GOVERNMENT COLLEGE OF ENGINEERING
SALEM - 636 011
(An Autonomous Institution Affiliated to Anna University, Chennai)

REGULATIONS 2022

CURRICULUM AND SYLLABUS

(For Candidates admitted from 2022 - 2023 onwards)

DEPARTMENT OF MECHANICAL ENGINEERING

(FULL TIME PROGRAMME)

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.

CURRICULUM

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

SEMESTER I

S. No.	Course Code	Course Title	Cat	Hours/Week			C	Max. Marks		
				L	T	P		CA	FE	Total
1	22MC101	Induction Program	MC	-	-	-	0	-	-	-
THEORY										
2	22MA101	Matrices, Calculus and Ordinary Differential Equations	BS	3	1	0	4	40	60	100
3	22CY101	Engineering Chemistry	BS	3	1	0	4	40	60	100
4	22EE101	Basic 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 Equations, 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*	40	60	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**

***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 III

S. No.	Course Code	Course Title	Cat	Hours/Week			C	Max. Marks		
				L	T	P		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*	40	60	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			C	Max. Marks		
				L	T	P		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	100	-	100
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			C	Max. Marks		
				L	T	P		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	2	0	0	0	100	-	100
PRACTICAL										
8	22ME506	Dynamics and Metrology Laboratory	PC	0	0	3	1.5	60	40	100
9	22EN501	Placement and Career Skills Laboratory	HS	0	0	3	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			C	Max. Marks		
				L	T	P		CA	FE	Total
THEORY										
1	22MEPEXX	Professional Elective – I	PE	3	0	0	3	40	60	100
2	22MEPEXX	Professional Elective – II	PE	3	0	0	3	40	60	100
3	22MEPEXX	Professional Elective – III	PE	3	0	0	3	40	60	100
4	22__OEXX	Open Elective –I	OE	3	0	0	3	40	60	100
5	22__ OEXX	Open Elective –II	OE	3	0	0	3	40	60	100
6	22__OEXX	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**			**C**	**Max. Marks**		
				L	**T**	**P**		**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	22PSEE01	Robotics	EE	0	0	6	3	100	0	100
TOTAL							**21**			**700**

SEMESTER VII										
S. No.	**Course Code**	**Course Title**	**Cat**	**Hours/Week**			**C**	**Max. Marks**		
				L	**T**	**P**		**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	22MEPEXX	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
TOTAL							**16.5**			**800**

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

PROFESSIONAL ELECTIVE COURSES

Code No.	Course	Hours/Week			C	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	1	0	4	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 and 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			C	Maximum Marks		
				L	T	P		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 Queueing 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 Concepts	OE	3	0	0	3	40	60	100
9	22CSOE02	Operating Systems Principles	OE	3	0	0	3	40	60	100
10	22CSOE03	Computer Communications and Networks	OE	3	0	0	3	40	60	100
11	22CSOE04	Python Programming	OE	3	0	0	3	40	60	100
12	22CSOE05	Introduction to Programming in Java	OE	3	0	0	3	40	60	100
13	22CSOE06	Computer Organization	OE	3	0	0	3	40	60	100
14	22CSOE07	Data Structures Using C++	OE	3	0	0	3	40	60	100
15	22CSOE08	Cloud Computing Fundamentals	OE	3	0	0	3	40	60	100
16	22CSOE09	Artificial Intelligence and ML	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	Basics of AI	OE	3	0	0	3	40	60	100
COURSES OFFERED BY THE DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING										
24	22EEOE01	Renewable Energy Sources	OE	3	0	0	3	40	60	100
25	22EEOE02	Industrial Drives	OE	3	0	0	3	40	60	100
26	22EEOE03	Energy Conservation and Management	OE	3	0	0	3	40	60	100

27	22EEOE04	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			C	Maximum Marks		
			L	T	P		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			C	Maximum Marks		
			L	T	P		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			C	Maximum Marks		
			L	T	P		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

MINOR DEGREE - VERTICALS

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	VERTICAL - IV	VERTICAL - V	VERTICAL - VI
Civil Engineering	**Computer Science and Engineering**	**Electronics and Communication Engineering**	**Electrical and Electronics Engineering**	**Mechanical Engineering**	**Metallurgical Engineering**
22CEM01 Construction Materials	22CSM01 Programming in C++	22ECM01 Electron Devices	22EEM01 – Linear and Digital Electronics Circuits	22MEM01 Engineering Thermodynamics	22MTM01 Advanced Physical Metallurgy
22CEM02 Building Construction & Equipment	22CSM02 Advanced Data Structures and Algorithms	22ECM02 Digital Electronics	22EEM02 – Microprocessor and Microcontrollers	22MEM02 Fluid Mechanics and Machinery	22MTM02 Metallurgical Thermodynamics and kinetics
22CEM03 Concrete Technology	22CSM03 Computer Organization and Design	22ECM03 Electronic Circuits	22EEM03 – Control Systems	22MEM03 Manufacturing Processes	22MTM03 Mechanical Behaviour of Materials
22CEM04 Environmental Engineering	22CSM04 Advanced Operating Systems	22ECM04 Signal Processing	22EEM04 – Measurement and Instrumentation	22MEM04 Materials Engineering	22MTM04 Rate Processing in Metallurgy
22CEM05 Basics of Transportation Engineering	22CSM05 Data Communication and Computer Networks	22ECM05 Fundamentals of Microprocessors and Microcontrollers	22EEM05 – Electrical Machines	22MEM05 Kinematics of Machinery	22MTM05 Corrosion and Surface Engineering
22CEM06 Repair and Rehabilitation Structures	22CSM06 Programming Essentials in Python	22ECM06 Analog and Digital Communication	22EEM06 – Electric Drives and Control	22MEM06 Hydraulics and Pneumatics	22MTM06 Characterization of Materials
22CEM07 Green Building Technology	22CSM07 Advanced Database System Concepts	22ECM07 Communication Networks	22EEM07 – Electric Vehicle and Control	22MEM07 Design of Machine Elements	22MTM07 Automotive, Aerospace and Defense Materials
-----	22CSM08 Virtualization and Cloud Computing	22ECM08 Fundamentals of IoT	22EEM08 – Electrical Energy Conservation and Auditing	22MEM08 Heat and Mass Transfer	-----
-----	-----	22ECM09 Wireless Sensors and Networking	22EEM09 – SMPS and UPS	22MEM09 Metrology and Quality Control	-----
-----	-----	22ECM10 Fundamentals of Embedded Systems	22EEM10 –Utilization of Electrical Energy	22MEM10 Dynamics of Machinery	-----

