression ratio engines, variable valve timing technology, Fuel cell, Hybrid electric technology.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	V. Ganesan, “Internal Combustion Engines”, V Edition, Tata McGraw Hill, 2017.
2.	John B. Heywood, “Internal Combustion Engines Fundamentals”, McGraw-Hill, 1988.

REFERENCES:

1	Thipse.S.S, " internal Combustion Engines & quot; Jaico Publication House., 2010.
2	B.P. Pundir, “IC Engines Combustion & Emission”, Narosa Publishing House, 2014.
3	K.K. Ramalingam, “Internal Combustion Engine Fundamentals”, SciTech Publications, 2011
4	R.B. Mathur and R.P. Sharma, “Internal Combustion Engines”, DhanpatRai & Sons, 2007.
5	Domkundwar.V.M, " A course in internal Combustion Engines & quot; Dhanpat Rai & Sons, 2010.

E-REFERENCES:

1.	https://www.energy.gov/eere/vehicles/articles/internal-combustion-engine-basics
2.	https://www.energy.gov/sites/prod/files/2014/03/f8/deer11_taub.pdf
3.	https://dieselnet.com/tech/engine_emission-control.php

COURSE OUTCOMES: **Upon completion of this course, the students will be able to:**		**Bloom Taxonomy Mapped**
CO1	Understand the concept, construction, and principle of operation of the engine and various engine Components.	Understand
CO2	Explain the fuel supply systems of SI and CI engines and understand the various injection systems of CI engine.	Analyze
CO3	Analyze the combustion phenomenon in SI and CI engines.	Analyze
CO4	Understand the Engine management system and exhaust emission control techniques.	Understand
CO5	Understand recent trends in internal combustion engines.	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	1	0	0	0	0	0	0	0	0	3	2	1
CO2	3	2	2	1	0	0	0	0	0	0	0	0	3	2	1
CO3	3	1	2	2	2	2	3	0	0	0	0	0	2	3	1
CO4	2	1	2	1	2	2	3	0	0	0	0	0	2	3	1
CO5	3	1	1	1	2	2	2	0	0	0	0	0	2	3	1
Avg	**2.8**	**1.4**	**1.8**	**1.2**	**1.2**	**1.2**	**1.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**2.4**	**2.6**	**1.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE26	MACHINE DRAWING	SEMESTER VI

PREREQUISITES	CATEGORY	PE	Credit		3
1.Engineering Drawing	Hours/Week	L	T	P	TH
		2	3	0	3

COURSE OBJECTIVES:

1.	Students learn about the conventional representation of materials, machine elements, and sizes of drawing sheets.
2.	Explain the concept of how to draw section of views, additional views for machine elements and parts like threaded joints, Keys, Cotters and Pin joints.
3.	Explain the concept of how to draw Section of Views, additional views for machine elements and parts like Gears, Shaft couplings and Bearings
4.	Students learn about the drawings of assembled views for the part drawings of the following using conventions like Engine parts and machine parts

UNIT I	FUNDAMENTALS OF MACHINE DRAWING	6	9	0	15

Code of practice for Engineering Drawing, BIS specifications – Welding symbols, riveted joints, keys, fasteners – Reference to hand book for the selection of standard components like bolts, nuts, screws, keys etc. - Limits, Fits – Tolerancing of individual dimensions – Specification of Fits – Preparation of production drawings and reading of part and assembly drawings, basic principles of geometric dimensioning & tolerancing.

UNIT II	BASIC MACHINE ELEMENTS	6	9	0	15

The required sectional view of the following machine elements are to be drawn as per the standards. Threaded joints, Riveted joints, Welded joints, Key, Cotter and Pin joints, Shaft coupling, Bearing, Pipe joints, Gears, Surface finish and its representation

UNIT III	ASSEMBLY DRAWING	18	0	27	45

The assembly drawing of the following machine tool parts is to be drawn from the given detailed drawing.

ings – Flange, Universal, Oldham's, Muff and gear couplings.

– Knuckle, Gib & cotter, strap, sleeve & cotter joints.

e parts – Piston, connecting rod, cross-head (vertical and horizontal), stuffing box, multi-plate clutch.

llaneous machine components – Screw jack, machine vice.

Total (30L + 45P) = 75 Periods

TEXT BOOKS:

1.	P.S Gill, "Machine Drawing", S K Kataria and sons, 18th edition, 2020 reprint.
2.	N.D.Bhatt, "Machine Drawing". Charotar publications, 49th edition, 2014

REFERENCES:

1	Ajeet Singh, "Machine Drawing (including Auto CAD)", Tata McGraw Hill, 2 nd edition,2012
2	G. Pohit, "Machine Drawing with Auto CAD", Pearson Education Asia, 2007
3	Dhawan, R.K., A Text Book of Machine Drawing, S. Chand & Company, 1996.
4	Ostrowsky, O., Engineering Drawing with CAD Applications, ELBS, 1995.
5	Gopalakrishna K.R., "Machine Drawing", 22th Edition, Subhas Stores Books Corner, Bangalore, 2013

E-REFERENCES:

1.	NPTEL Courses

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		Bloom Taxonomy Mapped
CO1	Follow the drawing standards, fits and tolerances	Understand
CO2	Re-create part drawings, sectional views and assembly drawings as per standards	Analyze
CO3	Analyze complex design systems related to mechanical engineering.	Analyze
CO4	Improve skills to adopt modern methods in mechanical engineering as continuous improvement.	Understand
CO5	Understand the impact of engineering solutions in a global, economic, environment and societal context.	Understand

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	2	1	0	1	1	0	0	0	1	0	2	2	1
CO2	2	1	2	1	0	1	1	0	0	0	1	0	2	2	1
CO3	2	2	2	2	0	0	2	0	0	0	1	0	2	2	1
CO4	1	1	2	2	0	1	0	0	0	0	1	0	2	2	1
CO5	1	1	1	2	0	2	2	1	0	0	0	0	1	1	1
Avg	**1.6**	**1.2**	**1.8**	**1.6**	**0.0**	**1.0**	**1.2**	**0.2**	**0.0**	**0.0**	**0.8**	**0.0**	**1.8**	**1.8**	**1.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE27	POWER PLANT ENGINEERING				SEMESTER VI	
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
1.Having sufficient knowledge on basics of power plant		**Hours/Week**	**L**	**T**	**P**	**TH**
2. Basic unit calculation for consumption of power			**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	Understanding of thermal power plant operation, different types of high-pressure boilers including supercritical and supercharged boilers, fluidized bed combustion systems, Design of chimney in thermal power plants, knowledge of cooling tower operation.
2.	Location of hydro power plant and its components to generate power.
3.	Complete knowledge about diesel and gas power plant.
4.	Basic knowledge of nuclear reaction and types of nuclear power plant.
5.	Basic knowledge of power plant economics and various tariff methods.

UNIT I	**STEAM POWER PLANT**	**9**	**0**	**0**	**9**

Layout of steam power plant – boilers - Modern high pressure and supercritical boilers -- Preparation and handling of coal - Pulverizer - Dust collector - Ash removal; Stokers - Different types - Pulverized fuel burning; Draught - Different types - Chimney design - Selection of blowers, Cooling towers - Different types - Waste heat recovery, Fluidised Bed & Circulated Fluidised Bed boilers

UNIT II	**HYDRO ELECTRIC POWER PLANT**	**9**	**0**	**0**	**9**

Layout of hydel power plant- classification –working – components – layout of pumped storage power plant - Plant equipment for Pumped Store Schemes.

UNIT III	**DIESEL AND GAS POWER PLANT**	**9**	**0**	**0**	**9**

Layout of Diesel power plant- Important components – performance analysis – Layout of gas power plant – classification of gas turbine cycles – components – relative thermal efficiencies of different cycles.

UNIT IV	**NUCLEAR, MHD POWER GENERATION**	**9**	**0**	**0**	**9**

Elementary treatment - Nuclear fission, chain reaction - Pressurized water reactors, boiling water reactors, gas cooled reactors - Fast breeder reactors, Magneto Hydro Dynamic power- open cycle and closed cycle system.

UNIT V	**ECONOMICS AND SAFETY**	**9**	**0**	**0**	**9**

Economics and safety - Actual load curves - Fixed and operating costs - Tariff methods for electrical energy - Peak load and variable load operations - Selection of generation type and general equipment. Introduction to safety aspects in power plants - Environmental impacts - assessment for thermal power plant.

Total(45L): 45 Periods

TEXT BOOKS:

1.	S. Domkundwar, A.V. Domkundwar, S.C. Arora A Course in Power Plant Engineering, Dhanpat Rai Publications. 2016.
2.	P.K. Nag, Power Plant Engineering, Tata McGraw Hill, Laxmi Publications Pvt. Ltd New Delhi, 5th Edition, 2014.

REFERENCES:

1	R.K. Rajput. A Text of Power Plant Engineering, Laxmi publications, New Delhi 5th Edition, 2016.
2	G.R. Nagpal, Power Plant Engineering, Khanna Publications 1998.
3	Bernhardt G. Askrotzki and William A. Vopat, “Power Station Engineering and Economy”, Tata McGraw Hill Publishing Co. Ltd., 1972.
4	Frederick T. Mores, “Power Plant Engineering”, Affiliated East-West Press Private Ltd., 1953.
5	Joel Weisman and Roy Eckart, “Modern Power Plant Engineering”, Prentice Hall International Inc., 1985.

E-REFERENCES:	
1.	https://en.wikipedia.org/wiki/Power_plant_engineering
2.	https://onlinecourses.nptel.ac.in/noc21_me86/preview

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		Bloom Taxonomy Mapped
CO1	Identify elements and their functions of steam power plant.	Understand
CO2	Identify elements and their functions of hydroelectric power plant	Understand
CO3	Identify elements and their functions of diesel and gas power plant.	Understand
CO4	Identify elements and their functions of nuclear power plant.	Understand
CO5	Study the applications of power plants while extend their knowledge to power plant economics and environmental hazards and estimate the cost of electrical energy production.	Understand

COURSE ARTICULATION MATRIX

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO7	PO8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	3	2	1	0	1	1	2	0	2	2	2	1	2
CO2	1	2	3	2	1	0	1	1	2	0	2	2	2	1	2
CO3	1	2	3	2	1	0	1	1	2	0	2	2	2	1	2
CO4	1	2	3	2	1	0	1	1	2	0	2	2	2	1	2
CO5	2	0	1	2	0	0	0	2	2	1	1	1	2	0	0
Avg	**1.2**	**1.6**	**2.6**	**2.0**	**0.8**	**0.0**	**0.8**	**1.2**	**2.0**	**0.2**	**1.8**	**1.8**	**2.0**	**0.8**	**1.6**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

PROFESSIONAL ELECTIVES – III

22MEPE31	FUELS AND COMBUSTION				SEMESTER VI	
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
1. Basic chemical reactions between various components		**Hours/Week**	**L**	**T**	**P**	**TH**
2. Fundamental about various types of fuels and its nature			**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To impart the acquaintance about characterize of the different types of fuels.
2.	To enhance the understanding of Classification, Composition & Properties of various fuels
3.	Understanding of thermodynamics and kinetics of combustion.
4.	Understand and analyze the combustion mechanisms of various fuels.

UNIT I	**CHARACTERIZATION**	**9**	**0**	**0**	**9**

Fuels-solid, liquid and gaseous fuels-characteristics. Determination of Properties of Fuels – Fuels Analysis Proximate and Ultimate Analysis - Moisture Determination - Calorific Value - Gross & Net Calorific Values - Calorimetry - DuLong's Formula for CV Estimation.

UNIT II	**SOLID FUELS & LIQUID FUELS**	**9**	**0**	**0**	**9**

Solid Fuels-Types - Coal Family - Properties - Calorific Value - ROM, DMMF, DAF and Bone Dry. Renewable Solid Fuels - Biomass - Agro Fuels – Manufactured Solid Fuels. Liquid Fuels-Types - Sources - Petroleum Fractions - Classification - Refining - Properties of Liquid Fuels - Calorific Value, Specific Gravity, Flash & Fire Point, Octane Number, Cetane Number etc., - Alcohols - Tar Sand Oil - Liquefaction of Solid Fuels.

UNIT III	**GASEOUS FUELS**	**9**	**0**	**0**	**9**

Classification - Composition & Properties - Estimation of Calorific Value – Gas Calorimeter. Rich & Lean Gas - Wobbe Index - Natural Gas - Dry & Wet Natural Gas- Stripped Natural Gas – Foul & Sweet Natural Gas - Liquefied Petroleum Gas - Liquefied natural gas - Compressed natural gas - Methane - Producer Gas - Gasifiers - Water Gas - Town Gas.

UNIT IV	**COMBUSTION**	**9**	**0**	**0**	**9**

Principle of combustion - stoichiometry, heat of reaction and formation. Combustion process- submerged combustion, slow combustion, pulsating and explosive combustion. Chemical kinetics-NOx and soot kinetics. Fuel and flue gas composition, Excess air calculation.

UNIT V	**COMBUSTION EQUIPMENT'S**	**9**	**0**	**0**	**9**

Coal Burning Equipment's - Types - Pulverized Coal Firing - Fluidized Bed Firing – Fixed Bed & Recycled Bed - Cyclone Firing - Spreader Stokers - Vibrating Grate Stokers - Sprinkler Stokers, Traveling Grate Stokers. Oil Burners - Vaporizing Burners, Atomizing Burners. Gas Burners - Atmospheric Gas Burners - Air Aspiration Gas Burners – Burners.

Total (45L) = 45Periods

Text Books:

1.	Samir Sarkar, Fuels & Combustion, 2nd Edition, Orient Longman, 2009.
2.	Bhatt, Vora Stoichiometry, 4th Edition, Tata McGraw Hill, 2004.

References:

1	Om Prakash Gupta, Elements of Fuels, Furnaces and Refractories, Khanna publishers, 1999.
2	Blokh AG,Heat Transfer in Steam Boiler Furnace, Hemisphere Publishing Corpn, 1988.
3	Sharma SP, Mohan Chander, Fuels & Combustion, Tata McGraw Hill, 1984.
4	Shaha AK (2003), Combustion Engineering & Fuel Technology, Oxford and IBH Publications, New York.
5	Kenneth K Kou (2002), Principles of Combustion, Wiley & Sons Publications, New York.

E-References:	
1.	https://nptel.ac.in/courses/112106299
2.	http://www.sitams.org/assets/pages/hands/material/R18/Engineering%20Chemistry/Fuels%20and%20combustion.pdf
3.	https://www.researchgate.net/publication/265602602_Fuels_and_Combustion_CHAPTER_-_4_FUELS_AND_COMBUSTION_41_Introduction_42_Requirements_of_a_Good_Fuel

COURSE OUTCOMES: **Upon completion of this course, the students will be able to:**		**Bloom Taxonomy Mapped**
CO1	Understand the various kinds of fuels characteristics.	Understand
CO2	Determine flash and fire points of various fuel blends.	Apply
CO3	Classification, composition, properties and estimation of calorific value of gaseous fuels	Understand
CO4	Understand the thermodynamics behind combustion, flame propagation and choice of combustion systems.	Understand
CO5	Vast knowledge on effective employment of combustion equipment's	Understand

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3	2	2	1	1	0	1	2	1	2	1	1	2	1
CO2	1	2	3	1	1	1	0	1	2	1	2	1	2	2	1
CO3	1	1	2	2	1	1	0	1	2	1	2	1	2	3	1
CO4	1	3	2	3	1	1	0	1	2	1	2	1	3	2	1
CO5	1	3	1	2	1	1	0	1	2	1	2	1	2	1	1
Avg	**1.0**	**2.4**	**2.0**	**2.0**	**1.0**	**1.0**	**0.0**	**1.0**	**2.0**	**1.0**	**2.0**	**1.0**	**2.0**	**2.0**	**1.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE32	MAINTENANCE ENGINEERING	SEMESTER VI

PREREQUISITES	CATEGORY	PE	Credit	3
1. Manufacturing Technology	Hours/Week	L	T	P	TH
2.Environmental Science and Engineering		3	0	0	3

COURSE OBJECTIVES:

1.	To understand the principles, functions and practices adapted in industry for the successful management of maintenance activities
2.	To explain the different maintenance categories like preventive maintenance, condition monitoring and repair of machine elements
3.	To illustrate the instruments used for condition monitoring in industry
4.	To apply the repair methods in basic machine elements
5.	To apply the repair methods in material handling equipment

UNIT I	INTRODUCTION	9	0	0	9

Objectives of maintenance - types of maintenance – Breakdown, preventive and predictive maintenance. Basic Principles of maintenance planning – Importance and benefits of sound maintenance systems – Repair cycle - Repair Complexity, Lubrication. Maintenance of Mechanical transmission systems and process plants– Maintenance economics.

UNIT II	RELIABILITY AND AVAILABILITY	9	0	0	9

Maintenance categories – Comparative merits of each category – Preventive maintenance, maintenance schedules, Total Productive Maintenance (TPM). Reliability: Definition, concept of reliability-based design, failure rate, MTTF, MTBF, failure pattern. Availability and Maintainability concepts- Applications

UNIT III	CONDITION MONITORING	9	0	0	9

Condition Monitoring – Cost comparison with and without CM – On load testing and offload testing – Methods and instruments for CM – Temperature sensitive tapes – Pistol thermometers – wear debris analysis, condition monitoring in industries.

UNIT IV	REPAIR METHODS FOR BASIC MACHINE ELEMENTS	9	0	0	9

Repair methods for beds, slide ways, spindles, gears, lead screws and bearings – Failure analysis – Failures and their development – Logical fault location methods – Sequential fault location, trouble shooting.

UNIT V	REPAIR METHODS FOR MATERIAL HANDLING EQUIPMENT	9	0	0	9

Repair methods for Material handling equipment – Equipment records – Job order systems -Use of computers in maintenance. Safety Codes and Standards - General Safety considerations in Material Handling equipment.

Total(45L) = 45Periods

TEXT BOOKS:

1.	Ricky smith and R.keith mobley, “Rules of Thumb for Maintenance and Reliability Engineers”, Butterworth-Heinemann,2011.
2.	Lindley Higgins, Keith Moley, “Maintenance Engineering Handbook”, McGraw-Hill Company, 2002.

REFERENCES:

1	Ahmed E.Haroun,Salih O.Duffuaa, “Handbook of Maintenance Management and Engineering”, Springer,2009.
2	Mohamed Ben-Daya,Uday Kumar, “Introduction to Maintenance Engineering, Modelling, Optimization and Management”, Wiley,2016.
3	B.S.Dhillon, “Engineering Systems Reliability, Safety and Maintenance : An integrated Approach”, Taylor & Francis; CRC Press,2017.
4	David J.Smith, “Reliability,Maintenance and Risk”, Butterworth- Heinemann,2011.
5	Paul Dempsey, “Troubleshooting and Repair of Diesel Engines, Fourth Edition”, McGraw- Hill ,2007.

E-REFERENCES:	
1.	NPTEL courses: http://nptel.iitm.ac.in/courses.php - web and video sources on Maintenance Engineering

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		Bloom Taxonomy Mapped
CO1	Understand the principles, functions and practices adapted in industry for the successful management of maintenance activities	Understand
CO2	Explain the different maintenance categories like preventive maintenance, condition monitoring and repair of machine elements	Understand
CO3	Illustrate the instruments used for condition monitoring in industry	Understand
CO4	Apply the repair methods in basic machine elements	Understand
CO5	Apply the repair methods in material handling equipment	Understand

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3	0	2	3	3	2	0	1	1	1	3	2	3	3
CO2	1	2	0	2	2	2	1	0	1	0	1	3	2	3	3
CO3	0	3	1	1	2	1	0	0	1	0	0	2	2	2	2
CO4	3	2	1	2	2	0	0	0	0	0	0	0	.3	2	1
CO5	3	2	0	2	2	0	0	0	0	0	0	0	3	2	1
Avg	**1.6**	**2.4**	**0.4**	**1.8**	**2.2**	**1.2**	**0.6**	**0.0**	**0.6**	**0.2**	**0.4**	**1.6**	**2.4**	**2.4**	**2.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE33	NON-TRADITIONAL MACHINING PROCESSES				SEMESTER VI			
PREREQUISITES		**CATEGORY**	**PE**		**Credit**			**3**
1.Manufacturing Technology		**Hours/Week**	**L**		**T**	**P**		**TH**
2.Engineering Chemistry			**3**		**0**	**0**		**3**

COURSE OBJECTIVES:

1.	To understand the various Non-Traditional machining processes and its applications
2.	To decide the appropriate process among various electro chemical processes
3.	To justify the appropriate Thermo - electric process based on the application and limitations
4.	To understand the working principle and applications of Laser machining processes
5.	To understand the working principle and applications of Micro-electro Mechanical processes

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Classification of NTM - Mechanical machining: Types - Ultrasonic Machining (USM) - Abrasive Jet Machining (AJM) - Abrasive Flow Machining (AFM) - Water Jet Machining (WJM) - Operating principle - Process parameters - Applications - Limitations.

UNIT II	**ELECTRO - CHEMICAL PROCESSES**	**9**	**0**	**0**	**9**

Electro chemical machining: Types - Electro Chemical Machining (ECM) - Electro Chemical Drilling (ECD) - Electro Chemical Grinding (ECG) - Electro Chemical Honing (ECH) - Shaped Tube Electrolytic Machining - Operating principle - Process parameters - Applications – Limitations.

UNIT III	**THERMO - ELECTRICAL PROCESSES**	**9**	**0**	**0**	**9**

Thermo electrical machining: Types - Electrical Discharge Machining (EDM) - Electrical Discharge Wire Cutting (EDWC) - Electron Beam Machining (EBM) - Ion Beam Machining (IBM) - Plasma Arc Machining (PAM) - Operating principle - Process parameters - Applications - Limitations.

UNIT IV	**LASER MACHINING PROCESSES**	**9**	**0**	**0**	**9**

Laser materials processing: Laser types - Processes - Laser Beam Machining (LBM) - Laser cutting - Laser drilling- Laser marking and engraving - Laser Micro Machining (LMM)-Laser Engineered Net Shaping (LENS) - Applications – Limitations.

UNIT V	**MICRO ELECTRO - MECHANICAL PROCESSES**	**9**	**0**	**0**	**9**

Introduction to silicon processing - Wafer cleaning - Oxidation - Photolithography - Electron beam and X-ray lithography - thin film deposition - sputtering - chemical vapour deposition - electro plating - Etching Process -wet etching, isotropic etching, anisotropic etching, dry etching.

Total(45L) = 45 Periods

TEXT BOOKS:

1.	Pandey P.C. and Shan H.S. "Modern Machining processes" Tata McGraw-Hill, New Delhi, 2017.
2.	Nano Tanigudi, "Nanotechnology", Oxford University Press, New York, 2003.
3.	Vijay K Jain, "Advanced Machining Processes", Allied Publications Private Limited, 2002.

REFERENCES:

1	Carl Sommer, "Non-traditional Machining Handbook", Advance Publishing Inc., 2000.
2	Groover, M.P. "Fundamentals of Modern Manufacturing Processes - Materials, Processes and Systems", 3rd Edition, John Wiley and Sons Inc., 2007.
3	Paul De Garmo, J.T.Black, and Ronald.A.Kohser, "Material and Processes in Manufacturing" Prentice Hall of India Pvt.Ltd., New Delhi, 8th Edition, 2001.
4	Steen, W.M. and Watkins, K. "Laser Materials Processing", Springer London Ltd, 2003.
5	Hassan Abdel and Gaward El-Hofy, "Advanced Machining Processes", McGraw Hill Publications, 2005.

E-REFERENCES:	
1.	NPTEL courses: http://nptel.iitm.ac.in/courses.php - web and video sources on Non-Traditional Machining Processes.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		Bloom Taxonomy Mapped
CO1	Understand the various Non-Traditional machining processes and its applications	Understand
CO2	Decide the appropriate process among various electro chemical processes	Understand
CO3	Justify the appropriate Thermo electric process based on the application and limitations	Apply
CO4	Understand the working principle and applications of Laser machining processes	Understand
CO5	Understand the working principle and applications of Micro-electro Mechanical processes	Understand

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	0	1	0	0	0	0	0	0	1	0	2	2	1
CO2	3	2	0	0	1	0	0	0	0	0	0	0	2	2	1
CO3	3	2	0	0	1	0	0	0	0	0	0	0	2	2	1
CO4	2	1	0	0	1	0	0	0	0	0	0	0	2	2	1
CO5	2	1	0	0	1	0	0	0	0	0	0	0	2	2	1
Avg	**2.6**	**1.6**	**0.0.**	**0.2**	**0.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.2**	**0.0**	**2.0**	**2.0**	**1.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE34	PROFESSIONAL ETHICS AND HUMAN VALUES		SEMESTER VI			
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
1.Human Rights		**Hours/Week**	**L**	**T**	**P**	**TH**
2. Product life Cycle Management			**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	Applying the core values toward the ethical behavior of an engineer.
2.	Applying the ethical and moral principles in engineering experimentation.
3.	Applying the ethical and moral principles in engineering for safety.
4.	Applying standard codes of moral conduct toward the ethical behavior of an engineer.
5.	Applying ethical and moral principles for engineers as managers, consultants, expert witness. Resolving global issues of ethics concerning weapon development and multinational companies.

UNIT I	**ENGINEERING ETHICS**	**9**	**0**	**0**	**9**

Senses of 'Engineering Ethics' – Variety of moral issues – Types of inquiry – Moral dilemmas – Moral Autonomy – Kohlberg's theory – Gilligan's theory – Consensus and Controversy – Professions and Professionalism – Professional Ideals and Virtues – Uses of Ethical Theories.

UNIT II	**ENGINEERING AS SOCIAL EXPERIMENTATION**	**9**	**0**	**0**	**9**

Engineering as Experimentation – Engineers as responsible Experimenters – Research Ethics Codes of Ethics – Industrial Standards - A Balanced Outlook on Law – The Challenger Case Study.

UNIT III	**ENGINEERING FOR SAFETY**	**9**	**0**	**0**	**9**

Safety and Risk – Assessment of Safety and Risk – Risk Benefit Analysis – Reducing Risk – The Government Regulator's Approach to Risk - Chernobyl Case Studies and Bhopal.

UNIT IV	**ENGINEER'S RESPONSIBILITIES AND RIGHTS**	**9**	**0**	**0**	**9**

Collegiality and Loyalty – Respect for Authority – Collective Bargaining – Confidentiality – Conflicts of Interest – Occupational Crime – Professional Rights – Employee Rights – Intellectual Property Rights (IPR) – Discrimination.

UNIT V	**GLOBAL ISSUES**	**9**	**0**	**0**	**9**

Multinational Corporations – Business Ethics - Environmental Ethics – Computer Ethics – Role in Technological Development – Weapons Development – Engineers as Managers – Consulting Engineers – Engineers as Expert Witnesses and Advisors – Honesty – Moral Leadership – Sample Code of Conduct

Total(45L) = 45 Periods

TEXT BOOKS:

1.	Mike Martin and Roland Schinzinger, "Ethics in Engineering", McGraw-Hill, New York 2017.
2.	Govindarajan M, Natarajan S, Senthil Kumar V. S, "Engineering Ethics", Prentice Hall of India, New Delhi, 2004

REFERENCES:

1	Charles D Fleddermann, "Engineering Ethics", Prentice Hall, New Mexico, 1999.
2	David Ermann and Michele S Shauf, "Computers, Ethics and Society", Oxford University Press, 2003
3	Edmund G Seebauer and Robert L Barry, "Fundamentals of Ethics for Scientists and Engineers", Oxford University Press, 2001.
4	John R Boatright, "Ethics and the Conduct of Business", Pearson Education, 2003.
5	Prof. (Col) P S Bajaj and Dr. Raj Agrawal, "Business Ethics – An Indian Perspective", Biztantra, New Delhi, 2004.

E-REFERENCES:

1.	Value Education websites, http://uhv.ac.in, http://www.uptu.ac.in
2.	IIT Delhi, Modern Technology – the Untold Story

3.	Gandhi A., Right Here Right Now, Cyclewala Productions

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the core values toward the ethical behavior of an engineer.	Understand
CO2	Apply the ethical and moral principles in engineering experimentation	Understand
CO3	Expose the ethical and moral principles in engineering for safety.	Apply
CO4	Apply standard codes of moral conduct toward the ethical behavior of an engineer	Apply
CO5	Apply ethical and moral principles for engineers as managers, consultants, expert witness. Resolve global issues of ethics concerning weapon development and multinational companies.	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	0	0	0	0	0	0	3	1	3	0	0	2	1	0	0
CO2	0	0	0	0	0	0	2	2	3	0	0	2	1	2	0
CO3	0	0	0	0	0	0	3	2	3	0	0	2	1	2	0
CO4	0	0	0	0	0	0	3	3	2	0	0	2	1	2	0
CO5	0	0	0	0	0	0	2	2	3	0	0	2	1	0	0
Avg	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**2.6**	**2**	**2.8**	**0.0**	**0.0**	**2.0**	**1.0**	**1.2**	**0.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE35	RAPID PRODUCT DEVELOPMENT TECHNOLOGIES				SEMESTER VI
PREREQUISITES		**CATEGORY**	**PE**	**Credit**	**3**
1. Design of Machine elements and transmission systems, CAD software		**Hours/Week**	**L**	**T**	**P**	**TH**
2. Material science, Tool Design, Engineering physics			**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To explain the Importance of RPT in Manufacturing
2.	To familiarize the students with recent developments in RPT
3.	To describe different methods for Post-processing of AM parts
4.	To list out the challenges in RPT
5.	To explain future Directions of AM

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Need for time compression in product development- Product development – conceptual design – development – detail design – prototype – tooling -History of RP systems- Survey of applications- Growth of RP industry- classification of RP systems

UNIT II	**STEREO LITHOGRAPHY SYSTEMS**	**9**	**0**	**0**	**9**

Stereo lithography systems – Principle – process parameters – process details – machine details- Applications. Selective laser sintering – Principle – process parameters – process details – machine details- Applications-Direct Metal Laser Sintering (DMLS) system – Principle – process parameters – process details – machine details- Applications.

UNIT III	**FUSED DEPOSITION MODELING**	**9**	**0**	**0**	**9**

Fusion Deposition Modelling – Principle – process parameters – process details – machine details- Applications. Laminated Object Manufacturing – Principle – process parameters – process details – machine details- Applications.

UNIT IV	**SOLID GROUND CURING AND CONCEPT MODELERS**	**9**	**0**	**0**	**9**

Solid Ground Curing – Principle – process parameters – process details – machine details- Applications. 3-Dimensional printers – Principle – process parameters – process details – machine details- Applications- and other concept modelers like thermo jet printers- Sander's model maker- JP system 5- Object Quadra system. Laser Engineering Net Shaping (LENS)- Ballistic Particle Manufacturing (BPM) -Principle.

UNIT V	**RAPID TOOLING AND SOFTWARES**	**9**	**0**	**0**	**9**

Introduction to rapid tooling – direct and indirect method- Indirect Rapid Tooling - Silicone rubber tooling- Aluminium filled epoxy tooling- Spray metal tooling- etc. Direct Rapid Tooling - Direct AIM- Quick cast process- Copper polyamide- Rapid Tool- DMILS- ProMetal- Sand casting tooling- Laminate tooling- soft tooling vs hard tooling. Software for RP – STL files- Magics- Mimics. Application of Rapid prototyping in medical field.

Total(45L) = 45 Periods

TEXT BOOKS:

1.	Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010
2.	Ali K. Kamrani, Emand Abouel Nasr, "Rapid Prototyping: Theory & Practice", Springer, 2006. 4. D.T. Ph

REFERENCES:

1	Pham D.T. & Dimov.S. S, "Rapid manufacturing", Springer Verlag, London, 2001.
2	Paul F Jacobs, "Rapid Prototyping and manufacturing – Fundamentals of Stereo lithographic", Society of Manufacturing Engineering, Dearborn, USA 1992.
3	Ali K. Kamrani, Emand Abouel Nasr, "Rapid Prototyping: Theory & Practice", Springer, 2006.
4	Chua Chee Kai, Leong Kah Fai, "Rapid Prototyping: Principles & Applications", World Scientific, 2003.
5	Terry wohlers, "Wohlers Report 2007", Wohlers Associates, USA 2007.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Learn about the hurdles, basic-essentials and key-drivers of innovation in digital manufacturing and its application in Automobile, Aerospace, Bio-medical etc.	Understand
CO2	Recognize the operational features of Stereo Lithography Systems.	Understand
CO3	Explain the concept of Fusion Deposition Modelling.	Understand
CO4	Design for manufacture solid ground curing and concept modelers	Apply
CO5	Acquire the knowledge of Software for RP and apply RPT in Tooling.	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	0	1	1	1	1	2	0	0	0	0	1	1	3	2	1
CO2	0	2	1	1	1	0	0	0	1	0	1	1	1	2	2
CO3	0	2	1	1	1	0	0	0	1	0	1	1	1	2	2
CO4	0	2	3	1	1	0	0	0	1	0	1	1	1	2	2
CO5	0	1	0	1	3	0	0	0	1	0	1	0	3	2	3
Avg	**0.0**	**1.6**	**1.2**	**1.0**	**1.4**	**0.4**	**0**	**0**	**0.8**	**0.0**	**1.0**	**0.8**	**1.8**	**2.0**	**2.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE36	REFRIGERATION & AIR CONDITIONING				SEMESTER VI
PREREQUISITES		**CATEGORY**	**PE**	**Credit**	**3**
1.Engineering Thermodynamics		**Hours/Week**	**L**	**T**	**P**	**TH**
2.Fluid Mechanics and Machinery			**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To understand the basic concepts and processes in refrigeration
2.	To understand the components of vapour compression refrigerating system and its effects
3.	To understand the other refrigeration systems and their applications
4.	To solve the problems using psychrometric charts and psychrometric properties
5.	To calculate the cooling load for designing air conditioning systems

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Basic concepts and definitions of refrigeration and air conditioning, comparison. Refrigeration: Ideal Refrigeration cycles and processes- Reversed Carnot cycle - Units of Refrigeration, refrigeration effect, tonne of refrigeration and C.O.P. Refrigerants - desirable properties – Classification – Nomenclature – ODP & GWP.

UNIT II	**VAPOUR COMPRESSION REFRIGERATION SYSTEM**	**9**	**0**	**0**	**9**

Refrigeration system components: Type of Compressors, Condensers, Expansion devices, Evaporators. Vapour compression cycle: P-H and T-S diagrams – deviations from theoretical cycle – sub cooling and super heating- effects of condenser and evaporator pressure on C.O.P of the system - problems on vapour compression refrigeration system.

UNIT III	**OTHER REFRIGERATION SYSTEMS**	**9**	**0**	**0**	**9**

Working principle of vapour absorption refrigeration system – Steam jet refrigeration, Ejector refrigeration system- Thermoelectric refrigeration, Pulse tube refrigeration system, low temperature refrigeration – Cascade systems.

UNIT IV	**PSYCHROMETRY**	**9**	**0**	**0**	**9**

Properties of moist air - Gibbs and Dalton's law. Psychrometric property- dry bulb temperature, wet bulb temperature, dew point temperature, Specific humidity, relative humidity, Degree of saturation, Relative humidity, Enthalpy. Psychometric chart; Psychometric processes, mixing of air streams.

UNIT V	**AIR CONDITIONING SYSTEMS AND LOAD ESTIMATION**	**9**	**0**	**0**	**9**

Air conditioning loads: Outside and inside design conditions; Heat transfer through structure, Solar radiation, Electrical appliances, Infiltration and ventilation, internal heat load, apparatus selection, fresh air load, human comfort and IAQ principles. Air distribution system-Filters. Air Conditioning Systems with Controls-Temperature, Pressure and Humidity sensors- Actuators & Safety controls.

Total(45L) = 45 Periods

TEXT BOOKS:

1.	Arora, C.P., "Refrigeration and Air Conditioning", 3rd edition, McGraw Hill, New Delhi, 2017.
2.	Arora S. C. and Domkundwar, "Refrigeration and Air-Conditioning", Dhanpat Rai and Co. (P) Ltd., 2010.

REFERENCES:

1	Roy J. Dossat, "Principles of Refrigeration", 4th Edition, Pearson Education Asia, 2009.
2	Stoecker, W.F. and Jones J. W., "Refrigeration and Air Conditioning", McGraw Hill, New Delhi, 1986.
3	Ballaney P. L, Refrigeration and Air-Conditioning, Khanna Publishers, New Delhi, 2014.
4	Manohar Prasad, Refrigeration and Air-Conditioning, New Age International, 2011.
5	ASHRAE Hand book, Fundamentals, 2010.

E-REFERENCES:

1.	NPTEL courses: http://nptel.iitm.ac.in/courses.php - web and video sources on Refrigeration and Air Conditioning.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the basic concepts and processes in refrigeration	Understand
CO2	Understand the components of vapour compression refrigerating system and its effects	Understand
CO3	Understand the other refrigeration systems and their applications	Understand
CO4	Solve the problems using psychrometric charts and psychrometric properties	Analyze
CO5	Calculate the cooling load for designing air conditioning systems	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	0	0	0	0	1	2	0	0	0	0	0	2	2	1
CO2	2	3	0	2	0	1	1	0	0	0	0	0	2	2	1
CO3	2	3	0	1	0	0	0	0	0	0	1	0	2	2	1
CO4	2	1	0	0	0	0	0	0	0	1	0	0	2	2	1
CO5	2	2	1	2	1	2	1	0	0	0	1	0	2	2	1
Avg	**2.2**	**1.8**	**0.2**	**1.0**	**0.2**	**0.8**	**0.8**	**0.0.**	**0.0**	**0.2**	**0.4**	**0.0**	**2.0**	**2.0**	**1.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE37	SOLAR ENERGY TECHNOLOGY				SEMESTER VI
PREREQUISITES		CATEGORY	PE	Credit	3
		Hours/Week	L	T	P	C
			3	0	0	3

COURSE OBJECTIVES:

1.	To explain various solar collectors in solar power plants.
2.	To describe the variety of solar systems used in solar water heating systems.
3.	To describe the solar radiation and its measurements.
4.	To analyze solar space conditioning systems.
5.	To design PV systems for power plants.

UNIT I	INTRODUCTION	9	0	0	9

Power plant scenario-classification, basic principles and features-comparison and selection criteria. Solar collectors- flat plate – evacuated tube – concentrated – pool and air collectors- function –suitability.

UNIT II	SOLAR WATER HEATING SYSTEMS	9	0	0	9

Integral collector storage system - thermosyphon system - open loop, drain down, drain back, antifreeze systems - refrigerant solar water heaters - solar heated pools - solar heated hot tubes and solar position algorithm.

UNIT III	SOLAR RADIATION	9	0	0	9

Source of radiation – solar constant– solar charts – measurement of diffuse, global and direct solar radiation: pyrheliometer, pyranometer, pyrgeometer, net pyradiometer-sunshine recorder.

UNIT IV	SOLAR SPACE CONDITIONINGSYSTEM	9	0	0	9

Liquid type solar heating system with / without storage - heat storage configurations - heat delivery methods - air-type solar heating systems - solar refrigeration and air conditioning.

UNIT V	SOLAR PV CELL	9	0	0	9

Photo-voltaic cell – characteristics-cell arrays-power electric circuits for output of solar panels-choppers-inverters-batteries-charge regulators, construction concepts.

Total (45L) = 45Periods

TEXT BOOKS:

1.	Duffie, J.A., and Beckman, W.A. Solar Energy Thermal Process, John Wiley and Sons, NewYork,2013.
2.	Kosuke Kurokawa (Ed.), Energy from the Desert – Feasibility of very large-scale photovoltaic power generation systems, JamesandJames2003.

REFERENCES:

1	Sukhatme S.P.,Solar Energy,TataMcGrawHills P Co., 3rdEdition, 2008.
2	C.J.Winter, R.L.Sizmann, L.L.VantHull, SolarPowerPlants, Springer Verlag Berlinand HeidelbergGmbH &Co., 2001.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		Bloom Taxonomy Mapped
CO1	Explain various solar collectors in solar power plants.	Understand
CO2	Describe the variety of solar systems used in solar water heating systems.	Understand
CO3	Describe the solar radiation and its measurements.	Understand
CO4	Analyze solar space conditioning systems.	Apply
CO5	Design PV systems for power plants	Apply

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	0	0	0	2	1	0	0	0	0	0	2	1	2
CO2	3	2	1	2	0	1	0	0	0	0	1	0	2	2	2
CO3	3	2	0	2	3	2	0	0	0	0	1	0	2	2	1
CO4	3	3	1	2	2	2	0	0	0	0	1	0	3	2	2
CO5	3	2	3	2	3	2	0	0	0	0	1	0	2	3	2
Avg	**3**	**2**	**1**	**1.6**	**1.6**	**1.8**	**0.2**	**0**	**0**	**0**	**0.8**	**0**	**2.2**	**2**	**1.8**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

PROFESSIONAL ELECTIVES – IV

22MEPE41	ADVANCED DECISION MODELING TECHNIQUES				SEMESTER VI	
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
1.Students are expected to have a background knowledge in probability.		**Hours/Week**	**L**	**T**	**P**	**TH**
2.Students are expected to have a basic understanding in the concepts of Calculus, and Algebra.			**3**	**0**	**0**	**3**
3.Basic knowledge in python programming.						