LIST OF MINOR DEGREE - VERTICALS

S.No.	Course Code	Course	Cat	Hours/Week			Credits	Maximum Marks		
				L	T	P		CA	FE	Total
CIVIL ENGINEERING										
1	22CEM01	Construction Materials	OE	3	0	0	3	40	60	100
2	22CEM02	Building Construction & Equipment's	OE	3	0	0	3	40	60	100
3	22CEM03	Concrete Technology	OE	3	0	0	3	40	60	100
4	22CEM04	Environmental Engineering	OE	3	0	0	3	40	60	100
5	22CEM05	Basics of Transportation Engineering	OE	3	0	0	3	40	60	100
6	22CEM06	Repair and Rehabilitation of Structures	OE	3	0	0	3	40	60	100
7	22CEM07	Green Building Technology	OE	3	0	0	3	40	60	100
COMPUTER SCIENCE AND ENGINEERING										
1	22CSM01	Programming in C++	OE	3	0	0	3	40	60	100
2	22CSM02	Advanced Data Structures and Algorithms	OE	3	0	0	3	40	60	100
3	22CSM03	Computer Organization and Design	OE	3	0	0	3	40	60	100
4	22CSM04	Advanced Operating Systems	OE	3	0	0	3	40	60	100
5	22CSM05	Data Communication and Computer Networks	OE	3	0	0	3	40	60	100
6	22CSM06	Programming Essentials in Python	OE	3	0	0	3	40	60	100
7	22CSM07	Advanced Database System Concepts	OE	3	0	0	3	40	60	100
8	22CSM08	Virtualization and Cloud Computing	OE	3	0	0	3	40	60	100
ELECTRONICS AND COMMUNICATION ENGINEERING										
1	22ECM01	Electron Devices	OE	3	0	0	3	40	60	100
2	22ECM02	Digital Electronics	OE	3	0	0	3	40	60	100
3	22ECM03	Electronic Circuits	OE	3	0	0	3	40	60	100
4	22ECM04	Signal Processing	OE	3	0	0	3	40	60	100
5	22ECM05	Fundamentals of Microprocessors and Microcontrollers	OE	3	0	0	3	40	60	100
6	22ECM06	Analog and Digital Communication	OE	3	0	0	3	40	60	100

7	22ECM07	Communication Networks	OE	3	0	0	3	40	60	100
8	22ECM08	Fundamentals of IoT	OE	3	0	0	3	40	60	100
9	22ECM09	Wireless sensors and networking	OE	3	0	0	3	40	60	100
10	22ECM10	Fundamentals of Embedded systems	OE	3	0	0	3	40	60	100
ELECTRICAL AND ELECTRONICS ENGINEERING										
1	22EEM01	Linear and Digital Electronics Circuits	OE	3	0	0	3	40	60	100
2	22EEM02	Microprocessors and Microcontrollers	OE	3	0	0	3	40	60	100
3	22EEM03	Control Systems	OE	3	0	0	3	40	60	100
4	22EEM04	Measurements and Instrumentation	OE	3	0	0	3	40	60	100
5	22EEM05	Electrical Machines	OE	3	0	0	3	40	60	100
6	22EEM06	Electric Drives and Control	OE	3	0	0	3	40	60	100
7	22EEM07	Electric Vehicles and Control	OE	3	0	0	3	40	60	100
8	22EEM08	Electrical Energy Conservation and Auditing	OE	3	0	0	3	40	60	100
9	22EEM09	SMPS and UPS	OE	3	0	0	3	40	60	100
10	22EEM10	Utilization of Electrical Energy	OE	3	0	0	3	40	60	100
MECHANICAL ENGINEERING										
1	22MEM01	Engineering Thermodynamics	OE	3	0	0	3	40	60	100
2	22MEM02	Fluid Mechanics and Machinery	OE	3	0	0	3	40	60	100
3	22MEM03	Manufacturing Processes	OE	3	0	0	3	40	60	100
4	22MEM04	Materials Engineering	OE	3	0	0	3	40	60	100
5	22MEM05	Kinematics of Machinery	OE	3	0	0	3	40	60	100
6	22MEM06	Hydraulics and Pneumatics	OE	3	0	0	3	40	60	100
7	22MEM07	Design of Machine Elements	OE	3	0	0	3	40	60	100
8	22MEM08	Heat and Mass Transfer	OE	3	0	0	3	40	60	100
9	22MEM09	Metrology and Quality Control	OE	3	0	0	3	40	60	100
10.	22MEM10	Dynamics of Machinery	OE	3	0	0	3	40	60	100
METALLURGICAL ENGINEEING										

1	22MTM01	Advanced Physical Metallurgy	OE	3	0	0	3	40	60	100
2	22MTM02	Thermodynamics and Kinetics in Metallurgy	OE	3	0	0	3	40	60	100
3	22MTM03	Mechanical Behaviour of Materials	OE	3	0	0	3	40	60	100
4	22MTM04	Rate Processes in Metallurgy	OE	3	0	0	3	40	60	100
5	22MTM05	Corrosion and Surface Engineering	OE	3	0	0	3	40	60	100
6	22MTM06	Materials Characterization	OE	3	0	0	3	40	60	100
7	22MTM07	Automotive, Aerospace and Defence Materials	OE	3	0	0	3	40	60	100

COMPARISON WITH AICTE AND ANNA UNIVERSITY CREDITS

S.No	Category	Suggested Breakup of Credits (Total 160) by AICTE	Suggested Breakup of Credits (Total 167) by Anna University	Breakup of credits (Total 167) by GCE	Breakup of GCE credits in Percentage
1	Humanities and Social Sciences including Management courses	12	12	11.5	6.8%
2	Basic Science courses	29	25	22	13.2%
3	Engineering Science courses including workshop, drawing, basics of electrical/mechanical/ computer etc.	27	25	25.5	15.3%
4	Professional core courses	58	56	59	35.3%
5	Professional Elective courses relevant to chosen specialization/branch	9	21	18	10.8%
6	Open subjects – Electives from other technical and /or emerging subjects	9	12	12	7.2%
7	Project work, seminar and internship in industry or elsewhere	16	16	17	10.2%
8	Mandatory Courses [Environmental Sciences, Induction Program, Indian Constitution, Essence of Indian Knowledge Tradition]	(non-credit)	0	2	1.2%
	Total Credit	**160**	**167**	**167**	**100%**

SUMMARY FOR REGULAR STREAM

Course Component	Credits Per Semester								Total Credit
	I	II	III	IV	V	VI	VII	VIII	
Humanities and Social Sciences (HS)/HSMC	2	7			1.5		3		**13.5**
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	6	**18**
Open Electives (OE)						9		3	**12**
Empl. Enhancement Courses (EE)		1	1	1	1	3		10	**17**
	24.5	**22.5**	**21**	**21**	**21.5**	**21**	**16.5**	**19**	**167**

SYLLABUS

PROFESSIONAL CORE COURSES

B.E MECHANICAL ENGINEERING - FULL TIME

REGULATION 2022 – SYLLABUS

SEMESTER-I

22MC101	**INDUCTION PROGRAM**				**SEMESTER I**	
PRE-REQUISITE		**Category**	**MC**	**Credit**		**0**
		Hours/Week	**L**	**T**	**P**	**TH**
			0	**0**	**0**	**0**
INDUCTION PROGRAM (MANDATORY) - 3 WEEKS DURATION						
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.						
						Total = 21Days