COURSE OBJECTIVES:

1.	To equip student, explain the fundamentals of machine learning, need for deep learning and ensemble learning algorithms, linear algebra concepts and application areas of deep learning models.
2.	To make the student explain the concepts of Convolutional Neural Network (CNN) architecture, training and implementation of different CNN models using Python.
3.	To make the student explain the concepts of Recurrent Neural Network (RNN) architecture, training and implementation of different CNN models using Python.
4.	To familiarize the need, methods and concepts for ensemble learning and apply with Python implementation of ensemble learning approaches.
5.	To identify alternate deep learning models for the listed use cases, identify a suitable algorithm by apprehend the differences between standard deep learning models.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Deep learning – rationale- concept of Eigenvalues and Eigenvectors- fundamentals of machine learning- history-neural network fundamentals – real world examples- implementation aspects of deep learning- training					
UNIT II	**CONVOLUTIONAL NEURAL NETWORKS**	**9**	**0**	**0**	**9**
Understand the process of convolution, convolutional layer, pooling layer, fully connected convolution layer concerning Convolutional Neural Network (CNN) - architecture and training of different CNN models, namely AlexNet, VGGNet, ResNet, and GoogLeNet - Implement the CNN models using Python.					
UNIT III	**RECURRENT NEURAL NETWORKS**	**9**	**0**	**0**	**9**
Basics of RNNs - Evolution of LSTM from RNN -Working of LSTM concerning gates - variants of LSTM such as peephole connections, coupled gates, Gated Recurrent Network -Implement RNN using Python.					
UNIT IV	**ENSEMBLE LEARNING**	**9**	**0**	**0**	**9**
Need for ensemble learning -methods involved in ensemble learning - bagging and boosting concepts- AdaBoost and XGBoost algorithms to a real-world problem - Python implementation of ensemble learning approaches.					
UNIT V	**CASE STUDIES**	**9**	**0**	**0**	**9**
Alternate deep learning models for the listed use cases like plant species identification, predict customer loss, Sequence classification/prediction, loan eligibility prediction and resume parsing - identify a suitable algorithm -differences between standard deep learning models and advanced deep learning models – selection of suitable deep learning or ensemble learning model for the application under consideration.					
Total(45L) = 45 Periods					

TEXT BOOKS:

1.	S. Sumathi, Suresh Rajappa, L. Ashok Kumar, And Surekha Paneerselvam, “Advanced Decision Sciences Based on Deep Learning and Ensemble Learning algorithms”, Nova Science Publishers, Inc, 2021.
2.	Singhal, Vanika, Shikha Singh, and Angshul Majumdar, “How to train your deep neural network with dictionary learning”. arXiv preprint arXiv:1612.07454 (2016).

REFERENCES:

1	Srivastava, Pranjal. Essentials of deep learning: introduction to long short-term memory. last updated on Dec 10

	(2017).
2	Sumathi, Sai, and Surekha Paneerselvam. Computational intelligence paradigms: theory & applications using MATLAB. CRC Press, 2010.
3	Goodfellow and Bengio, "Deep Learning", MIT press.
4	Christopher Bishop, "Pattern Recognition and Machine Learning", Springer Science+Business Media, LLC, 2006.
5	Francois Cholle, "Deep Learning with Python" Manning publications.
E-REFERENCES:	
1	Study-Material-BTech-IT-VIII-sem-Subject-Deep-Learning-deep_learning_Btech_IT_VIII-sem.pdf (ccsuniversity.ac.in)
2	ResNet, AlexNet, VGGNet, Inception: Understanding various architectures of Convolutional Networks – CV-Tricks.com.
3	Convolutional Neural Networks and their components for computer vision – MachineCurve.
4	Dive into Deep Learning — Dive into Deep Learning 0.16.4 documentation (d2l.ai).

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Learn the fundamentals of machine learning, need for deep learning and ensemble learning algorithms, linear algebra concepts and application areas of deep learning models.	Understand
CO2	Understand the concepts of Convolutional Neural Network (CNN) architecture, training and implementation of different CNN models using Python.	Understand
CO3	Studythe concepts of Recurrent Neural Network (RNN) architecture, training and implementation of different CNN models using Python.	Remember
CO4	Capture the need, methods and concepts for ensemble learning and apply with Python implementation of ensemble learning approaches.	Analyze
CO5	Identify alternate deep learning models for the listed use cases, identify a suitable algorithm by apprehend the differences between standard deep learning models.	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	3	2	0	0	0	0	1	1	0	1	1	0
CO2	3	2	0	3	2	0	0	0	0	1	1	0	1	1	0
CO3	3	2	0	3	2	0	0	0	0	1	1	0	1	1	0
CO4	3	2	0	3	2	0	0	0	0	1	1	0	1	1	0
CO5	3	2	2	3	1	0	0	0	0	1	1	0	1	1	0
Avg	**3.0**	**2.2**	**0.8**	**3.0**	**1.8**	**0.0**	**0.0**	**0.0**	**0.0**	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE42	AUTOMATION IN MANUFACTURING				SEMESTER VI
PREREQUISITES		CATEGORY	PE	Credit	3
1.Knowledge in manufacturing technology		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES:

1.	To get the knowledge of various elements of manufacturing automation
2.	To study various techniques of automatic material handling in a manufacturing organization
3.	To identify suitable automation hardware for the given application
4.	To incorporate application of electronics and computer engineering in mechanical engineering for enhancing manufacturing automation
5.	To develop CNC programs to manufacture industrial components.

UNIT I	INTRODUCTION TO AUTOMATION	9	0	0	9

Automation overview, Requirement of automation systems, Architecture of Industrial Automation system - Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations. Manufacturing Support System - Automation in Manufacturing Systems - Reasons for Automating- Automation Principles and Strategies- Automation Migration Strategy

UNIT II	DETROIT-TYPE AUTOMATION	9	0	0	9

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

UNIT III	CONTROL TECHNOLOGIES IN AUTOMATION	9	0	0	9

Industrial Control Systems, Process Industries Verses Discrete-Manufacturing Industries, Continuous Verses Discrete Control, Computer Process Control and its Forms. Computer Based Industrial Control: Introduction & Automatic Process Control, Building Blocks of Automation System: LAN, Analog & Digital I/O Modules, SCADA System and RTU. man-machine interface

UNIT IV	NUMERICAL CONTROL MACHINES	9	0	0	9

NC components, NC coordinate systems, Point to point, line and contouring systems, open and close loop control system, Steps in NC manufacturing, Role of NC/CNC technology in modern manufacturing, Features of CNC system, components and tooling of machining centre and CNC turning centre, Automatic tool changer, Feedback devices: Encoders and linear scale, Features of DNC and adaptive control systems.

UNIT V	CNC PROGRAMMING	9	0	0	9

Part programming fundamentals, Manual Part Programming, APT Programming, Geometric & motion commands, Post processor commands, Safety measures in CNC programming.

Total (45L) = 45Periods

TEXT BOOKS:

1.	M.P.Grover, Automation, Production Systems and Computer Integrated Manufacturing, Pearson Education. 2016.
2.	Computer Numerical Control (CNC) Machines Paperback – 1, P. Radhakrishnan, New Central Book Agency; 1st edition, 2013

REFERENCES:

1	Steve F Krar, "Computer Numerical Control Simplified ", Industrial Press, 2001.
2	Tien-Chien Chang, Richard A. Wysk and Hsu-Pin Wang - Computer Aided Manufacturing, Pearson 2009

3	Frank Lamb - Industrial Automation, Mc Graw Hill,2013
E-REFERENCES:	
1.	Steve F Krar, "Computer Numerical Control Simplified ", Industrial Press, 2001.
2.	Tien-Chien Chang, Richard A. Wysk and Hsu-Pin Wang - Computer Aided Manufacturing, Pearson 2009

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the effect of manufacturing automation strategies	Understand
CO2	Apply knowledge of industrial automation by transfer lines and automated assembly lines.	Apply
CO3	Understand the electronic control systems in metal machining and other manufacturing processes.	Understand
CO4	Identify different CNC components, systems and controls CNC machines	Apply
CO5	Write CNC programming to solve complex machining process	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	2	1	1	2	2	1	0	0	1	1	1	2	2
CO2	1	2	2	1	1	2	1	0	2	0	1	1	1	2	2
CO3	1	2	2	2	2	2	1	0	2	0	1	1	1	2	2
CO4	0	0	1	1	3	2	2	1	0	2	1	1	1	2	2
CO5	0	0	0	1	3	2	2	1	0	2	1	1	1	2	2
Avg	**0.6**	**1.0**	**1.4**	**1.2**	**2.0**	**2.0**	**1.6**	**0.6**	**0.8**	**0.8**	**1.0**	**1.0**	**1.0**	**2.0**	**2.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE43	CRYOGENIC ENGINEERING	SEMESTER VI

PREREQUISITES	CATEGORY	PE	Credit		3
1.Engineering Thermodynamics	Hours/Week	L	T	P	TH
2.Refrigeration and air conditioning		3	0	0	3

COURSE OBJECTIVES:

1.	To provide the knowledge of evolution of low temperature science
2.	To provide knowledge on the properties of materials at low temperature
3.	To familiarize with various gas liquefaction systems and to provide design aspects of cryogenic storage and transfer lines
4.	To learn information concerning low temperature processes and techniques
5.	To be familiar with the applications of low temperature technology

UNIT I	PROPERTIES OF CRYOGENIC FLUIDS & MATERIAL PROPERTIES AT LOW TEMPERATURE	9	0	0	9

Introduction to Cryogenics and its applications – Properties of Cryogenic Fluids – Hydrogen – Ortho-para forms, Helium – Phase diagram for He-4, He 3 and its mixture, Superfluidity in He. LOX, LN_2, Argon.

Properties of materials at Cryogenic Temperature – Mechanical Properties – Yield Strength, Ultimate Strength, Impact strength, Fatigue Strength, Ductility and Hardness -Thermal Properties – Thermal expansion, Thermal Conductivity and Specific heat - Electrical and Magnetic Properties- Superconductivity, BCS theory, HT and LT Superconducting materials, Applications of superconductivity.

UNIT II	BASICS OF GAS LIQUEFACTION AND REFRIGERATION SYSTEMS	9	0	0	9

Basics of Refrigeration-Methods of Production of low Temperatures- Critical Components of Liquefaction systems – Heat Exchangers, Compressors and Expanders (only description with figure).

Joule Thomson expansion of a real gas, Isentropic expansion, Comparison of J-T Expansion and Isentropic Expansion. Layout and Working of Liquid Helium and Nitrogen.

UNIT III	VARIOUS GAS LIQUEFACTION AND REFRIGERATION SYSTEMS AND CRYOCOOLERS	9	0	0	9

Gas Liquefaction Parameters – Calculation of Liquid Yield, Work requirement and Optimization of Yield for various cycles such as Ideal thermodynamic system, Linde Hampson Cycle, Precooled Linde Hampson system. Liquefaction system for Ne and Hydrogen - Precooled Claude System, Liquefaction systems for He – Collins and Simon systems. Cryocoolers -Basics of Cryocoolers-Ideal Stirling Cycle- Stirling Cryocooler, Philips Refrigerator, Solvey Refrigerator, G-M Cryocooler, Pulse Tube Cryocooler, Vuilleumier Refrigerator, Dilution Refrigerator and Magnetic Refrigerator.

UNIT IV	CRYOGENIC FLUID STORAGE AND TRANSFER SYSTEMS	9	0	0	9

Cryogenic Storage vessels - Dewar Vessel and Vapour Shielded Vessel, Transportation systems. Thermal insulation and their performance at cryogenic temperatures - Types of Insulation – Expanded Foam, Gas Filled Powders and Fibrous Materials, Vacuum, Evacuated Powder and Multi-Layer Insulation.

UNIT V	CRYOGENIC MEASUREMENT SYSTEMS	9	0	0	9

Cryogenic Instrumentation - Pressure, flow-level and temperature measurements. Cryopumping applications.

Total(45L) = 45 Periods

TEXT BOOKS:

1.	J. H. Boll Jr, Cryogenic Engineering
2.	R. B. Scott, Cryogenic Engineering, Van Nostrand Co., 1959

REFERENCES:

1	Klaus D. Timmerhaus and Thomas M.Flynn, “Cryogenic Process Engineering”, Plenum Press, New York, 1989.
2	Randal F.Barron, “Cryogenic systems”, McGraw Hill, 1986.

E-REFERENCES:	
1.	nptel.ac.in / courses / downloads

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		Bloom Taxonomy Mapped
CO1	Understand the properties of both cryogenic fluids and material properties for better design process in cryogenic applications.	Understand
CO2	Apply the knowledge of low temperature production methods	Understand
CO3	Analyze the performance parameters of various gas liquefaction systems	Analyze
CO4	Understand the various cryogenic fluid storage for transportation systems and transfer lines	Understand
CO5	Understand different instrumentation in cryogenics	Understand

COURSE ARTICULATION MATRIX

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3	1	0	0	0	0	0	0	0	0	2	1	0
CO2	2	2	2	1	0	0	0	0	0	0	0	0	3	1	0
CO3	2	2	3	1	0	0	0	0	0	0	0	0	3	1	0
CO4	2	2	2	1	0	0	0	0	0	0	0	0	1	1	0
CO5	2	1	1	1	0	0	0	0	0	0	0	0	1	1	0
Avg	**2.0**	**1.8**	**2.2**	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0.**	**0.0**	**0.0**	**0.0**	**2.0**	**1.0**	**0.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE44	FRACTURE MECHANICS AND FAILURE ANALYSIS	SEMESTER VI

PREREQUISITES	CATEGORY	PE	Credit		3
1. Student should study Strength of material.	Hours/Week	L	T	P	TH
2. Student should study Materials Engineering.		3	0	0	3

COURSE OBJECTIVES:

1.	Identify and explain the types of fractures of engineered materials and their characteristic features.
2.	Understand the differences in the classification of fracture mechanics and how their corresponding parameters can be utilized to determine conditions under which engineering materials will be liable to fail catastrophically in service.
3.	Understand and explain the mechanisms of fracture; and learn how to carry out engineering failure analysis.
4.	To Learn the microstructural aspects that lead to fracture.
5.	Apply advanced mathematical theories to characterize and predict fracture.

UNIT I	BASIC CONCEPTS IN FRACTURE MECHANICS	9	0	0	9

The geometry of stress and strain, elastic deformation, plastic and elasto-plastic deformation, Brittle fracture: Griffith's theory, Ductile fracture, Probabilistic aspects of fracture mechanics – Microstructure.

UNIT II	MECHANICS OF FRACTURE- STATIC LOADING	9	0	0	9

Elastic fields – Analytical solutions yielding near a crack front – Irwin's approximation – plastic zone size – Dugdale model – J integral and its relation to crack opening displacement. Strain energy release and stress intensity factor. Evaluation of fracture Toughness of different materials: size effect & control

UNIT III	FAILURE ANALYSIS OF FATIGUE FRACTURE	9	0	0	9

Fundamental sources of failures- Deficiency in design, Empirical Relation describing crack growth by fatigue – Life calculations for a given load amplitude – effects of changing the load spectrum – Effects of Environment. Micro structural analysis of fatigue failures, some case studies in analysis of fatigue failures.

UNIT IV	FAILURE ANALYSIS OF CREEP RUPTURE	9	0	0	9

Fracture at elevated temperature: Time dependent mechanical behavior, stress rupture, Micro Structural changes during creep, Mechanism of creep deformation and Creep deformation maps, Prediction of time to rupture, Creep-fatigue interaction. Some case studies in analysis of creep failures.

UNIT V	FAILURE ANALYSIS OF CORROSION AND WEAR	9	0	0	9

Types of wear, analyzing wear failure, corrosion failures- factors influencing corrosion failures, an overview of various types of corrosion, stress corrosion cracking, sources, characteristic of stress corrosion cracking, procedure for analyzing stress corrosion cracking, various types hydrogen damage failures.

Total (45L) = 45Periods

TEXT BOOKS:

1.	Hertz berg R W, "Deformation and fracture mechanics of Engineering Materials" Second Edition John Wiley's sons inc, New York 1983.
2.	Knott. J.F, "Fundamentals of Fracture Mechanics" Butterworth London, 1973.

REFERENCES:

1	Evalds H L and RJH Warnhil," Fracture Mechanics", Edward Arnold Ltd, Baltimore,1984.
2	Campbell J E, Underwood J H, and Gerberich W., "Applications of Fracture Mechanics for the selection of Materials ", American Society for Metals, Metals Park Ohio, 1982.
3	Fracture Mechanics Metals Handbook, ninth edition, vol. 8 437-491, American Society of Metals Metal Park Ohio, 1985.
4	Kare Hellan, "Introduction of Fracture Mechanics", McGraw-Hill Book Company, 1985.

5	Prashant Kumar, “Elements of Fracture Mechanics”, Wheeler Publishing, 1999.
E-REFERENCES:	
1	https://www.fracturemechanics.org/
2	https://archive.nptel.ac.in/courses/112/107/112107241/
3	http://vucoe.drbriansullivan.com/wp-content/uploads/Fundamentals-of-Fracture-Mechanics.pdf

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Familiarize the structure design to prevent failure from the internal defect.	Create
CO2	Illustrate the design structure to prevent fatigue and creep.	Create
CO3	Solve the problems related to deformation and related theories.	Evaluate
CO4	Formulate the empirical relations for fatigue fracture.	Apply
CO5	Analyse the failures in corrosion and wear.	Analyse

COURSE ARTICULATION MATRIX

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

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE45	FUNDAMENTALS OF TRIBOLOGY	SEMESTER VI

PREREQUISITES	CATEGORY	PE	Credit		
1.Engineering Mechanics	Hours/Week	L	T	P	TH
		3	0	0	3

COURSE OBJECTIVES:

1.	To provide broad based understanding of the interdisciplinary subject 'tribology' and its technological significance.
2.	To learn about consequences of wear, wear mechanisms, wear theories and analysis of wear problems.
3.	To study about properties of lubricants, testing methods and types of lubricants.
4.	To acquire the knowledge about the stress, Co-efficient of friction and viscous flow in journal bearings.
5.	To learn about the nature of engineering surfaces, their topography and bearings material.

UNIT I	SURFACES AND FRICTION	9	0	0	9

Topography of engineering surfaces- contact between surfaces – sources of sliding Friction– Adhesion-Ploughing-Energy dissipation mechanisms. Friction Characteristics of metals – Friction of non-metals. Friction of lamellar solids – friction of Ceramic materials and polymers – Rolling Friction – Source of Rolling Friction – Stick slip motion – Measurement of Friction.

UNIT II	WEAR	9	0	0	9

Types of wear – Simple theory of Sliding Wear Mechanism of sliding wear of metals – Abrasive wear – Materials for Adhesive and Abrasive wear situations – Corrosive wear – Surface Fatigue wear situations – Brittle Fracture – wear – Wear of Ceramics and Polymers – Wear Measurements.

UNIT III	LUBRICANTS AND LUBRICATION TYPES	9	0	0	9

Types and properties of Lubricants – Testing methods – Hydrodynamic Lubrication – Elasto- hydrodynamic lubrication-Boundary Lubrication – Solid Lubrication- Hydrostatic Lubrication.

UNIT IV	FILM LUBRICATION THEORY	9	0	0	9

Fluid film in simple shear – Viscous flow between very close parallel plates – Shear stress variation Reynolds Equation for film Lubrication – High speed unloaded journal bearings – Loaded journal bearings – Reaction torque on the bearings – Virtual Co-efficient of friction – The Sommer field diagram.

UNIT V	SURFACE ENGINEERING AND MATERIALS FOR BEARINGS	9	0	0	9

Surface modifications – Transformation Hardening, surface fusion – Thermo chemical processes – Surface coatings – Plating and anodizing – Fusion Processes – Vapour Phase processes – Materials for rolling Element bearings – Materials for fluid film bearings – Materials for marginally lubricated and dry bearings.

Total(45L): 45 Periods

TEXT BOOKS:

1.	A. Harnoy. "Bearing Design in Machinery "Marcel Dekker Inc, New York, 2003.
2.	B.C. Majumdar ; A.H.Wheeler "Introduction to Tribology of Bearings"

REFERENCES:

1	M. M. Khonsari & E. R. Booser, "Applied Tribology", John Willey &Sons, New York, 2001
2	E. P. Bowden and Tabor.D., "Friction and Lubrication ", Heinemann Educational Books Ltd., 1974.
3	A. Cameron, "Basic Lubrication theory", Longman, U.K.., 1981.
4	M. J. Neale (Editor), "Tribology Handbook", Newnes. Butterworth-Heinemann, U.K., 1995.

E-REFERENCES:

1.	NPTEL Videos/Tutorials

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Familiarize the surface phenomena related to relative motion, the nature of friction, and mechanisms of wear.	Remember
CO2	Analyze the various wear mechanism and fatigue wear of the engineering components	Analyze
CO3	Familiarize the lubricants testing methods and types of lubrication	Remember
CO4	Analyze the stress, co-efficient of friction and viscous flow in journal bearings	Analyze
CO5	Analyze the surface engineering and materials for bearings	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	2	3	3	1	1	2	0	0	0	0	0	1	2	1
CO2	0	1	2	2	1	1	1	0	0	0	0	0	1	1	1
CO3	1	2	2	2	1	1	0	0	0	0	0	0	2	1	1
CO4	0	1	2	2	1	0	0	0	0	0	0	0	2	1	1
CO5	0	2	2	2	0	0	0	0	0	0	0	0	1	2	1
Avg	**0.4**	**1.6**	**2.2**	**2.2**	**0.8**	**0.6**	**0.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.4**	**1.4**	**1.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE46	METAL FORMING PROCESSES				SEMESTER VI	
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
1.Manufacturing processes			**L**	**T**	**P**	**TH**
2.Strength of materials		**PE**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To familiarize the students about principle, procedure and applications of Bulk Metal Forming and Sheet Metal Forming
2.	To Illustrate capabilities and applications of metal forming processes.
3.	To analyze effect of parameters influencing metal forming processes.
4.	Outline tooling and equipment required for important metal forming processes.
5.	Examine effects of friction & lubrication and causes of common defects in metal forming.

UNIT I	**FUNDAMENTALS OF METAL FORMING**	**9**	**0**	**0**	**9**

Classification of forming processes, mechanisms of metal forming: slab method, Upper and lower bound analysis, Deformation energy method and finite element method temperature of metal working, hot working, cold working, friction and lubricants.

UNIT II	**ROLLING OF METALS**	**9**	**0**	**0**	**9**

Rolling processes, forces and geometrical relationship in rolling, simplified analysis, rolling load, rolling variables, theories of cold and hot rolling, problems and defects in rolling, torque and power calculations, Problems.

UNIT III	**FORGING**	**9**	**0**	**0**	**9**

Classification of forging processes, forging of plate, forging of circular discs, open die and closed-die forging, forging defects, and powder metallurgy forging. problems on flow stress, true strain and forging load. Press tool design: Design of various press tools and dies like piercing dies, blanking dies, compound dies and progressive blanking dies, design of bending, forming and drawing dies.

UNIT IV	**EXTRUSION**	**9**	**0**	**0**	**9**

Classification, Hot Extrusion, Analysis of Extrusion process, defects in extrusion, extrusion of tubes, production of seamless pipes. Problems on extrusion load. Drawing: Drawing of tubes, rods, and wires: Wire drawing dies, tube drawing process, analysis of wire, deep drawing and tube drawing. Problems on draw force

UNIT V	**SHEET METAL FORMING**	**9**	**0**	**0**	**9**

Forming methods, Bending, stretch forming, spinning and Advanced techniques of Sheet Metal Forming, Forming limit criteria, defect in formed parts. Advanced Metal forming processes: HERF, Electromagnetic forming, residual stresses, in-process heat treatment, and computer applications in metal forming. problems on Blanking force, Blank diagram in Cup Diagram, Maximum considering shear.

Total(45L) = 45 Periods

TEXT BOOKS:

1.	Surender Kumar, Technology of Metal Forming Processes, Prentice - Hall, Inc., 2008
2.	Nagpal G.R. Metal forming processes, Khanna publishers, New Delhi, 2004

REFERENCES:

1	Serope Kalpakjian, Steven R Schmid, Manufacturing Process for Engineering Materials, 4th Edition, Pearson Education, 2003.
2	Rao, P.N. Manufacturing Technology, TMH Ltd., 2003
3	Edward M.Mielink, Metal working Science Engineering", McGraw Hill, Inc, 2000.
4	Metal Handbook Vol.14, Forming and Forging, Metal Park, Ohio, USA, 1990

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand fundamentals of metal forming and stress curves.	Understand
CO2	Know various process parameters and applied loads in sheet metal working.	Evaluate
CO3	Brief various forging techniques and defects in forging.	Understand
CO4	State the principles of rolling and stresses developed under rolling loads.	Understand
CO5	Analyze Extrusion and drawing processes and associated stresses developed.	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	2
CO2	1	2	0	2	0	0	0	0	0	1	0	0	1	1	2
CO3	0	1	2	0	0	2	0	0	0	1	0	0	1	1	2
CO4	1	1	0	1	0	0	0	0	0	1	0	0	1	1	2
CO5	1	3	0	1	1	0	2	0	0	0	0	1	1	1	2
Avg	**0.6**	**1.6**	**0.4**	**0.8**	**0.2**	**0.4**	**0.4**	**0.0**	**0.2**	**0.8**	**0.0**	**0.2**	**1.0**	**0.8**	**2.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE47	MICRO AND NANO MACHINING				SEMESTER VI			
PREREQUISITES		CATEGORY	PE		Credit		3	
1.Manufacturing process		Hours/Week	L		T	P	TH	
			3		0	0	3	

COURSE OBJECTIVES:

1.	To give awareness of different techniques used in micro and nano machining/manufacturing.
2.	To give in-depth idea of the conventional techniques used in micro machining/manufacturing.
3.	To introduce Non-conventional micro-nano manufacturing and finishing approaches.
4.	Tointroduce Micro and Nanofabrication Techniques and other processing routes in Micro and Nano machining/manufacturing.

UNIT I	INTRODUCTION	9	0	0	9

Introduction, Basic elements of molecular dynamics modelling, Design and requirements for state-of-the-art MD cutting process simulations, Capabilities of MD for nanoscale material removal process analysis, Advances and recent developments in material removal process simulation, Summary. The mechanism of ductile mode cutting of brittle materials, the chip formation in cutting of brittle materials, Machined surfaces in relation to chip formation mode. Diamond Tools in Micromachining - Diamond technology, Diamond micromachining.

UNIT II	CONVENTIONAL PROCESSES: MICRO-TURNING, MICRO-DRILLING AND MICRO-MILLING	9	0	0	9

Introduction, Micro-turning, Micro-drilling, Micro-milling, Product quality in micromachining Micro-grinding and Ultra-precision Processes Introduction, Micro and nanogrinding, Nanogrinding tools

UNIT III	NON-CONVENTIONAL PROCESSES: LASER MICROMACHINING	9	0	0	9

Introduction, Fundamentals of lasers, Laser microfabrication, Laser nanofabrication. Evaluation of Subsurface Damage in Nano and Micromachining Destructive evaluation technologies, Non-destructive evaluation technologies

UNIT IV	MICRO AND NANO FINISHING PROCESSES, MICRO JOINING	9	0	0	9

Need for Nano finishing, Magnetic abrasive Finishing, Magnetorheological Finish, Elastic Emission Finishing, Magnetic Float Polishing, Ion Beam finishing. Micro Joining - Challenges, Micro Resistance welding, Ultrasonic welding, Micro TIG, Applications.

UNIT V	APPLICATIONS OF NANO AND MICROMACHINING IN INDUSTRY	9	0	0	9

Typical machining methods, Applications in optical manufacturing, Semiconductor and electronics related applications.

Total(45L) = 45 Periods

TEXT BOOKS:

1.	J. Paulo Davim, Mark J. JacksonNano and Micromachining,John Wiley & Sons, 2013 2 Mark.
2.	J. Jackson, Micro and Nano-manufacturing, Springer, 2006.

REFERENCES:

1	Mark. J. Jackson, Micro-fabrication and Nano-manufacturing - Pulsed water drop micromachining CRC Press 2006.
2	NitaigourPremchandMahalik, Micro-manufacturing and Nanotechnology, 2006
3	V.K.Jain, Micro-manufacturing Processes, CRC Press, 2012
4	Yi Qin, Micro-manufacturing Engineering and Technology, William Andrew, 2015
5	Kapil Gupta, Micro and Precision Manufacturing, Springer, 2017

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Identify different areas of micro and nano machining	Evaluate
CO2	Find the applications of all the areas in industries.	Evaluate

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	1	0	1	0	0	0	0	0	1	1	0	2	0	1
CO2	0	1	1	1	0	0	0	0	0	1	1	1	1	2	3
Avg	**1**	**1**	**0.5**	**1**	**0**		**0**	**0**	**0**	**1**	**1**	**0.5**	**1.5**	**1**	**1.5**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

PROFESSIONAL ELECTIVES – V

22MEPE51	ANALYSIS AND SYNTHESIS OF MECHANISMS		SEMESTER VIII			
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
1.Kinematics of Machinery			**L**	**T**	**P**	**TH**
2. Dynamics of Machinery.		**PE**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To Study of kinematics of various mechanisms and kinematic synthesis of linkages.
2.	To Study of various graphical constructions of acceleration analysis.
3.	To Study Static and dynamic force analysis of linkages.
4.	To Study Kinematic analysis and kinematic synthesis of spatial mechanisms
5.	To Study about the spatial mechanisms and robotics

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Review of Fundamentals of Kinematics - Mobility analysis - Classifications of mechanisms - Kinematic inversion - Grashoff's law - Mechanical Advantage - Transmission Angle - Position Analysis - Vector Loop Equations for four bar, Slider crank, six bar linkages - Analytical and Graphical methods for velocity and acceleration analysis - Four bar linkage jerk analysis. Plane complex mechanism

UNIT II	**KINEMATIC SYNTHESIS OF LINKAGES**	**9**	**0**	**0**	**9**

Type, Number and Dimensional Synthesis - Function Generation - Path Generation and Motion Generation. - Graphical Methods: Two Position, Three Position and Four Position synthesis of four bar Mechanism, Slider crank Mechanism, Precision positions Over lay Method. Analytical Methods: Blotch's Synthesis - Freudestien's Method - Coupler curve Synthesis - Cognate linkages - The Roberts - Chebyshev theorem.

UNIT III	**PATH CURVATURE THEORY**	**9**	**0**	**0**	**9**

Fixed and moving centrodes. - Hartmann's Construction - Inflection Points, The Inflection Circle - The Euler - Savary Equation - The collination axis and Bobiller's theorem - Conjugate points and inverse motion - The Cubic Stationary curvature - Ball's Point.

UNIT IV	**DYNAMICS OF MECHANISMS**	**9**	**0**	**0**	**9**

Static force analysis - Inertia force analysis - Combined static and inertia force Analysis - Shaking force - Introduction to force and moment balancing of linkages

UNIT V	**SPATIAL MECHANISMS AND ROBOTICS**	**9**	**0**	**0**	**9**

Introduction: Mobility of mechanisms - Description of spatial motions - Kinematic analysis of spatial mechanism - Kinematic synthesis of spatial mechanisms: position, velocity and acceleration analysis. Eulerian Angles - Introduction to Robotic Manipulators - Topological arrangements of robotic arms - Kinematic analysis of spatial mechanism - Denavit - Hartenberg Parameters, Forward and inverse kinematics of robotic manipulators

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Amitabha Ghosh and Asok Kumar Mallik, “Theory of Mechanism and Machines”, EWLP, Delhi,1999.
2.	Kenneth J, Waldron, Gary L. Kinzel, “Kinematics, Dynamics and Design of Machinery”, John Wiley-sons, 2016.

REFERENCES:

1	Uicker, J.J., Pennock, G. R. and Shigley, J.E., “Theory of Machines and Mechanisms”, Oxford University Press, 2017.
2	Sandor G.N., and Erdman A.G., “Advanced Mechanism Design Analysis and Synthesis”, Prentice Hall, 1984.

3	Robert L.Norton., “Design of Machinery”,Tata McGraw Hill, 2012
4	Sandor G.N., Erdman, A. G, “Advanced mechanism design”, Prentice Hall Inc, 1984
5	Suh C.H., Radcliff C.W, “Kinematics and mechanisms design”, John Wiley &Sons., 1978.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Analysis the kinematics of mechanisms	Evaluate
CO2	Synthesis the kinematics of linkages	Evaluate
CO3	Acquire knowledge about the theory of path curvature	Understand
CO4	Learned the dynamics of mechanisms	Evaluate
CO5	Design the robotics arms and manipulators	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	2	2	0	0	1	1	0	0	1	0	2	2	1
CO2	2	2	2	2	0	0	1	1	0	0	1	0	2	2	1
CO3	1	1	1	1	0	0	0	0	0	0	0	0	1	1	0
CO4	2	2	2	2	0	0	1	1	0	0	1	0	2	2	1
CO5	2	2	2	2	0	0	1	1	0	0	1	0	2	2	1
Avg	**1.8**	**1.8**	**1.8**	**1.8**	**0**	**0**	**0.8**	**0.8**	**0**	**0**	**0.8**	**0**	**1.8**	**1.8**	**0.8**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE52	DESIGN OF JIGS, FIXTURES AND PRESS TOOLS	SEMESTER VIII

PREREQUISITES	CATEGORY	PE	Credit	3

	Hours/Week	L	T	P	TH
		3	0	0	3

COURSE OBJECTIVES:

1.	To understand the functions and design principles of Jigs and fixtures
2.	To know the importance of work piece location and its design
3.	To know the importance of work piece clamping and its design
4.	To know about the importance of jigs bushings and drill jig
5.	To know about the design of fixtures

UNIT I	BASICS OF JIGS AND FIXTURES	9	0	0	9

Introduction- Jigs and Fixtures- Difference between Jigs and Fixtures- Advantages of jigs and Fixtures- Economy and cost- Elements of Jigs and Fixtures- Fool Proofing. Materials used in Jigs and Fixtures- Degrees of Freedom- 12 degrees of freedom. Essential features of Jigs and Fixtures- General Design Principles- Design steps- Common defects in Jigs design.

UNIT II	PRINCIPLES OF LOCATING AND CLAMPING DEVICES	9	0	0	9

Principles of location- types of locators- pins and studs- V block- cup and cone location points- adjustable locating points- special adjustable stops- location from finished holes in the work. Diamond pin locator- Cam operated 'V' locator – Quick action 'V' locator - Six-point location of a three-legged object. Principles of clamping- types of clamping- lever clamp- hinged clamp- two-way clamp - swinging clamp- wedge clamp- eccentric clamping arrangement- quick action clamp. Cam operated clamp- quarter turn screw. Toggle clamp- Pneumatic and hydraulic clamps- Washers- 'C' washer- Spherical and flat washers. Tolerance, Tolerance Analysis and problems.

UNIT III	DESIGN OF JIGS	9	0	0	9

Jigs, Types of Jigs – Post, turnover, Channel, Latch, Box, Pot, Angular post jigs –Hydraulic and Pneumatic Jigs - Indexing Jigs –Design and Development of Jigs and Fixtures for the given component.

UNIT IV	JIG BUSHINGS AND DRILL JIGS	9	0	0	9

Jig Bushing: Materials for jig bushing - press fit bushing- Fixed renewable bushing- slip renewable bushing- liner bushing- screw bushing- miscellaneous type of drill bushings- bushing specifications. Drill Jigs: Open drill jig plate drill jig- plate drill jig- template drill jig- channel drill jig- turn over drill jig- angle plate drill jig- closed box drill jig- leaf drill jig- post jig- indexing drill jig. Universal drill jig - design of template and leaf jig.

UNIT V	PRINCIPLE OF FIXTURE DESIGN	9	0	0	9

Introduction - principles of fixture design- element of fixtures. Design consideration of locators and clamps for fixtures- types of fixtures. Design of turning fixtures- Boring fixtures- Planning Fixtures - milling fixtures, Method of locating milling fixtures with respect to cutter position - Assembly and Inspection Fixtures – Special Purpose Fixtures. Grinding fixtures- surface grinding and cylindrical grinding fixtures. Broaching fixtures- internal and external broaching fixtures- welding fixtures. Modular Fixturing systems - Design and Development of Fixtures for given components.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Design of Jigs, Fixtures and Press tools, C.Elanchezhian,T.Sunderselvan, B.Vijayaramnath, Eswar Press, 2005.
2.	Nagpal, G R, Tool Engineering & Design, 2000, Khanna Publishers.

REFERENCES:

1	Joshi, P H, Jigs & Fixtures, 2010, 3rd Edition, McGraw Hill.
2	Jig and fixture design- 5th edition by Hoffman
3	Venkataraman, K, Design of Jigs, Fixtures & Press Tools, 2015, Wiley & Sons

4	Mehta, N K, Metal Cutting and Design of Cutting Tools, Jigs & Fixtures, 2015, McGraw
5	Design Data, PSG Tech, Coimbatore, 2003.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the basics of jigs and fixtures and its designing principles	Understand
CO2	Identify and design the various locating and clamping devices	Evaluate
CO3	Design the jigs for various components.	Create
CO4	Identify and design the jig bushes and drill jigs.	Evaluate
CO5	Design the fixtures for various components.	Create

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	2	2	1	1	0	2	1	1	0	1	0	2	2	1
CO2	1	2	2	1	1	0	1	1	1	0	1	0	2	2	1
CO3	1	2	2	2	2	0	1	1	1	0	1	0	2	2	1
CO4	1	2	1	1	3	0	2	1	1	0	1	0	2	2	1
CO5	1	2	1	1	3	0	2	1	1	0	1	0	2	2	1
Avg	**1**	**2**	**1.4**	**1.2**	**2.0**	**0**	**1.6**	**1**	**1**	**0**	**1**	**0**	**2**	**2**	**1**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE53	HEAT TRANSFER PROBLEMS IN ELECTRONICS AND INSTRUMENTATION	SEMESTER VIII

PREREQUISITES	CATEGORY	PE	Credit		3
1.Fundamental knowledge in various modes of heat transfer	Hours/Week	L	T	P	TH
2.Basic concepts of electronics and instrumentation		3	0	0	3

COURSE OBJECTIVES: The main learning objective of this course is to prepare the students for:

1.	Understanding the basic principles of heat transfer in electronic systems
2.	Learning to solve conduction heat transfer problems in electronic equipment
3.	Studying about the convection heat transfer phenomena in electronic applications
4.	Acquiring the knowledge in the radiation heat transfer in electronic instruments
5.	Understanding the principles of thermal design of electronic equipment

UNIT I	INTRODUCTION TO ELECTRONICS SYSTEMS AND HEAT TRANSFER	9	0	0	9

Basics of Electronic and instrumentations, basics of thermodynamics and heat transfer, Components of Electronic Systems, Thermal management in electronic devices - Packaging Trends. Electronic packaging and interconnection technology.

UNIT II	CONDUCTION HEAT TRANSFER IN ELECTRONIC EQUIPMENT	9	0	0	9

Thermal Conductivity, Thermal Resistances, Conductivity in Solids, Conductivity in Fluids, Conduction—Steady State, Conduction in Simple Geometries, Conduction through a Plane Wall, Conduction through Cylinders and Spheres. Conduction—Transient, Lumped Capacitance Method, Conduction in Extended Surfaces. Fin Efficiency, Fin Optimization, Fin Surface Efficiency, Thermal Contact Resistance in Electronic Equipment, Discrete Heat Sources and Thermal Spreading.

UNIT III	CONVECTION HEAT TRANSFER IN ELECTRONIC EQUIPMENT	9	0	0	9

Convection Heat Transfer in Electronic Equipment. Natural Convection in Electronic Devices, Overall Heat Transfer Coefficient. Liquid Cooling Systems, Coolant Selection, Pressure Drop and Pump Requirements. Air Cooling System, Induced or Draft Cooling, Selection of Fans and Blowers.

UNIT IV	RADIATION HEAT TRANSFER IN ELECTRONIC EQUIPMENT	9	0	0	9

The Electromagnetic Spectrum, Radiation Equations, Stefan-Boltzmann Law, Surface Characteristics, Emittance, Emittance Factor, Emittance from Extended Surface, Absorptance, Reflectance, Specular Reflectance, Heat Transfer with Phase Change. Combined Modes of Heat Transfer for Electronic Equipment, Radiation and Convection in Parallel.

UNIT V	THERMAL ANALYSIS OF ELECTRONIC EQUIPMENT	9	0	0	9

Analysis of Thermal Failure of Electronic Components. Analysis of Thermal Stresses and Strain, Effect of PCB Bending Stiffness on Wire Stresses, Vibration Fatigue in Lead Wires and Solder Joints. Electronics Cooling Methods in Industry. Heat Sinks, Heat Pipes, Heat Pipes in Electronics Cooling, Thermoelectric Cooling, Immersion Cooling, Cooling Techniques for High Density Electronics.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Heat transfer Dr. A.S. Padalkar, NiraliPrakashan, Pune 2012
2.	Heat & mass transfer, D.S. Kumar, S.K. Kataria& Sons, 2010

REFERENCES:

1	Heat transfer B.L. Singhal, Techmax, publication, Pune 2010
2	Heat & mass transfer,Mills and Ganesan, Pearson Publication, New Delhi 2010

E-REFERENCES:	
1	https://nptel.ac.in/courses

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		Bloom Taxonomy Mapped
CO1	Apply the concepts of heat transfer laws and principles in electronic systems	Apply
CO2	Solve conduction heat transfer problems in various electronic instruments	Evaluate
CO3	Analyze the real time convection heat transfer problems of electronic equipment	Analyze
CO4	Solve the problems of combined effect of heat transfer form electronic equipment	Apply
CO5	Determine the thermal stresses and strains in various real time electronic systems	Evaluate

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	0	1	0	0	2	0	0	0	0	1	1	1
CO2	3	2	0	0	0	0	0	1	0	0	0	0	2	1	1
CO3	3	3	0	0	1	0	0	2	0	0	0	0	3	3	2
CO4	3	2	0	0	2	0	0	1	0	0	0	0	3	1	1
CO5	0	0	1	1	0	1	1	0	0	0	0	1	0	0	0
Avg	**2.2**	**1.8**	**0.4**	**0.2**	**0.8**	**0.2**	**0.2**	**1.2**	**0**	**0**	**0**	**0.2**	**1.8**	**1.2**	**1**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE54	NANO TECHNOLOGY				SEMESTER VIII
PREREQUISITES		CATEGORY	PE	Credit	3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES:

1.	To motivate the students to understand the evolution of nanomaterials in the scientific era.
2.	To make them to understand different processing methods.
3.	To make them to understand properties of nanomaterials for the future engineering applications

UNIT I	INTRODUCTION	9	0	0	9

Nanoscale Science and Technology- Implications for Physics, Chemistry, Biology and Engineering Classifications of nanostructured materials- nano particles- quantum dots, nanowires-ultra-thinfilmsmultilayered materials. Length Scales involved and effect on properties: Mechanical, Electronic, Optical, Magnetic and Thermal properties.

UNIT II	GENERAL METHODS OF PREPARATION	9	0	0	9

Bottom-up Synthesis-Top-down Approach: Co-Precipitation, Ultrasonication, Mechanical Milling, Colloidal routes, Self-assembly, Vapour phase deposition, MOCVD, Sputtering, Evaporation, Molecular Beam Epitaxy, Atomic Layer Epitaxy, MOMBE.

UNIT III	NANOMATERIALS	9	0	0	9

Nanoforms of Carbon - Buckminster fullerene- graphene and carbon nanotube, Single wall carbon Nanotubes (SWCNT) and Multi wall carbon nanotubes (MWCNT)- methods of synthesis(arc-growth, laser ablation, CVD routes, Plasma CVD), structure-property Relationships applications- Nanometal oxides-ZnO, TiO_2,MgO, ZrO_2, NiO, nanoalumina, CaO, $AgTiO_2$, Ferrites, Nanoclays- functionalization and applications-Quantum wires, Quantum dots-preparation, properties and applications

UNIT IV	CHARACTERIZATION TECHNIQUES	9	0	0	9

X-ray diffraction technique, Scanning Electron Microscopy - environmental techniques, Transmission Electron Microscopy including high-resolution imaging, Surface Analysis techniques- AFM, SPM, STM, SNOM, ESCA, SIMS-Nano indentation.

UNIT V	APPLICATIONS	9	0	0	9

Nano InfoTech: Information storage- Nano computer, molecular switch, super chip, nanocrystal, Nanobiotechnology: nanoprobes in medical diagnostics and biotechnology, Nano medicines, Targeted drug delivery, Bioimaging - Micro Electro Mechanical Systems (MEMS), Nano Electro Mechanical Systems (NEMS)- Nano sensors, nano crystalline silver for bacterial inhibition, Nanoparticles for sun barrier products - In Photostat, printing, solar cell, battery.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Carl C. Koch (ed.), " Nanostructured Materials", Processing, Properties and Potential Applications, Noyes Publications, Norwich, New York, U.S.A.
2.	A.S. Edelstein and R.C. Cammearata, eds., “Nanomaterials: Synthesis, Properties and Applications”, Institute of Physics Publishing, Bristol and Philadelphia, 1996.

REFERENCES:

1	A Textbook of Nanoscience and Nanotechnology – T.Pradeep, Tata McGraw Hill edition.
2	G Timp, “Nanotechnology”, AIP press/Springer, 1999.
3	Akhlesh Lakhtakia, “The Hand Book of Nano Technology, Nanometer Structure, Theory, Modeling and Simulations”. Prentice-Hall of India (P) Ltd, New Delhi, 2007.
4	Mark Ratner and Daniel Ratner, “Nano Technology”, Pearson Education, New Delhi, 2003.
5	Charles P. Poole Jr., Frank J. Ownes, ‘Introduction to Nanotechnology”, Wiley Interscience, 2003

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Will familiarize about the science of nanomaterials	Remember
CO2	Will demonstrate the preparation of nanomaterials	Understand
CO3	Use of difficult characterization techniques to study the fundamental properties.	Apply
CO4	To know the various industrial applications using nanomaterials.	Understand
CO5	Will familiarize about the science of nanomaterials	Remember

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	2	1	0	2	0	1	0	0	1	0	2	2	1
CO2	2	1	1	1	0	0	1	0	0	0	1	0	2	1	0
CO3	2	1	1	1	0	0	1	0	0	0	1	0	2	1	0
CO4	2	1	1	1	0	1	1	1	0	0	1	0	2	1	0
CO5	2	2	1	1	0	1	1	1	0	0	1	0	2	2	1
Avg	**2.0**	**1.4**	**1.2**	**1.0**	**0.0**	**0.8**	**0.8**	**0.6**	**0.0**	**0.0**	**5.0**	**0.0**	**2.0**	**1.4**	**0.4**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE55	NUCLEAR ENGINEERING				SEMESTER VIII
PREREQUISITES		CATEGORY	PE	credit	3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES:

1.	To teach the fundamental physics about nuclear processes and a heat transfer technique from nuclear energy
2.	To introduce the nuclear fuels, its properties and extraction techniques of nuclear fuels.
3.	To teach the characteristics of spent fuel and reprocessing techniques.
4.	To teach the design, construction and heat transfer in nuclear reactor.
5.	To teach the safety aspects used in nuclear reactor and disposal of nuclear waste.

UNIT I	NUCLEAR REACTIONS	9	0	0	9

Mechanism of Nuclear Fission - Nuclides - Radioactivity – Decay Chains - Neutron Reactions - The Fission Process

UNIT II	REACTOR MATERIALS	9	0	0	9

Characteristics of Nuclear Fuels - Uranium - Production and Purification of Uranium - Conversion to UF4 and UF6 - Other Fuels like Zirconium, Thorium - Beryllium.

UNIT III	REPROCESSING	9	0	0	9

Nuclear Fuel Cycles - Spent Fuel Characteristics - Role of Solvent Extraction in Reprocessing - Solvent Extraction Equipment.

UNIT IV	NUCLEAR REACTOR	9	0	0	9

Nuclear reactors: types of fast breeding reactors-design and construction of fast breeding reactors-heat transfer techniques in nuclear reactors-reactor shielding. Fusion reactors.

UNIT V	SAFETY AND DISPOSAL	9	0	0	9

Safety and disposal: Nuclear plant safety-safety systems-changes and consequences of accident-criteria for safety-nuclear waste-types of waste and its disposal-radiation hazards and their prevention-weapons proliferation.

Total (45L) = 45Periods

TEXT BOOKS:

1.	Thomas J.Cannoly, “Fundamentals of nuclear Engineering” John Wiley 1978.
2.	Glasstone, S and Sesonske, A, “Nuclear Reactor Engineering”, 3rd Edition, Von Nostrand, 1981.
3.	Lamarsh, J.R., “Introduction to Nuclear Reactor Theory”, Wesley, 1966.

REFERENCES:

1	Winterton, R.H.S., “Thermal Design of Nuclear Reactors”, Pergamon Press, 1981.
2	Jelly N A, “Nuclear Engineering”, Cambridge University Press, 2005.
3	Duderstadt, J.J and Hamiition, L.J, “Nuclear Reactor Analysis”, John Wiley, 1976.
4	Walter, A.E and Reynolds, A.B, “Fast Breeder Reactor”, Pergamon Press, 1981.

E-REFERENCES:

1	http://nptel.ac.in/courses/112101007/

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the fundamental knowledge about nuclear reactions	Understand
CO2	Understand the various nuclear fuels and its properties.	Understand
CO3	Explain the nuclear fuel cycles and spent fuel characteristics.	Analyze
CO4	Understand the design and heat transfer in nuclear reactor	Understand
CO5	Explain the safe disposal of nuclear wastes.	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	2	2	1	1	1	1	0	0	0	0	0	1	1	1
CO2	1	1	2	1	2	1	2	0	0	0	0	0	2	3	3
CO3	1	1	1	1	1	1	1	0	0	0	0	0	1	2	1
CO4	3	1	1	1	1	2	1	0	0	0	0	0	3	1	1
CO5	1	1	2	1	1	1	1	0	0	0	0	0	1	3	1
Avg	**1.6**	**1.2**	**1.6**	**1.0**	**1.2**	**1.6**	**1.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.6**	**2.0**	**1.4**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE56	THERMAL TURBO MACHINES	SEMESTER VIII

PREREQUISITES	CATEGORY	PE	Credit	3

	Hours/Week	L	T	P	TH
		3	0	0	3

COURSE OBJECTIVES:

1. To understand the various systems, principles, operations and applications of different types of turbo machinery components.

UNIT I	INTRODUCTION TO TURBO MACHINES	9	0	0	9

Turbines, Pumps, Compressors, Fans and Blowers – Stages of Turbo machines – Energy transfer between fluid and rotor – Stage velocity triangles Thermal Turbo machines – Classification – General energy equation – Modified to turbo machines – compression and expansion process – Velocity triangles – Work – T-S and H-S diagram, Total – to – Total and Total – to – Static efficiencies. Dimensional analysis – Non dimensional parameters of compressible flow Turbo machines – Similarity laws, applications and limitations.

UNIT II	CENTRIFUGAL FANS AND COMPRESSOR	9	0	0	9

Definition, selection and classifications –Types of blading design-velocity triangles - Stage Parameters – Flow analysis in impeller blades –Design parameter- Volute and Diffusers – Efficiencies and Losses – Fan noises – Causes and remedial measures. Centrifugal Compressors: - Constructional details – Stage velocity triangles — Stage work – Stage pressure rise – Stage efficiency – Degree of reaction – Slip factor – H-S diagram – Efficiencies – Performance characteristics.

UNIT III	AXIAL FANS AND COMPRESSOR	9	0	0	9

Definition and classifications – Stage parameters – Types of fan stages-performance characteristics. Cascade of blades – Cascade tunnel - Blade Geometry-Cascade Variables-Energy transfer and loss in terms of lift and drag - Axial Flow Compressors: definition and classifications – Constructional details – Stage velocity triangles – Stage work – Stage pressure rise – H-S diagram – Stage efficiencies and losses- Degree of reaction – Radial Equilibrium-Surging and Stalling – Performance characteristics

UNIT IV	AXIAL FLOW TURBINES	9	0	0	9

Construction details –90^0 IFR turbine- Stage work – Stage Velocity triangles – Stage pressure rise – Impulse and reaction stage – Effect of degree of reaction – H-S diagram – Efficiencies and Losses –Performance characteristics.

UNIT V	RADIAL FLOW TURBINES AND WIND TURBINES	9	0	0	9

Constructional details — Stage velocity triangles – H-S diagram – Stage efficiencies and losses –Performance characteristics. Wind turbines: definition and classifications – Constructional details –Horizontal axis wind turbine-Power developed – Axial thrust – Efficiency.

Total (45L) = 45Periods

TEXT BOOKS:

1. Yahya, S.M., “Turbines, Compressors and Fans”, Tata McGraw Hill Publishing Company, 1996.
2. Dixon S.L, “Fluid Mechanics, Thermodynamics of Turbo Machines”, 2nd Edition, Pergamon press, 1990.
3. Kadambi V and Manohar Prasad, “An Introduction to Energy Conversion - Vol. III Turbo Machines”, Wiley Eastern India Ltd, 1977.

REFERENCES:

1. Bruneck, Fans, Pergamom Press, 1973.
2. Earl Logan, Jr., Hand book of Turbomachinery, Marcel Dekker Inc., 1992.
3. Shepherd, D.H., Principles of Turbomachinery, Macmillan, 1969.
4. Stepanpff, A.J., Blowers and Pumps, John Wiley and Sons Inc. 1965.
5. Ganesan, V., Gas Turbines, Tata McGraw Hill Pub. Co., 1999.
6. Rangwala A S, “Structural Dynamics of Turbo-Machines”, New Age International,2005.

7	Astashev VK, Babitsky VI and Kolovsky MZ, “Dynamics and Control of Machines”, Springer Pub, 2000

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the Basic Concept of Compressors, Turbines, Fans and Blowers	Understand
CO2	Analyze the velocity triangles of Centrifugal fans and Compressors.	Analyze
CO3	Analyze the construction details and performance of axial fans and compressor.	Analyze
CO4	Analyze the design variations of axial flow turbines	Analyze
CO5	Understand the construction features and performance analysis of radial flow turbine and wind turbine	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	2	1	1	3	1	1	0	0	0	0	0	1	2	2
CO2	1	3	1	1	2	1	1	0	0	0	0	0	1	1	3
CO3	2	1	3	1	1	2	1	0	0	0	0	0	1	1	2
CO4	2	1	1	1	3	1	1	0	0	0	0	0	1	1	2
CO5	2	1	1	3	1	2	1	0	0	0	0	0	2	3	1
Avg	**1.6**	**1.6**	**1.4**	**1.4**	**2.0**	**1.4**	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.2**	**1.6**	**2.0**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

22MEPE57	TOTAL QUALITY MANAGEMENT				SEMESTER VIII
PREREQUISITES		CATEGORY	PE	Credit	3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES:

1.	Teach the need for quality, its evolution, basic concepts, contribution of quality gurus, TQM framework, Barriers and Benefits of TQM.
2.	Explain the TQM Principles for application.
3.	Define the basics of Six Sigma and apply Traditional tools, New tools, Benchmarking and FMEA.
4.	Describe Taguchi's Quality Loss Function, Performance Measures and apply Techniques like QFD, TPM, COQ and BPR.
5.	Illustrate and apply QMS and EMS in any organization.

UNIT I	INTRODUCTION	9	0	0	9

Definition of Quality - Dimensions of Quality - Quality planning - Quality costs, Analysis techniques for quality costs - Basic concepts of total quality management (TQM) - Historical review - Principles of TQM - Leadership - Role of senior management - Quality council, Quality statements - Strategic planning - Deming philosophy - Barriers to TQM implementation

UNIT II	TQM PRINCIPLES	9	0	0	9

Customer satisfaction - Customer perception of quality, Customer complaints, Service quality, Customer Retention, Employee involvement - Motivation, Empowerment, Teams, Recognition and reward, Performance appraisal - Continuous process improvement – Juran Trilogy, PDSA Cycle, 5S, Kaizen - Supplier Partnership, Sourcing, Supplier selection, Supplier rating, Relationship development - Performance measures, Basic concepts, Strategy

UNIT III	STATISTICAL PROCESS CONTROL (SPC)	9	0	0	9

The seven tools of quality, Statistical fundamentals – Measures of central tendency and dispersion, Population and sample, Normal curve - Control charts for variables and attributes, Process capability - Concept of six sigma, new seven Management tools.

UNIT IV	TQM TOOLS	9	0	0	9

Benchmarking – Reasons to benchmark, Benchmarking process, Quality function deployment (QFD) process – House of quality, Benefits - Taguchi quality loss function - Total productive maintenance (TPM) concept, Improvement needs - FMEA – Stages of FMEA.

UNIT V	QUALITY MANAGEMENT SYSTEMS	9	0	0	9

Need for ISO 9000 and other quality systems, benefits of ISO registration, ISO 9001:2008 quality system – Elements, Implementation of quality system, Documentation, Quality auditing, AS 9100,TS 16949:2002 and TL 9000

Total (45L) =45 Periods

TEXT BOOKS:

1.	Dale H.Besterfiled, Carol B.Michna,Glen H. Bester field,MaryB.Sacre,HemantUrdhwareshe and RashmiUrdhwareshe, “Total Quality Management”, Pearson Education Asia, Revised Third Edition, Indian Reprint, Sixth Impression,2013.
2.	Feigenbaum.A.V. “Total Quality Management”, McGraw Hill, 1991.

REFERENCES:

1	Joel.E. Ross, “Total Quality Management – Text and Cases”,Routledge.,2017.
2	Kiran.D.R, “Total Quality Management: Key concepts and case studies, Butterworth – Heinemann Ltd, 2016.
3	Oakland, J.S. “TQM – Text with Cases”, Butterworth – Heinemann Ltd., Oxford, Third Edition, 2003.

4	Suganthi,L and Anand Samuel, “Total Quality Management”, Prentice Hall (India) Pvt. Ltd., 2006
5	Narayana V and Sreenivasan, N.S, “Quality Management – Concepts and Tasks”, New Age International, 1996.
E-REFERENCES:	
1	https://www.oreilly.com/library/view/total-quality-management/9780815330486/xhtml/Reference1.xhtml
2	https://www.sanfoundry.com/best-reference-books-total-quality-management/
3	https://www.routledge.com/Total-Quality-Management-TQM-Principles-Methods-and-Applications/Luthra-Garg-Agarwal-Mangla/p/book/9780367512835

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Ability to apply TQM concepts in a selected enterprise.	Apply
CO2	Ability to apply TQM principles in a selected enterprise.	Apply
CO3	Ability to understand Six Sigma and apply Traditional tools, new tools, Benchmarking and FMEA.	Understand
CO4	Ability to understand Taguchi's Quality Loss Function, Performance Measures and apply QFD, TPM, COQ and BPR.	Understand
CO5	Ability to apply QMS and EMS in any organization.	Apply

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3	0	0	2	0	1	0	2	0	0	2	1	2	1
CO2	1	2	0	0	0	0	0	0	2	0	0	2	0	0	0
CO3	1	2	2	0	1	0	0	1	0	0	0	2	1	0	1
CO4	1	2	0	0	2	3	0	2	0	3	0	2	2	2	1
CO5	1	2	2	0	2	2	1	2	2	3	0	2	2	2	1
Avg	**1**	**2.2**	**0.8**	**0**	**1.4**	**1**	**0.4**	**1**	**1.2**	**1.2**	**0**	**2**	**1.2**	**1.2**	**0.8**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

PROFESSIONAL ELECTIVES – VI

22MEPE61	DESIGN OF PRODUCTION TOOLING				SEMESTER VIII
PREREQUISITES	CATEGORY	PE	Credit		C
	Hours/Week	L	T	P	TH
		3	0	0	3

COURSE OBJECTIVES:

1.	Describe tool design methods and punch and die manufacturing techniques
2.	Select material for cutting tools and gages; classify various cutting tools and gages and identify their nomenclature
3.	Describe the principles of clamping, drill jigs and computer aided jig design
4.	Design fixtures for milling, boring, lathe, grinding, welding; identify fixtures and cutting tools for NC machine tools
5.	Explain the principles of dies and moulds design

UNIT I	DESIGN OF CUTTING TOOLS	9	0	0	9

Tool materials, design of single point cutting tool, form tool, drill, reamer, broach & plain milling cutter.

UNIT II	METAL CUTTING	9	0	0	9

Theory of metal cutting – design of tool holders for single point tools – Boring bars – selection of tools for machining applications – economics of machining.

UNIT III	DESIGN OF FIXTURES	9	0	0	9

Standard work holding devices – principles of location and clamping – clamping methods and elements – quick- acting clamps – design & sketching of milling fixtures for simple components – Turning, Grinding, Welding fixtures. Inspection fixtures and design of gauges.

UNIT IV	DESIGN OF DRILL JIGS	9	0	0	9

Drill bushings – types of jigs: Plate, Leaf, Turn over & Box Jigs – design & sketching of drill jigs for machining simple components.

UNIT V	PRESS TOOLS	9	0	0	9

Power presses – die cutting operations – centre of pressure – scrap strip lay out for blanking – press tonnage calculations – Progressive & Compound dies – die design for simple components. Drawing dies – blank development – estimation of drawing force – blank holders & blank holding pressure – design & sketching of drawing dies for simple components – Bending dies & Combination tools.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Cyril Donaldson, Lecain and Goold: Tool Design – Tata McGraw Hill publications
2.	A Bhattacharyya: Metal Cutting – Theory and Practice – Central Book Agency Kolkata

REFERENCES:

1	ASTME: Fundamentals of Tool Design – Prentice Hall
2	F W Wilson: Hand Book of Fixture Design - McGraw Hill publications.
3	Edward G Hoffman, “Jigs and Fixture Design”, Thomson – Delmar Learning, Singapore 2004.
4	Joshi P H, “Jigs and Fixtures”, Tata McGraw Hill Publishing Company Limited, New Delhi 2004.

E-REFERENCES:

1.	https://lecturenotes.in/subject/150/production-design-and-production-tooling-PDPT

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Identify the various cutting tools for different machining processes.	Evaluate
CO2	Select suitable tools for metal machining	Apply
CO3	Identify suitable fixtures for various components.	Apply
CO4	Ability to design jigs for machining components.	Create
CO5	Design jigs, fixtures and press tools	Create

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	1	0	0	0	0	0	0	0	0	0	0	1	1	0
CO2	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0
CO3	0	1	2	0	0	0	0	0	0	0	0	0	1	1	0
CO4	1	2	3	0	0	0	0	0	0	0	0	0	1	2	0
CO5	1	1	1	3	0	0	0	0	0	0	0	0	0	0	0
Avg	**0.8**	**1.2**	**1**	**0.6**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.8**	**1**	**0**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

22MEPE62	ENGINEERING SYSTEM MODELING AND SIMULATION				SEMESTER VIII
PREREQUISITES		CATEGORY	PE	Credit	3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES:

1.	Outline the fundamentals of system simulation
2.	Identify the different types of techniques to generate Random numbers
3.	Outline random number and variate generation.
4.	The ability to analyze a system and to make use of the information to improve the performance
5.	Outline the fundamentals of system simulation

UNIT I	INTRODUCTION	9	0	0	9

Static physical models, dynamic physical models, static mathematical models, dynamic mathematical models, principles used in modeling. System studies, a corporate model: Environment segment, production segment, management segment. Types of system study.

UNIT II	MATHEMATICAL AND STATISTICAL MODELS	9	0	0	9

Probability concepts, Queuing Models, Methods for generating random variables and Validation of random numbers.

UNIT III	DESIGN OF SIMULATION EXPERIMENTS	9	0	0	9

Problem formulation, data collection and reduction, time flow mechanism, key variables, logic flow chart, starting condition, run size, experimental design consideration, output analysis and interpretation validation.

UNIT IV	SIMULATION LANGUAGES	9	0	0	9

Input modeling: data collection, identifying the distribution with data, parameter estimation, goodness of fit test, fitting a non-stationary Poisson process, selecting input models without data, multivariate and time series input models. Verification and validation of simulation models, model building, verification and validation, verification of simulation models, calibration and validation of models.

UNIT V	CASE STUDIES	9	0	0	9

Development of simulation models using simulation language studied for systems like queuing systems, Production systems, Inventory systems, maintenance and replacement systems and Investment analysis.

Total(45L) = 45Periods

TEXT BOOKS:

1.	Geoffrey Gordon, “System Simulation”, 2nd Edition, Prentice Hall, India, 2002.
2.	Narsingh Deo, “System Simulation with Digital Computer, “Prentice Hall, India, 2001.

REFERENCES:

1	Jerry Banks and John S.Carson, Barry L. Nelson, David M.Nicol, “Discrete Event System Simulation”, 3rd Edition, Prentice Hall, India, 2002.
2	Thomas J. Schriber, Simulation using GPSS, John Wiley, 1991.
3	Shannon, R.E. Systems simulation, The art and science, Prentice Hall, 1975.
4	Averill M. Law and W. David Kelton, “Simulation modeling and analysis”, McGraw·HiII, Inc, 1991.

E-REFERENCES:

1.	https://www.cs.nmt.edu/~jholten/ModelingAndSimulation/lectures.html
2.	https://lecturenotes.in/subject/383/simulation-and-modelling-sm
3.	https://backbencher.club/system-modelling-and-simulation/

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Modeling any given system with rationality.	Create
CO2	Predicting the behavior through fine grained analysis.	Create
CO3	Simulate the life cycle analysis, and drives over issues like model verification and validation.	Evaluate
CO4	Design simulation models for various case studies like inventory, traffic flow networks, etc.,	Design
CO5	Practice on simulation tools and impart knowledge on building simulation systems.	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	1	1	1	0	0	0	0	0	0	0	0	1	1	0
CO2	1	2	1	0	0	0	0	0	0	0	0	0	1	1	0
CO3	2	1	1	1	0	0	0	0	0	0	0	0	1	1	0
CO4	2	2	1	0	0	0	0	0	0	0	0	0	0	1	0
CO5	1	1	1	0	3	0	0	0	0	0	0	0	1	2	0
Avg	**1.6**	**1.4**	**1**	**0.4**	**0.6**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.8**	**1.2**	**0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE63	ENTREPRENEURSHIP DEVELOPMENT				SEMESTER VIII
PREREQUISITES		**CATEGORY**	**PE**	**Credit**	**3**
1.Basic knowledge in business strategies and ideas		**Hours/Week**	**L**	**T**	**P**	**TH**
2.Current and existing business growth status in our country			**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	Understanding the business management and fundamental concepts of Entrepreneurship
2.	Learning about business idea generation and converting the idea into a business model.
3.	Understanding the role of government and the machinery that renders support in terms of policies, assistances etc.
4.	Discussing various information about the process, procedure and rules and regulations for setting up new projects.
5.	Acquiring knowledge and information about the sources of help, incentives and subsidies available from government in setting up new projects

UNIT I	**INTRODUCTION TO ENTREPRENEURSHIP**	**9**	**0**	**0**	**9**

Entrepreneur – Types of Entrepreneurs – Difference between Entrepreneur and Intrapreneur – Entrepreneurship in Economic Growth, Factors Affecting Entrepreneurial Growth. Women Entrepreneurship- concept- functions –growth-problems and development. Rural Entrepreneurship –meaning-needs-rural industrialization-problems-development-NGOs and Rural Entrepreneurship. Entrepreneurial motivation- motivation theories and factors-achievement motivation –stress management.

UNIT II	**SMALL ENTERPRISES AND OWNERSHIP STRUCTURES**	**9**	**0**	**0**	**9**

Definition-characteristics-objectives-opportunities and problems of small-scale industries-Role of small enterprises in economic development. Project identification and selection-project formulation- project appraisal-financing of an enterprise. Ownership structures-proprietorship-company-cooperative-selection of form and ownership pattern.

UNIT III	**FINANCING AND ACCOUNTING**	**9**	**0**	**0**	**9**

Institutional finance to entrepreneurs –commercial banks and other financial institutions. Institutional finance to entrepreneurs - taxation benefits to small scale industry- Government policy for small scale enterprises. Accounting for small enterprises- need-meaning-objectives. Accounting process-journal-ledger-trial balance-finance accounts and accounts from incomplete records.

UNIT IV	**ENTREPRENEURSHIP MANAGEMENT**	**9**	**0**	**0**	**9**

Fundamental of management process - meaning – characteristics scope-functions. Difference between management and administration. Working capital management, Inventory management, production and operation management, marketing management and human resource management

UNIT V	**ENTREPRENEURSHIP DEVELOPMENT**	**9**	**0**	**0**	**9**

Growth strategies in small business- sickness in small business-small enterprises in international business – export documents and procedure for small enterprises-Electronic commerce and small enterprises- Franchising.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	S.S.Khanka “Entrepreneurial Development”, S.Chand and Co. Ltd, 1999.
2.	Essentials of Entrepreneurship and Small Business management (5/ed.): Thomas W. Zimmerer, and Norman M.Scarborough. PHI

REFERENCES:

1	EDII, “Faulty and External Experts – A Hand Book for New Entrepreneurs Publishers. Entrepreneurship Development”, Institute of India, Ahmadabad, 1986.
2	Athore B. S and Saini J. S, “A Handbook of Entrepreneurship”, Aapga Publications, 2004.
3	Rabindra N. Kanungo, “Entrepreneurship and Innovation”, Sage Publications, New Delhi, 1998.
4	Gupta CB and Srinivasan P, “Entrepreneurship Development” Sultan Chand & Sons, New Delhi, 2005

5	Hisrich. R. D and Peters M. P, "Entrepreneurship", 5th Edition, Tata McGraw Hill, 2002
E-REFERENCES:	
1.	https://nptel.ac.in/courses

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Describe the types of entrepreneurships and their development & growth	Understand
CO2	Identify and select an appropriate project formation for any type of small enterprise	Apply
CO3	Recognize various financial institutions and adapt the existing government policies for the growth of small-scale enterprises	Remember
CO4	Illustrate various fields of entrepreneurship management and their functions	Understand
CO5	Elaborate the steps of development processes for the small-scale industries	Understand

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0
CO2	0	3	0	0	0	0	0	0	1	0	1	1	0	0	0
CO3	0	0	0	0	0	0	0	0	1	0	3	0	0	0	0
CO4	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
CO5	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0
Avg	**0**	**0.6**	**0.4**	**0.2**	**0**	**0.4**	**0.6**	**0**	**0.4**	**0.2**	**0.8**	**0.2**	**0**	**0**	**0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE64	INDUSTRIAL SAFETY	SEMESTER VIII

PREREQUISITES	CATEGORY	PE	Credit	3
1.Industrial Engineering	Hours/Week	L	T	P	TH
2.Power Plant Engineering		3	0	0	3

COURSE OBJECTIVES:

1.	To understand the safety norms and inspection procedures to create risk free working environment
2.	To apply adequate machine guarding to eliminate the hazards from flying chips and sparks and moving parts
3.	To apply the safety concepts in welding, gas cutting, storage and handling of gas cylinders, metal forming processes for safe working
4.	To predict, identify and evaluate, hazardous conditions and practices safety rules in in cold working and hot working of metals
5.	To employ the safety rules in inspection and testing processes and take preventive measures in health and welfare of workers' aspects in engineering industry

UNIT I	INTRODUCTION	9	0	0	9

General safety rules-principles-maintenance-Inspections of turning machines, boring machines, milling machine, planning machine and grinding machines, CNC machines, Wood working machinery, electrical guards. Material handling- inspection, standards and codes.

UNIT II	PRINCIPLES OF MACHINE GUARDING	9	0	0	9

Machine Guarding, guarding of hazards, Machine Guarding types and its application – Safety in welding and Gas cutting – Safety in Manual and Mechanical material handling, Safety in use of electricity, Zero Mechanical State (ZMS), Definition, Policy for ZMS - guarding of hazards - point of operation protective devices, machine guarding, types, fixed guard.

UNIT III	SAFETY IN WELDING AND GAS CUTTING	9	0	0	9

Safety in Gas welding and oxygen cutting, resistance welding, arc welding and cutting, common hazards-personal protective equipment-safety precautions in brazing, soldering and metalizing - Explosive welding- safety in generation, distribution and handling of industrial gases- colour coding - flashback arrestor - leak detection-pipeline safety-storage and handling of gas cylinders.

UNIT IV	SAFETY IN COLD FORMING AND HOT WORKING OF METALS	9	0	0	9

Cold working: Power presses-point of operation safe guarding-auxiliary mechanisms- feeding and cutting mechanism-hand or foot-operated presses, power press electric controls. Hot working: Safety in forging, hot rolling mill operation, safe guards in hot rolling mills - hot bending of pipes, hazards and control measures. Safety in gas furnace operation, cupola, crucibles, ovens.

UNIT V	SAFETY IN FINISHING, INSPECTION AND TESTING	9	0	0	9

Safety in heat treatment operations: Electro plating, paint shops, sand and shotblasting. Safety in inspection and testing: dynamic balancing, hydrotesting, valves, boiler drums and headers, pressure vessels, air leak test, steam testing, safety in radiography, personal monitoring devices, radiation hazards, Indian Boilers Regulation. Health and welfare measures in engineering industry-pollution control in engineering industry.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Andrew Furness, Martin Muckett, "Introduction to Fire Safety Management", Butterworth-Heinemann,2007.
2.	C.Rayasfahl, David W.Rieske, "Industrial Safety and Health Management",Pearson,2009.
3.	Philip Hagan "Accident Prevention Manual for Business and Industry", National Safety Council,Chicago, 13th edition 2009.

REFERENCES:

1	Peter Warren, "Handbook of Hazardous Chemicals Properties", Butterworth-Heinemann, 1997.

2	Louis Theodore,Ryan Dupont, "Environmental Health and Hazard Risk Assessment: Principles and Calculations", CRC Press,2012.
3	John V.Grimaldi and Rollin H.Simonds, "Safety Management", Richard D Irwin, 1994.
4	Krishnan N.V. "Safety Management in Industry" Jaico Publishing House, Bombay, 1997.
5	Charles D.Reese, "Industrial Safety and Health for People- Oriented Services". CRC Press, 2009.
E-REFERENCES:	
1.	NPTEL courses: http://nptel.iitm.ac.in/courses.php - web and video sources on Industrial Safety.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the safety norms and inspection procedures to create risk free working environment	Understand
CO2	Apply adequate machine guarding to eliminate the hazards from flying chips and sparks and moving parts	Apply
CO3	Apply the safety concepts in welding, gas cutting, storage and handling of gas cylinders, metal forming processes for safe working	Apply
CO4	Predict, identify and evaluate, hazardous conditions and practices safety rules in in cold working and hot working of metals	Evaluate
CO5	Employ the safety rules in inspection and testing processes and take preventive measures in health and welfare of workers' aspects in engineering industry	Evaluate

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	0	0	0	2	3	0	0	1	0	0	0	2	2	1
CO2	3	1	1	0	0	2	2	1	0	0	0	0	2	2	1
CO3	2	0	1	0	2	2	2	0	0	0	0	0	2	2	1
CO4	2	1	1	0	0	2	0	0	0	0	0	0	2	2	1
CO5	2	1	0	0	2	2	2	0	1	0	0	0	2	2	1
Avg	**2**	**0.6**	**0.6**	**0**	**1.2**	**2.2**	**1.2**	**0.2**	**0.4**	**0**	**0**	**0**	**2**	**2**	**1**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE65	INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS				SEMESTER VIII
PREREQUISITES		**CATEGORY**	**PE**	**Credit**	**3**
1.Fundamental knowledgein partial Differential Equations		**Hours/Week**	**L**	**T**	**P**	**TH**
2.Concepts of laws of motion and fluid mechanics			**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	Understanding the major theories, approaches, and methodologies and programming techniques in computational fluid dynamics.
2.	Studying various fluid flow governing equations from the conservation laws of motion and fluid mechanics.
3.	Identifying rigorous and comprehensive treatment of numerical methods in fluid flow and heat transfer problems in engineering applications.
4.	Demonstrating the computational methods, algorithms and applied boundary conditions that will affect the approximate solution.
5.	Building up the skills in the actual implementation of CFD methods and codes to investigate the results.

UNIT I	**INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS**	**9**	**0**	**0**	**9**

History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering, Numerical Methods Programming fundamentals, simple coding techniques for numerical problems.

UNIT II	**GOVERNING EQUATIONS OF FLUID FLOW AND HEAT TRANSFER**	**9**	**0**	**0**	**9**

Governing Equations of Fluid Dynamics: Models of the flow, The substantial derivative, Physical meaning of the divergence of velocity, The continuity equation, The momentum equation, The energy equation, Navier Stokes equations for viscous flow, Euler equations for in viscid flow, Physical boundary conditions.

UNIT III	**PARTIAL DIFFERENTIAL EQUATIONS AND ITS NUMERICAL BEHAVIOUR**	**9**	**0**	**0**	**9**

The Forms of the governing equations suited for CFD, Conservation form of the equations, shock fitting and shock capturing, Time marching and space marching problems. Mathematical Behavior of Partial Differential Equations: Classification of quasi-linear partial differential equations, Methods of determining the classification, General behavior of Hyperbolic, Parabolic and Elliptic equations

UNIT IV	**DISCRETIZATION AND NUMERICAL METHODS OF PDEs**	**9**	**0**	**0**	**9**

Basic aspects of Discretization: Introduction to finite differences, Finite difference equations using Taylor series expansion and polynomials, Explicit and implicit approaches, uniform and unequally spaced grid points. Grids With Appropriate Transformation: General transformation of the equations, Metrics and Jacobians. Stability Analysis: Discrete Perturbation Stability analysis, von Neumann Stability analysis, Error analysis, Modified equations, Artificial dissipation and dispersion; Grid Generation: Algebraic Grid Generation, Elliptic Grid Generation, Hyperbolic Grid Generation, and Parabolic Grid Generation.

UNIT V	**SOLUTION METHODS AND APPLICATIONS OF NUMERICS TO SIMPLE PROBLEMS**	**9**	**0**	**0**	**9**

Parabolic Partial Differential Equations: Finite difference formulations, Explicit methods – FTCS, Richardson. Implicit methods – Lasonen and Crank-Nicolson; Finite Volume Method for Structured and Unstructured Grids: Advantages, Cell Centered and Nodal point Approaches, Numerical Solution of Quasi 1D Flow equation and 2D heat conduction equation.

Total (45L) =45 Periods

TEXT BOOKS

1.	Anderson, J.D. (Jr), "Computational Fluid Dynamics", McGraw-Hill Book Company, 1st Edition, 1995.
2.	Hoffman, K.A., and Chiang, S.T., "Computational Fluid Dynamics", Vol. I, II and III, Engineering Education System, Kansas, USA, 2000.

REFERENCES:

1	Anderson, D.A., Tannehill, J.C., and Pletcher, R.H., "Computational Fluid Mechanics and Heat Transfer", McGraw Hill Book Company, 2002.
2	Chung, T.J., "Computational Fluid Dynamics", Cambridge University Press, 2003
3	Muralidhar K and Sundararajan., "Computational Fluid Flow & Heat Transfer", 2009.
E-REFERENCES:	
1.	https://nptel.ac.in/courses/112105045

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Summarize the basics of computational fluid dynamics and its applications in various industries as a tool for fluid analysis	Remember
CO2	Select an appropriate finite difference approach for numerical formulations based on fluid mechanics and/or heat transfer concepts to get the approximate solutions.	Apply
CO3	Develop the governing equations for computational fluid dynamics CFD analysis by setting appropriate boundary conditions.	Create
CO4	Identify different CFD techniques available for relevant partial differential equations to get analytical solutions for fluid flow.	Understand
CO5	Analyze the numerical solution of fluid flow problems using discretization methods addressing accuracy, stability and convergence aspects to minimize the errors.	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0
CO2	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
CO3	1	1	1	0	0	1	1	1	0	0	0	0	0	0	0
CO4	2	2	0	0	1	0	0	1	0	0	0	0	2	2	1
CO5	2	1	0	0	0	0	0	2	0	0	0	0	2	2	1
Avg	**1.2**	**0.8**	**0.4**	**0.2**	**0.2**	**0.2**	**0.6**	**0.8**	**0**	**0**	**0**	**0**	**0.8**	**0.8**	**0.4**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE66	MARINE ENGINEERING				SEMESTER VIII			
PREREQUISITES		**CATEGORY**	**PE**		**Credit**		**3**	
1. Internal Combustion Engines		**Hours/Week**	**L**		**T**	**P**	**TH**	
2.Fluid Mechanics and Machinery			**3**		**0**	**0**	**3**	

COURSE OBJECTIVES:

1.	To understand the basic principles of Marine Engineering
2.	To understand the naval architects and the fields related to the maritime industry
3.	To analyze the vibrations in various equipment used in marine engineering
4.	To understand various electrical systems and environmental control and safety in marine engineering
5.	To understand the nuclear applications in marine engineering

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Introduction of marine Engineering - Ship system formulations-main propulsion system requirements and main propulsion system trade-off studies, Arrangement of machinery- piping diagrams and auxiliary systems.

UNIT II	**ENGINES AND PROPULSION**	**9**	**0**	**0**	**9**

Characteristics of internal combustion engines-marine uses for such engines. Marine steam generators-selection and design of boilers. Main propulsion systems-steam engines, steam turbines, gas turbines. Electric propulsion drives

UNIT III	**VIBRATIONS ANALYSIS**	**9**	**0**	**0**	**9**

Propeller shafting and shafting system vibration analysis-Pumps, blowers, compressors, ejectors, condensers, heat exchangers, distilling plants. Hull machinery design considerations and machinery installations- machinery foundation designs- hydrostatic power transmission equipment and systems.