<table>
<tr><td>22MA101</td><td colspan="2">MATRICES, CALCULUS AND ORDINARY DIFFERENTIAL EQUATIONS</td><td colspan="4">SEMESTER I</td></tr>
<tr><td colspan="2">PRE-REQUISITE:</td><td>Category</td><td>BS</td><td colspan="2">Credit</td><td>4</td></tr>
<tr><td colspan="2" rowspan="2">Basic 12th level Matrices, Differential Calculus, Integral Calculus and ODE.</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td colspan="7">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="6">To know the use of matrix algebra needed by engineers for practical applications.</td></tr>
<tr><td>2.</td><td colspan="6">To understand effectively both the limit definition and rules of differentiation.</td></tr>
<tr><td>3.</td><td colspan="6">To familiarize in solving maxima and minima problems in two variables.</td></tr>
<tr><td>4.</td><td colspan="6">To obtain the knowledge of multiple integrations and their related applications.</td></tr>
<tr><td>5.</td><td colspan="6">To obtain the knowledge to solve second order differential equations with constant and variable coefficients</td></tr>
<tr><td>Unit I</td><td colspan="2">MATRICES</td><td>9</td><td>3</td><td>0</td><td>12</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>Unit II</td><td colspan="2">DIFFERENTIAL CALCULUS</td><td>9</td><td>3</td><td>0</td><td>12</td></tr>
<tr><td colspan="7">Representation of functions - Limit of a function - Continuity - Derivatives - Differentiation rules - Maxima and Minima of the function of a single variable.</td></tr>
<tr><td>Unit III</td><td colspan="2">FUNCTIONS OF SEVERAL VARIABLES</td><td>9</td><td>3</td><td>0</td><td>12</td></tr>
<tr><td colspan="7">Partial derivatives – Euler’s theorem for homogenous functions – Total Derivatives -Jacobians – Maxima, Minima and Saddle point- – Method of Lagrangian multipliers- Taylor’s series.</td></tr>
<tr><td>Unit IV</td><td colspan="2">MULTIPLE INTEGRALS</td><td>9</td><td>3</td><td>0</td><td>12</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>Unit V</td><td colspan="2">ORDINARY DIFFERENTIAL EQUATIONS</td><td>9</td><td>3</td><td>0</td><td>12</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7">Total (45L+15T) = 60 Periods</td></tr>
</table>

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		2									2		
CO2	3	2		2									2		
CO3	3	2		2									2		
CO4	3	2		2									2		
CO5	3	2		2									2		
Avg	**3**	**2**		**2**									**2**		

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**	**TH**
			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		3		0							3	1	1
CO2	3	2		1		2							3	1	1
CO3	3	1		1		0							2	1	1
CO4	2	1		1		2							2	3	2
CO5	3	2		3		2							1	1	1
Avg	**2.8**	**1.8**		**1.8**		**2**							**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** **(Common to Civil Engineering, Mechanical Engineering, and Computer Science and Engineering)**	**Semester**	**II**

PREREQUISITES	**Category**	**ES**	**Credit**		**4**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**1**	**0**	**4**

Course Learning 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 Kirchhoff’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 and 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 OF 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 this course, the students will be able to:		**Bloom's Taxonomy Level**
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**
CO1	1	1									1	1		
CO 2	1	1									1	1		
CO 3	1										1	1		
CO 4	1										1	1		
CO 5	1										1	1		
Avg	**1**	**1**									**1**	**1**		

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”, 28th Ed., Dhanalakshmi Publishers, Chennai, 2015.
4.	Shah, M. B., and Rana, B. C., “Engineering Drawing”, Pearson, 2nd Ed., 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	Ability to understand the fundamental concepts of projection of points, lines and planes.	Understand
CO2	Ability to project the different views of solids with various positions.	Understand
CO3	Ability to section the solids with various positions and develop the lateral surfaces of solids.	Analyze
CO4	Familiarize to convert the isometric projection into orthographic projection of simple solids and vice versa.	Apply
CO5	Visualize and project the 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											3	1	
CO2	3	1											3	1	
CO3	3	1											3	1	
CO4	3	1											3	1	
CO5	3	1											3	1	
Avg	**3**	**1**											**3**	**1**	

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

<table>
<tr><td>22CS101</td><td colspan="3">PROBLEM SOLVING AND C PROGRAMMING</td><td colspan="4">SEMESTER I</td></tr>
<tr><td colspan="3">PRE-REQUISITE</td><td>Category</td><td>ES</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="3" rowspan="2"></td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="8">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="7">To use general problem-solving techniques to device solutions to problems</td></tr>
<tr><td>2.</td><td colspan="7">To understand the input-output relations of software involved in developing and converting a C program to an executable code.</td></tr>
<tr><td>3.</td><td colspan="7">To provide complete knowledge about the programming concepts of C language.</td></tr>
<tr><td>UNIT I</td><td colspan="3">SYSTEM SOFTWARE, PROBLEM SOLVING AND C PROGRAMMING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">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.</td></tr>
<tr><td>UNIT II</td><td colspan="3">CONTROL STATEMENTS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">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</td></tr>
<tr><td>UNIT III</td><td colspan="3">ARRAYS, POINTERS, AND STRINGS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">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.</td></tr>
<tr><td>UNIT IV</td><td colspan="3">FUNCTIONS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">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.</td></tr>
<tr><td>UNIT V</td><td colspan="3">STRUCTURES, UNIONS AND FILE</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">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.</td></tr>
<tr><td colspan="8" align="right">Total (45L) = 45 Periods</td></tr>
</table>

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	3	3	2	2	2			1			2	2		1	
CO2	3	3	2	2	2			1			2	2		1	
CO3	3	3	2	2	2			1			2	2		1	
Avg	**3**	**3**	**2**	**2**	**2**			**1**			**2**	**2**		**1**	

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

22MC102	தமிழர் மரபு B.E (Common to all Branches)	Semester I			
முன்நிபந்தனைகள்:	Category	HSMC	Credit		1
இலக்கணம் மற்றும் இலக்கியத்தின் அடிப்படைகள்	Hours/Week	L	T	P	TH
		1	0	0	1

பாடநெறி நோக்கங்கள்: மாணவர்களால்

1.	தமிழ் மொழி மற்றும் இலக்கியம் பற்றிய அறிவைப் பெற முடியும்.
2.	பாரம்பரியம், பாறை ஓவியங்கள் முதல் நவீன ஓவியங்கள் மற்றும் சிற்பக் கலைகள் பற்றி தெரிந்து கொள்ள முடியும்
3.	நாட்டுப்புறக் கலைகள் மற்றும் வீர விளையாட்டுகள் பற்றி அறிந்து கொள்ள முடியும்
4.	தமிழர்களின் ஒழுக்க நெறிமுறைகளைப் பற்றி தெரிந்து கொண்டு அதன்படி நடந்து கொள்ள முடியும்.
5.	பழங்கால இந்திய தேசிய இயக்கம் பற்றியும், இந்திய மக்களின் பன்பாட்டில் தமிழர்களின் பங்களிப்பு பற்றியும் நன்கு அறிந்து கொள்ள முடியும்.

அலகு I	மொழி மற்றும் இலக்கியம்	3	0	0	3

இந்திய மொழிக் குடும்பங்கள் – திராவிட மொழிகள் – தமிழ் ஒரு செம்மொழி – தமிழ் செவ்விலக்கியங்கள் – சங்க இலக்கியத்தின் சமயச் சார்பற்ற தன்மை – சங்க இலக்கியத்தில் பகிர்தல் அறம் – திருக்குறளில் மேலாண்மைக் கருத்துக்கள் – தமிழ்க்காப்பியங்கள், தமிழகத்தில் சமண பௌத்த சமயங்களின் தாக்கம் – பக்தி இலக்கியம், ஆழ்வார்கள் மற்றும் நாயன்மார்கள் – சிற்றிலக்கியங்கள் – தமிழில் நவீன இலக்கியத்தின் வளர்ச்சி – தமிழ் இலக்கிய வளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின் பங்களிப்பு.

அலகு II	மரபு – பாறைஓவியங்கள்முதல்நவீன ஓவியங்கள் வரைசிற்பக்கலை	3	0	0	3

நடுகல் முதல் நவீன சிற்பங்கள் வரை – ஐம்பொன் சிலைகள் – பழங்குடியினர் மற்றும் தயாரிக்கும் கைவினைப் பொருட்கள், பொம்மைகள் – தேர் செய்யும் கலை – சுடுமண் சிற்பங்கள் – நாட்டுப்புறத் தெய்வங்கள்- குமரி முனையில் திருவள்ளுவர் சிலை- இசைக் கருவிகள் – மிருதங்கம், பறை, வீணை, யாழ், நாதஸ்வரம் – தமிழர்களின் சமூக பொருளாதார வாழ்வில் கோவில்களின் பங்கு.