UNIT IV	**POWER DISTRIBUTION**	**9**	**0**	**0**	**9**

Electric generating plants- switchboards and panels-lighting and power distribution- power equipment- lighting fixtures. Electronics navigation and radio communication-automation systems- safety considerations. Machinery for environmental control and waste treatment.

UNIT V	**NUCLEAR APPLICATION**	**9**	**0**	**0**	**9**

Fundamentals of pressurized-water nuclear steam supply systems for use in marine propulsion. Reactor design considerations- Nuclear fuels, reactor coolants, reactor control, shielding, safety, health physics, and economics.

Total(45L) = 45 Periods

TEXT BOOKS:

1.	Grover T K, “Marine Engineering”, Anmol Publications Pvt Ltd, 2008.
2.	Harrington and Roy, L, “Marine Engineering”, The Society of Naval Architects and Marine Engineers, 1991.
3.	D.A.Taylor, “Introduction to Marine Engineering”,Butterworth Heinmann,1996.

REFERENCES:

1	Cameron, I.R., “Nuclear Fission Reactors”, Plenum Press, 1998.
2	Henke and Russell, W., “Introduction to Fluid Power Circuits and Systems”, Addison-Wesley, 1970.
3	John W.Gaythwaite, “Design of Marine Facilities: Engineering for Port and Harbour Structures”, American Soceity of Civil Engineers,2016.
4	Doug Woodyard, “Pounder’s Marine Diesel Engines and Gas Turbines”, Elsevier Ltd,2009.
5	Kuwahara,Takuya, “New Technologies for Emission Control in Marine Diesel Engines”, Elsevier Science & Technology, 2019.

E-REFERENCES:

1.	NPTEL courses: http://nptel.iitm.ac.in/courses.php - web and video sources on Marine Engineering.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the basic principles of marine engineering	Understand
CO2	Understand the naval architects and the fields related to the maritime industry	Understand
CO3	Analyze the vibrations in various equipment used in marine engineering	Analyze
CO4	Understand various electrical systems and environmental control and safety in marine engineering	Understand
CO5	Understand the nuclear applications in marine engineering	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	1	1	0	0	0	0	0	0	0	0	2	2	1
CO2	2	1	1	1	1	0	0	0	0	0	0	0	2	2	1
CO3	2	2	3	1	1	0	0	0	0	0	0	0	2	2	1
CO4	2	0	3	0	0	3	2	0	0	2	0	1	2	2	1
CO5	1	1	2	1	0	3	2	0	0	1	0	0	2	2	1
Avg	**2.0**	**1.0**	**2.0**	**0.8**	**0.4**	**1.2**	**0.8**	**0.0**	**0.0**	**0.6**	**0.0**	**0.2**	**2.0**	**2.0**	**1.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEPE67	ROBOTICS	SEMESTER VIII

PREREQUISITES	CATEGORY	PE	Credit		
	Hours/Week	L	T	P	TH
		3	0	0	3

COURSE OBJECTIVES:

1.	To explore concepts of Robot technologies that is playing vital role in manufacture
2.	Describe various Robot technology applications.
3.	Develop an understanding of Robot Kinematics and dynamics.
4.	Explain and summarize Robot end effectors and Sensors.
5.	Explore conceptual understanding of robot programming.

UNIT I	FUNDAMENTALS OF ROBOT	9	0	0	9

Robot - definition - robot anatomy - co-ordinate systems - work envelope - types and classification - specifications – joint notations – types of joints - speed of motion - pay load - robot parts and their functions - need for robots in Indian scenario.

UNIT II	ROBOT DRIVE SYSTEMS AND END EFFECTORS	9	0	0	9

Drives - hydraulic, pneumatic, mechanical, electrical - servo motors - stepper motors - salient features, application – end effectors – types: tools - grippers - mechanical grippers - pneumatic and hydraulic grippers, magnetic grippers, vacuum grippers, multiple grippers.

UNIT III	SENSORS AND MACHINE VISION	9	0	0	9

Requirements of sensors – principles, types and applications of following types of sensors proximity (inductive, Hall effect, capacitive, ultrasonic and optical) – range (Triangulation, structured light approach, laser range) – speed, position (resolvers, optical encoders, pneumatic) – force – torque – touch sensors (binary, analog sensor) - introduction to machine vision -functions - image processing and analysis.

UNIT IV	ROBOT KINEMATICS AND ROBOT PROGRAMMING	9	0	0	9

Forward kinematics and reverse kinematics of manipulators - two, three degrees of freedom (in 2 dimensional) – homogeneous transformation matrix - simple problems - lead through programming, robot programming languages - VAL programming –motion commands - sensor commands - end effecter commands - simple programs for loading, unloading and palletizing operations.

UNIT V	APPLICATIONS, IMPLEMENTATION AND ROBOT ECONOMICS	9	0	0	9

Robot cell design – types - Application of robots in processing - assembly - inspection - material handling - loading - unloading - automobile - implementation of robots in industries - safety considerations for robot operations – economic analysis of robots - pay back method and rate of return method.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	M.P.Groover, “Industrial Robotics – Technology, Programming and Applications”, McGraw-Hill, 2001
2.	Fu.K.S. Gonzalz.R.C., and Lee C.S.G., “Robotics Control, Sensing, Vision and Intelligence”, Mc Graw Hill Book Co.,1987

REFERENCES:

1	Richard D.Klafter, Thomas A.Chmielewski and Micheal Negin, “Robotic engineering –An Integrated Approach”,Prentice Hall Inc, Englewoods Cliffs, NJ, USA, 2005.
2	Janakiraman.P.A. “Robotics and Image Processing”, Tata McGraw-Hill, 1995.
3	Yoram Koren, “Robotics for Engineers”, McGraw-Hill Book Co., 1992.
4	A.K.Gupta and S.K.Arora, “Industrial Automation and Robotics”, Laxmi Publications Pvt ltd, 2007.

E-REFERENCES:	
1.	NPTEL Videos/Tutorials

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Describe the basic concepts, parts of robots and types of robots	Understand
CO2	Know the potential applications of robots in industries as part of automation tool	Understand
CO3	Familiar with the various drive systems for robot, sensors and their applications in robots, programming of robots.	Remember
CO4	Discuss about the various applications of robots, justification, implementation and safety of robot	Analyze
CO5	Select an appropriate robot for a particular application with economically.	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	1	2	1	2	0	1	0	0	0	2	0	2	2	1
CO2	2	1	1	1	0	1	2	1	0	0	1	0	2	2	1
CO3	1	1	1	1	0	1	1	1	0	0	1	0	2	2	1
CO4	1	1	1	2	2	2	1	0	0	0	2	0	1	1	1
CO5	1	1	1	1	2	1	1	0	0	0	1	0	2	2	1
Avg	**1.4**	**1**	**1.2**	**1.2**	**1.2**	**1**	**1.2**	**0.4**	**0**	**0**	**1.4**	**0**	**1.8**	**1.8**	**1**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

OPEN ELECTIVES COURSES

22MEOE01	DESIGN OF MACHINE ELEMENTS AND MACHINING		SEMESTER VI/VIII			
		CATEGORY	OE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES

1	To familiarize the various steps involved in the design process
2	To understand the basic concepts of machining techniques
3	To know the factors influencing the processes and their applications
4	Applying the principles of milling and gear cutting machines.
5	To gain the knowledge of cutting tool materials and surface finishing process.

UNITI	**STRESSES IN MACHINE ELEMENTS**	**9**	**0**	**0**	**9**

Stress in simple machine members- axial, bending, torsional, bearing stress, Hertz contact stress; combined stresses, principle stresses, Theories of failure, factor of safety, stress concentration, preferred numbers.

UNITII	**DESIGN OF SHAFTS AND WELDED JOINTS**	**9**	**0**	**0**	**9**

Design of shaft members subjected to simple and combined stresses - Welded joints- Types of welding symbols, design of welded joints subjected to various load -Design of Riveted joints

UNITIII	**DESIGN OF MACHINE ELEMENTS**	**9**	**0**	**0**	**9**

Springs: Design of helical springs- stresses and deflection - design procedure. Bearings: Need for bearing, Types, sliding and rolling contact bearings, hydro- dynamic and hydro static bearings- Life of bearings – Selection of bearings- Problems.

UNITIV	**METAL CUTTING**	**9**	**0**	**0**	**9**

Theory of metal cutting: Introduction, mechanics of metal cutting, orthogonal and oblique cutting, merchants' equation, chip formation, heat generation, cutting fluids, cutting tool life, recent developments and applications (Dry machining and high-speed machining)

UNITV	**MACHINE TOOLS AND SURFACE FINISHING PROCESSES**	**9**	**0**	**0**	**9**

Tools and machine tools: Cutting tool materials, cutting tool nomenclature, introduction to machine tools, lathe, shaper, planning, milling, drilling and boring machines, working principle, operations, work holding devices. Surface finishing processes: Introduction to Grinding honing, lapping processes and machines. Introduction to CAD/CAM/CIM.

Total(45L) = 45Periods

REFERENCE BOOKS:

1	Rao P N, "Manufacturing Technology" Tata McGraw-Hill Publishing Company Ltd, New Delhi, 2006
2	HMT, "Production Technology" Tata McGraw-Hill Co., New Delhi, 1998
3	Milton C Shaw, "Metal Cutting Principles", Clarendon Press, Oxford, 1999.
4	James Brown, "Advanced Machining Technology Handbook", McGraw- Hill Book Company, New York, 1988.
5	Robert L Mott, "Machine Elements in Mechanical Design", Macmillan Publishing Co., London. UK, 1992.
6	Shighley and Mische, "Mechanical Engineering Design" McGraw Hill, 1992.
7	Rao. P.N "Manufacturing Technology," Metal Cutting and Machine Tools, Tata McGraw- Hill, New Delhi, 2003.

E-REFERENCES:

1.	https://nptel.ac.in/courses/112105124
2.	Design of Machine Elements - V. B. Bhandari - Google Books
3.	A Textbook of Machine Design by R.S.Khurmi and J.K.Gupta [tortuka]_1490186411865.pdf | DocDroid

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Analyze the stresses induced in a machine element.	Analyze
CO2	Familiarize the design concept of joints under various loading.	Remember
CO3	Familiarize the design of various types of bearings and Spring.	Remember
CO4	Identify the process parameters associated with various machining processes.	Apply
CO5	Familiarize the cutting tools materials and surface finishing processes.	Remember

COURSE ARTICULATION MATRIX

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

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEOE02	INDUSTRIAL ENGINEERING	SEMESTER VI/VIII

	CATEGORY	OE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

COURSE OBJECTIVES

1	Assume Technical and Managerial roles in the industries.
2	Apply Engineering Principles to the working environment.
3	Use quality tools to foresee and solve issues in the industrial situations.
4	Work collaboratively
5	To know the importance of EBQ

UNITI	FORECASTING	9	0	0	9

Characteristics and Principles - Qualitative Methods, Delphi Technique, Market Research-TimeSeries Methods-Moving Average, Exponential Smoothing- Box Jenkins Method –autoregressivemoving average (ARMA) or autoregressive integrated moving average (ARIMA) models – FittingRegression Models - Measurement of Forecast Errors, Coefficient of Correlation- Problem solving.

UNITII	FACILITIES PLANNING AND WORK STUDY	9	0	0	9

Factors affecting Site Location Decisions - Principles and Types of Layout - Layout Planning -Layout Tools and Computerised Layout Techniques - Design of Group Technology Layout – LineBalancing - Line Balancing Methods-Objectives of Work Study -Method Study Procedure,Recording Techniques - Motion Study - Principles of Motion Economy - Techniques of Work measurement - Time Study - Synthesis Method - Analytical Estimating - Predetermined Motion Time System (PMTS) - Work Sampling Techniques.

UNITIII	LEAN MANUFACTURING	9	0	0	9

Elements of Just In Time (JIT) - Pull and Push System, Kanban System- Optimized ProductionTechnology and Synchronous Manufacturing – Implementation of Six Sigma - Single MinuteExchange of Die (SMED) 5S concept - Concurrent Engineering- Cellular Manufacturing – Enablersof Agile Manufacturing – Rapid Manufacturing - Business process reengineering (BPR) - Basics ofSupply Chain Management, Supply chain and "Keiretsu" – Enterprises Resources Planning (ERP) -Role of KAIZEN, Quality Circles and POKA YOKE in Modern Manufacturing – Seven wastes inLean Manufacturing.

UNITIV	AGGREGATE PRODUCTION PLANNING	9	0	0	9

Objectives of Aggregate Planning - Capacity Requirement Planning (CRP) Process - Types ofCapacity Planning - Strategies for Aggregate Capacity Planning - Master Production Scheduling -Procedure for Developing MPS – Materials Requirements Planning (MRP-I), Issues in MRP,Designing and Managing the MRP System, Evaluation of MRP - Manufacturing Resources Planning(MRP-II).

UNITV	SCHEDULING OF OPERATIONS	9	0	0	9

Operations Planning and Scheduling - Scheduling Techniques - Stages in Scheduling – Loading,Dispatching, Expediting - Finite Loading and Infinite Loading - Load Charts and Machine LoadingCharts - Priority Sequencing - Dynamic Sequencing Rules - Batch Scheduling – Economic BatchQuantity (EBQ) or Economic Run Length (ERL) – Scheduling in Repetitive, Batch and Job ShopManufacturing – Allocation of units for a single resource, allocation of multiple resources – Resource balancing - Flexible manufacturing system.

Total(45L)= 45Periods

REFERENCE BOOKS:

1	R.Panneerselvam, "Production & Operations Management", 3rd Edition, PHI LearningPrivate Limited, New Delhi, 2012
2	Elwood S.Buffa, and Rakesh K.Sarin, "Modern Production/Operation Management", 8thEdition, John Wiley & Sons, 2000

3	Dilworth B.James, "Operations Management Design, Planning and Control forManufacturing and Services", Mcgraw Hill Inc., New York, 1992
4	Vollman T.E, "Manufacturing Planning and Control Systems", Galgotia Publications,2002.
E-REFERENCES:	
1.	https://www.newtondesk.com/industrial-engineering-study-notes-hand-written/
2.	https://en.wikipedia.org/wiki/Lean_manufacturing
3.	https://www.planettogether.com/blog/types-of-scheduling-in-production-planning-and-control

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Apply the knowledge of Engineering and Sciences to improve the productivity of Industries.	Apply
CO2	Design a system to meet the desired needs within realistic constraints.	Create
CO3	Function in multidisciplinary teams.	Apply
CO4	Use the techniques, skills, and modern engineering tools in manufacturing practice.	Understand
CO5	Perform as an effective Industrial Engineer integrating high and low levels of management	Create

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	0	0	2	2	0	0	0	0	0	0	0	0	3
CO2	0	0	3	0	0	0	0	0	0	0	0	0	0	2
CO3	0	0	0	0	0	3	2	0	3	2	3	2	3	0
CO4	3	3	0	2	3	3	0	0	0	0	0	2	0	3
CO5	0	0	0	0	0	3	2	3	0	0	0	0	3	0
Avg	**1.2**	**0.6**	**0.6**	**0.8**	**1**	**1.8**	**0.8**	**0.6**	**0.6**	**0.4**	**0.6**	**0.8**	**1.2**	**1.6**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEOE03	INDUSTRIAL ROBOTICS	SEMESTER VI/VII

CATEGORY	OE	Credit		3
Hours/Week	L	T	P	TH
	3	0	0	3

COURSE OBJECTIVES

1	To explore concepts of Robot technologies that is playing vital role in manufacture.
2	Describe various Robot technology applications.
3	Develop an understanding of Robot Kinematics and dynamics.
4	Explain and summarize Robot End effectors and Sensors.
5	Explore conceptual understanding of Robot programming.

UNITI	INTRODUCTION	9	0	0	9

Robot - definition - robot anatomy - co-ordinate systems - work envelope - types and classification - specifications – joint notations – types of joints - speed of motion - pay load - robot parts and their functions - need for robots in Indian scenario.

UNIT II	ROBOT DRIVE SYSTEMS AND END EFFECTORS	9	0	0	9

Drives - hydraulic, pneumatic, mechanical and electrical - servo motors - stepper motors - salient features, application – end effectors – types: tools - grippers - mechanical grippers - pneumatic and hydraulic grippers, magnetic grippers, vacuum grippers, multiple grippers.

UNIT III	SENSORS AND MACHINE VISION	9	0	0	9

Requirements of sensors – principles, types and applications of following types of sensors proximity (inductive, Hall effect, capacitive, ultrasonic and optical) – range (Triangulation, structured light approach, laser range) – speed, position (resolvers, optical encoders, pneumatic) – force – torque – touch sensors (binary, analog sensor) - introduction to machine vision -functions - image processing and analysis.

UNIT IV	ROBOT KINEMATICS AND ROBOT PROGRAMMING	9	0	0	9

Forward kinematics and reverse kinematics of manipulators - two, three degrees of freedom (in 2 dimensional) – homogeneous transformation matrix - simple problems - lead through programming, robot programming languages - VAL programming –motion commands - sensor commands - end effecter commands - simple programs for loading, unloading and palletizing operations.

UNIT V	APPLICATIONS, IMPLEMENTATION AND ROBOT ECONOMICS	9	0	0	9

Robot cell design – types - Application of robots in processing - assembly - inspection - material handling - loading - unloading - automobile - implementation of robots in industries - safety considerations for robot operations – economic analysis of robots - pay back method and rate of return method.

Total (45L)= 45Periods

REFERENCE BOOKS:

1	Mikell. P. Groover, 'Industrial Robotics Technology', Programming and Applications, McGraw Hill Co, 1995.
2	Fu.K.S. Gonzalz.R.C., and Lee C.S.G., "Robotics Control, Sensing, Vision and Intelligence", McGraw Hill Book Co.,1987.
3	Richard D.Klafter, Thomas A.Chmielewski and MichealNegin, "Robotic engineering –An Integrated Approach",Prentice Hall Inc, Englewoods Cliffs, NJ, USA, 2005.
4	Janakiraman.P.A. "Robotics and Image Processing", Tata McGraw-Hill, 1995.
5	YoramKoren, "Robotics for Engineers", McGraw-Hill Book Co., 1992.
6	A.K.Gupta and S.K.Arora, "Industrial Automation and Robotics", Laxmi Publications Pvt ltd, 2007.
7	Fu. K. S., Gonzalez. R. C. & Lee C.S.G., 'Robotics control, sensing, vision and intelligence', McGraw Hill Book co, 1987.

8	Craig. J. J. 'Introduction to Robotics mechanics and control',Addison- Wesley, 1999
9	Ray Asfahl. C., 'Robots and Manufacturing Automation', John Wiley & Sons Inc., 1985.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the basic concepts, parts of robots and types of robots.	Understand
CO2	Understand the potential applications of robots in industries as part of automation tool	Understand
CO3	Familiar with the various drive systems for robot, sensors and their applications in robots, programming of robots.	Remember
CO4	Discuss about the various applications of robots, justification, implementation and safety of robot	Analyze
CO5	Select an appropriate robot for a particular application.	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	0	0	1	0	0	0	0	0	0	1	1
CO2	0	0	1	0	1	1	0	0	0	0	0	0	1	1
CO3	0	1	0	0	0	0	0	0	0	0	0	0	1	1
CO4	0	0	1	0	0	3	0	0	0	0	0	0	0	1
CO5	0	2	0	0	0	0	0	0	0	0	0	0	1	2
Avg	**0.6**	**1**	**0.6**	**0**	**0.2**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0.8**	**1.2**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEOE04	POWER PLANT ENGINEERING	SEMESTER VI/VII

PREREQUISITES	CATEGORY	OE	Credit		3
1. Having sufficient knowledge on basics of power plant	Hours/Week	L	T	P	TH
2. Basic unit calculation for consumption of power		3	0	0	3

COURSE OBJECTIVES:

1.	Understanding of thermal power plant operation, different types of high-pressure boilers including supercritical and supercharged boilers, fluidized bed combustion systems, Design of chimney in thermal power plants, knowledge of cooling tower operation
2.	Location of hydro power plant and its components to generate power
3.	Complete knowledge about diesel and gas power plant
4.	Basic knowledge of nuclear reaction and types of nuclear power plant
5.	Basic knowledge of power plant economics and various tariff methods.

UNIT I	STEAM POWER PLANT	9	0	0	9

Layout of steam power plant – boilers - Modern high pressure and supercritical boilers - Preparation and handling of coal - Pulverizer - Dust collector - Ash removal; Stokers - Different types - Pulverized fuel burning; Draught - Different types - Chimney design - Selection of blowers, Cooling towers - Different types - Waste heat recovery, Fluidised Bed & Circulated Fluidised Bed boilers

UNIT II	HYDRO ELECTRIC POWER PLANT	9	0	0	9

Layout of hydel power plant- classification –working – components – layout of pumped storage power plant - Plant equipment for Pumped Store Schemes.

UNIT III	DIESEL AND GAS POWER PLANT	9	0	0	9

Layout of Diesel power plant- Important components – performance analysis – Layout of gas power plant – classification of gas turbine cycles – components – relative thermal efficiencies of different cycles.

UNIT IV	NUCLEAR, MHD POWER GENERATION	9	0	0	9

Elementary treatment - nuclear fission, chain reaction - Pressurized water reactors, boiling water reactors, gas cooled reactors - Fast breeder reactors, Magneto Hydro Dynamic power- open cycle and closed cycle system.

UNIT V	ECONOMICS AND SAFETY	9	0	0	9

Economics and safety - Actual load curves - Fixed and operating costs - Tariff methods for electrical energy - Peak load and variable load operations - Selection of generation type and general equipment. Introduction to safety aspects in power plants - Environmental impacts - assessment for thermal power plant.

Total(45L) = 45 Periods

TEXT BOOKS:

1.	S. Domkundwar, A.V. Domkundwar, S.C. Arora.A Course in Power Plant Engineering, Dhanpat Rai Publications. 2013
2.	P.K. Nag, Power Plant Engineering, Tata McGraw Hill, Laxmi Publications Pvt.Ltd New Delhi, 5th Edition, 2014.

REFERENCES:

1	R.K. Rajput. A Text of Power Plant Engineering, Laxmi publications, New Delhi 5th Edition, 2016.
2	G.R. Nagpal, Power Plant Engineering, Khanna Publications 1998.
3	Bernhardt G. Askrotzki and William A. Vopat, “Power Station Engineering and Economy”, Tata McGraw Hill Publishing Co. Ltd., 1972.
4	Frederick T. Mores, “Power Plant Engineering”, Affiliated East-West Press Private Ltd., 1953.

5	Joel Weisman and Roy Eckart, "Modern Power Plant Engineering", Prentice Hall International Inc., 1985.
E-REFERENCES:	
1.	https://en.wikipedia.org/wiki/Power_plant_engineering
2.	https://onlinecourses.nptel.ac.in/noc21_me86/preview

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Ample knowledge on thermal power plant operation and its merits and demerits.	Analyze
CO2	Potential Power of water to convert into useful energy by hydropower.	Remember
CO3	Augment with diesel and gas power plant operation and its components.	Understand
CO4	Able to cope with recent developments on nuclear power plant.	Understand
CO5	Understanding of various economics to construct power plant and to measure the consumption of power by different tariff.	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO7**	**PO8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	2	3	2	1	0	1	1	2	0	2	2	2	1	2
CO2	1	2	3	2	1	0	1	1	2	0	2	2	2	1	2
CO3	1	2	3	2	1	0	1	1	2	0	2	2	2	1	2
CO4	1	2	3	2	1	0	1	1	2	0	2	2	2	1	2
CO5	2	0	1	2	0	0	0	2	2	1	1	1	2	0	0
Avg	**1.2**	**1.6**	**2.6**	**2.0**	**0.8**	**0.0**	**0.8**	**1.2**	**2.0**	**0.2**	**1.8**	**1.8**	**2.0**	**0.8**	**1.6**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEOE05	PRINCIPLES OF MANAGEMENT					SEMESTER VI/VIII
		CATEGORY	OE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES

1.	To understand the management basic features of management.
2.	Principles usages in all walks of life and industrial growth.
3.	Able to have a clear understanding of the managerial functions like planning, organizing, staffing, leading and controlling.
4.	To gain some basic knowledge in international aspect of management.

UNITI	**MANAGEMENT ANINTRODUCTIONANDOVERVIEW**	**9**	**0**	**0**	**9**

Definitions of management – features of management – Management thoughts – different schools of management – Scientific management – Arts or Science, Management Vs administration – Principles of Management.

UNIT II	**FUNCTIONS OF MANAGEMENT**	**9**	**0**	**0**	**9**

Role of managers. Functions approach to management, Management functions, Management levels –, reconciling functions and role, responsibility of managers – towards subordinates, peers, supervisors, customers, government, company, creditors, shareholders, competitors etc.

UNIT III	**MANAGERIAL PLANNING AND DECISION MAKING**	**9**	**0**	**0**	**9**

Planning fundamentals, objectives. Management by objectives – Changes in objectives – goal distortions – major types of planning, policies and objectives, procedures – methods, rules, programmes and schedule, projects, budgets – importance of decision making, types of decisions, decision making process – decision theory – quantitative techniques – decision making conditions – Operation Research (OR), Definition, successful areas of operation research - Decision tree.

UNIT IV	**ORGANIZATION**	**9**	**0**	**0**	**9**

Organization: Basic concepts – organization as a structure – as a process – as a group property of modern organization – typology, importance of organization – business /industrial organization – sole trading, partnership company, co – operative, public enterprise line (military), line and staff, functional, matrix committee-based organization - departmentalization – need, bases of departmentation – career planning and management.

UNIT V	**STAFFING, CONTROLLING AND COMMUNICATION**	**9**	**0**	**0**	**9**

Nature and purpose of staffing – man power planning, aims and objectives of HR recruitment, selection and training sources of recruitment, process of recruitment, training methods – performance appraisal methods – communication – importance process – barriers to communications. How to remove obstacles of effective communication – controlling – definition – Characteristics of control – types of control – requirements of effective control – direct and preventive control repairing, control techniques.

Total (45L) = 45Periods

REFERENCE BOOKS:

1	HeraldknootzandHeinzweihrich,EssentialsofManagement‖,McGraw-HillPublishingCompany, SingaporeInternationalEdition,2007
2	JosephL,Massie,EssentialsofManagement. PrenticeHallofIndiaPvt.,Ltd(Pearson)FourthEdition, 2003.
3	StephenA. Robbins &David A. Decenzo &Mary Coulter, “Fundamentals of Management”

	7thEdition,PearsonEducation,2011.
4	RobertKreitner&MamataMohapatra,"Management",Biztantra,2008.
5	HaroldKoontz &HeinzWeihrich"Essentialsof management"TataMcGrawHill,1998.
6	TripathyPC &ReddyPN,"Principles of Management", Tata McGrawHill, 1999.
7	R.S.N. Pillai&S. Kala "Principles and Practice of Management", S Chand & company, 2014.
E-REFERENCES:	
1.	https://nptel.ac.in/courses/110105146
2.	https://nptel.ac.in/courses/122106031

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the basic concept so management	Understand
CO2	Familiarize the contribution sand functions, types of business organization	Understand
CO3	List the various types of leadership and evaluate the motivation the oriesand techniques.	Evaluate
CO4	Select forecasting models for future demands and to make decision in the management processes.	Evaluate

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	0	0	0	0	0	0	1	3	1	0	2	2	1	1
CO2	0	0	0	0	0	0	1	1	2	0	3	2	1	1
CO3	0	0	0	0	0	0	0	1	2	0	1	1	1	1
CO4	0	0	0	0	0	0	2	1	2	0	2	1	1	1
Avg	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1.5**	**1.75**	**0**	**2**	**1.5**	**1**	**1**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEOE06	PROFESSIONAL ETHICS IN ENGINEERING		SEMESTER VI/VIII			
		CATEGORY	OE	Credit		3
		Horus/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES

1	To create awareness on Engineering Ethics and providing basic knowledge about engineering Ethics, Variety of moral issues and Professional Ideals.
2	To provide basic familiarity about Engineers as responsible Experimenters, Codes of Ethics, Industrial Standards.
3	To inculcate knowledge and exposure on Safety and Risk, Risk Benefit Analysis.

UNITI	HUMAN VALUES	9	0	0	9

Morals, Values and Ethics – Integrity – Work Ethic – Service Learning – Civic Virtue – Respect for Others – Living Peacefully – caring – Sharing – Honesty – Courage – Valuing Time – Co-operation – Commitment – Empathy – Self-Confidence – Character – Spirituality.

UNITII	ENGINEERING ETHICS	9	0	0	9

Senses of 'Engineering Ethics' - variety of moral issued - types of inquiry - moral dilemmas - moral autonomy - Kohlberg's theory - Gilligan's theory - consensus and controversy – Models of Professional Roles - theories about right action – Self-interest- customs and religion - uses of ethical theories.

UNITIII	ENGINEERING AS SOCIAL EXPERIMENTATION	9	0	0	9

Engineering as experimentation - engineers as responsible experimenters - codes of ethics - a balanced outlook on law – the challenger case study.

UNITIV	SAFETY, RESPONSIBILITIES AND RIGHTS	9	0	0	9

Safety and risk - assessment of safety and risk - risk benefit analysis and reducing risk - the three-mile island and Chernobyl case studies. Collegiality and loyalty - respect for authority - collective bargaining - confidentiality - conflicts of interest – occupational crime - professional rights - employee rights - Intellectual Property Rights (IPR) - discrimination.

UNITV	GLOBAL ISSUES	9	0	0	9

Multinational corporations - Environmental ethics - computer ethics - weapons development - engineers as managers consulting engineers-engineers as expert witnesses and advisors -moral leadership-sample code of Ethics like ASME,ASCE, IEEE, Institution of Engineers (India), Indian Institute of Materials Management, Institution of electronics and telecommunication engineers (IETE),India.

Total(45L) = 45Periods

REFERENCE BOOKS:

1	Mike Martin and Roland Schinzinger, "Ethics in Engineering", McGraw-Hill, New York 2005.
2	Govindarajan M, Natarajan S, Senthil Kumar V. S, "Engineering Ethics", Prentice Hall of India, New Delhi, 2004.
3	Tripathi A N, "Human values", New Age international Pvt. Ltd., New Delhi, 2002.
4	Charles D. Fleddermann, "Engineering Ethics", Pearson Education / Prentice Hall, New Jersey, 2004.
5	Charles E Harris, Michael S. Protchard and Michael J Rabins, "Engineering Ethics – Concepts and Cases", Wadsworth Thompson Learning, United States, 2000.

6	John R Boatright, “Ethics and the Conduct of Business”, Pearson Education, New Delhi, 2003.
7	R S Naagarazan, “A Textbook on Professional Ethics and Human Values” New age international (p) limited, publishers, New Delhi – 110002, 2006.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the importance of ethics and values in life and society.	Understand
CO2	Understood the core values that shape the ethical behavior of an engineer.	Understand
CO3	Exposed awareness on professional ethics and human values.	Remember

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	0	0	0	0	0	2	1	3	2	0	1	0	0	1
CO2	0	0	0	0	0	1	1	3	1	0	1	0	0	1
CO3	0	0	0	0	0	2	1	3	1	0	1	0	0	1
Avg	**0**	**0**	**0**	**0**	**0**	**1.66**	**1**	**3**	**1.33**	**0**	**1**	**0**	**0**	**1**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEOE07	RENEWABLE SOURCES OF ENERGY	SEMESTER VI/VIII			
PRE-REQUISITE: 1. Basic idea about solar radiation and other renewable energy that exists.	**CATEGORY**	**OE**	**Credit**		**3**
2. Understanding about various chemical reactions occur in the process	**Horus/Week**	**L**	**T**	**P**	**TH**
		3	**0**	**1**	**4**

COURSEOBJECTIVES	
1.	To recognize the consciousness of energy conservation in scholars
2.	To identify the employ of renewable energy sources for electrical power generation
3.	To collect different energy storage methods
4.	To detect about environmental effects of energy conversion

UNITI	**SOLAR RADIATION AND ITS MEASUREMENTS**	**9**	**0**	**0**	**9**
Alternative energy sources, Global and Indian energy scenario. Solar Energy: Introduction – Solar Radiation Measurement and Instruments – Data and estimation.					
UNITII	**SOLAR ENERGY COLLECTORS, SOLAR ENERGY STORAGE AND APPLICATIONS OF SOLAR ENERGY**	**9**	**0**	**0**	**9**
Flat Plate and Concentrating Collectors –Solar direct Thermal Applications – Solar thermal Power Generation – Fundamentals of Solar Photo Voltaic Conversion – Solar Cells – Solar PV Power Generation –Solar Energy Storage: Thermal energy, Chemical Energy and Electromagnetic energy storage; Solar PV Applications: Solar water heating, Space heating and cooling, Solar distillation, Solar pumping, Solar furnace, Solar cooking.					
UNITIII	**BIOMASS AND ITS CONVERSION TECHNOLOGIES**	**9**	**0**	**0**	**9**
Bio-mass conversion Techniques: Direct combustion (incineration); Thermo-chemical conversion-Gasification and its types; Wet Process- Classification of biogas plant- types of Anaerobic digestion (Khadi and Village Industries type, Pragati design, Gasnesh biogas plant and Ferro-cement digester biogas plant) – Fermentation process;					
UNITIV	**WIND, GEOTHERMAL AND TIDAL ENERGY**	**9**	**0**	**0**	**9**
Basic principle of wind energy conversion, types of wind energy conversion; Geothermal sources – hydrothermal geothermal resources, geopressurised resources, hot dry rock resources of petrothermal systems, Magma resources – Comparison of flashed steam and total flow concept. Basic principle of tidal power, components of tidal power plants, operation methods of utilization of tidal power.					
UNITV	**CHEMICAL ENERGY, HYDROGEN ENERGY AND MAGNETO HYDRO DYNAMIC**	**9**	**0**	**0**	**9**
Design and principle operation of a Fuel cells, classification of fuel cells, types of fuel cells, Advantages, disadvantages and applications of fuel cells. Basic principle of Magneto Hydro Dynamic – Open cycle and closed cycle system.					
Total (45L) = 45Periods					

REFERENCE BOOKS:	
1	G.D. Rai, "Non-Conventional Energy Sources", Khanna Publishers, New Delhi, 2014.
2	Suhas P. Sukhatme, “Solar Energy”, Tata McGraw Hill Publishing Company Ltd., 2007.
3	Khan, B.H., "Non-Conventional Energy Resources", The McGraw Hill Companies, 2009.
4	Twidell, J.W. & Weir, A., "Renewable Energy Resources", EFN Spon Ltd., UK, 2005.
5	Solanki: Renewable Energy Technologies: Practical Guide for Beginners, PHI Learning Pvt.Ltd., 2008

6	D. Mukherjee: Fundamentals of Renewable Energy Systems, New Age International publishers, 2007.
7	Gilbert M. Masters: Renewable and Efficient Electric Power Systems, John Wiley & Sons, 2004.
E-REFERENCES:	
1.	https://en.wikipedia.org/wiki/Renewable_energy
2.	Ellabban, Omar; Abu-Rub, Haitham; Blaabjerg, Frede (2014). "Renewable energy resources: Current status, future prospects and their enabling technology". Renewable and Sustainable Energy Reviews. 39: 748–764 [749]

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the principles ofsolar radiation and its measuring devices	Understand
CO2	Comprehend the ideology of solar energy collectors, solar photovoltaic power generationsolar energy storage and applications of solar energy	Analyze
CO3	Acquire awareness about biomass sources of energy technologies	Understand
CO4	Design various renewable energy gadgets such as wind and tidal plant	Create
CO5	Learn about extracting energy from chemical methods	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	1	2	3	2	1	0	2	2	3	1	1	2	2	1
CO2	1	2	3	2	1	0	2	2	3	1	1	2	2	1
CO3	0	2	3	2	1	0	2	2	3	1	1	2	2	1
CO4	1	2	3	2	0	0	2	2	3	1	1	2	2	1
CO5	1	2	3	2	1	0	2	2	3	1	1	2	2	1
Avg	**0.8**	**2**	**3**	**2**	**1**	**0**	**2**	**2**	**3**	**1**	**1**	**2**	**2**	**1**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

2MEOE08	ROBOTIC PROCESS AUTOMATION	SEMESTER VI/VIII			
Pre-requisite:	**CATEGORY**	**OE**	**Credit**		**3**
1. Basics in kinematics and dynamics	**Hours/Week**	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

COURSEOBJECTIVES

1.	To study the various parts of robots and fields of robotics.
2.	To study the various kinematics and inverse kinematics of robots.
3.	To study the Euler, Lagrangian formulation of Robot dynamics.
4.	To study the trajectory planning for robot.
5.	To study the control of robots for some specific applications

UNITI	**BASIC CONCEPTS**	**9**	**0**	**0**	**9**

Definition and origin of robotics – different types of robotics – various generations of robots – degrees of freedom – Asimov‟s laws of robotics – dynamic stabilization of robots.

UNITII	**POWER SOURCES AND SENSORS**	**9**	**0**	**0**	**9**

Hydraulic, pneumatic and electric drives – determination of HP of motor and gearing ratio – variable speed arrangements – path determination – micro machines in robotics – machine vision – ranging – laser – acoustic – magnetic, fiber optic and tactile sensors

UNITIII	**MANIPULATORS, ACTUATORS AND GRIPPERS**	**9**	**0**	**0**	**9**

Construction of manipulators – manipulator dynamics and force control – electronic and pneumatic manipulator control circuits – end effectors – U various types of grippers – design considerations.

UNITIV	**KINEMATICS AND PATH PLANNING**	**9**	**0**	**0**	**9**

Solution of inverse kinematics problem – multiple solution jacobian work envelop – hill Climbing Techniques – robot programming languages

UNITV	**CASE STUDIES**	**9**	**0**	**0**	**9**

Multiple robots – machine interface – robots in manufacturing and non- manufacturing applications – robot cell design – selection of robot.

Total (45L) = 45Periods

REFERENCE BOOKS:

1	Mikell P. Weiss G.M., Nagel R.N., Odraj N.G., “Industrial Robotics”, Mc Graw-Hill Singapore, 1996.
2	Ghosh, Control in Robotics and Automation: Sensor Based Integration, Allied Publishers, Chennai, 1998.
3	Deb. S.R.,“Robotics Technology and flexible Automation”, John Wiley, USA 1992.
4	Klafter R.D., Chimielewski T.A., Negin M., “Robotic Engineering – An integrated approach”, Prentice Hall of India, New Delhi, 1994.
5	Barry Leatham – Jones, “Elements of industrial Robotics” PITMAN Publishing, 1987.
6	Mikell P.Groover, Mitchell Weiss, Roger N.Nagel Nicholas G.Odrey, “Industrial Robotics Technology, Programming and Applications “, McGraw Hill Book Company 1986.
7	Fu K.S. Gonzaleaz R.C. and Lee C.S.G., “Robotics Control Sensing, Vision and Intelligence” McGraw Hill International Editions, 1987.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Explain the basic concepts of working of robot.	Understand
CO2	Analyze the function of sensors in the robot.	Analyze
CO3	Analyze the working of manipulates, actuators and grippers.	Analyze
CO4	Write program to use a robot for a typical application.	Create
CO5	Use robots in different applications.	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	2	0	2	0	0	0	0	1	0	2	2	2
CO2	1	3	2	1	1	0	0	0	0	0	0	2	1	3
CO3	0	2	2	1	1	0	0	0	0	0	0	2	1	3
CO4	0	1	1	2	3	0	0	1	3	2	1	2	0	0
CO5	0	1	2	2	2	1	2	2	3	2	1	2	0	0
Avg	**1**	**1**	**2**	**1.4**	**2**	**0.2**	**0.4**	**0.6**	**1.2**	**1**	**0.4**	**2**	**2**	**2**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEOE09	TOTAL QUALITY MANAGEMENT	SEMESTER VI/VIII			
	CATEGORY	OE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

COURSEOBJECTIVES

1.	Teach the need for quality, its evolution, basic concepts, contribution of quality gurus, TQM framework, Barriers and Benefits of TQM.
2.	Explain the TQM Principles for application.
3.	Define the basics of six sigma and apply traditional tools, new tools, Benchmarking and FMEA.
4.	Describe Taguchi's Quality Loss Function, Performance measures and apply techniques like QFD, TPM, COQ and BPR.
5.	Illustrate and apply QMS and EMS in any organization.

UNITI	INTRODUCTION	9	0	0	9

Definition of Quality - Dimensions of Quality - Quality planning - Quality costs, Analysis techniques for quality costs- Basic concepts of total quality management (TQM)-Historical review- Principles of TQM- Leadership- Roleofseniormanagement-Qualitycouncil,Qualitystatements- Strategic planning- Deming philosophy-Barriers to TQM implementation

UNITII	TQM PRINCIPLES	9	0	0	9

Customer satisfaction - Customer perception of quality, Customer complaints, Service quality, Customer Retention, Employee involvement - Motivation, Empowerment, Teams, Recognition and reward, Performance appraisal - Continuous process improvement – Juran Trilogy, PDSA Cycle, 5S, Kaizen - Supplier Partnership, Sourcing, Supplier selection, Supplier rating, Relationship development - Performance measures, Basic concepts, Strategy

UNITIII	STATISTICAL PROCESS CONTROL (SPC)	9	0	0	9

The seven tools of quality, Statistical fundamentals – Measures of central tendency and dispersion, Population and sample, Normal curve - Control charts for variables and attributes, Process capability - Concept of six sigma, new seven Management tools.