அலகு III	நாட்டுப்புறக்கலைகள்மற்றும்வீரவிளையாட்டுகள்	3	0	0	3

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

அலகு IV	தமிழர்களின்திணைக்கோட்பாடுகள்	3	0	0	3

தமிழகத்தின் தாவரங்களும், விலங்குகளும் – தொல்காப்பியம் மற்றும் சங்க இலக்கியத்தில் அகம் மற்றும் புறக்கோட்பாடுகள் – தமிழர்கள் போற்றிய அறக்கோட்பாடு – சங்ககாலத்தில் தமிழகத்தில் எழுத்தறிவும், கல்வியும் – சங்ககால நகரங்களும் துறை முகங்களும் – சங்ககாலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி – கடல் கடந்த நாடுகளில் சோழர்களின் வெற்றி.

அலகு V	இந்தியதேசியஇயக்கம்மற்றும்இந்தியபண்பாட்டிற்குத்தமிழர்களின்பங்களிப்பு	3	0	0	3

இந்திய விடுதலைப் போரில் தமிழர்களின் பங்கு – இந்தியாவின் பிறப்பகுதிகளில் தமிழ்ப்பண்பாட்டின் தாக்கம் – சுயமரியாதை இயக்கம் – இந்திய மருத்துவத்தில், சித்த மருத்துவத்தின் பங்கு – கல்வெட்டுகள், கையெழுத்துப்படிகள் – தமிழ்ப்புத்தகங்களின் அச்சு வரலாறு.

Total= 15 Periods

Text Books:	
1	தமிழக வரலாறு - மக்களும் பண்பாடும் - கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியல் பணிகள் கழகம்)
2	கணினித் தமிழ் - முனைவர் இல.சுந்தரம் (விகடன் பிரசுரம்)
3	கீழடி - வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4	பொருநை - ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)

பாடநெறி முடிவுகள்: இந்தப் படிப்பு முடிந்ததும், மாணவர்களால்		**Bloom’s Taxonomy Mapped**
CO1	இந்திய மொழிகள், இந்திய மொழிக் குடும்பங்கள் பற்றியும் மற்றும் இலக்கியம், இலக்கியதின் வளர்ச்சி, தமிழ் இலக்கிய வளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின் பங்களிப்புகளை பற்றியும் அறிந்து கொண்டனர்.	Understanding
CO2	சிற்பக் கலைகளில் அடங்கியுள்ள பாறை ஓவியங்கள் முதல் நவின ஓவியங்கள் வரை பற்றியும், தமிழர்களின் சமூக, பொருளாதார வாழ்வில் கோவில்களின் பங்கினை பற்றியும் தெரிந்து கொண்டனர்.	Understanding
CO3	தமிழர்களின் வாழ்வியல் முறைகளோடு ஒன்றிய நாட்டுபுறக் கலைகள் மற்றும் தமிழர்களின் வீர விளையாட்டுகளை பற்றி அறிந்து கொண்டனர்.	Understanding
CO4	சங்ககாலத்தில் தமிழர்கள் பின்பற்றிய தினைக் கோட்பாடுகள் பற்றி நடந்து கொண்டனர்.	Applying
CO5	இந்திய தேசிய இயக்கம் மற்றும் இந்திய பண்பாட்டிற்க்குத் தமிழர்களின் பங்கினை பற்றியும் அறிந்து கொண்டனர்.	Understanding

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		
CO2			3			2				1			2		
CO3			3			2				1			2		
CO4			3			2				1			2		
CO5			3			2				1			2		
Avg			**3**			**2**				**1**			**2**		

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

22MC102	**HERITAGE OF TAMILS**	**Semester**			**I**
PREREQUISITES	**Category**	**HS MC**	**Credit**		**1**
Basics of Tamil Language and Literature	**Hours/Week**	**L**	**T**	**P**	**TH**
		1	**0**	**0**	**1**
1.	To obtain the knowledge of Tamil Language and Literature				
2.	To familiarize with painting and Sculpture				
3.	To know about the folks and martial arts				
4.	To understand the Thinai concept of Tamils				
5.	To know about the contribution of Tamils to Indian National Movement and Indian Culture.				
Unit I	**LANGUAGE AND LITERATURE**	**3**	**0**	**0**	**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)

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Learn the knowledge of Tamil Language and Literature	Understanding
CO2	Familiarize about painting and Sculpture	Understanding
CO3	Acquire the knowledge about folks and Martial arts	Understanding
CO4	Learn the knowledge of Thinai concepts of Tamils	Applying
CO5	Acquire the knowledge about contribution of Tamils to Indian national movement and Indian culture	Understanding

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		
CO2			3			2				1			2		
CO3			3			2				1			2		
CO4			3			2				1			2		
CO5			3			2				1			2		
Avg			**3**			**2**				**1**			**2**		

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

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	**NARRATION**	**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	**PRESENTATION**	**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	**SHORT SPEECH**	**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	**ORGANIZING EVENTS**	**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	**DESCRIBING PROCESS**	**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 (30P) = 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				1					2	3		1			1
CO2				1					2	3		1			1
CO3				2					2	3		1			1
CO4				2					2	3		1			3
Avg				**1.5**					**2**	**3**		**1**			**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**
Basic theorietical knowledge in Physics		**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		3	3				3	1		2	1	1	1
CO2	3	2		2	1				2	0		1	1	1	1
Avg	**3**	**2**		**2.5**	**2**				**2.5**	**0.5**		**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**	**TH**
			0	**0**	**3**	**3**

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 (45P) = 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									2		
CO2	1	2	0	3									2		
CO3	2	2	0	3									2		
Avg	**1.3**	**1.7**	**0**	**3**									**2**		
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 (45P) = 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

<u>COURSE ARTICULATION MATRIX</u>

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

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

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	**COMPREHENSION**	**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	**RECOMMENDATION**	**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	**CONVERSATION**	**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	**REPORTING**	**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	**INTERPRETATION**	**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, and 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				1					1	3		1			1
CO2				1					1	3		2			2
CO3				2					1	3		1			1
CO4				3					1	3		1			1
Avg				**1.75**					**1**	**3**		**1.25**			**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 Ramakrishna Das. 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