UNITIV	TQM TOOLS	9	0	0	9

Benchmarking – Reasons to benchmark, Benchmarking process, Quality function deployment (QFD) process – House of quality, Benefits - Taguchi quality loss function - Total productive maintenance (TPM) concept, Improvement needs - FMEA – Stages of FMEA.

UNITV	QUALITY MANAGEMENT SYSTEMS	9	0	0	9

Need for ISO 9000 and other quality systems, benefits of ISO registration, ISO 9001:2008 quality system – Elements, Implementation of quality system, Documentation, Quality auditing, AS 9100,TS 16949:2002 and TL 9000

Total (45L) = 45Periods

REFERENCE BOOKS:

1	Dale H.Besterfiled, Carol B.Michna,Glen H. Bester field,MaryB.Sacre,HemantUrdhwareshe and RashmiUrdhwareshe, “Total Quality Management”, Pearson Education Asia, Revised Third Edition, Indian Reprint, Sixth Impression,2013.
2	Feigenbaum.A.V. “Total Quality Management”, McGraw Hill, 1991.

3	Joel.E. Ross, “Total Quality Management – Text and Cases”,Routledge.,2017.
4	Kiran.D.R, “Total Quality Management: Key concepts and case studies, Butterworth – Heinemann Ltd, 2016.
5	Oakland, J.S. “TQM – Text with Cases”, Butterworth – Heinemann Ltd., Oxford, Third Edition, 2003.
6	Suganthi,L and Anand Samuel, “Total Quality Management”, Prentice Hall (India) Pvt. Ltd., 2006
7	Narayana V and Sreenivasan, N.S, “Quality Management – Concepts and Tasks”, New Age International,1996.
E-REFERENCES:	
1.	https://www.oreilly.com/library/view/total-quality-management/9780815330486/xhtml/Reference1.xhtml
2.	https://www.sanfoundry.com/best-reference-books-total-quality-management/
3.	https://www.routledge.com/Total-Quality-Management-TQM-Principles-Methods-and-Applications/Luthra-Garg-Agarwal-Mangla/p/book/9780367512835

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Ability to apply TQM concepts in a selected enterprise.	Apply
CO2	Ability to apply TQM principles in a selected enterprise.	Apply
CO3	Ability to understand Six Sigma and apply Traditional tools, new tools, Benchmarking and FMEA.	Understand
CO4	Ability to understand Taguchi's Quality Loss Function, Performance Measures and apply QFD, TPM, COQ and BPR.	Understand
CO5	Ability to apply QMS and EMS in any organization.	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	1	3	0	0	2	0	1	0	2	0	0	2	1	2
CO2	1	2	0	0	0	0	0	0	2	0	0	2	0	0
CO3	1	2	2	0	1	0	0	1	0	0	0	2	1	0
CO4	1	2	0	0	2	3	0	2	0	3	0	2	2	2
CO5	1	2	2	0	2	2	1	2	2	3	0	2	2	2
Avg	**1**	**2.2**	**0.8**	**0**	**1.4**	**1**	**0.4**	**1**	**1.2**	**1.2**	**0**	**2**	**1.2**	**1.2**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

PROFESSIONAL ELECTIVE COURSES – VERTICALS

VERTICAL 1 – CLEAN AND GREEN ENERGY TECHNOLOGY

22MEHO101	HYDROGEN AND FUEL CELL TECHNOLOGIES					
		CATEGORY	PE	Credit		C
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES	
1	To study in detail on the hydrogen production methodologies, possible applications and various storage options
2	To understand the working principle of atypical fuel cell, its types and to elaboration its thermodynamics and kinetics
3	To study the cost effectiveness and eco-friendliness of Fuel Cells

UNITI	INTRODUCTION	9	0	0	9
Hydrogen–physical and chemical properties, salient characteristics, Production of hydrogen – steam reforming–water electrolysis–gasification–biological hydrogen production–photo dissociation– direct thermal or catalytic splitting of water.					
UNITII	**HYDROGENSTORAGE**	**9**	**0**	**0**	**9**
Hydrogenstorageoptions–compressedgas–liquidhydrogen–Hydride–chemicalStorage– comparisons, safety and management of hydrogen.					
UNITIII	**FUELCELLS**	**9**	**0**	**0**	**9**
History–principle-working-thermodynamicsandkineticsoffuelcellprocess–performance evaluation of fuel cell– comparison on battery Vs fuel cell.					
UNITIV	**FUELCELL–TYPES**	**9**	**0**	**0**	**9**
Types of fuel cells–AFC, PAFC,SOFC, MCFC, DMFC, PEMFC– Relative merit sand demerits.					
UNITV	**APPLICATIONOFFUELCELLANDECONOMICS**	**9**	**0**	**0**	**9**
Fuel cell usage for domestic power systems, large scale power generation, Auto mobile, Space, Economic and environmental analysison usage of Hydrogen and Fuel cell, Future trendsin fuel cells.					
Total (45L) = 45Periods					

REFERENCE BOOKS:	
1	ViswanathanB.andAuliceScibioh.M,FuelCells–Principlesand Applications,UniversitiesPress,2006
2	RebeccaL.andBusby,HydrogenandFuelCells:AComprehensiveGuide,Penn WellCorporation,Oklahoma,2005
3	BentSorensen(Sorensen),HydrogenandFuelCells:EmergingTechnologies andApplications,Elsevier,UK2005
4	KordeschK.AndG.Simader,FuelCellandtheirApplications,Wiley-Vch,Germany1996
5	HartA.B.andG.J.Womack,FuelCells:TheoryandApplication,PrenticeHall,NewYorkLtd., London1989
6	JeremyRifkin,TheHydrogenEconomy,PenguinGroup,USA2002
7	BarclayF.J.,FuelCells,EnginesandHydrogen,Wiley,2009

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Describe and analyze the techniques of Hydrogen generation	Analyze
CO2	Describe and classify various options for Hydrogen storage	Analyze
CO3	Explain the principal operations of fuel cell, its thermodynamics and kinetics	Understand
CO4	Comprehendthedifferenttypesoffuelcellscomparetheirmeritsanddemerits	Understand
CO5	Identify the potential application of a fuel cells for domestic ,automotive, spacecraft power generations and evaluate the techno-economics of a fuel cells	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	0	0	1	0	0	0	0	0	0	0	1	1
CO2	3	2	0	0	1	0	0	0	0	0	0	0	1	1
CO3	3	2	1	1	1	0	1	0	0	0	0	0	1	1
CO4	3	3	1	2	1	1	1	0	0	0	0	0	1	1
CO5	3	2	1	1	2	2	1	0	0	0	0	1	1	1
Avg	**3**	**2.2**	**0.6**	**0.8**	**1.2**	**1.5**	**0.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.2**	**1**	**1**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEHO102	THERMAL MANAGEMENT OF ELECTRIC VEHICLE BATTERY SYSTEMS					
		CATEGORY	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES

1	To know Thermal Management of Electric Vehicle Battery Systems
2	To recognize the applications of PC Min Thermal Management
3	To investigate the Thermal be haviorsin Electric Vehicle Battery Systems through Simulation and Experimental
4	To calculate the Energy and Exergy Analyses of Battery TMSs
5	ToobtainsolutionsforcaseStudiesonThermalManagementSolutionsofElectricbatteries

UNITI	INTRODUCTION	9	0	0	9

Introduction, Current Battery Technologies: Lead Acid Batteries, Nickel Cadmium Batteries, Nickel Metal Hydride Batteries, Lithium-Ion Batteries, Battery Environmental Impact, Battery Management Systems, Safety Management/Fault Diagnosis/Thermal Management.

UNITII	PHASECHANGEMATERIALSFORTHERMALMANAGEMENT SYSTEMS	9	0	0	9

Basic Properties and Types of PCMs, Organic PCMs, Inorganic PCMs ,Measurement of Thermal Properties of PCMs ,Heat Transfer Enhancements, Environmental Impact of Phase Change Materials, Applications of PCMs.

UNIT III	SIMULATION AND EXPERIMENTAL NVESTIGATION OF BATTERY TMS	9	0	0	9

numerical Model Development for Cell and Sub modules, Cell and Module Level Experimentation Set Up and Procedure, Vehicle Level Experimentation Set Up and Procedure, Illustrative, Simulation and Experimentations on the liquid battery TMS using PCMs

UNITIV	ENERGYANDEXERGYANALYSESOFBATTERYTMS	9	0	0	9

TMS Comparison, Mode ling of Major TMS Components ,Energy and Exergy Analyses, Illustrative Example: Liquid Battery Thermal Management Systems

UNITV	CASE STUDIESONTHERMALMANAGEMENT SOLUTIONSOF ELECTRIC BATTERIES	9	0	0	9

Case Study1:Experimental and Theoretical Investigation of Temperature Distributions in a Prismatic Lithium- Ion Battery.

CaseStudy2: Thermal Management Solutions for Electric Vehicle Lithium-Ion Batteries based on Vehicle Charge and Discharge Cycles

Total (45L) = 45Periods

REFERENCE BOOKS:

1	IbrahimDinçer,HalilS.Hamut,NaderJavani,ThermalManagement ofElectricVehicle BatterySystems,C,2017
2	Halil S.Hamut,NaderJavani,IbrahimDinçer,Thermal Management ofElectricVehicle BatterySystems,Wiley,2016
3	WeixiangShen,RuiXiong,AdvancedBatteryManagementTechnologiesforElectric Vehicles,JohnWileyandsons,Firstedition2019
4	ChitraA.,SanjeevikumarPadmanaban,JensBoHolm-Nielsen,ArtificialIntelligentTechniques

	forElectricandHybridElectricVehicles,JohnWileyandsons,Firstedition2020
5	BrunoScrosati, JurgenGarche,WernerTillmetz,AdvancesinBatteryTechnologiesfor ElectricVehicles,WoodheadPublishing,2015

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Describeandanalyzethetechniquesofthermalmanagementofelectricvehiclebatterysystems	Analyze
CO2	Describe and classify various applications of PC Min thermal management	Understand
CO3	Investigate the thermal behaviour sin electric vehicle battery systems through simulation and experimental.	Analyze
CO4	Calculate the energy and exergy analyses of battery TMSS	Analyze
CO5	Identifythesolutionsforcasestudiesonthermalmanagementsolutionsofelectricbatteries	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	0	0	2	0	1	0	0	0	0	0	1	0	0
CO2	3	2	1	0	1	0	1	0	0	0	1	0	2	0	0
CO3	3	2	2	3	1	0	1	0	0	0	1	0	2	0	0
CO4	3	2	1	2	1	1	0	0	0	0	1	0	2	0	0
CO5	3	3	0	0	1	2	1	1	1	1	1	0	2	0	0
Avg	**2.8**	**2.2**	**0.8**	**1**	**1.2**	**0.6**	**0.8**	**0.2**	**0.01**	**0.01**	**0.04**	**0.0**	**1.8**	**0.0**	**0.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEHO103	ELECTRIC AND HYBRID VEHICLE TECHNOLOGY				
	CATEGORY	PE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

COURSE OBJECTIVES

1	To introduce the concept of hybrid and electric drive trains
2	Toelaborateonthetypesandutilizationofhybridandelectricdrivetrains
3	To exposeon different types of AC and DC drives for electric vehicles
4	To understand and utilize different types of energy storage systems
5	To introduce concept of energy management strategies and drive sizing

UNIT I	INTRODUCTION	9	0	0	9

Basics of vehicle performance, vehicle power source characterization, transmission characteristics, History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles

UNIT II	HYBRID ELECTRIC DRIVE TRAINS	9	0	0	9

Basic concept of hybridtraction, introduction to various hybrid drive-train to pologies, power flow controlin hybriddrive-traintopologies,fuel efficien cyanalysis.ElectricDrive-trains:Basicconceptofelectrictraction, introduction to various electric drive-traintopologies, power flow control in electricdrive-train.

UNIT III	CONTROLOFAC&DCDRIVES	9	0	0	9

Introduction to electric components used in hybrid and electric vehicles, Configuration and control– DC Motor drives, Induction Motor drives, Permanent MagnetMotordrive,and SwitchReluctanceMotordrives, drivesystem efficiency

UNIT IV	ENERGYSTORAGE AND DRIVE SIZING	9	0	0	9

Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Energy storage and it sanalysis, Hybridization of different energy storage devices, Sizing the drive system: Matching the electric machine and the internalcombustionengine(ICE),Sizingthepropulsionmotor,sizingthepowerelectronics,selectionof appropriate energy storage technology

UNIT V	ENERGY MANAGEMENTSTRATEGIES	9	0	0	9

EnergyManagementStrategies:Introductiontoenergymanagementstrategiesusedinhybridandelectricvehicles,classificationa ndcomparisonofenergymanagementstrategies,implementationissues

Total(45L) = 45 Periods

REFERENCE BOOKS:

1	IqbalHussein,ElectricandHybridVehicles:DesignFundamentals,CRC press,2003
2	JamesLarminie,johnlowry,ElectricVehicleTechnologyExplained,Wiley,2003
3	MehrdadEhsani, YimiGao, SebastianE. Gay,AliEmadi, ModernElectric,HybridElectric andfuelcellvehicles: Fundamentals,theoryanddesign, CRC press,2004
4	Randd.A.J,Woods,R&dellrmbatteriesforelectricvehicles,johnwiley&Sons,1998

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Characterize and configure hybrid drive trains requirement for a vehicle	Understand
CO2	Design and apply appropriate hybrid and electric drive train sina vehicle	Create
CO3	Design and install suitable AC and DC drives for electric vehicles	Create
CO4	Arrive at a suitable energy storage system for a hybrid/electric vehicle	Understand
CO5	Apply energy management strategiestoen sure better economy and efficiency	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	0	1	1	1	0	0	0	0	0	0	0	1
CO2	3	2	2	0	1	1	0	1	1	0	0	0	0	0	2
CO3	3	1	3	1	2	1	1	2	0	1	0	0	0	0	2
CO4	2	3	1	1	1	1	1	1	0	1	2	0	0	1	1
CO5	3	2	0	0	1	1	1	0	0	2	1	2	0	1	1
Avg	**2.8**	**2**	**1.6**	**0.4**	**1.2**	**1**	**1**	**0.8**	**0.2**	**0.8**	**0.6**	**0.4**	**0.0**	**0.4**	**1.4**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEHO104	ALTERNATE FUELS FORICENGINES					
		CATEGORY	PE	Credit		C
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES

1	To expose potential alternate fuels and their characteristics
2	Touseappropriatesyntheticfuelsandfueladditivesforbettercombustioncharacteristics
3	To utilize alcohol fuels effectively for low emissions
4	ToelaborateontheutilizationofBio-Dieselanditstypesasasuitablefuelin CIengines
5	To utilize different gaseousfuelsandpredicttheirperformanceandcombustioncharacteristics

UNIT I	INTRODUCTION	9	0	0	9

Availability, Need, Suitability,Properties,MeritsandDemeritsofPotentialAlternativeFuels– Alcohols, Bio- Diesel, Hydrogen, Liquefied Petroleum Gas, Natural Gas, Biogas, Fuel standards Fuel standards–ASTM&EN

UNIT II	SPECIAL AND SYNTHETIC FUELS	9	0	0	9

Different synthetic fuels, Merits and demerits, Dual, Bi-fuel and Pilot inject defuel systems, Fuel additives– types and their effect on performance and emission characteristics of engines,Ethers– asfuelandfueladditives,propertiesandcharacteristics

UNIT III	ALCOHOL FUELS	9	0	0	9

Alcohols–Properties, Production methods and usage in engines. Performance, combustion and emission Characteristics in engines. Issues & limitation in alcohols

UNIT IV	BIO-DIESEL FUELS	9	0	0	9

Vegetable oils and their important properties. Fuel properties characterization. Methods of using vegetable oils– Blending,preheating,Transesterificationandemulsification–Performance,combustion and emission Characteristics in diesel engines

UNIT V	GASEOUS FUELS	9	0	0	9

Biogas, Natural gas, LPG, Hydrogen–Properties, problems, storage and safety spects. Methods of utilization in engines. Issues &limitation in Gaseous fuels

Total (45L) = 45 Periods

REFERENCE BOOKS:

1	KeithOwenandtrevoreoley,AutomotiveFuelsHandbook,SAE publications,1990
2	PundirB.P,I.C.EnginesCombustionandEmission,2010, Narosapublishinghouse
3	PundirB.P,EngineCombustionandEmission,2011, Narosapublishinghouse, Keith
4	Richardl.Bechtold,AutomotiveFuelsguidebook, SAE publications,1997

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		Bloom Taxonomy Mapped
CO1	Analyze potential alternate fuels and their characteristics	Analyze
CO2	Useappropriatesyntheticfuelsandfueladditivesforbettercombustioncharacteristics	Understand
CO3	Describethepropertiesofalcoholfuelandestimatetheperformanceofalcoholfuelsand its emissions	Understand
CO4	Explainthepropertiesandcombustionandemissioncharacteristicsofbio-diesel	Understand
CO5	Explain different gaseous fuels and predicttheir performance and combustion characteristics	Understand

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	0	1	1	1	0	0	0	0	0	0	3	2
CO2	3	2	1	1	0	1	0	0	0	0	1	0	2	2
CO3	2	3	2	1	1	0	1	0	0	1	0	0	2	2
CO4	2	1	1	1	1	1	1	0	1	0	2	0	0	2
CO5	1	0	0	0	0	2	0	0	0	2	1	0	0	0
Avg	**2.2**	**1.8**	**0.8**	**0.8**	**0.6**	**1**	**0.4**	**0.0**	**0.2**	**0.6**	**0.8**	**0.0**	**1.4**	**1.6**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEHO105	ADVANCED ENERGY STORAGE TECHNOLOGIES				
	CATEGORY	PE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

COURSE OBJECTIVES

1	Tounderstandthevarioustypesofenergystoragetechnologiesanditsapplications
2	Tostudythevariousmodelingtechniquesofenergystoragesystemsusing TRNSYS
3	To learn the concepts and types of batteries
4	TomakethestudentstogetunderstandtheconceptsofHydrogenandBiogasstorage
5	To provide the insight son Fly wheel and compressed energy storage systems

UNITI	INTRODUCTION	9	0	0	9

Necessityofenergystorage–typesofenergystorage–comparisonofenergystoragetechnologies–Applications

UNIT II	THERMAL STORAGE SYSTEM	9	0	0	9

Thermal storage–Types–Modelling of thermal storage units–Simple water and rock bed storage system– pressurized water storage system–Modelling of phase change storage system–Simple units, packed bed storage units

UNIT III	ELECTRICAL ENERGY STORAGE	9	0	0	9

Fundamentalconceptofbatteries–measuringofbatteryperformance,charginganddischargingofa battery,storagedensity,energydensity,andsafetyissues.Typesofbatteries–LeadAcid,Nickel–Cadmium,Zinc Manganese di oxide and Lithium Battery

UNIT IV	HYDROGEN AND BIOGAS STORAGE	9	0	0	9

Hydrogenstorage options–compressed gas–liquid hydrogen–MetalHydrides,chemicalStorage,Biogas storage-comparisons.Safety and management of hydrogen and Bio gas storage- Applications

UNIT V	ALTERNATE ENERGY STORAGE TECHNOLOGIES	9	0	0	9

Flywheel,Supercapacitors,Principles&Methods–Applications,CompressedairEnergystorage,ConceptofHybridStorage–Applications

Total(45L) = 45 Periods

REFERENCE BOOKS:

1	IbrahimDincerandMark A.Rosen, ThermalEnergyStorageSystemsand Applications, JohnWiley&Sons2002
2	JamesLarminieandAndrewDicks,FuelcellsystemsExplained,Wileypublications,2003
3	LuisaF.Cabeza,AdvancesinThermalEnergyStorageSystems:Methodsand Applications,ElsevierWoodheadPublishing,2015
4	RobertHuggins,EnergyStorage:Fundamentals,MaterialsandApplications,2ndedition, Springer,2015
5	Ru-shiliu,Leizhang,Xueliangsun,electrochemicaltechnologiesforenergystorageand conversion,Wileypublications,2012

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		Bloom Taxonomy Mapped
CO1	Identify the energy storage technologies for suitable applications	Analyze
CO2	Analyze the energy storage systems	Analyze
CO3	Recognize the concept sand types of batteries	Understand
CO4	Diagnose the principle of operations of Hydrogen and Bio gas storage	Understand
CO5	Analyze the concepts of Fly wheel and compressed energy storage systems	Analyze

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	0	0	1	1	0	1	0	0	0	0	3	1
CO2	2	3	1	1	1	0	1	0	1	0	0	0	0	0
CO3	3	2	0	1	0	0	1	1	0	0	1	0	3	0
CO4	3	1	2	1	1	2	1	0	0	2	0	0	1	1
CO5	2	3	1	1	0	0	0	0	1	0	0	0	0	1
Avg	**2.6**	**2.2**	**0.8**	**0.8**	**0.6**	**0.6**	**0.6**	**0.4**	**0.4**	**0.4**	**0.2**	**0.0**	**1.4**	**0.6**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEHO106	SOLAR POWER PLANTS					
		CATEGORY	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES

1	Toexplainconceptofvariouspowercyclesinvolvedinthesolarpowerplants
2	To learn and study the solar adiation and various solar power plants
3	To outline the variety of solar systems used to collect solar energy
4	To learn electrical performance of PV power plants
5	To summarize basic economics of solar power plants

UNITI	**INTRODUCTION**	**9**	**0**	**0**	**9**
PowerPlantScenario-Classification,BasicPrinciplesandFeatures-Comparisonandselection Criteria					
UNITII	**SOLARPOWERCYCLES**	**9**	**0**	**0**	**9**
Vapourcycles–Organiccycles–CombinedCycles–BinaryCycles–StirlingCycle–BraytonCycle– Ericsson Cycle					
UNIT III	**SOLAR THERMAL POWER PLANTS**	**9**	**0**	**0**	**9**
Collector, Receiver, Energy Transfer Power cycles-Tower, Trough and Dish Systems- Concentrating Dish Systems - Solar Chimneys – Hybrid Systems					
UNIT IV	**SOLAR PV POWER PLANTS**	**9**	**0**	**0**	**9**
InternationalPVPowerProgrammes-PhotovoltaicPowerSystems-SystemIntegration–EnergyStorage - Power Electronics - Stand-Alone Systems - Grid-Connected Systems –Electrical Performance.					
UNIT V	**ECONOMICS OF POWER PLANTS**	**9**	**0**	**0**	**9**
Methods of fixing power tariff –Simple Methods to Calculate the Plant Economy –Life Cycle Cost - Payback Period - Economic Analysis for the Selection of Alternative Decisions and the future of the Power Plants					
Total(45L): 45Periods					

REFERENCE BOOKS:

1	Duffie, J.A., and Beckman, W.A. Solar Energy Thermal Process, John Wiley and Sons, NewYork,2006
2	Kosuke Kurokawa (Ed.), Eergyfrom the Desert –Feasibilityofverylarge-scale photovoltaicpowergenerationsystems,JamesandJames2003
3	SukhatmeS.P.,SolarEnergy,TataMcGrawHillsPvtCo.,3rdEdition,2008
4	C.J.Winter, R.L.Sizmann, L.L.Vant-Hull, SolarPowerPlants, Springer-Verlag Berlinand Heidelberg GmbH&Co.K,2001

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Describetheconceptofvariouspowercyclesinvolvedinthesolarpowerplantswerelearnt	Understand
CO2	Analyze different cycle for solar power generation	Analyze
CO3	Describetheconstructionandworkingofcomponentsolarthermalpowerplant	Understand
CO4	Explain PV system and its Integration	Understand
CO5	Fix power tariff and analyze economical aspects of power plant	Analyze

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	1	0	1	2	1	0	0	0	0	0	2	2
CO2	3	2	1	1	2	0	1	0	0	0	0	0	2	2
CO3	2	1	0	0	1	0	1	0	0	0	0	0	1	0
CO4	3	2	1	2	0	0	0	1	0	0	0	0	1	0
CO5	1	2	0	0	2	0	0	0	0	0	0	0	1	0
Avg	**2.4**	**1.6**	**0.6**	**0.6**	**1.2**	**0.4**	**0.6**	**0.2**	**0**	**0**	**0**	**0**	**1.4**	**0.8**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEHO107	MATERIALS FOR SOLAR DEVICES					
		CATEGORY	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES

1	To comprehend the materials that has been implicated in various forms of solar energy sources and its storages
2	To educate the structure-property relationship and appreciate enovel developments in the materials
3	To explain the concept and the diverse materials used for solar devices
4	To explicate in depth knowledge of about solar cells, thermal energy storage and electrical energy storages
5	To gather idea of system balance and analysis with reference toitscost

UNITI	**MATERIALSFORSOLAR COLLECTORS**	**9**	**0**	**0**	**9**

Collector Materials for Low, Medium and High Temperature Applications-Glazing Materials, Optical Materials– Absorber Coatings, Insulations, Use of Plastics–Reliability and Durability of Solar Collectors– Environmental Degradation of Low- Cost Solar Collectors

UNIT II	**MATERIALS FOR SOLAR CELLS**	**9**	**0**	**0**	**9**

Crystalline Structure – Fundamental Principles of Energy Bands–Types of Semiconductors – Doping and influence of impuritieson energy levels—Structure of Silicon solar cell–Fabrication and Optimization of solar cells– Amorphous silicon solar cells

UNIT III	**NOVEL AND THIN FILM SOLAR CELLS**	**9**	**0**	**0**	**9**

Cadmium Telluride, Galium-Arsenic, GaInP/GaAs/Ge-Thin Film, Single Crystalline, Polycrystalline Materials-Multi Junction and Tandem Junction Solar Cells – Conversion Efficiency of Solar Cells–Organic solar cells.

UNIT IV	**ENERGY STORAGE MATERIALS**	**9**	**0**	**0**	**9**

Thermal Storage Concepts-Materials for Sensible and Latent Heat Energy Storage. Chemical storage Concepts – Rechargeable Batteries–Types, Operating range, Comparison and suitability for various applications-Super Capacitors.

UNIT V	**MATERIALS AND COST ANALYSIS**	**9**	**0**	**0**	**9**

FunctionalrequirementsofothermaterialsforcomponentslikeInvertors,ChargeControllers, Wires,Pipes,Valves,etc.andidentificationofsuitablematerials-SimpleCostAnalysisfor alternatives election of materials-Case studies.

Total (45L) = 45 Periods

REFERENCE BOOKS:

1	Ibrahim Dincer and Marc A Rosan,Thermal Energy Storage: Systems and Applications, JohnWiley,2003.
2	Sukhatme and Nayak, Solar Energy: Principles of Thermal Collection & Storage,Tata McGrawHill,2008
3	Nelson,J, The Physics of Solar Cells, Imperial College Press, 2003
4	Jef Poortmans and VladimirArkhipov, Thin Film Solar Cells, JohnWiley and Sons,2008.
5	ThomasMarkvart, SolarElectricity, JohnWiley and Sons,2007

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Describethefundamentalprinciplesofmaterialsbestsuitedformakingsolarcollectors,their reliability, characteristics and possibility of using plastics.	Understand
CO2	Explorethematerialsforsolarcells,principles,dopingandfabricationandoptimizationsofsolar cells.	Analyze

CO3	Explorethenovelmaterialsforthefabricationofsolarcell,theirefficiencyandorganic solar cells.	Analyze
CO4	Explain the concept and the diverse materials used for solar energy devices for diverse applications.	Understand
CO5	Describetherequirementsofsystembalanceandanalysiswithreferencetoitscost.	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	0	0	0	0	1	0	0	0	0	1	1	1
CO2	3	2	1	0	0	0	1	0	0	0	0	0	1	1	2
CO3	2	3	0	0	1	0	0	0	0	0	0	0	2	2	2
CO4	2	1	0	0	2	1	0	0	1	0	0	0	1	1	1
CO5	3	2	0	1	0	0	1	0	0	0	0	1	1	1	2
Avg	**2.6**	**2**	**1**	**1**	**1.5**	**1**	**1**	**1**	**1**	**0**	**0**	**1**	**1.2**	**1.2**	**1.6**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEHO108	DESIGN OF SOLAR AND WIND SYSTEMS					
		CATEGORY	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES

1	To learn and study the radiation principles with respective solar energy estimation.
2	TounderstandPVtechnologyprinciplesandtechniquesofvarioussolarcells/materialsforenergy conversion
3	To understand the fundamentals of wind energy and its conversion system.
4	Tounderstandtheaerodynamicsandtypesofloads,generatorsinwindturbines
5	To learn and study the radiation principles with respective solar energy estimation.

UNITI	SOLAR RADIATION AND COLLECTORS	9	0	0	9

Sun angles–Radiation-extra-terrestrial characteristics -estimation on horizontal and tilted surfaces - flat plate collector thermal analysis –evacuated tubular collectors-concentrator collectors–classification-design and performance parameters - compound parabolic concentrators - parabolic trough concentrators -Heliostats.

UNIT II	SOLAR THERMAL TECHNOLOGIES	9	0	0	9

Principle of working, types, design and operation of-Solar heating and cooling systems– Thermal Energy storage systems – Solar Desalination – Solar cooker: domestic, community – Solar Pond – Solar drying.

UNIT III	SOLAR PV SYSTEM DESIGN	9	0	0	9

Solar cells - p-njunction- Solar cell array system analysis and performance prediction-solar cell array design concepts-PVsystemdesign-designprocessandoptimization–detailedarraydesign-storageautonomy-voltage regulation-centralized and decentralized SPV systems – hybrid and grid connected system.

UNIT IV	WIND ENERGY FUNDAMENTALS AND WIND MEASUREMENTS	9	0	0	9

Wind Energy Basics, Wind Speed sand scales, Terrain, Roughness, Wind Mechanics, Power Content, Class of wind turbines, Atmospheric Boundary Layers, Instrumentation for wind measurements, wind data analysis, tabulation, Betz's Limit, Turbulence Analysis.

UNIT V	AERODYNAMIC THEORY AND WIND TURBINES	9	0	0	9

Air foil terminology, Bladeelementtheory, Blade design, Rotor performance and dynamics, Balancing technique (Rotor& Blade), Types of loads, Sources of loads Vertical Axis, Horizontal Axis, Constant Speed Constant Frequency, Variable speed Variable Frequency, Stall Control, Pitch Control, Gear Coupled Generator type, Direct Generat or Drive systems.

Total (45L) = 45 Periods

REFERENCE BOOKS:

1	Sukhatme S.P., Nayak.J.P,'SolarEnergy –PrincipleofThermalStorageand collection", TataMcGrawHill,2008.
2	SolarEnergyInternational,"Photovoltaic – Designand InstallationManual" –New SocietyPublishers,2006.
3	DuffieA.andBeckannW.A.,"SolarEngineeringofThermalProcesses,JohnWiley,1991.
4	JohnDSorensenandJensNSorensen, "WindEnergySystems", WoodheadPublishing

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Classify and describe solar radiation and collectors.	Understand
CO2	Describe the principle and design the solar heating, cooling and other solar applications.	Understand
CO3	Explain the principle, working, design optimization of PV system for different applications.	Understand
CO4	Describe the basics and measurements of wind energy.	Understand
CO5	Explain the aerodynamic constructional details of wind turbine.	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	0	0	0	0	0	0	0	0	0	3	1	0
CO2	3	1	2	1	0	0	0	0	0	0	0	0	3	2	0
CO3	3	2	2	0	1	0	0	0	0	1	0	0	3	2	2
CO4	3	2	0	1	0	1	0	0	0	0	0	0	3	2	0
CO5	3	2	0	0	1	1	0	0	0	0	0	0	3	2	0
Avg	**3**	**1.8**	**1**	**0.6**	**0.5**	**0.4**	**0**	**0**	**0**	**0.2**	**0**	**0**	**3**	**1.8**	**0.4**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEHO109	FIRE ENGINEERING AND EXPLOSION CONTROL					
		CATEGORY	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES

1	Tounderstandandlearnthefundamentalsoffire,explosionandtheoryofcombustion.
2	To know various classes of fires & types of fire extinguishers
3	To understand and learn various fire protection systems, components and their working
4	To understand the various fire-resistant materials and to design fire protection of building
5	To understand the principles of explosion protection systems

UNITI	FIREANDEXPLOSIONS	9	0	0	9

Fire properties of solid, liquid and gases - fire spread -toxicity of products of combustion – theory of combustion and explosion –vapour clouds– flash fire– jetfires– pool fires-auto-ignition–boiling liquid expanding vapour explosion – Flix borough, Mexico disaster, Bombay Victoria dock ship explosions.

UNIT II	FIRE PREVENTION AND PROTECTION	9	0	0	9

Sources of ignition– fire triangle – principles of fire extinguishing – active and passive fire protection systems– various classes offires– A,B, C,D,E –types of fire extinguishers– fire stoppers– hydrant pipes – hoses -fire alarms and sirens – foam generators – escape from fire rescue operations–fire drills–notice- first aid for burns.

UNIT III	FIRE PREVENTION AND PROTECTION	9	0	0	9

Sprinkler-hydrants-standpipes–specialfiresuppressionsystemslikedelugeandemulsifier,selectioncriteria of the above installations, reliability, maintenance, evaluation and standards –alarmand detection systems, suppression systems – CO2system, foam system– smoke venting-firefighting systems.

UNIT IV	BUILDING FIRE SAFETY	9	0	0	9

Objectives of fire safe building design, Fire load, fire resistant material and fire testing–structural fire protection– structural integrity–concept of egress design–with calculations-fire certificates–fire safety requirements for high rise buildings–snookers.

UNIT V	EXPLOSION PROTECTING SYSTEMS	9	0	0	9

Principles of explosion-detonation and blast waves-explosion parameters – Explosion Protection, Containment,FlameArrestors,isolation,suppression,venting,explosionreliefoflargeenclosure- explosion venting-inert gases, suppression system based on carbon dioxide (CO_2)and halons-hazards in LPG, Ammonia(NH_3), Sulphur dioxide(SO_2),chlorine(Cl_2).

Total (45L) = 45 Periods

REFERENCE BOOKS:

1	Gupta,R.S.,"HandBookofFire Technology"OrientLongman,Bombay1977.
2	"AccidentPreventionmanualforindustrialoperations"N.S.C.,Chicago,1982.
3	DinkoTuhtar,"Fireandexplosionprotection".
4	"DavisDanieletal,"HandBookoffiretechnology".
5	FirefightershazardousmaterialsreferencebookFirePreventioninFactories",anNostrandReinHold,New York,1991.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Describe the fundamentals of fire, explosion and theory of combustion.	Understand
CO2	Classify the fire, class of fire and equipment for fire extinguishing.	Understand
CO3	Explainvariousindustrialfireprotectionsystemscomponentsandtheirworking.	Understand
CO4	Design the building with fire protection and concepts of their design.	Create
CO5	Describe the explosion protection system for various application.	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	0	1	0	1	0	0	0	0	0	0	2	0	0
CO2	3	2	0	0	0	1	2	0	0	0	0	0	2	0	0
CO3	3	2	0	1	2	1	2	0	0	0	0	0	2	0	0
CO4	2	1	3	2	0	1	2	0	0	0	1	0	2	0	0
CO5	3	2	0	1	2	2	1	0	0	0	1	0	2	0	0
Avg	**2.8**	**1.8**	**3**	**1.25**	**2**	**1.2**	**1.75**	**0**	**0**	**0**	**1**	**1**	**2**	**0**	**0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEHO110	ENERGY MANAGEMENT AND ENVIRONMENTAL BENEFITS				
		CATEGORY	PE	Credit	3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES

1	To create a warenesson the energy scenario of India with respect to world
2	To learn the methodology adopted for an energy audit
3	To appreciate the concepts adopted in project management
4	Tostudythedifferenttechniquesadoptedforfinancialappraisalofaproject
5	To Comprehend the impact of energy on environment

UNITI	ENERGYSCENARIO	9	0	0	9

Comparison of energy scenario – India and World (energy sources, generation mix, consumption pattern, T&D losses, energy demand, percapitaenergy consumption)– energy pricing–energy security-energy conservation and its importance, Energy Conservation Act 2001.

UNIT II	ENERGY MANAGEMENT	9	0	0	9

Energy audit-need–types– methodology– barriers-analysis on energy costing and sharing bench marking- fuel and energy substitution–billing parameters in TANGEDCO–demand side management-instruments for energy audit–energy monitoring and targeting- CUSUM energy labeling.

UNIT III	PROJECT MANAGEMENT	9	0	0	9

Four Basic Elements of Project Management- Project Management Life Cycle- Stepsin Project Management- Project Definition and Scope, Technical Design, Financing, Contracting, Implementation Techniques (Gantt chart, CPM and PERT) and Performance Monitoring.

UNIT IV	FINANCIAL MANAGEMENT	9	0	0	9

Investment appraisal for energy conservation projects - Financial analysis techniques, Simple payback period, Returnoninvestment,Netpresentvalue,Internalrateofreturn-Cashflows,Riskandsensitivityanalysis:microandmacrofactors.

UNIT V	ENERGY AND ENVIRONMENT	9	0	0	9

Greenhouse effect and the carbon cycle - current evidence and future effects of climate change – Global Environmental Concerns– United Nations Frame work Convention on Climate Change (UNFCC),Kyoto Protocol, Conference of Parties (COP), Emissions trading (ET), Joint Implementation (JI), Clean Development Mechanism (CDM),Proto type Carbon Fund(PCF), sustainable development.

Total (45L) = 45 Periods

REFERENCE BOOKS:

1	Energy Manager Training Manual (4Volumes) available at http://www.em- ea.org/gbook1.asp, a website administered by Bureau of Energy Efficiency (BEE), a statutory body under Ministry of Power, Government ofIndia.2004.
2	L.C.Witte,P.S.Schmidt,D.R.Brown,"IndustrialEnergyManagementandUtilisation"HemispherePubl,Washington,1988.
3	W.C.turner,"EnergyManagementHandbook"Wiley,NewYork,1982.
4	W.R.MurphyandG.McKay"EnergyManagement"Butterworths,London1987.
5	Eastop.T.D&Croft D.R,Energy Efficiency for Engineers andTechnologists,.LogmanScientific &Technical,ISBN-0-582-03184,1990.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Recognize the importance of energy conservation and suggest measures for improving percapita energy consumption.	Understand
CO2	Analyses the energy sharing and cost sharing pattern of fuel susedin industries.	Analyze
CO3	Apply Gantt Chart, CP M and PERT in energy conservation projects.	Apply
CO4	Evaluatethetechno-economicsofaprojectadoptingdiscountingandnon-discountingcashflow techniques.	Evaluate
CO5	Assess the sources of additional revenue generation for energy conservation projects adopting	Evaluate

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	1	0	1	0	0	0	1	1	0	0	2	2
CO2	3	2	0	0	0	1	0	0	0	0	0	2	0	2	0
CO3	3	1	1	1	0	1	0	0	0	0	0	0	0	2	3
CO4	3	2	0	0	0	0	1	0	0	0	0	1	0	0	2
CO5	2	1	0	0	1	2	1	0	0	0	0	0	0	0	0
Avg	**2.8**	**1.6**	**1**	**1**	**1**	**1.25**	**1**	**0**	**1**	**1**	**1**	**1.5**	**0**	**2**	**0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

VERTICAL 2 - COMPUTATIONAL ENGINEERING

22MEHO201	NUMERICAL METHODS IN MECHANICAL ENGINEERING				
PREREQUISITES	**CATEGORY**	**PE**	**Credit**		**C**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	Upon completion of this course, the students will understand and systematize numerical solution techniques for the partial differential equations governing the physics of mechanical engineering problems.
2.	Numerical Methods use computers to solve problems by step-wise, repeated and iterative solution methods, which would otherwise be tedious or unsolvable by hand-calculations.
3.	This course is designed to give an overview of numerical methods of interest to scientists and mechanical engineers.

UNIT I	**ERRORS**	**9**	**0**	**0**	**9**

Errors: Introduction, Types of errors, Rules for estimate errors, Error propagation, Error in the approximation of function. Roots of Equation - Bracketing Method: Bisection Methd, False position method - Open method: Newton-Raphson's method for Single root, multiple roots, Iterative method for Non-linear equations - Roots of polynomial: Muller's Method, limited to TWO Iterations.

UNIT II	**LINEAR ALGEBRAIC EQUATION**	**9**	**0**	**0**	**9**

Linear Algebraic Equation - Gauss Elimination Method. Pitfalls and improving techniques - LU decomposition method, Gauss-Jacobi and Gauss-Seidel Iteration method. Curve Fitting & Interpolation- Least Square Regression – Linear regression, Parabolic regression - Interpolation–Interpolating polynomial, Lagrange's interpolating polynomial, Divided Difference Formula

UNIT III	**NUMERICAL DIFFERENTIATION AND INTEGRATION**	**9**	**0**	**0**	**9**

Numerical Differentiation and Integration - Newton-Cote's Integration of equation: Trapezoidal rule, Simpson's rules - Integration of Equation: Gauss Quadrature methods. - Numerical differentiation: For Equally spaced Data: Forward difference Formula, Central difference Formula, Backward difference Formula, - For unequally spaced Data: Divided difference Formula.

UNIT IV	**ORDINARY DIFFERENTIAL EQUATION**	**9**	**0**	**0**	**9**

Ordinary Differential Equation - Taylor's series method, Picard's Method, Euler's Method, Runge-Kutta 4th Order method - Boundary value Problem-Finite Difference Method -- Eigen value problem: Eigen value problem based on Power method.

UNIT V	**PARTIAL DIFFERENTIAL EQUATION**	**9**	**0**	**0**	**9**

Partial Differential Equation - Finite Difference–Elliptical equation, Liebmann's method to Solve Laplace's and Poisson's Equations - Finite Difference- Parabolic Equation - Implicit Method- Crank-Nicolson method (Derivation Only)

Total (45L) = 45 Periods

TEXT BOOKS:

1.	B. S. Grewal and J. S. Grewal, "Numerical methods in Engineering and Science," 6 th Edition, Khanna publishers, New Delhi, 2004.
2.	D. G. Luenberger, "Linear and Nonlinear Programming," Springer, 3rd Edition, 2008.

REFERENCES:

1.	K. E. Atkinson, "An Introduction to Numerical Analysis," Wiley, 2nd Edition, 1989.
2.	S. D. Conte and C. de Boor, Elementary Numerical Analysis, Third Edition, Tata McGraw-Hill Education, 2005.

3.	F.B. Hildebrand, Introduction to Numerical Analysis, Second (Revised) Edition, Courier Dover Publications, 1987.
4.	E. Kreyszig, Advanced Engineering Mathematics, Tenth Ed., John Wiley and Sons, 2010
5.	R. L. Burden and J. D. Faires, Numerical Analysis, 9th Edition (second Indian Reprint 2012), Brooks/Cole, 2011.
6.	L.N. Trefethen, David Bau III, Numerical Linear Algebra, SIAM, 1997.
7.	A.Quarteroni, R. Sacco, and F. Saleri. Numerical Mathematics, Springer-Verlag, New York, 2000.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Apply various methods to find roots of equations.	Apply
CO2	Implement different methods to solve simultaneous equations and apply the methods of Regression and interpolation.	Apply& Evaluate
CO3	Implement various numerical methods for differentiation and Integration.	Apply
CO4	Apply various methods to solve engineering problems with Ordinary differential equations.	Apply
CO5	Solve Partial differential equations involved in Engineering Problems.	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	1	2	1	0	0	0	0	0	0	0	2	1	0
CO2	3	3	1	2	1	0	0	0	0	0	0	0	2	1	0
CO3	3	3	1	2	1	0	0	0	0	0	0	0	2	1	0
CO4	3	3	1	2	1	0	0	0	0	0	0	0	2	1	0
CO5	3	3	1	2	1	0	0	0	0	0	0	0	2	1	0
Avg	**3**	**3**	**1**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**0**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

22MEHO202	ADVANCED FLUID MECHANICS					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1. Enhanced understanding of fluid mechanics, including the equations of motion in differential form and turbulence.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Eulerian and Lagrangian Description of Fluid Motion, Lines of Flow Visualization and Acceleration of Flow, Angular Deformation of Fluid Elements, Linear and Volumetric Deformation; Perspectives from Mass Conservation, Continuity Education in Integral Form Stream Function and Velocity Potential.

UNIT II	**VISCOUS FLUID FLOW**	**9**	**0**	**0**	**9**

Euler Equation for Inviscid Flow, Bernoulli's Equation, Examples of Bernoulli's Equation, Reynolds Transport Equation, Reynolds Transport Theorem Mass and Linear Momentum Conservation, Reynolds transport theorem arbitrarily moving control volume, Reynolds transport theorem angular momentum conservation, Introduction to traction vector and stress tensor, Cauchy/Navier equation, Navier Stokes equation.

UNIT III	**FLUID DYNAMICS**	**9**	**0**	**0**	**9**

Lubrication Theory, Thin Film Dynamics, Stokes Flow past a Sphere.

UNIT IV	**TURBULENCE**	**9**	**0**	**0**	**9**

Introduction to Turbulence, Statistical Treatment of Turbulence and Near - Wall Velocity Profiles, Introduction to Boundary Layer Theory, Similarity Solution of Boundary Layer Equation, Momentum Integral Method, Application of Momentum Integral Method and Boundary Layer Separation, Potential Flow.

UNIT V	**COMPRESSIBLE FLOWS**	**9**	**0**	**0**	**9**

Stagnation properties, Compressible Flows - variable area- Normal Shock- Converging Nozzle- Converging Diverging Nozzle- Compressible Flow with Friction.

Total (45L) = 45 Periods

TEXT BOOKS:

1. Rouse, H. (1957), “Advanced Fluid Mechanics”, John Wiley & Sons, N York
2. Mohanty A.K. (1994), “Fluid Mechanics”, Prentice Hall of India, N Delhi

REFERENCES:

1. Wand D.J., and Harleman D.R. (91964) “Fluid Dynamics”, Addison Wesley.
2. Schlichting, H.: (1976) “Boundary Layer theory”, International Text – Butterworth
3. Lamb, H.R. (1945) “Hydrodynamics”, Rover Publications
4. White, F.M. (1980) “Viscous Fluid Flow”, McGraw Hill Pub. Co, N York
5. Yalin, M.S.(1971), “Theory of Hydraulic Models”, McMillan Co., 1971.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Explain the fundamental concepts of fluid flow.	Understand
CO2	Apply the Bernoulli to solve problems related to Viscous fluid flow.	Apply
CO3	Device the concepts of fluid dynamics in various geometry.	Create
CO4	Depict the turbulence of fluid flow.	Analyze
CO5	Interpret the knowledge for Compressible Flows in various geometrical configuration.	Evaluate

COURSE ARTICULATION MATRIX															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	3	0	0	0	0	0	0	0	1	2	2	0
CO2	3	3	2	3	0	0	0	0	0	0	0	1	2	2	0
CO3	3	3	2	3	3	0	0	0	0	0	0	1	2	2	0
CO4	3	3	2	3	0	0	0	0	0	0	0	1	2	2	0
CO5	3	3	2	3	3	0	0	0	0	0	0	1	2	2	0
Avg	**3**	**3**	**2**	**3**	**1.2**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**2**	**0**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

22MEHO203	FUNDAMENTALS OF BIO-MECHANICS				
PREREQUISITES	**CATEGORY**	**PE**	**Credit**		**C**
1.Basic knowledge of physics and biology which includes kinetics &kinematics.	**Hours/Week**	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	Explain the principles of mechanics.
2.	Discuss the mechanics of physiological systems.
3.	Explain the mechanics of joints.
4.	Illustrate the mathematical models used in the analysis of biomechanical systems

UNIT I	**INTRODUCTION TO MECHANICS**	**9**	**0**	**0**	**9**

Introduction – Scalars and vectors, Statics – Force types, Resolution and composition of forces, Moments of force and couple, Resultant force determination, parallel forces in space, equilibrium of coplanar forces, Dynamics - Basic principles – Linear motion, Newton's laws of motion, Impulse and Momentum, Work and Energy. Kinetics – Velocity and acceleration, Kinematics – Link segment models, Force transducers, Force plates, Introduction to Constitutive equations – Constitutive equations of Non-viscous fluid, Newtonian Viscous fluid and Hookean Elastic solid

UNIT II	**BIO-FLUID MECHANICS**	**9**	**0**	**0**	**9**

Intrinsic fluid properties – Density, Viscosity, Compressibility and Surface Tension, Viscometers – Capillary, Coaxial cylinder and cone and plate, Rheological properties of blood, Pressure-flow relationship for Non-Newtonian Fluids, Fluid mechanics in straight tube – Steady Laminar flow, Turbulent flow, Flow development, Viscous and Turbulent Sheer Stress, 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 III	**BIO-SOLID MECHANICS**	**9**	**0**	**0**	**9**

Constitutive equation of viscoelasticity – Maxwell & Voight models, anisotropy, Hard Tissues – Structure, blood circulation, elasticity and strength, viscoelastic properties, functional adaptation, Soft Tissues – Structure, functions, material properties and modeling of Soft Tissues – Cartilage, Tendons and Ligaments Skeletal Muscle – Muscle action, Hill's models, mathematical modeling, Bone fracture mechanics, Implants for bone fracture

UNIT IV	**BIO-MECHANICS OF JOINTS**	**9**	**0**	**0**	**9**

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 using video.

UNIT V	**MODELING AND ERGONOMICS**	**9**	**0**	**0**	**9**

Introduction to Finite Element Analysis, finite element analysis of lumbar spine; Ergonomics – Musculoskeletal disorders, Ergonomic principles contributing to good workplace design, Design of a Computer work station, Whole body vibrations, Hand transmitted vibrations.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Y.C. Fung, "Bio-Mechanics- Mechanical Properties of Tissues", Springer-Verlag, 1998.
2.	Subrata Pal, "Textbook of Biomechanics", Viva Books Private Limited, 2009.

REFERENCES:

1.	Krishna B. Chandran, Ajit P. Yoganathan and Stanley E. Rittgers, "Biofluid Mechanics: The Human Circulation", Taylor and Francis, 2007.
2.	Sheraz S. Malik and Shahbaz S. Malik, "Orthopaedic Biomechanics Made Easy", Cambridge University Press, 2015.
3.	Jay D. Humphrey, Sherry De Lange, "An Introduction to Biomechanics: Solids and Fluids, Analysis and

	Design", Springer Science Business Media, 2004.
4.	Shrawan Kumar, "Biomechanics in Ergonomics", Second Edition, CRC Press 2007.
5.	Neil J. Mansfeild, "Human Response to Vibration", CRC Press, 2005.
6.	Carl J. Payton, "Biomechanical Evaluation of movement in sports and Exercise", 2008
7.	NPTEL: Mechanical Engineering - NOC:Biomechanics of Joints and Orthopaedic Implants

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the fundamentals of mechanics and its application in human system.	Understand
CO2	Understand the principles of bio-fluid dynamics and its application in human system.	Understand
CO3	Understand the fundamentals of bio-solid mechanics.	Understand
CO4	Analyze the biomechanics of different human joints and also the forces at a skeletal joint for various static and dynamic human activities.	Analyze
CO5	Give Examples of computational mathematical modelling applied in Bio-mechanics.	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	2	2	0	0	0	0	0	0	1	0	2	2	0
CO2	2	2	2	2	0	0	0	0	0	0	1	0	2	2	0
CO3	2	2	2	2	0	0	0	0	0	0	1	0	2	2	0
CO4	2	2	2	2	0	0	0	0	0	0	1	0	2	2	0
CO5	2	2	2	2	2	0	0	0	0	0	1	0	2	2	0
Avg	**2**	**2**	**2**	**2**	**0.4**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**2**	**2**	**0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEHO204	INTRODUCTION TO MACHINE LEARNING					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**C**
Machine learning is a mathematical discipline, and students will benefit from a good background in probability, linear algebra and calculus, programming, and experience is essential.		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	Understand a wide variety of learning algorithms.
2.	Understand how to evaluate models generated from data.
3.	Apply the algorithms to a real problem.
4.	Optimize the models learned and report on the expected accuracy that can be achieved by applying the models.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Introduction: Basic definition-types of learning-designing a learning system-perspective and issues in machine learning-hypothesis space and inductive bias- evaluation-cross-validation.					
UNIT II	**CONCEPT LEARNING AND THE GENERAL-TO-SPECIFIC ORDERING**	**9**	**0**	**0**	**9**
Introduction-a concept task, concept learning as search-find S: finding a maximally specific hypothesis- version spaces and the candidate elimination algorithm-remarks on version spaces and candidate elimination-inductive bias.					
UNIT III	**DECISION TREE LEARNING**	**9**	**0**	**0**	**9**
Introduction-decision tree representation-appropriate problems for decision tree learning-the basic decision tree learning algorithm-hypothesis space search in decision tree learning-inductive bias in decision tree learning-issues in decision tree learning.					
UNIT IV	**ARTIFICIAL NEURAL NETWORKS**	**9**	**0**	**0**	**9**
Introduction-neural network representation-appropriate problems for neural network learning- perceptrons-multilayer networks and the back propagation algorithm-remarks on the back propagation algorithm-an illustrative example: face recognition, advanced topics in artificial neural networks.					
UNIT V	**LEARNING SYSTEM**	**9**	**0**	**0**	**9**
Probability and Bayes learning, bayes optimal classifier, gibbs algorithm, Naïve bayes classifier, instance-based learning - K nearest neighbour learning - locally weighted regression, Computational learning theory-PAC learning model -Sample complexity-VC Dimension -Ensemble learning, analytical learning-learning with perfect domain theories: prolog –EBG.					
Total (45L) = 45 Periods					

REFERENCES:

1.	Machine Learning. Tom Mitchell. First Edition, McGraw- Hill, 1997.
2.	Introduction to Machine Learning Edition 2, by Ethem Alpaydin
3.	T. Hastie, R. Tibshirani, and J. Friedman. The Elements of Statistical Learning. Springer 2011. (Available for download on the authors' web-page: http://statweb.stanford.edu/ ~tibs/ElemStat Learn/)
4.	Kevin P. Murphy. Machine Learning: A Probabilistic Perspective, MIT Press 2012. (Electronic copy available through the Bodleian library.)
5.	Christopher M. Bishop. Pattern Recognition and Machine Learning, Springer 2007.
6.	S. Haykin. Neural networks and learning machines. Pearson 2008.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Have a good understanding of the fundamental issues and challenges of machine learning: data, model selection, model complexity, etc.	Understand
CO2	Have an understanding of the strengths and weaknesses of many popular machine learning approaches.	Understand
CO3	Appreciate the underlying mathematical relationships within and across Machine Learning algorithms and the paradigms of supervised and un-supervised learning.	Understand
CO4	Be able to design and implement Artificial Neural Networks algorithms in a range of real-world applications.	Create
CO5	Be able to design and implement various machine learning algorithms in a range of real-world applications.	Create

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	0	1	3	0	0	0	0	0	0	1	2	2	0
CO2	2	2	0	1	3	0	3	0	0	0	0	1	2	2	0
CO3	2	2	0	1	3	0	0	0	0	0	0	1	2	2	0
CO4	2	2	0	1	3	0	3	0	0	0	0	1	2	2	0
CO5	2	2	0	1	3	0	3	0	0	0	0	1	2	2	0
Avg	**2**	**2**	**0**	**1**	**3**	**0**	**1.8**	**0**	**0**	**0**	**0**	**1**	**2**	**2**	**0**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

22MEHO205	DESIGN OPTIMIZATION & DESIGN THEORY				
PREREQUISITES	**CATEGORY**	**PE**	**Credit**		**C**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	The primary objective of this course is for students to gain knowledge to translate practical engineering design problems into mathematical optimization problems that can be solved using numerical methods for optimization

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
General Characteristics of mechanical elements, adequate and optimum design, principles of optimization, formulation of the objective function, design constraints, and classification of optimization problems. Single and multivariable optimization techniques					
UNIT II	**DESIGN OPTIMIZATION TECHNIQUE**	**9**	**0**	**0**	**9**
The technique of unconstrained minimization. The golden section, Random, Pattern, and Gradient search methods, interpolation methods, and equality and inequality constraints.					
UNIT III	**PROGRAMME**	**9**	**0**	**0**	**9**
Direct methods and indirect methods using penalty function, Lagrange multipliers, Geometric programming, stochastic programming, Genetic algorithms					
UNIT IV	**ENGINEERING APPLICATION**	**9**	**0**	**0**	**9**
Engineering applications, structural-design application axial and transverse loaded members for minimum cost, maximum weight. Design of shafts and torsion members, design optimization of springs.					
UNIT V	**DYNAMICS APPLICATION**	**9**	**0**	**0**	**9**
Dynamics applications for a two-degree freedom system. Vibration absorbers. Application in mechanisms.					
Total (45L) = 45 Periods					

TEXT BOOKS:

1.	S. S. Rao, Engineering Optimization: Theory and Practice, 4th edition, John Wiley & Sons, 2009. ISBN: 0470183527.
2.	Kalyanmoy Deb, “Optimization for Engineering Design”, Prentice Hall of India, New Delhi, 2005

REFERENCES:

1.	R.C. Johnson, “Optimum Design of Mechanical Elements”, Willey, New York, 1980
2.	Kalyanmoy Deb, “Evolutionary multi-objective optimization, Willey, New York.
3.	S. S. Stricker, “Optimising performance of energy systems” Battelle Press, New York, 1985.
4.	J. S. Arora, “Introduction to Optimum Design”, McGraw Hill, New York, 1989.
5.	L.C.W. Dixon, “Non-Linear Optimisation - Theory and Algorithms”, Birkhauser, Boston, 1980.
6.	R.J. Duffin, E.L. Peterson and C.Zener “Geometric Programming-Theory and Applications”, Willey, New York, 1967.
7.	G.B.Dantzig “Linear Programming and Extensions Princeton University Press”, Princeton, N. J., 1963
8.	R. Bellman “Dynamic Programming-Princeton” University Press, Princeton, N.J. 1957.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Demonstrate an understanding of how design optimization fits into the overall engineering design process.	Create
CO2	Formulate practical engineering design problems as well-posed optimization problems.	Create
CO3	Determine the advantages and disadvantages of applying different optimization techniques for a specific problem.	Analyze
CO4	Model and analyze multi-objective and multi-disciplinary optimization problems.	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	3	3	1	0	0	0	0	0	0	2	2	2	0
CO2	2	2	3	3	1	0	0	0	0	0	0	2	2	2	0
CO3	2	2	2	3	1	0	0	0	0	0	0	2	2	2	0
CO4	2	2	2	3	1	0	0	0	0	0	0	2	2	2	0
Avg	**2**	**2**	**2.5**	**3**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**2**	**0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEHO206	ADVANCED FINITE ELEMENT METHODS					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**C**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To develop a thorough understanding of the advanced finite element analysis techniques.
2.	An ability to effectively use the tools of the analysis for solving practical problems arising in engineering design.
3.	To understand and solve the Finite Element 1-D structural and 2-D structural problems.
4.	To develop and understand the dynamic problems in structures
5.	To gain the knowledge of FEM for heat transfer analysis and flow analysis

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Classification of problems – Dimensionality, time dependence, Boundary value problems, Initial value problems, Linear/Non-linearetc., Historical Perspective of FEM and applicability to mechanical engineering design problems. Differential equation as the starting point for FEM, steps in finite element method, discretization, types of elements used, Shape functions, Linear Elements, Local and Global coordinates, Coordinate transformation and Gauss- Legendre scheme of numerical integration, Nodal degrees of freedom. Compatibility conditions, Assembly and boundary considerations.

UNIT II	**ONE DIMENSIONAL PROBLEMS**	**9**	**0**	**0**	**9**

Structural problems with one dimensional geometry. Formulation of stiffness matrix, consistent and lumped load vectors. Boundary conditions and their incorporation: Elimination method, Penalty Method. Introduction to higher order elements and their advantages and disadvantages. Formulation for Truss elements, Case studies with emphasis on boundary conditions and introduction to contact problems. Beams and Frames: Review of bending of beams, higher order continuity (C0 and C1 Continuity), interpolation for beam elements and formulation of FE characteristics, Plane and space frames and examples problems involving hand calculations. Algorithmic approach for developing computer codes involving 1-D elements.

UNIT III	**TWO DIMENSIONAL PROBLEMS**	**9**	**0**	**0**	**9**

Interpolation in two dimensions, natural coordinates, Isoparametric representation, Concept of Jacobian. Finite element formulation for plane stress plane strain and axi-symmetric problems; Triangular and Quadrilateral elements, higher order elements, sub parametric, Isoparametric and super parametric elements. General considerations in finite element analysis of two-dimension problems. Introduction plate bending elements and shell elements.

UNIT IV	**DYNAMIC ANALYSIS**	**9**	**0**	**0**	**9**

FE formulation in dynamic problems in structures using Lagragian Method, Consistent and lumped mass models, Formulation of dynamic equations of motion and introduction to the solution procedures. Modelling of structural damping and formulation of damping matrices, Model analysis, Mode superposition methods and reduction techniques.

UNIT V	**FEM IN HEAT TRANSFER & FLUID MECHANICS**	**9**	**0**	**0**	**9**

Finite element solution for one dimensional heat conduction with convective boundaries. Formulation of element characteristics and simple numerical problems. Formulation for 2-D and 3-D heat conduction problems with convective boundaries. Introduction to thermo-elastic contact problems. Finite element applications in potential flows; Formulation based on Potential function and stream function. Design case studies.

Total (45L) = 45 Periods

REFERENCES:

1.	K. J. Bathe, Finite Element Procedures, Prentice-Hall of India Private Limited, New Delhi, 1996
2.	J. C. Simo and T. J. R. Hughes, Computational Inelasticity, Springer-Verlag New York, Inc., New York, 1998
3.	Cook and Robert Davis etal, “Concepts and Applications of Finite Element Analysis”, 4th Edition, John Wiley and Sons, 2001.
4.	Segerlind L.J, “Applied Finite Element Analysis”, 2nd Edition, John Wiley, 1984.

5.	O. C. Zienkiewicz and R. L. Taylor, Finite Element Method: Volume 2 Solid Mechanics, Fifth Edition, Butterworth-Heinemann, Oxford,

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the concept of the finite element method for solving design problems.	Understand
CO2	Formulate and solve manually problems in 1-D structural systems involving bars, trusses, beams and frames.	Apply
CO3	Develop 2-D FE formulations involving triangular, quadrilateral elements, and higher-order elements	Create
CO4	Apply the knowledge of FEM for stress analysis, model analysis, heat transfer analysis and flow analysis	Evaluate
CO5	Apply the knowledge of FEM for heat transfer analysis and flow analysis	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	3	1	0	0	0	1	1	0	0	0	1	2	0
CO2	3	1	3	3	3	0	0	1	1	0	0	0	0	0	3
CO3	3	1	3	3	2	0	0	1	1	0	0	0	0	0	0
CO4	3	2	3	3	2	0	2	2	1	0	0	0	1	2	0
CO5	3	1	1	1	1	0	0	0	1	0	0	0	1	1	0
Avg	**3.0**	**1.2**	**2.6**	**2.2**	**1.6**	**0.0**	**0.4**	**1.0**	**1.0**	**0.0**	**0.0**	**0.0**	**0.6**	**1.0**	**0.6**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

22MEHO207	ADVANCED COMPUTATIONAL FLUID DYNAMICS (CFD)				
PREREQUISITES		**CATEGORY**	**PE**	**Credit**	**3**
Knowledge of undergraduate heat transfer and fluid mechanics, basic computational fluid dynamics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	The primary objective of the course is to teach fundamentals of computational method for solving non-linear partial differential equations (PDE) primarily in complex geometry. The emphasis of the course is to teach CFD techniques for solving incompressible and compressible N-S equation in primitive variables, grid generation in complex geometry, transformation of N-S equation in curvilinear coordinate system and introduction to turbulence modelling.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Brief introduction of boundary layer flow, incompressible and compressible flows, finite difference and finite volume method, example of parabolic and hyperbolic systems and time discretization technique, explicit and implicit methods, upwind and central difference schemes, stability, dissipation and dispersion errors

UNIT II	**SOLUTION OF SIMULTANEOUS EQUATIONS**	**9**	**0**	**0**	**9**

Point iterative/block iterative methods, Gauss-Seidel iteration (concept of central coefficient and residue, SOR), CGS, Bi-CGSTAB and GMRES (m) matrix solvers, different acceleration techniques.

UNIT III	**INCOMPRESSIBLE FLOW**	**9**	**0**	**0**	**9**

Higher order upwind schemes: second order convective schemes, QUICK. Solution of NS equations: Solution of incompressible N-S equation (Explicit time stepping, Semi–explicit time stepping). SMAC method for staggered grid: Predictor - Corrector step, discretization of N-S and continuity equations, Pressure correction Poisson's equation, boundary conditions (no-slip, moving wall, slip boundary and inflow conditions), outflow (zero gradient/Orlanski) boundary conditions for unsteady flows, algorithm for the SMAC method, stability considerations for SMAC method.

UNIT IV	**FDE IN COMPLEX GEOMETRIES**	**9**	**0**	**0**	**9**

Transformation of governing equation in ξ $\eta-$ plane, transformation of Laplace equation, introduction to geometrical parameters and the accuracy of the solution, basic facts about transformation, grid transformation on complex geometries. N-S equations in transformed plane, matrices and Jacobians

UNIT V	**COMPRESSIBLE FLOW**	**9**	**0**	**0**	**9**

N-S and energy equations, properties of Euler equation, linearization. Solution of Euler equation: Explicit and implicit treatment such as Lax-Wendroff, MacCormark, Beam and Warming schemes, Upwind schemes for Euler equation: Steger and Warming, Van Leer's flux splitting, Roe's approximate Riemann solver, TVD schemes. Solution of N-S equations: MacCormack, Jameson algorithm in finite volume formulation and transformed coordinate system.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Computational Fluid Flow and Heat Transfer, Second Edition by K. Muralidhar, T. Sundararajan (Narosa), 2011.
2.	Computational Fluid Dynamics by Chung T. J., Cambridge University Press, 2003.
3.	Computational Fluid Dynamics by Tapan K. Sengupta, University Press, 2005.
4.	Numerical Computation of Internal and External Flows by Hirch C., Elesvier 2007.

REFERENCES:

1.	K. J. Bathe, Finite Element Procedures, Prentice-Hall of India Private Limited, New Delhi, 1996
2.	J. C. Simo and T. J. R. Hughes, Computational Inelasticity, Springer-Verlag New York, Inc., New York, 1998
3.	Cook and Robert Davis et.al, "Concepts and Applications of Finite Element Analysis", 4th Edition, John Wiley and Sons, 2001.

4.	Segerlind L.J, "Applied Finite Element Analysis", 2nd Edition, John Wiley, 1984.
5.	O. C. Zienkiewicz and R. L. Taylor, Finite Element Method: Volume 2 Solid Mechanics, Fifth Edition, Butterworth-Heinemann, Oxford,

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand and be able to numerically solve the incompressible and compressible flows.	Understand
CO2	Solve computational problems related to iterative methods.	Evaluate
CO3	Solve the problems related to incompressible fluid flow.	Evaluate
CO4	Interpret the knowledge, capability of analyzing and solving FDE in complex geometries problem.	Apply
CO5	Solve the problems related to compressible fluid flow.	Evaluate

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	1	1	2	0	0	0	0	0	0	0	2	2	0
CO2	2	2	1	3	2	0	0	0	0	0	0	0	2	2	0
CO3	2	2	1	3	2	0	0	0	0	0	0	0	2	2	0
CO4	2	2	1	1	2	0	0	0	0	0	0	0	2	2	0
CO5	2	2	1	3	2	0	0	0	0	0	0	0	2	2	0
Avg	**2**	**2**	**1**	**2.2**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEHO208	SMART MATERIALS AND STRUCTURES				
PREREQUISITES	CATEGORY	PE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

COURSE OBJECTIVES:

1.	Knowledge of smart materials and structures is essential designing mechanical systems for advanced engineering applications, the course aims at training students in smart materials and structures application and analysis

UNIT I	SMART STRUCTURES	9	0	0	9

Types of Smart Structures, Potential Feasibility of Smart Structures, Key Elements of Smart Structures, Applications of Smart Structures. Piezoelectric materials, Properties, piezoelectric Constitutive Relations, Depoling and Coersive Field, field strain relation. Hysteresis, Creep and Strain Rate effects, Inchworm Linear Motor. Beam Modeling: Beam Modeling with induced strain Rate effects, Inchworm Linear Motor Beam Modeling with induced strain Actuation-single Actuators, dual Actuators, Pure Extension, Pure Bending harmonic excitation, Bernoulli-Euler beam Model, problems, Piezoelectrical Applications.

UNIT II	SHAPE MEMORY ALLOY	9	0	0	9

Experimental Phenomenology, Shape Memory Effect, Phase Transformation, Tanaka's Constitutive Model, testing of SMA Wires, Vibration Control through SMA, Multiplexing. Applications Of SMA and Problems. ER and MR Fluids: Mechanisms and properties, Fluid Composition and behavior, The Bingham Plastic and Related Models, Pre-Yield Response. Post-Yield flow applications in Clutches, Dampers and Others.

UNIT III	VIBRATION ABSORBERS	9	0	0	9

series and Parallel Damped Vibrations (OverView), Active Vibration Absorbers, Fiber Optics, Physical Phenomena, Characteristics, Sensors, Fiber Optics in Crack Detection, applications. Control of Structures: Modeling, Control Strategies and Limitations, Active Structures in Practice. 13Hours

UNIT IV	MEMS	9	0	0	9

Mechanical Properties of MEMS Materials, Scaling of Mechanical Systems, Fundamentals of Theory, The Intrinsic Characteristics of MEMS, Miniaturization, Microelectronics Integration.

UNIT V	DEVICES	9	0	0	9

Sensors and Actuators, Conductivity of Semiconductors, Crystal Planes and Orientation, (Stress and Strain Relations, Flexural Beam Bending Analysis Under Simple Loading Conditions), Polymers in MEMS, Optical MEMS Applications.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Smart Materials and Structures - M. V. Gandhi and B. So Thompson, Chapman and Hall, London; New York, 1992 (ISBN: 0412370107).
2.	Smart Structures and Materials - B. Culshaw, Artech House, Boston, 1996 (ISBN :0890066817). 3. Smart Structures: Analysis and Design - A. V. Srinivasan, Cambridge University Press, Cambridge; New York, 2001 (ISBN: 0521650267).

REFERENCES:

1.	Electro ceramics: Materials, Properties and Applications - A. J. Moulson and J. M. Herbert. John Wiley &Sons, ISBN: 0471497429
2.	Piezoelectric Sensories: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors. Materials and Amplifiers, Springer, Berlin; New York, 2002 (ISBN: 3540422595).
3.	Piezoelectric Actuators and Transonic Motors - K. Uchino, Kluwer Academic Publishers, Boston, 1997 (ISBN: 0792398114).
4.	Handbook of Giant Magneto strictive Materials - G. Engdahl, Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012238640X).

5.	Shape Memory Materials - K. Otsuka and C. M. Wayman, Cambridge University Press, Cambridge; New York, 199~ (ISBN: 052144487X).

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the behavior and applicability of various smart materials	Understand
CO2	Design simple models for smart structures & materials	Create
CO3	Perform simulations of smart structures & materials application	Analyse
CO4	Conduct experiments to verify the predictions	Analyze

COURSE ARTICULATION MATRIX

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

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEHO209	DESIGN OF PRESSURE VESSELS				
PREREQUISITES	**CATEGORY**	**PE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To study about the various types of stresses act in the pressure vessels
2.	To design components of pressure vessel using codes and standards.
3.	To study the design the supportive members of pressure vessels.
4.	To study about design considerations of pressure vessels.
5	To study about the design of pipes related to design of pressure vessels.

UNIT I	**STRESSES IN PRESSURE VESSELS**	**9**	**0**	**0**	**9**

Types of Smart Structures, Potential Feasibility of Smart Structures, Key Elements of Smart Structures, Applications of Smart Structures. Piezoelectric materials, Properties, piezoelectric Constitutive Relations, Depoling and Coersive Field, field strain relation. Hysteresis, Creep and Strain Rate effects, Inchworm Linear Motor. Beam Modeling: Beam Modeling with induced strain Rate effects, Inchworm Linear Motor Beam Modeling with induced strain Actuation-single Actuators, dual Actuators, Pure Extension, Pure Bending harmonic excitation, Bernoulli-Euler beam Model, problems, Piezoelectrical Applications.

UNIT II	**DESIGN OF VESSELS USING CODES**	**9**	**0**	**0**	**9**

General theory of membrane stresses in vessel under internal pressure and its application to shells (Cylindrical, Conical and Spherical) and end closures. Bending of circular plates and determination of stresses in simply supported and clamped circular plate. Thermal stresses, Stress concentration in plate having circular hole due to bi-axial loading, Excessive elastic deformation, Plastic instability, Brittle rupture and creep. Theory of reinforced opening and reinforcement limits, design of composite analysis, wind and seismic load consideration in the design of pressure vessel.

UNIT III	**SUPPORTS FOR VERTICAL & HORIZONTAL VESSELS**	**9**	**0**	**0**	**9**

Introduction to ASME codes for pressure vessel design, Pressure vessel and related components' design using ASME codes; Supports for short vertical vessels, Stress concentration at a variable thickness transition section in a cylindrical vessel; Design of nozzles.

UNIT IV	**OTHER DESIGN CONSIDERATIONS**	**9**	**0**	**0**	**9**

Buckling phenomenon, Elastic Buckling of circular ring and cylinders under external pressure, Collapse of thick-walled cylinders or tubes under external pressure, Effect of supports on Elastic Buckling of Cylinders, Design of circumferential stiffeners, and buckling under combined External pressure and Axial loading. Fatigue, shock, high pressure, high temperature, irradiation, corrosion, and other hostile environments; High strength, light weight pressure vessels, Vessels resistant to external high pressures found in undersea exploration, offshore drilling, and mineral mining.

UNIT V	**PIPING DESIGN**	**9**	**0**	**0**	**9**

Flow diagram, Piping layout and piping stress analysis; Flexibility factor and stress intensification factor; Design of piping system as per B31.1 piping code. Piping components - bends, tees, bellows and valves. Types of piping supports and their behavior; Introduction to piping Codes and Standards.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Dennis Moss "Pressure Vessel Design Manual"
2.	Henry H Bednar, "Pressure vessel Design Hand book", CBS publishers and distributors.

REFERENCES:

1.	Harvey J F, "Pressure vessel design", CBS, publication.
2.	Brownell L. E & Young. E. D, "Process equipment design", Wiley Eastern Ltd., India.
3.	Stanley M Wales, "Chemical Process Equipment, Selection and Design", Butterworths,

4.	Series in Chemical Engineering, 1988. 6. J. Phillip Ellenberger “Pressure Vessels: ASME Code Simplified”.
5.	“ASME Pressure Vessel and Boiler Code”, Section VIII Div. 1, 2, and 3.
6.	“American standard code for pressure piping”, B 31.1.
7.	Smith P, “Fundamentals of Piping Design”, Elsevier.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Determine stresses in pressure vessels	Evaluate
CO2	Design pressure vessels using ASME codes	Create
CO3	Design support members of pressure vessels	Create
CO4	Apply other design considerations for pressure vessels	Apply
CO5	Design of pressurized fluid piping	Create

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	2	2	2	0	0	0	0	0	0	0	0	3	3	0
CO2	2	3	3	3	0	0	0	0	0	0	0	0	3	3	0
CO3	2	3	3	3	0	0	0	0	0	0	0	0	3	3	0
CO4	3	1	1	1	0	0	0	0	0	0	0	0	3	3	0
CO5	2	3	3	3	0	0	0	0	0	0	0	0	3	3	0
Avg	**2**	**2.4**	**2.4**	**2.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**3**	**3**	**0.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEHO210	MECHANICAL VIBRATIONS				
PREREQUISITES	**CATEGORY**	**PE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To understand the Fundamentals of Vibration and its practical applications.
2.	To understand the characteristics of free and forced vibration.
3.	To understand the Single and Multi DOF of vibration system.
4.	To understand the working principle and operations of various vibration measuring instruments
5	To understand about the vibration analysis methods.

UNIT I	**FUNDAMENTALS OF VIBRATIONS**	**9**	**0**	**0**	**9**

Basic concepts of vibration – causes and effects of vibrations – vibration parameters – spring, mass, damper models. Motion – periodic, non-periodic, harmonic, non-harmonic. Degree of freedom, static equilibrium position, vibration classification – steps involved in vibration analysis.

UNIT II	**FREE VIBRATION OF SINGLE DEGREE OF FREEDOM SYSTEMS**	**9**	**0**	**0**	**9**

Free undamped single DOF vibration system – Longitudinal, transverse, torsional vibration system – Methods for formulation of differential equations by newton, energy, lagrangian and Rayleigh's method. Viscous damped system – under damped, critically damped, over damped – logarithmic decrement – Coulomb's damping; combined viscous and coulomb's damping.

UNIT III	**FORCED VIBRATION OF SINGLE DEGREE OF FREEDOM SYSTEMS**	**9**	**0**	**0**	**9**

Forced Single DOF system – Analysis of linear and torsional systems subjected to harmonic force excitation and harmonic motion excitation (excluding elastic damper) – vibration isolation – force transmissibility – motion transmissibility, typical isolators & mounts – Rotor dynamics, critical speed of single rotor, undamped and damped.

UNIT IV	**VIBRATION OF MULTI DEGREE OF FREEDOM SYSTEMS**	**9**	**0**	**0**	**9**

Free undamped Multi Degree of Freedom vibration system – Influence Coefficients and stiffness coefficients- Flexibility Matrix and Stiffness Matrix - Eigen values and Eigen vectors for linear system and torsional two degree of freedom; Holzer method for linear and torsional unbalanced system; Two rotors, three rotors and geared system; Dunkerley's and Rayleigh's method for transverse vibratory system.

UNIT V	**VIBRATION MEASURING INSTRUMENTS AND VIBRATION ANALYSIS**	**9**	**0**	**0**	**9**

Vibration Analysis Overview - Experimental Methods in Vibration Analysis. -Vibration Measuring Instruments - Selection of Sensors- Accelerometer Mountings. -Vibration Exciters-Mechanical, Hydraulic, Electromagnetic and Electrodynamics – Frequency Measuring Instruments-. System Identification from Frequency Response -Testing for resonance and mode shapes.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Mechanical Vibration by V.P.Singh
2.	Singiresu S. Rao, "Mechanical Vibrations", Pearson Education Incorporated, 2017.

REFERENCES:

1.	Benson H. Tongue, "Principles of Vibrations", Oxford University, 2007.
2.	Grover. G.K., edited by Nigam. S. P., "Mechanical Vibrations", Nem Chand and Bros., 2014.

3.	David A. Bies and Colin H. Hansen, “Engineering Noise Control – Theory and Practice”, Spon Press, 2009.
4.	Julian Happian-Smith – “An Introduction to Modern Vehicle Design”, Butterworth-Heinemann, 2001.
5.	William T. Thomson, “Theory of Vibration with Applications”, Taylor and Francis, 2003.
6.	Balakumar Balachandran and Edward B. Magrab, “Fundamentals of Vibrations”, 1st Editon, Cengage Learning, 2009
7.	Grover. G.T., “Mechanical Vibrations”, Nem Chand and Bros., 2009
8.	NPTEL :: Mechanical Engineering - NOC:Introduction to Mechanical Vibration

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Determine stresses in pressure vessels	Evaluate
CO2	Design pressure vessels using ASME codes	Create
CO3	Design support members of pressure vessels	Create
CO4	Apply other design considerations for pressure vessels	Apply
CO5	Design of pressurized fluid piping	Create

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	2	2	1	0	0	0	0	0	0	0	0	2	2	0
CO2	3	3	2	2	0	0	0	0	0	0	0	0	2	2	0
CO3	3	3	2	2	0	0	0	0	0	0	0	0	2	2	0
CO4	3	3	2	2	0	0	0	0	0	0	0	0	2	2	0
CO5	1	1	2	2	0	0	0	0	0	0	0	0	2	2	0
Avg	**2.2**	**2.4**	**2**	**1.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**2**	**2**	**0.0**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

VERTICALS -3 PRODUCT AND PROCESS DEVELOPMENT

22MEHO301	PRECISION ENGINEERING					
PREREQUISITES		CATEGORY	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES:

1.	Explain the need and progress of precision engineering.
2.	To know about the principle and working of different methods of precision machining.
3.	To understand about micromachining.
4.	To know about Laser devices and machine vision.
5.	To understand about SEM and 3D surface topography.

UNIT I	INTRODUCTION	9	0	0	9

Introduction to Precision Engineering, Need for precision manufacturing, Four Classes of Achievable Machining Accuracy – Normal, Precision, High-precision, Ultraprecision Processes and Nanotechnology

UNIT II	PRECISION MACHINING	9	0	0	9

Overview of Micro- and Nano-machining, Conventional micro machining techniques - micro turning, micro-milling, micro-grinding, Ultra-precision diamond turning, SPDT Single point diamond turning.

UNIT III	MICRO MACHINING	9	0	0	9

Micro electrical discharge machining, Photochemical machining, Electro chemical micromachining, Laser beam micromachining, Electron beam micromachining, Focused Ion Beam micromachining, etc

UNIT IV	LASER AND OPTICS	9	0	0	9

Micro electrical discharge machining, Photochemical machining, Electro chemical micromachining, Laser beam micromachining, Electron beam micromachining, Focused Ion Beam micromachining.