<u>COURSE ARTICULATION MATRIX</u>

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

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

<table>
<tr><td colspan="2">22PH101</td><td colspan="2">ENGINEERING PHYSICS</td><td colspan="4">SEMESTER II</td></tr>
<tr><td colspan="3">PRE-REQUISITE:</td><td>Category</td><td>BS</td><td colspan="2">Credit</td><td>4</td></tr>
<tr><td colspan="3" rowspan="2">Basic knowledge in sound, light and heat.</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td colspan="8">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="7">To understand Principles of ultrasonic production, its applications and acoustics of buildings.</td></tr>
<tr><td>2.</td><td colspan="7">To understand Principle, working and industrial applications of LASER and optical fiber</td></tr>
<tr><td>3.</td><td colspan="7">To gain knowledge in mode of transmission of heat by conduction mechanism with experimental illustrations</td></tr>
<tr><td>4.</td><td colspan="7">To obtain knowledge in basic concepts of quantum physics and matter waves</td></tr>
<tr><td>5.</td><td colspan="7">To acquire knowledge in basics of crystal structure, types of crystal, its defects and crystal growth techniques</td></tr>
<tr><td colspan="2">UNIT I</td><td colspan="2">ULTRASONICS AND ACOUSTICS</td><td>9</td><td>3</td><td>0</td><td>12</td></tr>
<tr><td colspan="8">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.</td></tr>
<tr><td colspan="2">UNIT II</td><td colspan="2">LASER AND FIBRE OPTICS</td><td>9</td><td>3</td><td>0</td><td>12</td></tr>
<tr><td colspan="8">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).</td></tr>
<tr><td colspan="2">UNIT III</td><td colspan="2">THERMAL PHYSICS</td><td>9</td><td>3</td><td>0</td><td>12</td></tr>
<tr><td colspan="8">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.</td></tr>
<tr><td colspan="2">UNIT IV</td><td colspan="2">QUANTUM PHYSICS</td><td>9</td><td>3</td><td>0</td><td>12</td></tr>
<tr><td colspan="8">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).</td></tr>
<tr><td colspan="2">UNIT V</td><td colspan="2">CRYSTAL PHYSICS</td><td>9</td><td>3</td><td>0</td><td>12</td></tr>
<tr><td colspan="8">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.</td></tr>
<tr><td colspan="8" align="right">Total (45L+15T) = 60 Periods</td></tr>
</table>

<table>
<tr><td colspan="2">Text Books:</td></tr>
<tr><td>1.</td><td>Arumugam M, ‘Engineering Physics’, Anuradha publishers, 2019.</td></tr>
<tr><td>2.</td><td>Rajendran V. and Marikani A, ‘Engineering Physics’, PHI Learning Pvt., India, 2018.</td></tr>
<tr><td>3.</td><td>Palanisamy P.K, ‘Engineering Physics’, SCITECH Publications, 2018.</td></tr>
<tr><td>4.</td><td>Ragavan V, ‘Material science and engineering’, Prentice Hall of India Pvt Ltd, NewDelhi, 2004.</td></tr>
<tr><td>5.</td><td>Introduction to crystal growth, Principles and Practice, H.L. Bhat, Taylor and Francis, 2015 edition.</td></tr>
<tr><td colspan="2">Reference Books:</td></tr>
<tr><td>1.</td><td>Gaur R.K. and Gupta S.L, ‘Engineering Physics’, DhanpatRai publishers, 2012.</td></tr>
</table>

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						2	2	1	
CO2	2	3	1	1	2	1						2	1	1	
CO3	3	2	1	1	0							1	2		
CO4	3	2	1	1	2		1					1	1		
CO5	2	2	1	1	2							1	0	1	1
Avg	**2.6**	**2.2**	**1**	**1**	**1.4**	**0.4**	**0.2**					**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 (45L) = 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, 5th Edition, 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								1	3	1	
CO2	3	2	2	1								1	3	1	
CO3	3	2	2	1								2	3	2	
CO4	3	1	2	1								1	3	2	
CO5	3	1	2	1								1	3	2	
Avg	**3**	**1.6**	**2**	**1**								**1.2**	**3**	**1.6**	

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	**BASIC CONCEPTS OF HUMAN VALUES**	**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	**UNDERSTANDING HARMONY IN THE HUMAN BEING**	**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	**UNDERSTANDING HARMONY IN THE FAMILY AND SOCIETY**	**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	**UNDERSTANDING HARMONY IN THE NATURE AND EXISTENCE**	**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	**HOLISTIC UNDERSTANDING OF HARMONY**	**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			1			1		2		1		3	2		1
CO2			1			3		1		1		3	1		1
CO3			1			2		1		1		3	1		2
CO4			2			1		1		1		3	1		1
Avg			**1.25**			**1.75**		**1.25**		**1**		**3**	**1.25**		**1.25**

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

<table>
<tr><td>22MCIN01</td><td colspan="4">ENGINEERING SPRINTS</td><td colspan="3">SEMESTER II</td></tr>
<tr><td colspan="3">PRE-REQUISITE:</td><td>Category</td><td>EE</td><td colspan="2">Credit</td><td>1</td></tr>
<tr><td colspan="3" 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>2</td><td>2</td></tr>
<tr><td colspan="8">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="7">To strengthen conceptual understanding of fundamental engineering concepts.</td></tr>
<tr><td>2.</td><td colspan="7">To spark curiosity in students’ Minds.</td></tr>
<tr><td>3.</td><td colspan="7">To focus on teaching through a problem-solving approach using Street Fight Engineering principles pioneered.</td></tr>
<tr><td>4.</td><td colspan="7">To foster the growth of functional independence and self-driven learning habits</td></tr>
<tr><td>5.</td><td colspan="7">To maximize the interest levels toward learning - as students aspire to create meaningful changes in the world.</td></tr>
<tr><td colspan="2">UNIT I</td><td colspan="2">STREET FIGHTING ENGINEERING</td><td>0</td><td>0</td><td>6</td><td>6</td></tr>
<tr><td colspan="8">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</td></tr>
<tr><td colspan="2">UNIT II</td><td colspan="2">PROGRAMMING PARADIGM</td><td>0</td><td>0</td><td>6</td><td>6</td></tr>
<tr><td colspan="8">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</td></tr>
<tr><td colspan="2">UNIT III</td><td colspan="2">BRAINS OF MACHINES</td><td>0</td><td>0</td><td>6</td><td>6</td></tr>
<tr><td colspan="8">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</td></tr>
<tr><td colspan="2">UNIT IV</td><td colspan="2">MACHINES THAT MAKE-UP THE WORLD</td><td>0</td><td>0</td><td>6</td><td>6</td></tr>
<tr><td colspan="8">Basic of Electronics Passive Components -Need for sensors & Actuators - Analyzing & Understanding electronic circuits - How to Build a Basic Custom Hardware - Bootloader& its purpose</td></tr>
<tr><td colspan="2">UNIT V</td><td colspan="2">ENGINEERING THE REAL WORLD</td><td>0</td><td>0</td><td>6</td><td>6</td></tr>
<tr><td colspan="8">Real-world as systems - Introduction to Systems Thinking - Stock and Flow Diagrams - System Traps - Intervening in System - Living in a World of Systems</td></tr>
<tr><td colspan="8" align="right">Total (30P) = 30 Periods</td></tr>
</table>

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							2		2				2
CO2	2			3					2						2
CO3	2	2		3					2		2				2
CO4	2	2		3				1	2		2				2
CO5		3				1	2		2	1	2				2
Avg	**2**	**2.5**		**2**		**1**	**2**	**1**	**2**	**1**	**2**				**2**

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

22MC201	**தமிழரும் தொழில்நுட்பமும்** **B.E (Common to all Branches)**		**Semester**			**II**
முன்நிபந்தனைகள்:		**Category**	**HS MC**	**Credit**		**1**
இலக்கணம் மற்றும் இலக்கியத்தின் அடிப்படைகள்		**Hours/Week**	**L**	**T**	**P**	**TH**
			1	**0**	**0**	**1**

பாடநெறி நோக்கங்கள்: மாணவர்களால்

1.	நெசவுத் தொழிலின் நன்மைகள், அதன் பயன்கள், பானைத் தொழில் நுட்பத்தைப் பற்றி நன்கு அறிந்து கொள்ள முடியும்.
2.	கட்டிடம் கட்டுதல் மற்றும் கட்டிடத் தொழிலுள்ள நுட்பங்கள் பற்றி அறிந்து கொள்ள முடியும்.
3.	உற்பத்தி தொழில் நுட்பம், இரும்பு, உலோகம், கனிமம், தொழிற்சாலைகள் பற்றி அறிந்து அவற்றின் பயன்பாடுகளை வெளிப்படுத்த முடியும்.
4.	வேளாண்மை மற்றும் நீர் பாசன முறைகள், தொழில் நுட்பம், ஏர் உழுதல் போன்ற பண்டைய கால நெறி முறைகளைப் பற்றி தெரிந்து நடைமுறைப் படுத்த முடியும்.
5.	இன்றைய கால கட்டத்தில் உள்ளவாறு அறிவியல் வளர்ச்சி, கணினித் தமிழ் பற்றி தெரிந்து கொண்டு அறிவை விரிவாக்க முடியும்.

அலகு I	**நெசவு மற்றும் பானை தொழில்நுட்பம்**	**3**	**0**	**0**	**3**

சங்க காலத்தில் நெசவுத் தொழில் - பானை தொழில் நுட்பம் - கருப்பு சிவப்பு பாண்டங்கள்- பாண்டங்களில் கீறல் குறியீடுகள்

அலகு II	**வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம்**	**3**	**0**	**0**	**3**

சங்க காலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் & சங்க காலத்தில் வீட்டுப் பொருட்களில் வடிவமைப்பு- சங்க காலத்தில் கட்டுமான பொருட்களும் நடுகல்லும்- சிலப்பதிகாரத்தில் மேடை அமைப்பு பற்றிய விவரங்கள் - மாமல்லபுரச் சிற்பங்களும், கோவில்களும் - கோவில்களும் - சோழர் காலத்துப் பெருங்கோயில்கள் மற்றும் பிற வழிபாட்டுத் தலங்கள்- நாயக்கர் காலக் கோயில்கள் - மாதிரி கட்டகமைப்புகள் பற்றி அறிதல், மதுரை மீனாட்சி அம்மன் ஆலயம் மற்றம் திருமலை நாயக்கர் மஹால் - செட்டிநாட்டு வீடுகள் - பிரிட்டிஷ் காலத்தில் சென்னையில் இந்தோ சாரோசெனிக் கட்டிடக் கலை.

அலகு III	**உற்பத்தித் தொழில் நுட்பம்**	**3**	**0**	**0**	**3**

கப்பல் கட்டும் கலை - உலோகவியல் - இரும்புத் தொழிற்சாலை - இரும்பை உருக்குதல், எஃகு - வரலாற்றுச் சான்றுகளாக செம்பு மற்றும் தங்க நாணயங்கள் - நாணயங்கள் அச்சிடித்தல் - மணி உருவாக்கம் தொழிற்சாலைகள் - கல்மணிகள், கண்ணாடி மணிகள் - சுடுமண் மணிகள் - சங்கு மணிகள் - எலும்புத்துண்டுகள் - தொல்லியல் சான்றுகள் - சிலப்பதிகாரத்தில் மணிகளின் வகைகள்.

அலகு IV	**வேளாண்மை மற்றும் நீர்ப்பாசனத் தொழில் நுட்பம்**	**3**	**0**	**0**	**3**

அனை, ஏரி, குளங்கள், மதகு, - சோழர்காலக் குமுழித் தூம்பின் முக்கியத்துவம் - கால்நடை பராமரிப்பு - கால்நடைகளுக்காக வடிவமைக்கப்பட்ட கிணறுகள் - வேளாண்மை மற்றும் வேளாண்மை சார்ந்த செயல்பாடுகள் - கடல்சார் அறிவு - மீன்வளம் - முத்து மற்றும் முத்துக்குளித்தல் - பெருங்கடல் குறித்த பண்டைய அறிவு - அறிவுசார் சமூகம்.

அலகு V	**அறிவியல் தமிழ் மற்றும் கணித்தமிழ்**	**3**	**0**	**0**	**3**

அறிவியல் தமிழின் வளர்ச்சி - கணித்தமிழ் வளர்ச்சி - தமிழ் நூல்களை மின் பதிப்பு செய்தல் - தமிழ் மென் பொருட்கள் உருவாக்கம் - தமிழ் இணையக் கல்விக்கழகம் - தமிழ் மின் நூலகம் - இணையத்தில் தமிழ் அகராதிகள் - சொற்குவைத் திட்டம்.

Total = 15 Periods

Text Books:	
1	தமிழக வரலாறு - மக்களும் பண்பாடும் - கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியல் பணிகள் கழகம்)
2	கணினித் தமிழ் - முனைவர் இல.சுந்தரம் (விகடன் பிரசுரம்)
3	கீழடி - வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4	பொருநை - ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)

பாடநெறி முடிவுகள்: இந்தப் படிப்பு முடிந்ததும், மாணவர்களால்		**Bloom's Taxonomy Mapped**
CO1	சங்காலத்தில் இருந்த நல்ல தொழில்களையும் கைவினை கலைகளால் ஏற்படும் நன்மைகளையும் பற்றி அறிந்து கொண்டனர்.	Understanding
CO2	கட்டிடங்கள் மற்றும் வீட்டுப்பொருட்களை வடிவமைப்பது, சங்காலத்தில் இருந்த கோவில்களை பற்றி அறிந்து கொண்டனர்	Understanding
CO3	உலோகவியல், இரும்பு தொழிற்சாலைகள், தொல்லியல் சான்றுகள், உற்பத்தி தொழல் நுட்பத்தை பற்றி அறிந்து கொண்டனர்.	Applying
CO4	பழங்காலத்தில் வோளண்மை, நீர்பாசனம், மீன் வளம், கால்நடை பராமரிப்பு, அறிவுசார் சமுகம் பற்றி அறிந்து கொண்டனர்.	Applying
CO5	அறிவியல் தமிழன் வளர்ச்சி, கணித்தமிழ் வளர்ச்சி, மென்பொருள் உருவாக்கம், இணைய கல்வி கழகம், இணையத்தில் தமிழ் அகராதிகள் பற்றி அறிந்து கொண்டனர்.	Understanding

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			3			2						1	2		
CO2			3			2						1	2		
CO3			3			2						1	2		
CO4			3			2						1	2		
CO5			3			2						1	2		
Avg			**3**			**2**						**1**	**2**		
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

22MC201	**TAMILS AND TECHNOLOGY**			**Semester**		**II**
PREREQUISITES		**Category**	**HS MC**	**Credit**		**1**
Basics of Tamils Language and Literature		**Hours/Week**	**L**	**T**	**P**	**TH**
			1	**0**	**0**	**1**

1.	To Obtain the knowledge of weaving and ceramic technology
2.	To familiarize about design and construction technology during sangam age and British period
3.	To know about the manufacturing technologices
4.	To obtain the knowledge of agriculture and irrigation technology
5.	To know about the development of Scientific Tamil and Tamil computing

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)

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Obtain the knowledge about weaving and ceramic technology.	Understatnding
CO2	Familiarize about design and construction technology during sangam age and British period	Understatnding
CO3	Understanding about the manufacuturing technologies	Applying
CO4	Acquire the skills in agriculture and irrigation technology	Applying
CO5	Acquire the knowledge about the development of Scientific Tamils and Tamil computing.	Understatnding

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			3			2						1	2		
CO2			3			2						1	2		
CO3			3			2						1	2		
CO4			3			2						1	2		
CO5			3			2						1	2		
Avg			**3**			**2**						**1**	**2**		
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

22NC201	**NCC COURSE-I (Only for NCC Students)**	**Semester II**			
PREREQUISITES	**Category**	**NC**	**Credit**		**3**
	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 (45L) = 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