UNIT V	MEASUREMENT AND CHARACTERISATION	9	0	0	9

Measurement of Typical Nanofeatures, Surface metrology - 3D surface topography - Need, Measurement – Chromatic confocal Microscopy, Interferometry, Non-optical Scanning Microscopy – Scanning electron Microscopes, Scanning probe microscopes, Parameters for characterizing 3D surface topography.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Jain, V.K., Introduction to micromachining, Narosa publishers, 2018
2.	Venktesh V.C., Sudin Izman, Precision Engineering, Tata Mc.Graw Hill Publishing Company, New Delhi 2007.

REFERENCES:

1.	David Dornfeld, Dae-Eun Lee, Precision Manufacturing, Springer, 2008
2.	Kevin Harding, “Handbook of Optical Dimensional Metrology, Series: Series in Optics and optoelectronics”, Taylor & Francis, 2013
3.	Murty, R.L., Precision Engineering in Manufacturing, New Age publishers, 2005.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Impart knowledge progress of precision engineering	Understand
CO2	Identify principle and working of different methods of precision machining	Understand
CO3	Apply knowledge on micromachining	Apply
CO4	Define the uses of Laser devices and machine vision	Remember
CO5	Apply knowledge on Surface metrology	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	0	1	0	0	1	0	0	0	0	2	1	2	2
CO2	1	3	1	1	0	0	1	0	0	0	0	2	0	1	1
CO3	3	3	1	1	2	0	1	0	0	0	0	3	0	1	3
CO4	3	2	1	2	2	0	1	0	0	0	0	3	2	1	3
CO5	2	3	0	3	1	0	1	0	0	0	0	3	0	1	2
Avg	**2.2**	**2.6**	**0.6**	**1.6**	**1.0**	**0.0**	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**2.6**	**0.6**	**1.2**	**2.2**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEHO302	ADVANCED MATERIALS TECHNOLOGY					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To understand knowledge of crack and failure of metals
2.	To know different types of coatings
3.	Apply knowledge of composites
4.	To understand properties of modern alloys
5.	To know about advanced aerospace alloys

UNIT I	REVIEW OF MECHANICAL BEHAVIOUR OF MATERIALS	9	0	0	9

Plastic deformation in poly phase alloys – Strengthening mechanism –Griffith's theory of failure modes- brittle and ductile fractures- damping property of materials- fracture toughness –initiation and propagation of fatigue cracks – Creep mechanism –Hydrogen embrittlement of metals

UNIT II	SURFACE MODIFICATION OF MATERIALS	9	0	0	9

Mechanical surface treatment and coating –Case hardening and hard facing –thermal spraying –Vapour deposition –Ion implantation- diffusion coating –electroplating and electroforming –conversion coating –Ceramic and organic coating – Diamond coating – Advanced surface modification of steels

UNIT III	ADVANCED HEAT TREATMENT OF MATERIALS	9	0	0	9

Composite- Types- Natural composites- Metal matrix composites- Ceramic matrix composites- Applications

UNIT IV	MODERN MATERIALS AND ALLOYS	9	0	0	9

Super alloys Hastelloy, Inconel, Invar, and Monel and uses.–Refractory materials - Fireclay refractories. High alumina refractories, Silica brick, Magnesite refractories

Ceramic and their applications - Low melting alloys Mercury, Cadmium, Zinc, Lead– Shape memory alloys -Copper – Aluminium-Nickel and Nickel -Titanium

UNIT V	APPLICATION OF ADVANCED MATERIALS	9	0	0	9

Ti and Ni based alloys for gas turbine applications –Maraging (Low carbon and high Nickel) and cryogenic steels – Newer materials and their treatment for automobile applications – Materials for aerospace (AL6061,AL 7075), Marine(AH36, DH36, and EH36)and nuclear systems

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Dowling, ''Mechanical Behaviour Of Materials, Engineering Method Of Determination, Fracture",Mcgraw Hill,1999
2.	Dieter, 'Engineering Design, A materials And Processing Approach'', Third Edition, Mcgraw Hill,1999

REFERENCES:

1.	P.Rama Rao, "Advances In Materials And Their Applications", Willey Eastern Ltd.,1993.
2.	Serope Kalpakjian, "Manufacturing Engineering And Technology' Third Edition, Addison Wisley Publishing Co.,1995.
3.	Kennith G .Budinski, ''Surface Engineering For Wear Resistance'', Prentice Hall,1998.
4.	Dieter, ''Mechanical Metallurgy' 'Mcgraw Hill, 1989
5.	D.R.Gabe, 'Principles Of Metal Surface Treatment And Protection', Pergamon Press1978.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Impartknowledge of crack and failure of metals	Understand
CO2	Identify the different types of coatings	Understand
CO3	Applyknowledge of composites	Apply
CO4	Definethe properties of modern alloys	Remember
CO5	Provide information of advanced aerospace alloys	Remember

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	0	1	0	0	1	0	0	0	0	2	1	2	2
CO2	1	3	1	1	0	0	1	0	0	0	0	2	0	1	1
CO3	3	3	1	1	2	0	1	0	0	0	0	3	0	1	3
CO4	3	2	1	2	2	0	1	0	0	0	0	3	2	1	3
CO5	2	3	0	3	1	0	1	0	0	0	0	3	0	1	2
Avg	**2.2**	**2.6**	**0.6**	**1.6**	**1.0**	**0.0**	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**2.6**	**0.6**	**1.2**	**2.2**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

22MEHO303	ADDITIVE MANUFACTURING					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
1. Manufacturing technology, Drafting software		**Hours/Week**	**L**	**T**	**P**	**TH**
2. Engineering Materials			**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To introduce the development of Additive Manufacturing (AM), various business opportunities and applications
2.	To familiarize various software tools, processes and techniques to create physical objects that satisfy product development / prototyping requirements, using AM.
3.	To be acquainted with vat polymerization and material extrusion processes.
4.	To be familiar with powder bed fusion and direct energy deposition.
5.	To gain knowledge on applications of binder jetting, material jetting and laminated object manufacturing processes

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Overview – Need - Development of Additive Manufacturing (AM) Technology: Rapid Prototyping- Rapid Tooling – Rapid Manufacturing – Additive Manufacturing. AM Process Chain- Classification – Benefits. Applications: Building Printing-Bio Printing- Food Printing-Printing Electronics. Business Opportunities and Future Directions - Intellectual Property.

UNIT II	**DESIGN FOR ADDITIVE MANUFACTURING (DFAM)**	**9**	**0**	**0**	**9**

Concepts and Objectives- AM Unique Capabilities: Part Consolidation-Topology Optimization Light weight Structure - DFAM for Part Quality Improvement. Data Processing - CAD Model Preparation -Part Orientation and Support Structure Generation -Model Slicing - Tool Path Generation-Customized Design and Fabrication for Medical Applications- Case Studies.

UNIT III	**VAT POLYMERIZATION AND MATERIAL EXTRUSION**	**9**	**0**	**0**	**9**

Photo polymerization: Stereo lithography Apparatus (SLA)- Materials -Process -Advantages Limitations- Applications. Digital Light Processing (DLP) - Materials – Process - Advantages - Applications. Extrusion Based System: Fused Deposition Modeling (FDM)- Process-Materials - Applications and Limitations.

UNIT IV	**POWDER BED FUSION AND DIRECT ENERGY DEPOSITION**	**9**	**0**	**0**	**9**

Powder Bed Fusion: Selective Laser Sintering (SLS): Process – Powder Fusion Mechanism –Process Parameters – Typical Materials and Application. Selective Laser Melting (SLM) and Electron Beam Melting (EBM): Materials – Process - Advantages and Applications.

Beam Deposition Process: Laser Engineered Net Shaping (LENS)- Process -Material Delivery - Process Parameters - Materials -Benefits -Applications.

UNIT V	**OTHER ADDITIVE MANUFACTURING PROCESSES**	**9**	**0**	**0**	**9**

Binder Jetting: Three -Dimensional Printing - Materials -Process - Benefits and Limitations. Material Jetting: Multi-jet Modeling- Materials - Process - Benefits. Sheet Lamination Process: Laminated Object Manufacturing (LOM)- Basic Principle- Mechanism: Gluing or Adhesive Bonding – Thermal Bonding- Materials-Application and Limitation.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Andreas Gebhardt and Jan-Steffen Hötter “Additive Manufacturing: 3D Printing for Prototyping and Manufacturing”, Hanser publications, United States, 2015, ISBN: 978-1-56990-582-1.
2.	Ian Gibson, David W. Rosen and Brent Stucker “Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing”, 2nd edition, Springer., United States, 2015, ISBN13: 978-1493921126.

REFERENCES:

1.	Amit Bandyopadhyay and Susmita Bose, “Additive Manufacturing”, 1st Edition, CRC Press., United States, 2015, ISBN-13: 978-1482223590.
2.	Andreas Gebhardt, “Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing”, Hanser

	Gardner Publication, Cincinnati., Ohio, 2011, ISBN: 9783446425521.
3.	Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer., United States, 2006, ISBN: 978-1-4614-9842-1.
4.	Liou, L.W. and Liou, F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press., United States, 2011, ISBN: 9780849334092.
5.	Milan Brandt, "Laser Additive Manufacturing: Materials, Design, Technologies, and Applications", Woodhead Publishing., United Kingdom, 2016, ISBN: 9780081004333.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Recognize the development of AM technology and how AM technology propagated into various businesses and developing opportunities.	Remember
CO2	Acquire knowledge on process of transforming a concept into the final product in AM technology.	Understand
CO3	Elaborate the vat polymerization and material extrusion processes and its applications.	Apply
CO4	Acquire knowledge on process and applications of powder bed fusion and direct energy deposition.	Apply
CO5	Evaluate the advantages, limitations, applications of binder jetting, material jetting and laminated object manufacturing processes.	Evaluate

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	0	0	0	0	0	1	2	0	1	0	2	1	1	1
CO2	2	1	1	1	1	0	2	1	0	1	0	2	1	2	1
CO3	2	1	0	0	0	0	1	0	0	1	0	2	1	1	1
CO4	2	1	0	0	0	0	1	0	0	1	0	2	1	1	1
CO5	2	1	0	0	0	0	1	0	0	1	0	2	1	1	1
Avg	**2.0**	**0.8**	**0.2**	**0.2**	**0.2**	**0.0**	**1.2**	**0.6**	**0.0**	**1.0**	**0.0**	**2.0**	**1.0**	**1.2**	**1.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEHO304	NON DESTRUCTIVE TESTING AND FAILURE ANALYSIS					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To develop the fundamental knowledge about non-destructive and destructive analysis, in order to control the quality in manufacturing and production engineering components.

UNIT I	**INTRODUCTION AND SURFACE NDT**	**9**	**0**	**0**	**9**

Non destructive testing– Comparison with destructive testing, importance, scope and difficulties. Visual Inspection: Tools, applications and limitations. Liquid penetrant Inspection - Principles, properties required for a good penetrant and developers. Magnetic particle inspection - Principles, advantage and limitations.

UNIT II	**RADIOGRAPHY AND ACOUSTIC EMISSION**	**9**	**0**	**0**	**9**

Radiography- basic principle, electromagnetic radiation sources, radiographic imaging, inspection techniques, applications, limitations and safety. Acoustic emission testing- procedures and its importance.

UNIT III	**EDDY CURRENT AND ULTRASONIC TESTING**	**9**	**0**	**0**	**9**

Eddy current testing – principle, application, limitation; Ultrasonic testing – basic properties of sound beam, transducers, inspection methods, flaw characterization techniques, immersion testing, advantage and limitations.

UNIT IV	**LEAK TESTING AND THERMOGRAPHY**	**9**	**0**	**0**	**9**

Leak testing, Holography and Thermography – principles, procedures and applications; Comparison and selection of Non destructive testing methods; Defects in casting, forging, rolling and welding.

UNIT V	**FAILURE ANALYSIS METHODOLOGY**	**9**	**0**	**0**	**9**

Failure analysis methodology, tools and techniques of failure analysis, failure data retrieval, procedural steps for investigation of a failure analysis; types of failure and techniques for failure analysis.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Baldev Raj, “Practical Non-Destructive Testing”, Narosa Publishing House, 1997.
2.	J. Prasad and C. G. K. Nair, Non-Destructive Test and Evaluation of Materials, Tata McGraw-Hill Education, 2nd edition (2011).
3.	Peter J Shull, “Nondestructive Evaluation- Theory, Techniques and Applications” Marcel Dekker, Inc, USA 2002, ISBN: 0-8247-8872-9.

REFERENCES:

1	George E Dieter, “Mechanical Metallurgy”, McGraw Hill Book Company
2	B.Hull and V.John. “Non-Destructive Testing”, McMillan
3	A.K Das, “Metallurgy of failure analysis”, TMH, 1992

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the concept of destructive and Non-destructive testing methods.	Understand
CO2	Explain the working principle and application of die penetrant test and magnetic particle inspection.	Remember
CO3	Understand the working principle of eddy current inspection, Ultrasonic testing and applications.	Understand
CO4	Apply radiographic techniques for testing and acoustic emission testing.	Apply

CO5	Define tools and techniques of failure analysis, procedural steps for investigation of failure.	Remember

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	1	1	0	0	0	0	0	0	0	0	2	2	0
CO2	2	2	1	3	0	0	0	0	0	0	0	0	2	2	0
CO3	2	2	1	3	1	0	0	0	0	0	0	0	2	2	0
CO4	2	2	1	3	1	0	0	0	0	0	0	0	2	2	0
CO5	2	2	1	3	3	0	0	0	0	0	0	0	2	2	0
Avg	**1.8**	**2**	**1**	**2.6**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEHO305	PRODUCT LIFE CYCLE MANAGEMENT					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To study about the history, concepts and terminology in PLM
2.	To learn the functions and features of PLM/PDM
3.	To develop different modules offered in commercial PLM/PDM tools
4.	To demonstrate PLM/PDM approaches for industrial applications
5.	To use PLM/PDM with legacy data bases, Coax& ERP systems

UNIT I	**HISTORY, CONCEPTS AND TERMINOLOGY OF PLM**	**9**	**0**	**0**	**9**

Introduction to PLM, Need for PLM, opportunities of PLM, Different views of PLM - Engineering Data Management (EDM), Product Data Management (PDM), Collaborative Product Definition Management (cPDm), Collaborative Product Commerce (CPC), Product Lifecycle Management (PLM). PLM/PDM Infrastructure – Network and Communications, Data Management, Heterogeneous data sources and applications

UNIT II	**PLM/PDM FUNCTIONS AND FEATURES**	**9**	**0**	**0**	**9**

User Functions – Data Vault and Document Management, Workflow and Process Management, Product Structure Management, Product Classification and Programme Management. Utility Functions – Communication and Notification, data transport, data translation, image services, system administration and application integration

UNIT III	**DETAILS OF MODULES IN A PDM/PLM SOFTWARE**	**9**	**0**	**0**	**9**

Case studies based on top few commercial PLM/PDM tools – Teamcenter, Windchill, ENOVIA, Aras PLM, SAP PLM, Arena, Oracle Agile PLM and Autodesk Vault.-Architecture of PLM software- selection criterion of software for particular application - Brand name to be removed

UNIT IV	**ROLE OF PLM IN INDUSTRIES**	**9**	**0**	**0**	**9**

Case studies on PLM selection and implementation (like auto, aero, electronic) - other possible sectors, PLM visioning, PLM strategy, PLM feasibility study, change management for PLM, financial justification of PLM, barriers to PLM implementation, ten step approach to PLM, benefits of PLM for–business, organisation, users, product or service, process performance- process compliance and process automation

UNIT V	**BASICS ON CUSTOMISATION/INTEGRATION OF PDM/PLM SOFTWARE**	**9**	**0**	**0**	**9**

PLM Customization, use of EAI technology (Middleware), Integration with legacy data base, CAD, SLM and ERP

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Product Lifecycle Management for a Global Market, Springer; 2014 edition (29 September 2016),ISBN-10 : 3662516330
2.	Product Life Cycles and Product Management, Praeger Publishers Inc (27 March 1989)ISBN-10 : 0899303196

REFERENCES:

1.	AnttiSaaksvuori and AnselmiImmonen, “Product Lifecycle Management”, Springer Publisher, 2008 (3rd Edition)
2.	IvicaCrnkovic, Ulf Asklund and AnnitaPerssonDahlqvist, “Implementing and Integrating Product Data Management and Software Configuration Management”, Artech House Publishers, 2003.
3.	J ohn Stark, “Global Product: Strategy, Product Lifecycle Management and the Billion Customer Question”, Springer Publisher, 2007
4.	John Stark, “Product Lifecycle Management: 21st Century Paradigm for Product Realisation”, Springer Publisher, 2011 (2nd Edition).

5.	Michael Grieves, “Product Life Cycle Management”, Tata McGraw Hill, 2006.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Summarize the history, concepts and terminology of PLM	Remember
CO2	Develop the functions and features of PLM/PDM	Create
CO3	Discuss different modules offered in commercial PLM/PDM tools.	Evaluate
CO4	Interpret the implement PLM/PDM approaches for industrial applications.	Analyze
CO5	Integrate PLM/PDM with legacy data bases, cax& ERP systems	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	0	0	0	0	0	0	0	0	2	2	1	1	0
CO2	1	1	0	0	0	0	0	0	0	0	2	2	1	1	0
CO3	1	1	0	0	1	0	0	0	0	0	2	2	1	1	0
CO4	1	1	0	0	2	0	0	0	2	0	2	2	1	1	0
CO5	1	1	0	0	3	0	0	0	2	0	2	2	1	1	0
Avg	**1**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**0.8**	**0**	**2**	**2**	**1**	**1**	**0**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

22MEHO306	ERGONOMICS IN DESIGN				
PREREQUISITES	CATEGORY	PE	Credit		3
	Horus/Week	L	T	P	TH
		3	0	0	3

COURSE OBJECTIVES:

1.	Accurately recognize and evaluate hazards (ergonomic in nature) Accurately recognize and evaluate hazards (ergonomic in nature) which are likely to cause occupational illnesses or injuries.
2.	To introduce students about the essentials of Static and dynamic anthropometry and Posture and job relation
3.	Apply the knowledge, skills, and abilities obtained in through subject into an industrial based problem.

UNIT I	**INTRODUCING ERGONOMICS AND DISCIPLINE APPROACH: ERGONOMICS/ HUMAN FACTORS**	**9**	**0**	**0**	**9**

Design today- Human aid to lifestyle, Journey, Fitting task to man their contractual structure, Domain, Philosophy and Objective, Mutual task comfort: two way dialogue, communication model, Ergonomics/ human Factors fundamentals, Physiology (work physiology) and stress

UNIT II	**HUMAN PHYSICAL DIMENSION CONCERN AND POSTURE AND MOVEMENT**	**9**	**0**	**0**	**9**

Human body- structure and function, anthropometrics, Anthropometry: body growth and somatotypes, Static and dynamic anthropometry, Stand Posture- erect, Anthropometry landmark: Sitting postures, Anthropometry: squatting and cross-legged postures, Anthropometric measuring techniques, Statistical treatment of data and percentile calculations Human body- structure and function, Posture and job relation, Posture and body supportive devices, Chair characteristics, Vertical work surface, Horizontal work surface, Movement, Work Counter.

UNIT III	**BEHAVIOUR AND PERCEPTION AND VISUAL ISSUES, ENVIRONMENTS FACTORS**	**9**	**0**	**0**	**9**

Communication and cognitive issues, Psycho-social behaviour aspects, behaviour and stereotype, Information processing and perception, Cognitive aspects and mental workload, Human error and risk perception; Visual performance, Visual displays, Environmental factors influencing human performance.

UNIT IV	**ERGONOMIC DESIGN PROCESS, PERFORMANCE SUPPORT AND DESIGN INTERVENTION**	**9**	**0**	**0**	**9**

Ergonomics design methodology, Ergonomics criteria/check while designing, Design process involving ergonomics check, Some checklists for task easiness. Occupational safety and stress at workplace in view to reduce the potential fatigue, errors, discomforts and unsafe acts, Workstation design, Furniture support, Vertical arm reach and design application possibility, Humanising design: Design and human compatibility, comfort and adaptability aspects.

UNIT V	**OFFICE FURNITURE GUIDELINES FOR FIT AND FUNCTION, DESIGN ERGONOMICS IN INDIA AND UNIVERSAL DESIGN CONSIDERATIONS**	**9**	**0**	**0**	**9**

Office Furniture Guidelines for Fit and Function Anticipate Actions, Chairs, Desk and Work surfaces, Storage and Files, Accessories Resources for Designing Ergonomic Products. Design Ergonomics in India: scope for exploration. Universal Design Considerations Wheelchairs Crutches, Canes, and Walkers Knobs, Handles, and Controls Access Ramps and Stairs, Resources on Universal Design.

Total (45L) = 45Periods

TEXT BOOKS:

1.	Bridger, RS: Introduction to Ergonomics, 2nd Edition, Taylor &Francis, 2003.
2.	Dul, J. and Weerdmeester, B. Ergonomics for beginners, a quick reference guide, Taylor & Francis, 1993.

REFERENCES:

1.	Green, W.S. and Jordan, P .W, Human Factors in Product Design, Taylor & rancis, 1999.
2.	D. Chakrabarti, Indian Anthropometric Dimensions for ergonomic design practice, National Institute of Design,

	Ahmedabad, 1997
3.	G. Salvendy (edit), Handbook of Human Factors and ergonomics, John Wiley & Sons,Inc., 1998.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Learn about the basics of Human aid to lifestyle, Physiology and stress	Understand
CO2	Learn about the anthropometry: body growth and somatotypes, further about Vertical work surface, Horizontal work surface can also be obtained.	Remember
CO3	Study about the communication and cognitive issues, it promotes about environmental factors influencing human performance.	Understand
CO4	Learn about the Ergonomics design methodology and gives fathom notion on Occupational safety and stress at workplace	Apply
CO5	Study about Office furniture guidelines for fit and function and universal design considerations	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	0	0	0	0	3	2	2	0	0	0	2	1	2	1
CO2	1	0	0	0	0	3	2	2	0	0	0	2	1	2	1
CO3	1	0	0	0	0	3	2	2	0	0	0	2	1	2	1
CO4	1	0	0	0	0	3	2	2	0	0	0	2	1	2	1
CO5	1	0	0	0	0	3	2	2	0	0	0	2	1	2	1
Avg	**1**	**0**	**0**	**0**	**0**	**3**	**2**	**2**	**0**	**0**	**0**	**2**	**1**	**2**	**1**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

22MEHO307	SURFACE ENGINEERING					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To teach students fundamental about surface properties in engineering applications and Wear modes
2.	To introduce students about the essentials of electroplating and Other plating processes
3.	To teach about the thin film for wear application, Coating specifications.
4.	To teach about the special surfacing processes
5.	To teach about the hard facing processes and applications

UNIT I	**BASICS OF SURFACE ENGINEERING**	**9**	**0**	**0**	**9**

Importance of surfaces and wear surface properties in engineering applications, Current status of surface engineering. Wear modes; Categories of wear, Low stress, High stress and Gouging abrasion, Cavitation, Slurry erosion, Impingement erosion, Fretting wear, Adhesive wear, Seizure, Galling, Oxidative wear, Spalling, Impact wear brinelling.

UNIT II	**PLATING PROCESSES**	**9**	**0**	**0**	**9**

Fundamentals of electroplating, Electro deposition from plating baths, Electroless plating, Mentalliding, Selective plating, Hard anodizing, Other plating processes, Applicability of plating for wear resistance.

UNIT III	**THIN FILM COATINGS**	**9**	**0**	**0**	**9**

Thermal evaporation, PVD and CVD, Sputter coating, Ion plating, Thin film for wear application, Coating specifications.

UNIT IV	**SPECIAL SURFACING PROCESSES**	**9**	**0**	**0**	**9**

Rebuilding and surface cements, Wear tiles, Electrospark deposition coatings, Fused carbide cloth ceramic coatings, Wear sleeves, Wear plates.

UNIT V	**HARD FACING PROCESSES AND APPLICATIONS**	**9**	**0**	**0**	**9**

Shielded metal arc welding, Gas tungsten arc welding, Gas metal arc welding, Flux coaxed are welding, Submerged arc welding, Plasma arc welding oxyacetylene welding, Furnace fusing, Thermal spray processes and their applications, Hardfacing transformation, Fusion alloys, Non fusion materials. Hardfacing in new designs, Hardfacing for repairs, Hardfacing with fusion processes, Nonfusion deposits, Weldability considerations, Finishing considerations.

Total (45L) = 45Periods

TEXT BOOKS:

1.	Budinski, K.G., Surface Engineering for Wear Resistance, Prentice Hall (1988).
2.	Mathews, A., Advanced Surface Coatings: A Hand book of Surface Engineering, Spinger (1991)

REFERENCES:

1.	Hocking, M.G., Metallic and Ceramic Coatings, John Wiley (1989)
2.	Strafford, K.N., Datta, P.K., and Gray, J.S., Surface Engineering Practice, Processes, Fundamentals and Applications in Corrosion and Wear, Ellis Harwood (1990).

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Learn about the basics and Current status of surface engineering. Wear modes	Understand
CO2	Learn about the Fundamentals of electroplating and Other plating processes	Understand
CO3	Study about the Thermal evaporation and wear application, Coating specifications.	Remember
CO4	Learn about the rebuilding and surface cements, Wear sleeves, Wear plates	Understand

CO5	Study about Shielded metal arc welding, Gas tungsten arc welding and Nonfusion deposits, Weldability considerations, Finishing considerations.	Understand

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	2	0	1	0	0	0	0	0	0	0	2	1	0
CO2	1	1	2	0	1	0	0	0	0	0	0	0	2	1	0
CO3	1	1	2	0	1	0	0	0	0	0	0	0	2	1	0
CO4	1	1	2	0	1	0	0	0	0	0	0	0	2	1	0
CO5	1	1	2	0	1	0	0	0	0	0	0	0	2	1	0
Avg	**1**	**1**	**2**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**0**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

22MEHO308	INDUSTRIAL LAYOUT DESIGN AND SAFETY					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
1. Knowledge in basic manufacturing systems.		**Hours/Week**	**L**	**T**	**P**	**TH**
2. Knowledge in operations research			**3**	**0**	**0**	**3**
3. Knowledge in safety regulations.						

COURSE OBJECTIVES:

1.	To get the basics of process layout & product layout
2.	To explore the layout planning by computer applications following different algorithms.
3.	To imbibe knowledge on safety management functions and its techniques.
4.	To introduce knowledge on accident reporting & investigation procedure.
5.	To assimilate knowledge on workplace hazards & its control

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Objectives of a good plant layout, principles of a good layout, Classification of Layout, Advantages and Limitations of different layouts, Layout design procedures, Overview of the plant layout. Process layout & Product layout: Selection, specification, Implementation and follow up, comparison of product and process layout.

UNIT II	**COMPUTERIZED LAYOUT PLANNING**	**9**	**0**	**0**	**9**

Heuristics for Plant layout – ALDEP, CORELAP, CRAFT, Group Layout, Fixed position layout- Quadratic assignment model. Branch and bound method, Evaluation of layout.

UNIT III	**SAFETY REGULATIONS**	**9**	**0**	**0**	**9**

Need for safety. Safety and productivity. Definitions: Accident, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. Theories of accident causation. Safety organization- objectives, types, functions, Role of management, supervisors, workmen, unions, government and voluntary agencies in safety. Safety policy. Safety Officer, Safety committee, Overview of factories act 1948 – ISO-45001.

UNIT IV	**SAFETY HARAZDS IN MACHINES**	**9**	**0**	**0**	**9**

Machine Guarding, Guarding of hazards, Machine Guarding types and its application – Safety in welding and Gas cutting – Safety in Manual and Mechanical material handling- Safety in use of electricity

UNIT V	**CHEMICAL AND FIRE HAZARDS**	**9**	**0**	**0**	**9**

Toxicity- TLV- Types of Chemical Hazards-Occupational diseases caused by dust, fumes, gases, smoke and solvent hazards- control measures Fire triangle- Types of fire - first aid fire fighting equipment – flammability limit- LPG safety - Hazard identification and Risk Analysis, case studies

Total (45L) = 45Periods

TEXT BOOKS:

1.	James M Moore-Plant Layout Design, Mac Millan Co.1962 LCCCN61-5204.
2.	Krishnan N.V. “Safety Management in Industry” Jaico Publishing House, Bombay, 1997

REFERENCES:

1.	James Apple, "Plant Layout & Material Handling", The Ronalt Press Co., New Delhi, 1998.
2.	Pannerselvam. R, “Production and Operations Management”, PHI, 2017
3.	Sunderesh Heragu-Facilities Design, PWS Publishing Company, ISBN-0-534-95183.
4.	Heinrich H.W. “Industrial Accident Prevention” McGraw-Hill Company, New York, 1980.
5.	Blake R.B., “Industrial Safety” Prentice Hall, Inc., New Jersey, 1973
6.	John Ridley, “Safety at Work”, Butterworth & Co., London, 1983.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Able to get the basics of layout design procedure and selection of appropriate layout for industries.	Create
CO2	The students will be able to plan and design plant and production layouts through basic strategies and with computer application	Create
CO3	Apply principles of safety management, its functions and technique in any organization.	Apply
CO4	Apply machine guarding principles in industrial applications.	Apply
CO5	Realize chemical hazards, toxicity, fire and explosion in the work place and involve to take various control measures to prevent hazards	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	2	1	2	3	2	1	1	2	2	2	2	3	2	2
CO2	0	1	2	3	0	1	0	1	2	0	2	0	1	2	1
CO3	0	2	2	1	3	1	1	1	1	0	1	2	2	3	2
CO4	0	2	1	1	2	0	0	1	1	1	2	0	2	1	1
CO5	1	2	2	1	2	0	0	1	1	1	2	1	3	2	1
Avg	**0.4**	**1.8**	**1.6**	**1.6**	**2.0**	**0.8**	**0.4**	**1.0**	**1.4**	**0.8**	**1.8**	**1.0**	**2.2**	**1.0**	**1.4**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEHO309	DIGITAL MANUFACTURING AND IOT					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To study the various aspects of digital manufacturing.
2.	To inculcate the importance of DM in Product Lifecycle Management and Supply chain Management
3.	To formulate of smart manufacturing systems in the digital work environment
4.	To interpret IOT to support the digital manufacturing
5.	To elaborate the significance of digital twin

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Introduction – Need – Overview of Digital Manufacturing and the Past – Aspects of Digital Manufacturing: Product life cycle, Smart factory, and value chain management – Practical Benefits of Digital Manufacturing – The Future of Digital Manufacturing.

UNIT II	**DIGITAL LIFE CYCLE & SUPPLY CHAIN MANAGEMENT**	**9**	**0**	**0**	**9**

Collaborative Product Development, Mapping Requirements to specifications – Part Numbering, Engineering Vaulting, and Product reuse – Engineering Change Management, Bill of Material and Process Consistency – Digital Mock up and Prototype development – Virtual testing and collateral. Overview of Digital Supply Chain - Scope& Challenges in Digital SC - Effective Digital Transformation - Future Practices in SCM

UNIT III	**SMART FACTORY**	**9**	**0**	**0**	**9**

Smart Factory – Levels of Smart Factories – Benefits – Technologies used in Smart Factory – Smart Factory in IoT- Key Principles of a Smart Factory – Creating a Smart Factory – Smart Factories and Cybersecurity

UNIT IV	**INDUSTRY 4.0**	**9**	**0**	**0**	**9**

Introduction – Industry 4.0 –Internet of Things – Industrial Internet of Things – Framework: Connectivity devices and services – Intelligent networks of manufacturing – Cloud computing – Data analytics –Cyber physical systems –Machine to Machine communication – Case Studies.

UNIT V	**STUDY OF DIGITAL TWIN**	**9**	**0**	**0**	**9**

Basic Concepts – Features and Implementation – Digital Twin: Digital Thread and Digital Shadow- Building Blocks – Types – Characteristics of a Good Digital Twin Platform – Benefits, Impact & Challenges – Future of Digital Twins

Total (45L) = 45Periods

TEXT BOOKS:

1.	Zude Zhou, Shane (Shengquan) Xie and Dejun Chen, Fundamentals of Digital Manufacturing Science, Springer-Verlag London Limited, 2012.
2.	Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, A press, 2016.

REFERENCES:

1.	Lihui Wang and Andrew YehChing Nee, Collaborative Design and Planning for Digital Manufacturing, Springer-Verlag London Limited, 2009.
2.	Andrew Yeh Chris Nee, Fei Tao, and Meng Zhang, “Digital Twin Driven Smart Manufacturing”, Elsevier Science., United States, 2019.
3.	Alp Ustundag and Emre Cevikcan, “Industry 4.0: Managing The Digital Transformation”, Springer Series in Advanced Manufacturing., Switzerland, 2017
4.	Ronald R. Yager and Jordan Pascual Espada, “New Advances in the Internet of Things”, Springer., Switzerland, 2018.

5.	Ronald R. Yager and Jordan Pascual Espada, “New Advances in the Internet of Things”, Springer., Switzerland, 2018

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Impart knowledge to use various elements in the digital manufacturing.	Understand
CO2	Differentiate the concepts involved in digital product development life cycle process and supply chain management in digital environment.	Analyze
CO3	Select the proper procedure of validating practical work through digital validation in Factories.	Apply
CO4	Implementation the concepts of iot and its role in digital manufacturing.	Apply
CO5	Analyse and optimize various practical manufacturing process through digital twin.	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	0	0	0	0	2	0	0	0	2	2	2	2	2
CO2	1	1	0	0	0	0	2	0	0	0	2	2	2	2	2
CO3	1	1	0	0	0	0	2	0	0	0	2	2	2	2	2
CO4	1	1	0	0	0	0	2	0	0	0	2	2	2	2	2
CO5	1	1	0	0	0	0	2	0	0	0	2	2	2	2	2
Avg	**1**	**1**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**2**	**2**	**2**	**2**	**2**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

22MEHO310	SMART MOBILITY AND INTELLIGENT VEHICLES					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To introduce students to the various technologies and systems used to implement smart mobility and intelligent vehicles
2.	To learn Basics of Radar Technology and Systems, Ultrasonic Sonar Systems, LIDAR Sensor Technology and Systems and other sensors for automobile vision system
3.	To learn Basic Control System Theory applied to Autonomous Automobiles
4.	To produce overall impact of automating like various driving functions, connecting the automobile to sources of information that assist with a task
5.	To allow the automobile to make autonomous intelligent decisions concerning future actions of the vehicle that potentially impact the safety of the occupants through connected car & autonomous vehicle technology

UNIT I	**INTRODUCTION TO AUTOMATED, CONNECTED AND INTELLIGENT VEHICLES**	**9**	**0**	**0**	**9**

Concept of Automotive Electronics, Electronics Overview, History & Evolution, Infotainment, Body, Chassis, and Powertrain Electronics, Introduction to Automated, Connected, and Intelligent Vehicles. Case studies: Automated, Connected, and Intelligent Vehicles

UNIT II	**SENSOR TECHNOLOGY FOR SMART MOBILITY**	**9**	**0**	**0**	**9**

Basics of Radar Technology and Systems, Ultrasonic Sonar Systems, Lidar Sensor Technology and Systems, Camera Technology, Night Vision Technology, Other Sensors, Use of Sensor Data Fusion, Integration of Sensor Data to On-Board Control Systems

UNIT III	**CONNECTED AUTONOMOUS VEHICLE**	**9**	**0**	**0**	**9**

Basic Control System Theory applied to Automobiles, Overview of the Operation of ECUs, Basic Cyber-Physical System Theory and Autonomous Vehicles, Role of Surroundings Sensing Systems and Autonomy, Role of Wireless Data Networks and Autonomy.

UNIT IV	**VEHICLE WIRELESS TECHNOLOGY AND NETWORKING**	**9**	**0**	**0**	**9**

Wireless System Block Diagram and Overview of Components, Transmission Systems – Modulation/Encoding, Receiver System Concepts– Demodulation/Decoding, Wireless Networking and Applications to Vehicle Autonomy, Basics of Computer Networking – the Internet of Things, Wireless Networking Fundamentals, Integration of Wireless Networking and On-Board Vehicle Networks

UNIT V	**CONNECTED CAR AND AUTONOMOUS VEHICLE TECHNOLOGY**	**9**	**0**	**0**	**9**

Connectivity Fundamentals, Navigation and Other Applications, Vehicle-to-Vehicle Technology and Applications, Vehicle-to-Roadside and Vehicle-to-Infrastructure Applications, Autonomous Vehicles - Driverless Car Technology, Moral, Legal, Roadblock Issues, Technical Issues, Security Issues

Total (45L) = 45Periods

TEXT BOOKS:

1.	"Intelligent Transportation Systems and Connected and Automated Vehicles", 2016, Transportation Research Board
2.	Radovan Miucic, "Connected Vehicles: Intelligent Transportation Systems", 2019, Springer

REFERENCES:

1.	Tom Denton, "Automobile Electrical and Electronic systems, Roultedge", Taylor & Francis Group, 5th Edition, 2018.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Recognize the concept of cyber-physical control systems and their application to collision avoidance and autonomous vehicles	Understand
CO2	Select the concept of remote sensing and the types of sensor technology needed to implement remote sensing	Understand
CO3	Familiar with the concept of fully autonomous vehicles	Understand
CO4	Apply the basic concepts of wireless communications and wireless data networks	Apply
CO5	Analyse the concept of the connected vehicle and its role in automated vehicles	Analyse

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	2	0	2	1	0	0	0	0	1	2	2	2	0
CO2	2	2	2	0	2	1	0	0	0	0	1	2	2	2	0
CO3	2	2	2	0	2	1	0	0	0	0	1	2	2	2	0
CO4	2	2	2	0	2	1	0	0	0	0	1	2	2	2	0
CO5	2	2	2	0	2	1	0	0	0	0	1	2	2	2	0
Avg	**2**	**2**	**2**	**0**	**2**	**1**	**0**	**0**	**0**	**0**	**1**	**2**	**2**	**2**	**0**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

MINOR DEGREE COURSES

22MEMI01	ENGINEERING THERMODYNAMICS *(Use of standard thermodynamic tables, Mollier diagram are permitted)*				
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**	**C**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To impart the knowledge on concepts of zeroth and first law of thermodynamics.
2.	To make the learners to understand the third law of thermodynamics and analyze the various work and heat interactions in closed and open systems.
3.	To teach properties of pure substance.
4.	To impart knowledge on the concepts of steam power cycle.
5.	To derive thermodynamic relations for ideal and real gases.

UNIT I	**BASIC CONCEPT AND FIRST LAW**	**9**	**0**	**0**	**9**

Role of Thermodynamics in Engineering and Science - Applications of Thermodynamics. Basic concepts - concept of continuum, macroscopic approach, thermodynamic systems, Property, state, path and processes, quasi-static process, Thermodynamic equilibrium, Displacement work, P-V diagram. Zeroth law of thermodynamics – concept of temperature and heat. First law of thermodynamics – application to closed and open systems, steady flow processes with reference to various thermal equipment.

UNIT II	**SECOND LAW AND ENTROPY**	**9**	**0**	**0**	**9**

Heat engine – Refrigerator – Heat Pump, Second law of thermodynamics – Kelvin's and Clausius statements- Equivalence of these statements their corollaries. Reversibility and irreversibility. Carnot cycle, reversed Carnot cycle. Clausius inequality, Concept of entropy, principle of increase of entropy, T-s diagram, T-ds equations, Entropy.

UNIT III	**PROPERTIES OF PURE SUBSTANCES**	**9**	**0**	**0**	**9**

Steam - formation and its thermodynamic properties - p-v, p-T, T-v, T-s, h-s diagrams. PVT surface. Determination of dryness fraction. Calculation of work done and heat transfer in non-flow and flow processes using Steam Table and Mollier Chart.

UNIT IV	**STEAM POWER CYCLE**	**9**	**0**	**0**	**9**

Basic Rankine cycle, T-s & h-s diagrams - Performance Improvement - Reheat cycle, regenerative cycle and their combination cycles.

UNIT V	**IDEAL AND REAL GASES AND THERMO DYNAMIC RELATIONS**	**9**	**0**	**0**	**9**

Properties of ideal and real gases, equation of state of ideal and real gases, Avogadro's law, Vander Waal's equation of states, Principle of corresponding states, reduced properties and compressibility chart. Exact differentials, Maxwell relations, Specific heat equations, Tds, relations, ClausiusClapeyron equations and Joule Thomson Coefficient.

Total (45L)= 45 Periods

Text Books:

1.	Nag. P.K, "Engineering Thermodynamics", Tata McGraw-Hill, New Delhi, 2017.
2.	Sonntag, R.E., Borgnakke, C., and Van Wylen, G.J., Fundamentals of Thermodynamics, 6th ed., John Wiley, 2003.
3.	Arora C.P, "Thermodynamics", Tata McGraw Hill, New Delhi, 2003.
4.	Venwylen and Sontag, "Classical Thermodynamics", Wiley Eastern, 1987.