<table>
<tr><td>22CS102</td><td colspan="2">COMPUTER PRACTICE AND C PROGRAMMING LABORATORY</td><td colspan="4">SEMESTER II</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>Category</td><td>ES</td><td colspan="2">Credit</td><td>1.5</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>3</td><td>3</td></tr>
</table>

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 (45P) = 45 Periods

<table>
<tr><td colspan="2">Course Outcomes:
Upon completion of this course, the students will be able to:</td><td>Bloom’s Taxonomy Level</td></tr>
<tr><td>CO1</td><td>Demonstrate the usage of features supported by word processing applications.</td><td>Apply</td></tr>
<tr><td>CO2</td><td>Demonstrate the usage of features supported by spread sheet applications.</td><td>Apply</td></tr>
<tr><td>CO3</td><td>Apply general programming techniques to develop digital solution to problems</td><td>Apply</td></tr>
<tr><td>CO4</td><td>Implement solutions develop with general programming techniques in C programming language</td><td>Apply</td></tr>
</table>

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										3				1	
CO2	3	3												1	
CO3	3	3	2	2	2	1	1	1			2	3		1	
CO4	3	3	2	2	2	1	1	1			2	3		1	
Avg	**3**	**3**	**2**	**2**	**2**	**1**	**1**	**1**		**3**	**2**	**3**		**1**	
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

<table>
<tr><th>22ME102</th><th colspan="4">WORKSHOP MANUFACTURING PRACTICES</th><th colspan="3">SEMESTER II</th></tr>
<tr><td colspan="2">PREREQUISITES</td><td colspan="2">Category</td><td>ES</td><td colspan="2">Credit</td><td>2</td></tr>
<tr><td colspan="2" rowspan="2"></td><td colspan="2" 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>4</td><td>4</td></tr>
</table>

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 (60P) = 60 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” Mnual 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	Prepare the mould cavity by using proper moulding tools in foundry section.	Apply
CO4	Fabrication of components using welding, lathe and drilling machine.	Apply
CO5	Make the model using sheet metal works.	Apply

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1					22	3									
CO2		3		2	1										2
CO3		3		2	1										2
CO4		3		2	1										2
CO5		3		2	1										2
Avg		**3**		**2**	**1**	**3**									**2**
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

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 (45L) = 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		2	0								2		
CO2	3	2		2	0								2		
CO3	3	2		2	0								2		
CO4	3	2		2	0								2		
CO5	3	2		2	0								2		
Avg	**3**	**2**		**2**	**0**								**2**		
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			1					1	3	1	1
CO2	3	3	2	2			1					1	3	1	1
CO3	3	3	3	2		1	1					1	3	1	1
CO4	2	3	2	2		1	1					1	3	1	1
CO5	3	3	2	2		1	0					1	3	1	1
Avg	**2.8**	**3**	**2.2**	**2**		**1**	**1**					**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				2				1		2	2	1
CO2	3	3	1		2								2	2	1
CO3	2	3	2	2	1								2	2	1
CO4	3	3	3	2	1	2	1						2	2	1
CO5	3	3	3	2	1	2	1						2	2	1
Avg	**2.8**	**2.6**	**2**	**2**	**1.25**	**2**	**1.3**				**1**		**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(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 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						1			1	2	1
CO2	2	1	2	1		1			1	1			1	2	1
CO3	1	1	1	1						1			1	1	1
CO4	1	1	1		1					1			1	1	1
CO5		1							1	1			1		1
Avg	**1.2**	**1**	**1.5**	**1**	**1**	**1**			**1**	**1**			**1**	**1.5**	**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 (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						2	3	1
CO2	1		2	1	1	2	1						2	3	1
CO3		1	1	1	1		1						3	2	1
CO4		2	2	1	1	1	1						2	3	1
CO5		2	2	2	1		1						2	2	1
Avg	**1**	**1.5**	**1.8**	**1.4**	**1.0**	**1.3**	**1**						**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 and 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**			**0**	**0**	**6**	**6**
Introduction: Design Thinking Principles - Design Thinking Values - Design Thinking Methods - Challenge impact setting - Framing the design challenge.							
UNIT II	**CUSTOMER-CENTRIC INNOVATION**			**0**	**0**	**6**	**6**
Understanding Customer needs - Empathy building techniques - gap analysis - adoption barriers - observations and insights - Translating Insights into Innovation Opportunities							
UNIT III	**IDEA GENERATION**			**0**	**0**	**6**	**6**
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**			**0**	**0**	**6**	**6**
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**			**0**	**0**	**6**	**6**
Science of Story telling - the blueprint for story telling - Pitch Script - Pitch Presentations - Best practices to creating a compelling pitch - communication fundamentals							
Total (30P) = 30 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	**2**	**3**	**2**	**2**	**0**	**2**	**1**	**1**	**2**	**3**	**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**		**3**
		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 (45L) = 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**	**2**	**1.4**	**2**	**0**	**1.5**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**2**	**1**
3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)															

<table>
<tr><td>22ME304</td><td colspan="2">CAD LABORATORY</td><td colspan="4">SEMESTER III</td></tr>
<tr><td colspan="2">PRE-REQUISITE:</td><td>Category</td><td>PC</td><td colspan="2">Credit</td><td>1.5</td></tr>
<tr><td colspan="2" rowspan="2">1. Engineering Drawing
2. Machine Drawing</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>3</td><td>3</td></tr>
</table>

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 (45P) = 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		1				2		2	2	1
CO2	1	1	1	1	3		1				0		2	2	1
CO3	2	2	2	1	2		1				1		2	2	1
Avg	**1.6**	**1.6**	**1.33**	**1.33**	**2.6**		**1**				**1**		**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 (45P) = 45 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					1				1	1	3
CO2	1	2	1	1					1				2	1	2
CO3	1	2	2	2					1				2	1	3
Avg	**1**	**2**	**1.33**	**1.33**					**1**				**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									3	1	
CO2	3	2	2	1									3	1	
CO3	3	2	2	1									3	1	
CO4	3	2	2	1									3	1	
CO5	3	2	2	1									3	1	
Avg	**3**	**2**	**2**	**1**									**3**	**1**	

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

22ME402	**THERMAL ENGINEERING** *(Use of standard thermodynamic tables, Mollier diagram, Psychrometric 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”, Dhanpat Rai 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											3	1	1
CO2	3	3	2	3									3	2	1
CO3	3	2	3	1		2							3	2	1
CO4	3	2	2	2									3	2	1
CO5	3					1							3	3	1
Avg	**3**	**2**	**2.3**	**2**		**1.5**							**3**	**2**	**1**

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

<table>
<tr><td>22ME403</td><td colspan="2">METAL CUTTING AND MACHINE TOOLS</td><td colspan="4">SEMESTER IV</td></tr>
<tr><td colspan="2">PRE-REQUISITE:</td><td>Category</td><td>PC</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">Introduction to Materials, force analysis
Heat treatment processes and Engineering physics.</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="6">To provide knowledge on basic mechanics of metal cutting.</td></tr>
<tr><td>2.</td><td colspan="6">Summarize the constructional and operational features of machine tools for manufacturing various components.</td></tr>
<tr><td>3.</td><td colspan="6">Explain the machine tools for hole making grinding and broaching.</td></tr>
<tr><td>4.</td><td colspan="6">To analyze various unconventional machining processes and their needs in industries</td></tr>
<tr><td>5.</td><td colspan="6">Describe the necessity of additive manufacturing techniques and ready to interpret with industries requirements</td></tr>
<tr><td>UNIT I</td><td colspan="2">THEORY OF METAL CUTTING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>UNIT II</td><td colspan="2">AUTOMATS, SHAPING AND PLANING MACHINES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>UNIT III</td><td colspan="2">DRILLING, BROACHING AND GRINDING MACHINES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>UNIT IV</td><td colspan="2">MILLING AND GEAR GENERATING MACHINES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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</td></tr>
<tr><td>UNIT V</td><td colspan="2">ADVANCES IN MACHINING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7">Total (45L) = 45 Periods</td></tr>
</table>