Reference Books:

1.	Cengel, "Thermodynamics- An Engineering Approach", 3rd Edition, Tata McGraw Hill,2015.

2.	Merala C, Pother, Craig W and Somerton, "Thermodynamics for Engineers", Schaum Outline Series, Tata McGrawHill, New Delhi, 2004.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the concepts of zeroth, first and second law of thermodynamics.	Remember
CO2	Analyze the various work and heat interactions for different types of processes for closed and open systems	Evaluate
CO3	Evaluate the different properties of pure substances using steam tables and Mollier chart	Evaluate
CO4	Analyze the performance of steam power cycle.	Analyze
CO5	Derive thermodynamic relations for ideal and real gases.	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	2	0	0	1	0	0	0	0	1	3	1	1
CO2	3	3	2	2	0	0	1	0	0	0	0	1	3	1	1
CO3	3	3	3	2	0	1	1	0	0	0	0	1	3	1	1
CO4	2	3	2	2	0	1	1	0	0	0	0	1	3	1	1
CO5	3	3	2	2	0	1	0	0	0	0	0	1	3	1	1
Avg	**2.8**	**3**	**2.2**	**2**	**0**	**0.6**	**0.8**	**0**	**0**	**0**	**0**	**1**	**3**	**1**	**1**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

22MEMI02	FLUID MECHANICS AND MACHINERY					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**C**
1.Engineering Physics		**Hours/Week**	**L**	**T**	**P**	**TH**
2.Engineering Chemistry			**3**	**0**	**0**	**3**
3.Engineering Mathematics						

Course Objectives:

1.	To understand the basic concepts and properties of fluids
2.	To analyze the kinematic and dynamic concepts of fluid flow
3.	To understand the various incompressible fluid flow through pipes and between parallel plates
4.	To apply the principles of fluid mechanics to design and operation of hydraulic turbines
5.	To apply the principles of fluid mechanics to design and operation of hydraulic pumps

UNIT I	**INTRODUCTION AND FLUID STATICS**	**9**	**0**	**0**	**9**

Basic concepts and units of measurement of physical quantities- Classification of fluids - Properties of fluids – density, relative density, vapour pressure, surface tension, Capillarity and viscosity. Fluid statics- hydrostatic pressure, buoyancy and Archimedes' principle.

UNIT II	**FLUID KINEMATICS AND DYNAMICS**	**9**	**0**	**0**	**9**

Classification of fluid flow - system and control volume - Lagrangian and Eulerian description for fluid flow - flow patterns- streamline, pathline, streakline and timeline. Velocity potential function and Stream function - continuity equation and its applications. Fluid dynamics - Bernoulli's equation and its applications. Dimensional analysis – Buckingham's theorem, dimensional homogeneity, similarity-laws and models.

UNIT III	**FLOW THROUGH PIPES AND PLATES**	**9**	**0**	**0**	**9**

Incompressible fluid flow-Laminar flow- Hagen-Poiseuille equation, shear stress, pressure gradient relationship - flow through pipes and flow between parallel plates. Turbulent flow – flow through pipes, friction factors in turbulent flow - total energy line, hydraulic gradient line, flow through pipes in series and parallel- Moody's friction factor chart. Power transmission-Boundary layer flows - Boundary layer thickness, momentum thickness, energy thickness-boundary layer separation.

UNIT IV	**HYDRAULIC TURBINES**	**9**	**0**	**0**	**9**

Hydraulic turbines classification-impulse and reaction turbines-Working Principle, work done-efficiency and performance curves for Pelton, Francis and Kaplan turbines (Only descriptive) - Comparison between impulse and reaction turbine-specific speed degree of reaction -draft tubes.

UNIT V	**HYDRAULIC PUMPS**	**9**	**0**	**0**	**9**

Classification of hydraulic pumps-Centrifugal pumps - working principle, specific speed, performance curves and priming(Only descriptive) -Reciprocating pumps - classification, working principle, indicator diagram, air vessels and performance curves. Cavitation in pumps(Only descriptive) - Working principles of gear and vane pumps.

Total (45L)= 45 Periods

Text Books:

1.	Bansal, R.K., "A Textbook of Fluid Mechanics and Hydraulic Machines, 9th Ed", Laxmi Publication Pvt Ltd, 2010.
2.	Rajput, R.K., "A Textbook of Fluid Mechanics and Hydraulic Mechanics", S.Chand and Company Ltd, 2011.
3.	Subramanya. K., "Fluid Mechanics and Hydraulic Machines", Tata McGraw Hill Publishing Company Ltd, 2011.

Reference Books:

1.	White, "Fluid Mechanics, 8 Ed", McGraw Hill India, 2017.
2.	Munson, Young and Okiishi, "Fundamentals of Fluid Mechanics 8 th Edition", Wiley, 2016.

3.	Yunuscengel, John. M.cimbala, “Fluid Mechanics Fundamentals and Applications”, McGraw Hill, 2017.
4.	Som, S.K, Biswas.G and SumanChakraborty, “Introduction to Fluid Mechanics and Fluid Machines”, Tata McGraw Hill India, 2011.
5.	Dr.P.N.Modi, Dr.S.M.Seth, “Hydraulics and Fluid Mechanics including Hydraulic Machines”, Standard book house, 2018.
E-References:	
1.	NPTEL courses: http://nptel.iitm.ac.in/courses.php - web and video sources on fluid mechanics.

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom’s Taxonomy Mapped**
CO1	Understand the basic concepts and properties of fluids	Remember
CO2	Analyze the kinematic and dynamic concepts of fluid flow	Analyze
CO3	Understand the various incompressible fluid flow through pipes and between parallel plates	Understand
CO4	Apply the principles of fluid mechanics to design and operation of hydraulic turbines	Apply
CO5	Apply the principles of fluid mechanics to design and operation of hydraulic pumps	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	1	0	0	0	2	0	0	0	1	0	2	2	1
CO2	3	3	1	0	2	0	0	0	0	0	0	0	2	2	1
CO3	2	3	2	2	1	0	0	0	0	0	0	0	2	2	1
CO4	3	3	3	2	1	2	1	0	0	0	0	0	2	2	1
CO5	3	3	3	2	1	2	1	0	0	0	0	0	2	2	1
Avg	**2.8**	**2.6**	**2**	**1.2**	**1**	**0.8**	**0.8**	**0**	**0**	**0**	**0.2**	**0**	**2**	**2**	**1**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

22MEMI03	MANUFACTURING PROCESSES					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
1. Basic science, Engineering mathematics, Engineering Physics		**Hours/Week**	**L**	**T**	**P**	**TH**
2.Engineering Materials			**3**	**0**	**0**	**3**

Course Objectives:

1.	To make the students familiarize with various manufacturing processes and fabrication techniques of metals and design of casting.
2.	To develop design concepts of various manufacturing processes.
3.	Gain knowledge to select appropriate manufacturing processes for various parts.
4.	To develop an entrepreneur skill among the students.
5.	To evaluate and select plastic deformation processes for various parts.

UNIT I	**CASTING**	**9**	**0**	**0**	**9**

Concepts of Manufacturing Process -Sand casting -Patterns – Design of Pattern, mould and cores- gating and risering design, solidification time calculation - Moulding machines - Core making. Special moulding processes – CO2 moulding; shell moulding, investment moulding, pressure die casting, centrifugal casting, casting defects.

UNIT II	**WELDING**	**9**	**0**	**0**	**9**

Classification of welding processes. Principles of Oxy-acetylene gas welding. Metal arc welding, resistance welding, submerged arc welding, tungsten inert gas welding, metal inert gas welding, plasma arc welding, thermit welding, electron beam welding, laser beam welding, defects in welding, Soldering and Brazing, Adhesive Bonding.

UNIT III	**METAL FORMING**	**10**	**0**	**0**	**10**

Metallurgical aspects of metal forming, slip, twinning mechanics of plastic deformation, load estimation of bulk deformation processes, Hot working and cold working of metals, Forging processes – open, closed and impression die forging – forging operations. Rolling of metals– Types of Rolling mill – Flat strip rolling – shape rolling operations – Defects in rolled parts. Principle of rod and wire drawing – Tube drawing – Principles of Extrusion – Types.

UNIT IV	**SHAPING OF PLASTICS**	**8**	**0**	**0**	**8**

Types of plastics - Characteristics of the forming and shaping processes – Moulding of Thermoplastics – Working principles and typical applications of - Injection moulding – Plunger and screw machines – Blow moulding – Rotational moulding – Film blowing – Extrusion - Typical industrial applications – Thermoforming – Processing of Thermosets – Working principles and typical applications - Compression moulding – Transfer moulding.

UNIT V	**SHEET METAL FORMING AND POWDER METALLURGY**	**9**	**0**	**0**	**9**

Formability of Sheet Metal, load estimation of sheet metal processes - Shearing, Deep drawing, Bending operations- types of presses used, Super Plastic forming; Introduction to Powder Metallurgy– Principal steps involved – sintering and compacting techniques, Advantages, limitations and applications of powder metallurgy.

Total (45L) = 45 Periods

Text Books:

1.	HajraChoudhury, "Elements of Workshop Technology", Vol. I and II, Media Promoters and Publishers Pvt., Ltd., Mumbai, 2005.
2.	NagendraParashar B.S. and Mittal R.K., "Elements of Manufacturing Processes", Prentice-Hall of India Private Limited, 2007.

Reference Books:

1.	SeropeKalpajian, Steven R.Schmid, "Manufacturing Processes for Engineering Materials",4/e, Pearson Education, Inc. 2007.
2.	Jain. R.K., and S.C. Gupta, "Production Technology", 16th Edition, Khanna Publishers, 2001.
3.	"H.M.T. "Production Technology – Handbook", Tata McGraw-Hill, 2000.

4.	Roy. A. Linberg, "Process and Materials of Manufacture", PHI, 2000.
5.	Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems.
E-References:	
1.	https://fdocuments.in/document/production-technology-55844cac00bfc.html?page=40

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Describe the operational features of various casting processes, design gate and riser and discover various defects in casting.	Understand
CO2	Explain various metal joining processes and compare them.	Understand
CO3	Summarize several types of metal forming processes and select suitable method for different applications.	Analyze
CO4	Analyze various manufacturing methods for plastics and their needs in industry.	Analyze
CO5	Describe various sheet metal forming processes, load estimation calculation and principles of powder metallurgy	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	1	2	1	0	0	0	0	0	1	0	0	1	2	1
CO2	2	1	2	1	0	1	0	0	1	1	0	0	1	2	1
CO3	1	1	1	1	0	0	0	0	0	1	0	0	1	1	1
CO4	1	1	1	0	1	0	0	0	0	1	0	0	1	1	1
CO5	0	1	0	0	0	0	0	0	1	1	0	0	1	0	1
Avg	**1.2**	**1**	**1.2**	**0.6**	**0.2**	**0.2**	**0**	**0**	**0.4**	**1**	**0**	**0**	**1**	**1.2**	**1**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEMI04	MATERIALS ENGINEERING					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
1. Engineering Physics		**Hours/Week**	**L**	**T**	**P**	**TH**
2.Engineering Chemistry			**3**	**0**	**0**	**3**

Course Objectives:

1.	To impart concept on reactions, treatment, microstructure and mechanical behavior of engineering materials at different temperature.
2.	To learn basic principles in metallurgy and materials engineering.
3.	To identity and select suitable engineering materials based on their applications

UNIT I	**PHASE DIAGRAMS**	**9**	**0**	**0**	**9**

Crystal structures, Phases, solid solution types, compounds, Hume- Rothery rules; Gibb's phase rule; Binary isomorphous alloy systems – Eutectic, Eutectoid , Peritectic systems. Lever rule, Equilibrium and non-equilibrium cooling, Fe-C Equilibrium diagram - effects of alloying elements – Ferrite and Austenite Stabilizers, TTT and CCT diagrams.

UNIT II	**HEAT TREATMENT**	**9**	**0**	**0**	**9**

Definition – Full annealing, stress relief, recrystallisation and spheroidizing –normalizing, hardening and Tempering of steel. Isothermal transformation diagrams – cooling curves superimposed on I.T. diagram CCR - Hardenability, Jominy end quench test – Austempering, martempering – case hardening, carburising, nitriding, cyaniding, carbo-nitriding – Flame and Induction hardening. Heat treatment of non-ferrous alloys - precipitation hardening .Heat treatment of HSS tools, gears, springs and gauges.

UNIT III	**FERROUS AND NON FERROUS METALS**	**9**	**0**	**0**	**9**

Plain carbon steels – Tool steels - maraging steels – HSLA steels .Stainless steels- ferritic and Austenitic, martensitic, duplex and precipitation hardened stainless steels. Types of Cast Irons- Gray cast iron, white cast iron, malleable cast iron, S.G.Iron .Copper alloys – Brass, Bronze and Cupronickel , Aluminium alloys, Bearing alloys.

UNIT IV	**MECHANICAL PROPERTIES AND TESTING**	**9**	**0**	**0**	**9**

UNIT V	**NON DESTRUCTIVE TESTING AND SURFACE ENGINEERING**	**9**	**0**	**0**	**9**

Non Destructive Testing: Basic principles - Testing method - radiographic Testing, Ultrasonic testing, Magnetic Particle Inspection and Liquid Penetrant Inspections Introduction to surface engineering - Definition, diffusion techniques, deposition methods, high and low energy beam methods, surface engineering charts, elastic contact mechanics

Total (45L) = 45 Periods

Text Books:

1.	Kenneth G. Budinski and Michael K. Buinski, "Engineering Materials", Prentice Hall of India Ltd, 2002.
2.	Raghavan, V, "Materials Science and Engineering", Prentice Hall of India (P) Ltd., 1999.
3.	Aswani.K.G, "A Text Book of Material Science", S.Chand and Co. Ltd., New Delhi, 2001.
4.	Khanna O.P., "A Text Book of Materials Science and Metallurgy", DhanpatRai Sons, 2004.

Reference Books:

1.	William. D.Callsber, "Material Science and Engineering", John Wiley and Sons, 1997.
2.	Sydney.H.Avner, "Introduction to Physical Metallurgy" Mc Graw Hill Book Company, 1994.

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Understand the formation of materials and their classification based on atomic structure.	Understand
CO2	Understand the principles of various heat treatment processes in fabrication industry.	Understand
CO3	Describe properties, applications and types of various ferrous and non-ferrous metals used in fabrication industry	Understand
CO4	Describe various types of failure and select methods for destructive testing	Understand
CO5	Select methods for Non destructive testing	Evaluate

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	2	2	1	1	1	0	0	0	0	0	2	3	1
CO2	1	0	2	1	1	2	1	0	0	0	0	0	2	3	1
CO3	0	1	1	1	1	0	1	0	0	0	0	0	3	2	1
CO4	0	2	2	1	1	1	1	0	0	0	0	0	2	3	1
CO5	0	2	2	2	1	0	1	0	0	0	0	0	2	2	1
Avg	**0.4**	**1.2**	**1.8**	**1.4**	**1.0**	**0.8**	**1**	**0**	**0**	**0**	**0**	**0**	**2.2**	**2.6**	**1.0**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

22MEMI05	KINEMATICS OF MACHINERY					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**C**
1. Engineering graphics. 2.Engineering Mechanics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the basic components and layout of linkages in the assembly of a system/ machine.
2.	To understand the principles in analyzing the assembly with respect to the displacement, velocity, and acceleration at any point in a link of a mechanism.
3.	To understand basics of cam profile and its displacement.
4.	To understand the basic concepts of toothed gearing and kinematics of gear trains.
5.	Illustrate the effects of friction drives in transmission system.

UNIT I	**BASICS OF MECHANISMS**	**9**	**0**	**0**	**9**

Classification of mechanisms- Basic kinematic concepts and definitions- Degree of freedom, mobility- Grashof's law, Kinematic inversions of four bar chain and slider-crank chains Limit positions- Mechanical advantage - Transmission angle- Description of some common mechanisms- Quick return mechanism, straight-line generators.

UNIT II	**KINEMATIC ANALYSIS**	**9**	**0**	**0**	**9**

Displacement, velocity and acceleration analysis of simple mechanisms, graphical velocity analysis using instantaneous centres - kinematic analysis of simple mechanisms- slider-crank mechanism dynamics Coincident points- Coriolis component of acceleration introduction to linkage synthesis three Position graphical synthesis for motion and path generation.

UNIT III	**KINEMATICS OF CAM**	**9**	**0**	**0**	**9**

Classification of cams and followers- Terminology and definitions- Displacement diagrams Uniform velocity, parabolic, simple harmonic and cycloidal motions- derivatives of follower motions- specified contour cams circular and tangent cams- pressure angle and undercutting, sizing of cams, graphical method for cam profile design.

UNIT IV	**GEARS AND GEAR TRAINS**	**9**	**0**	**0**	**9**

Involute and cycloidal gear profiles, gear parameters, fundamental law of gearing and conjugate action, spur gear contact ratio and interference/undercutting- helical, bevel, worm, rack & pinion gears, epicyclic and regular gear train kinematics.

UNIT V	**FRICTION IN MACHINE ELEMENTS**	**9**	**0**	**0**	**9**

Surface contacts- sliding and rolling friction- friction drives- friction in screw threads – bearings and lubrication- friction Clutches- belt and rope drives.

Total (45L) = 45 Periods

Text Books:

1.	Rattan S.S, "Theory of Machines", Tata McGraw Hill Publishing Company Ltd., New Delhi, 1998.
2.	Ghosh, A and Mallick, A.K, "Theory of Mechanisms and Machines", East-West Pvt. Ltd., New Delhi, 1988.

Reference Books:

1.	Thomas Bevan, "Theory of Machines", CBS Publishers and Distributors, 1984.
2.	Rao J.S and Dukkipati R.V, "Mechanism and Machine Theory", Wiley-Eastern Ltd., New Delhi, 1992.
3.	Erdman AG and Sandor G N, "Mechanism Design, Analysis and Synthesis", Vol.I, PHI Inc., 1997.
4.	Ambekar A.G, "Mechanism and Machine Theory" Prentice Hall of India, New Delhi, 2007.
5.	John Hannah and Stephens R C, "Mechanisms of Machines", Viva Low Price Student Edition, New Delhi, 1999.

E-References:

1.	https://archive.nptel.ac.in/courses/112/104/112104121/
2.	https://nptel.ac.in/courses/112106270
3.	http://velhightech.com/Documents/ME8492 Kinematics of Machinery.pdf

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Demonstrate and understand the concepts of various mechanisms and pairs.	Apply
CO2	Analyze the velocity and acceleration of simple mechanisms.	Analyze
CO3	Construct the cam profile for various motion.	Create
CO4	Solve problems on gears and gear trains.	Evaluate
CO5	Evaluate the friction in transmission system	Evaluate

COURSE ARTICULATION MATRIX

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

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEMI06	HYDRAULICS AND PNEUMATICS					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To enable the students understand the basics of hydraulics and pneumatics
2.	Applying the working principles of hydraulic actuators and control components.
3.	Designing and develop hydraulic circuits and systems.
4.	Applying the working principles of pneumatic power system and its components.
5.	Solving problems and troubles in fluid power systems.

UNIT I	**FLUID POWER PRINICIPLES AND HYDRAULIC PUMPS**	**9**	**0**	**0**	**9**

Introduction to Fluid power – Advantages and Applications – Fluid power systems – Types of fluids - Properties of fluids and selection – Basics of Hydraulics – Pascal's Law – Principles of flow - Friction loss – Work, Power and Torque - Problems, Sources of Hydraulic power; Pumping Theory – Pump Classification – Construction, Working, Design, Advantages, Disadvantages, Performance, Selection criteria of pumps – Fixed and Variable displacement pumps – Problems.

UNIT II	**HYDRAULIC ACTUATORS AND CONTROL COMPONENTS**	**9**	**0**	**0**	**9**

Hydraulic Actuators: Cylinders – Types and construction, Application, Hydraulic cushioning – Rotary actuators - Hydraulic motors - Control Components : Direction Control, Flow control and pressure control valves – Types, Construction and Operation – Accessories; Reservoirs, Pressure Switches – Filters – types and selection - Applications – Fluid Power ANSI Symbols – Problems.

UNIT III	**HYDRAULIC CIRCUITS AND SYSTEMS**	**9**	**0**	**0**	**9**

Accumulators, Intensifiers, Industrial hydraulic circuits – Regenerative, Pump Unloading, Double - Pump, Pressure Intensifier, Air-over oil, Sequence, Reciprocation, Synchronization, Fail - Safe, Speed Control, Deceleration circuits, Sizing of hydraulic systems, Hydrostatic transmission, Electro hydraulic circuits – Servo and Proportional valves – Applications - Mechanical, hydraulic servo systems.

UNIT IV	**PNEUMATIC AND ELECTRO PNEUMATIC SYSTEMS**	**9**	**0**	**0**	**9**

Properties of air – Air preparation and distribution – Filters, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust Valves, Pneumatic actuators, Design of Pneumatic circuit – classification - single cylinder and multi cylinder circuits - Cascade method – Integration of fringe circuits, Electro Pneumatic System – Elements – Ladder diagram – timer circuits problems, Introduction to fluidics and pneumatic logic circuits.

UNIT V	**DESIGN OF FLUID POWER CIRCUITS AND TROUBLESHOOTING**	**9**	**0**	**0**	**9**

Servo systems, Hydro mechanical servo systems, electro hydraulic servo systems and proportional Valves, Introduction to electro hydraulic pneumatic logic circuits, ladder diagrams, PLC applications in fluid power control. Fluid power circuits, failure and troubleshooting. Design of Pneumatic circuits for metal working, handling, clamping counter and timer circuits. – Low cost Automation – Hydraulic and Pneumatic power packs. Case studies: A simple sequence, synchronize circuits using hydraulic and pneumatics components.

Total (45L) = 45 Periods

Text Books:

1.	Manjumdar S.R, "Oil Hydraulics", Tata McGraw-Hill, December 2002.
2.	Anthony Esposito, "Fluid Power with Applications", Pearson Education 2013.

Reference Books:

1.	Andrew Parr, "Hydraulic and Pneumatics", Jaico Publications House, 2005.

2.	Bolton W. “Pneumatic and hydraulic system”, Butterworth-Heinemann 1997
3.	Majumdar S.R., “Pneumatic systems – Principles and maintenance”, Tata McGraw Hill, 2010
4.	Shanmugasundaram.K, “Hydraulic and Pneumatic controls”, Chand & Co, 2006
5.	Srinivasan.R. “Hydraulic and Pneumatic Controls”, Vijay Nicole Imprints, 2008.
E-References:	
1.	http://www.fluidpowerjournal.com
2.	http://14.139.160.15/courses/112102011/2
3.	https://www.nfpa.com/home.htm

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom’s Taxonomy Mapped**
CO1	Select the components as per the application	Evaluate
CO2	Apply the working principles of hydraulic actuators and control components.	Apply
CO3	Design and develop hydraulic circuits and systems.	Create
CO4	Apply the working principles of pneumatic power system and its components.	Apply
CO5	Solve problems and troubles in fluid power systems.	Evaluate

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1	0	0	0	0	0	0	0	0	0	1	1	1
CO2	0	2	2	1	0	0	0	0	0	0	0	0	1	1	1
CO3	1	2	3	0	0	1	0	0	0	0	0	0	1	2	1
CO4	1	1	3	2	2	0	0	0	0	0	0	0	2	1	1
CO5	1	1	2	0	0	0	0	0	0	0	0	0	1	1	1
Avg	**1**	**1.4**	**2.2**	**0.6**	**0.4**	**0.2**	**0**	**0**	**0**	**0**	**0**	**0**	**1.2**	**1.2**	**1**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

22MEMI07	DESIGN OF MACHINE ELEMENTS					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
1. Student should study engineering mechanics.		**Hours/Week**	**L**	**T**	**P**	**TH**
2. Student should study kinematic of machinery.			**3**	**0**	**0**	**3**

Course Objectives:

1.	Understanding of background in mechanics of materials and design of machine components.
2.	An understanding of the origins, nature and applicability of empirical design principles, based on safety considerations
3.	An understanding the design of shafts and couplings.
4.	Familiarize the design of energy storing elements and engine components.
5.	An appreciation of the relationships between component level design and overall machine system design and performance

UNIT I	**STEADY STRESSES AND VARIABLE STRESSES IN MACHINE MEMBERS**	**9**	**0**	**0**	**9**

Introduction to the design process – Product development cycle- factors influencing machine design, selection of materials based on mechanical properties - Preferred numbers– Direct, Bending and Torsional stress – Impact and shock loading – Calculation of principle stresses for various load combinations, eccentric loading – Factor of safety -theories of failure – stress concentration – design for variable loading – Soderberg, Goodman and Gerber relations .

UNIT II	**DESIGN OF SHAFTS AND COUPLINGS**	**9**	**0**	**0**	**9**

Design of solid and hollow shafts based on strength, rigidity and critical speed – Design of keys and key ways - Design of rigid and flexible couplings.

UNIT III	**DESIGN OF THREADED FASTENERS, RIVETED AND WELDED JOINTS**	**9**	**0**	**0**	**9**

Threaded fasteners - Design of bolted joints including eccentric loading – Design of riveted and welded joints for pressure vessels and structures- theory of bonded joints.

UNIT IV	**DESIGN OF ENERGY STORING ELEMENTS AND ENGINE COMPONENTS**	**9**	**0**	**0**	**9**

Various types of springs, optimization of helical springs - rubber springs - Flywheels considering stresses in rims and arms for engines and punching machines- Connecting Rods and crank shafts.

UNIT V	**DESIGN OF BEARINGS**	**9**	**0**	**0**	**9**

Sliding contact and rolling contact bearings - Hydrodynamic journal bearings, Sommerfeld Number - Selection of Rolling Contact bearings.

Total (45L) = 45 Periods

Text Books:

1.	Bhandari V.B, “Design of Machine Elements”, Tata McGraw Hill Book Co, 2020
2.	Md.Jalaludeen.S, “A text book of Machine Design”, Anuradha Publications, 2006

Reference Books:

1.	Shigley, J.E. and Mischke, C.R., Mechanical Engineering Design, Fifth Edition, McGraw-Hill International; 1989.
2.	Deutschman, D., Michels, W.J. and Wilson, C.E., Machine Design Theory and Practice, Macmillan, 1992.
3.	Juvinal, R.C., Fundamentals of Machine Component Design, John Wiley, 1994.
4.	PSG Tech, “Design Data Handbook”, M/s.DPV Printers, Coimbatore, 2009

E-References:

1.	https://nptel.ac.in/courses/112105124
2.	Design of Machine Elements - V. B. Bhandari - Google Books
3.	A Textbook of Machine Design by R.S.Khurmi And J.K.Gupta [tortuka]_1490186411865.pdf | DocDroid

COURSE OUTCOMES: On completion of the course the student will be able to		**Bloom's Taxonomy Mapped**
CO1	Explain the influence of steady and variable stresses in machine component design.	Understand
CO2	Apply the concepts of design to shafts, keys and couplings.	Apply
CO3	Familiarize the design of temporary and permanent joints	Understand
CO4	Design the various energy storing elements and engine components.	Analyse
CO5	Familiarize the design of various types of bearings.	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	1	2	0	1	1	0	0	0	1	0	3	2	1
CO2	2	2	1	2	0	1	1	0	0	0	1	0	3	2	1
CO3	2	2	1	2	0	1	1	0	0	0	1	0	3	2	1
CO4	2	2	1	2	0	1	1	0	0	0	1	0	3	2	1
CO5	2	2	1	2	0	1	1	0	0	0	1	0	3	2	1
Avg	**2.0**	**2.0**	**1.0**	**2.0**	**0.0**	**1.0**	**1.0**	**0.0**	**0.0**	**0.0**	**1.0**	**0.0**	**3.0**	**2.0**	**1.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEMI08	HEAT AND MASS TRANSFER					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**C**
1.The laws and basic concepts of thermodynamics		**Hours/Week**	**L**	**T**	**P**	**TH**
2. The concept of energy transfers and their conversion principles			**3**	**0**	**0**	**3**

COURSE OBJECTIVES

1.	Understanding the science behind conduction heat transfer and its applications
2.	Differentiating the concepts of forced and natural convection heat transfer
3.	Describing the laws and concepts of radiation heat transfer
4.	Understanding phase change processes and analyzing heat exchangers
5.	Studying the concept of mass transfer process and its modes

UNIT-I	**CONDUCTION HEAT TRANSFER**	**9**	**0**	**0**	**9**

General Differential equation – Cartesian(derivation of General Differential Equation), Cylindrical (derivation of General Differential Equation) and Spherical Coordinates – One DimensionalSteady State Heat-Concepts of electrical analogy, Conduction — plane and Composite Systems – Conduction with Internal HeatGeneration., Critical thickness of insulation.

Extended Surfaces – Unsteady Heat Conduction – Lumped Analysis – Semi Infiniteand Infinite Solids –Use of Heisler's charts.

UNIT-II	**CONVECTION HEAT TRANSFER**	**9**	**0**	**0**	**9**

Conservation equations, boundary layer concept – Forced convection: external flow – flow over plates, cylinders, spheres and bank of tubes. Internal flow – entrance effects.

Free convection –flow over vertical plate, horizontal plate, inclined plate, cylinders and spheres.

UNIT-III	**BOILING, CONDENSATION AND HEAT EXCHANGERS**	**9**	**0**	**0**	**9**

Regimes of Pool boiling and Flow boiling, Nusselt's theory of condensation- correlations in boilingand condensation. Heat Exchanger Types - Overall Heat Transfer Coefficient – Fouling Factors.LMTD and NTU methods.

UNIT-IV	**RADIATION HEAT TRANSFER**	**9**	**0**	**0**	**9**

Radiation laws, Black Body and Gray body Radiation. Shape Factor. Electrical Analogy. RadiationShields.

UNIT-V	**MASS TRANSFER**	**9**	**0**	**0**	**9**

Basic Concepts – Diffusion Mass Transfer – Fick's Law of Diffusion – Steady state MolecularDiffusion-Equimolal counter diffusion. Basic Convective Mass Transfer Problems.

Total(45L) = 45 Periods

TEXT BOOKS:

1	R.C. Sachdeva, "Fundamentals of Engineering Heat & Mass transfer", New Age International Publishers, 2017
2	Frank P. Incropera and David P. Dewitt, "Fundamentals of Heat and Mass Transfer", John Wiley & Sons, 7th Edition, 2014.

REFERENCE BOOKS:

1	Yunus A. Cengel, "Heat Transfer A Practical Approach" – Tata McGraw Hill, 5 th Edition - 2013
2	Holman, J.P., "Heat and Mass Transfer", Tata McGraw Hill, 2017
3	Kothandaraman, C.P., "Fundamentals of Heat and Mass Transfer", New Age International, New Delhi, 2012
4	Ozisik, M.N., "Heat Transfer", McGraw Hill Book Co., 1994.

COURSE OUTCOMES: On completion of the course the student will be able to:		**Bloom's Taxonomy Mapped**
CO1	Analyze the mechanism of heat conduction under steady and transient conditions.	Apply
CO2	Develop solutions to problems involving convective heat transfer	Create
CO3	Design a heat exchanger for any specific application	Understand
CO4	Adopt the concept of radiation heat transfer in real time systems	Understand
CO5	Develop solutions to problems involving combined heat and mass transfer	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	3	2	0	1	0	0	0	0	0	3	3	1
CO2	3	3	3	3	2	0	1	0	0	0	0	0	3	3	1
CO3	3	3	3	3	2	0	1	0	0	0	0	0	3	3	1
CO4	3	3	3	3	2	0	1	0	0	0	0	0	3	2	1
CO5	2	2	2	2	1	0	1	0	0	0	0	0	3	1	0
Avg	**2.8**	**2.8**	**2.8**	**2.8**	**1.8**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**3**	**2.4**	**0.8**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEMI09	METROLOGY AND QUALITY CONTROL					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
		Horus/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES

1.	Explaining the importance of measurements in engineering and the factors affecting measurements and to compute measurement uncertainty
2.	Applying the applications of linear and angular measuring instruments
3.	Interpretation of various tolerance symbols.
4.	Applying the SQC methods in manufacturing
5.	Applying the advances in measurements for quality control

UNIT-I	**BASICSOFMEASUREMENTSYSTEMANDDEVICES**	**9**	**0**	**0**	**9**

Definition of metrology, accuracy, precision and sensitivity, Abbe's principle. Three stages of generalizedmeasurementsystem-mechanicalloading-staticcharacteristicsofinstruments-factorsconsideredinselection of instruments - commonly used terms, error analysis and classification - sources of error. Measurement uncertainty

UNIT-II	**CALIBRATION OF INSTRUMENTS AND QUALITY STANDARDS**	**9**	**0**	**0**	**9**

Calibration of measuring instruments - principles of calibration, Calibration of Instruments - Vernier caliper, Micrometer, feeler gauges, dial indicator, surface plates, slip gauges, care of gauge blocks. General cares and rules in measurement, ISO 9000qualitystandards.Comparators-mechanical, electrical, optical and pneumatic.

UNIT-III	**GEOMETRICAL MEASUREMENT AND MACHINE ELEMENTS**	**9**	**0**	**0**	**9**

Angular measurement - optical protractors, sine bar, roundness measurement, limit gauge, design of plug gauge, Taylor's principle, three basic types of limit gauges, Tomlinson surface meter, computer controlled CMM. ISO metric thread, measurement of major, minor and effective diameters. Gear terminology; spur gear measurement, checking of composite errors ,base pitch measurement. Principle of interferometry, laser interferometer, Machine vision, Fundamental of GD and T. Inspection of straightness, flatness ,roundness deviations.,

UNIT-IV	**STATISTICAL QUALITY CONTROL**	**9**	**0**	**0**	**9**

Surfacefinish-terminologyandmeasurements-Opticalmeasuringinstruments-AcceptancetestformachinesStatisticalQuality Control-Control charts-Sampling plans

UNIT-V	**SIX SIGMA**	**9**	**0**	**0**	**9**

Sixsigma:definemeasure,analyse,improveandcontrolphases.Analyzephasetools:CommonTools:Histogram,BoxPlot,Controlc hart,Scatterchart,Causeandeffectdiagram,Paretoanalysis,interrelationsdiagram. Special Tools: Regression Analysis, Hypothesis Testing, ANOVA Multi variate analysis.

Total(45L) = 45 Periods

TEXT BOOKS:

1	Gupta.I.C, ―A text book of Engineering Metrology, Dhanpat Rai publications, New Delhi, 2018
2	Beckwith.T.G,Roy D. Marangoni, John H. Lienhard, - Mechanical Measurements‖, Prentice Hall, 2006

REFERENCE BOOKS:

1	Jain.R.K, ―Mechanical and Industrial Measurements, Khanna Publishers, Delhi, 1999.
2	Holmen.J.P, ―Experimental Methods for Engineers‖, Tata McGraw Hill Publications Co Limited, 2017.
3	Grant, E.L., Statistical Quality Control, Mc Graw-Hill, 2004. 3. Doeblin E.O., Measurement Systems, Mc

	Graw-Hill, 2004.
4	Alan S Morris, ―Measurement and Instrumentation Principles‖, Butterworth, 2006.
5	De Feo J A and Barnard W W, ―Six Sigma: Break trough and BeyondG, Tata McGraw-Hill, New Delhi, 2005.
E-REFERENCES:	
1	https://nitsri.ac.in/Department/Mechanical%20Engineering/MEC_405_Book_2,_for_Unit_2B.pdf
2	https://www.nist.gov/system/files/documents/srm/NIST-SRM-RM-Articlefinal.pdf
3	https://www.researchgate.net/publication/319587859_Computer-Aided_Metrology-CAM

COURSE OUTCOMES: On completion of the course the student will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the importance of measurements in engineering and the factors affecting measurements and to compute measurement uncertainty	Understand
CO2	Apply the working principle and the applications of linear and angular measuring instruments[	Apply
CO3	Interpret of various tolerance symbols.	Apply
CO4	Apply the SQC methods in manufacturing.	Apply
CO5	Apply the advances in measurements for quality control in manufacturing industries.	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	0	0	0	0	0	0	2	1	2	0	0	0	2	1	0
CO2	0	0	0	0	0	0	3	1	2	0	0	0	1	2	0
CO3	0	0	0	0	0	0	2	1	0	0	0	0	2	1	0
CO4	0	0	0	3	0	0	2	0	1	0	0	0	1	2	0
CO5	0	0	0	2	0	0	0	3	1	0	0	0	2	1	0
Avg	**0.0**	**0.0**	**0.0**	**1.0**	**0.0**	**0.0**	**1.8**	**1.2**	**1.2**	**0.0**	**0.0**	**0.0**	**1.6**	**1.4**	**0.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22MEMI10	DYNAMICS OF MACHINERY					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Engineering Mechanics, Kinematics of Machinery, Strength of Materials		**Hours\Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To impart students with the knowledge about motion, masses and forces in machines and the Principle of Virtual Work
2.	To facilitate students to understand the concept of balancing of rotating and reciprocating masses
3.	To teach concepts of free vibration analyses of one and two degree-of-freedom rigid body systems
4.	To teach concepts of forced vibrations analyses of rigid body systems and to give awareness to students on the phenomenon of vibration and its effects
5.	To learn about the concept of various types of governors

UNIT I	**FORCE ANALYSIS**	**9**	**0**	**0**	**9**

Static Force Analysis, Free Body Diagrams, Conditions of Two, Three and Four Force Members. Inertia Forces and D'Alembert's Principle – Inertia Force Analysis in Reciprocating Engines – Crank Shaft Torque. Flywheels – Turning Moment Diagrams and Fluctuation of Energy of Reciprocating Engine Mechanisms, Coefficient of Fluctuation of Energy and Speed, Weight of Flywheel Required.

UNIT II	**BALANCING**	**9**	**0**	**0**	**9**

Static and dynamic balancing - Balancing of rotating masses - Balancing a single cylinder Engine - Balancing Multi-cylinder Engines - Partial balancing in locomotive Engines - Balancing linkages - balancing machines

UNIT III	**FREE VIBRATION**	**9**	**0**	**0**	**9**

Basic Features of Vibratory Systems – Types – Single Degree of Freedom System – Transverse Vibration of Beams – Natural Frequency by Energy Method, Dunkerly's Method - Critical Speed - Damped Free Vibration of Single Degree Freedom System -Types of Damping – Free Vibration with Viscous Damping, Critically Damped System, Under Damped System. Torsional Systems: Natural Frequency of Two and Three Rotor Systems.

UNIT IV	**FORCED VIBRATION**	**9**	**0**	**0**	**9**

Response to Periodic Force – Harmonic Force – Force caused by Unbalance – Support Motion - Logarithmic Decrement-Magnification Factor – Vibration Isolation and Transmissibility.

UNIT V	**GOVERNORS**	**9**	**0**	**0**	**9**

Governors - Types - Centrifugal governors - Gravity controlled and spring controlled centrifugal governors –Characteristics - Effect of friction - Controlling Force - other Governor mechanisms.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Design of Machinery, Fourth Edition, by R.L. Norton, McGraw Hill, 2007
2.	Mechanical Vibration, V.P.Singh, Dhanpatrai, Delhi

REFERENCE BOOKS:

1.	Ballaney, P.L., "Theory of Machines and Mechanisms", Khanna Publishers, New Delhi, 2002.
2.	Shigley, J.E. and Uicker, J.J., "Theory of Machines and Mechanisms", TMH ND, 1998.
3.	Amithabha Ghosh, and Ashok Kumar Malik., "Theory of Mechanisms and Machines", 2nd Ed., Affiliated East and West Press Limited, 1998.
4.	Prof.Nakara, IIT-Delhi Reference Books

E-REFERENCES:	
1.	www.university.youth4work.com/IIT_Kharagpur_Indian-Institute-of-Technology/study/1653-dynamics-of-Machinery-ebook
2.	http://nptel.ac.in/courses/112104114/

COURSE OUTCOMES: On completion of the course the student will be able to		Bloom's Taxonomy Mapped
CO1	Apply basic principles of mechanisms in mechanical system	Apply
CO2	Familiarize the static and dynamic analysis of simple mechanisms	Understand
CO3	Analyze the mechanical systems subjected to free vibration	Analyze
CO4	Analyze mechanical systems subjected to forced vibration	Analyze
CO5	Analyze the various types of governors and its speed control mechanism	Analyze

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3	3	1	0	0	0	0	1	0	3	2	1	2
CO2	2	2	3	2	1	0	0	0	0	1	0	3	2	1	2
CO3	2	2	3	2	0	0	0	0	0	1	0	3	2	1	2
CO4	2	2	3	2	1	0	0	0	0	1	0	3	2	1	2
CO5	1	2	3	2	0	0	0	0	0	1	0	3	2	1	1
Avg	**1.8**	**2.0**	**3.0**	**2.2**	**1.2**	**0.0**	**0.0**	**0.0**	**0.0**	**1.0**	**0.0**	**3.0**	**2.0**	**1.0**	**1.8**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)