<table>
<tr><td colspan="2">Text Books:</td></tr>
<tr><td>1.</td><td>Kalpakjian and Schmid, “Manufacturing processes for Engineering Materials” (5th Edition) - Pearson India, 2014.</td></tr>
<tr><td>2.</td><td>Rao. P.N “Manufacturing Technology - Metal Cutting and Machine Tools", 3rd Edition, Tata McGraw-Hill, New Delhi, 2013</td></tr>
<tr><td colspan="2">Reference Books:</td></tr>
<tr><td>1.</td><td>HajraChoudhury, "Elements of Workshop Technology", Vol.II., Media Promoters 2014</td></tr>
<tr><td>2.</td><td>"H.M.T. "Production Technology – Handbook", Tata McGraw-Hill, 2000.</td></tr>
<tr><td>3.</td><td>Roy. A. Linberg, "Process and Materials of Manufacture", PHI, 2000.</td></tr>
<tr><td>4.</td><td>Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems.</td></tr>
<tr><td>5.</td><td>Jain. R.K., and S.C. Gupta, "Production Technology", 16th Edition, Khanna Publishers, 2001</td></tr>
</table>

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		1						1	1		2		1
CO2		1	1	1						1	1	1	1	2	3
CO3		1	1							1	1	1	1	2	2
CO4		1	1							1	1	1	1	2	2
CO5		1			2		2		2	1	1	1	1	2	2
Avg	**2**	**1**	**1**	**1**	**2**		**2**		**2**	**1**	**1**	**1**	**1.2**	**2**	**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 TROUBLE SHOOTING**	**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										1	1	1
CO2		2	2	1									1	1	1
CO3	1	2	3			1							1	2	1
CO4	1	1	3	2	2								2	1	1
CO5	1	1	2										1	1	1
Avg	**1.25**	**1.4**	**2.2**	**1.5**	**2**	**1**							**1.2**	**1.2**	**1**
3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)															

<table>
<tr><td>22CE409</td><td colspan="2">STRENGTH OF MATERIALS</td><td colspan="4">SEMESTER IV</td></tr>
<tr><td colspan="2">PRE-REQUISITE:</td><td>Category</td><td>ES</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">Differentiation, Partial Differential Equations
Engineering Mechanics.</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="6">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</td></tr>
<tr><td>2.</td><td colspan="6">To calculate the shear force and bending moment of various beams transverse loading</td></tr>
<tr><td>3.</td><td colspan="6">To estimate the slope and the deflection of beams and strengths of the columns</td></tr>
<tr><td>4.</td><td colspan="6">To evaluate the axial and hoop stresses in thin and thick shells for the applied internal and external pressures.</td></tr>
<tr><td>5.</td><td colspan="6">To learn about the torsion behavior of shafts and coil springs</td></tr>
<tr><td>UNIT I</td><td colspan="2">STRESS, STRAIN AND DEFORMATION OF SOLIDS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>UNIT II</td><td colspan="2">TRANSVERSE LOADING ON BEAMS AND STRESSES IN BEAMS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>UNIT III</td><td colspan="2">DEFLECTION OF BEAMS AND COLUMNS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>UNIT IV</td><td colspan="2">THIN CYLINDERS, SPHERES AND THICK CYLINDERS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>UNIT V</td><td colspan="2">TORSION AND SPRINGS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7">Total (45L) = 45 Periods</td></tr>
</table>

<table>
<tr><td colspan="2">Text Books:</td></tr>
<tr><td>1.</td><td>Rajput, R.K, “Strength of Materials”, S.Chand and Co, 3rd Edition, 2003.</td></tr>
<tr><td>2.</td><td>Bansal, R.K., "Strength of Materials", Laxmi Publications (P) Ltd., 2016.</td></tr>
<tr><td colspan="2">Reference Books:</td></tr>
<tr><td>1.</td><td>Strength of Materials, D.S. Bedi, Khanna Publishing House</td></tr>
<tr><td>2.</td><td>Subramanian R., "Strength of Materials", Oxford University Press, Oxford Higher Education Series, 2010.</td></tr>
<tr><td>3.</td><td>Mechanics of Materials, Punmia, Jain and Jain, Laxmi Publications</td></tr>
<tr><td>4.</td><td>Strength of Materials (Mechanics of Solid), R.S. Khurmi, S.Chand Publications</td></tr>
<tr><td>5.</td><td>Strength of Materials, Jindal U.C., Asian Books Pvt. Ltd., New Delhi, 2009</td></tr>
</table>

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 shear 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												
CO2	2	2	1	1									1	2	
CO3	3	2	1	1									2	2	
CO4	3	2	2	2									2		1
CO5	2	2	2	2									2		1
Avg	**2.4**	**1.8**	**1.4**	**1.5**									**1.75**	**2**	**1**
3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)															

<table>
<tr><td>22MCIN03</td><td colspan="2">DESIGN SPRINTS</td><td colspan="4">SEMESTER IV</td></tr>
<tr><td colspan="2">PRE-REQUISITE:</td><td>Category</td><td>EE</td><td colspan="2">Credit</td><td>1</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>2</td><td>2</td></tr>
<tr><td colspan="7">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="6">Develop key skill areas essential for a product designer from the perspective of design, its inherent complexity and supports them with tools and techniques to prototype rapidly.</td></tr>
<tr><td>2.</td><td colspan="6">To enable the participants to visualize the experience for a user.</td></tr>
<tr><td>3.</td><td colspan="6">To learn the roles and responsibilities of a designer in creating and shaping experiences for the user.</td></tr>
<tr><td>4.</td><td colspan="6">The participants shall learn through the lenses of system thinking of how existing products work.</td></tr>
<tr><td>5.</td><td colspan="6">Learn to select and apply various practice tools to aid them in rapid prototyping</td></tr>
<tr><td>UNIT I</td><td colspan="2">DESIGN FUNDAMENTALS</td><td>0</td><td>0</td><td>6</td><td>6</td></tr>
<tr><td colspan="7">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</td></tr>
<tr><td>UNIT II</td><td colspan="2">SYSTEM THINKING AND REVERSE ENGINEERING</td><td>0</td><td>0</td><td>6</td><td>6</td></tr>
<tr><td colspan="7">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</td></tr>
<tr><td>UNIT III</td><td colspan="2">USER INTERFACE & USER EXPERIENCE</td><td>0</td><td>0</td><td>6</td><td>6</td></tr>
<tr><td colspan="7">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</td></tr>
<tr><td>UNIT IV</td><td colspan="2">MECHANICAL PROTOTYPING</td><td>0</td><td>0</td><td>6</td><td>6</td></tr>
<tr><td colspan="7">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</td></tr>
<tr><td>UNIT V</td><td colspan="2">ELECTRONIC & SOFTWARE PROTOTYPING</td><td>0</td><td>0</td><td>6</td><td>6</td></tr>
<tr><td colspan="7">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</td></tr>
<tr><td colspan="7">Total (30P) = 30 Periods</td></tr>
</table>

<table>
<tr><td colspan="2">Text Books:</td></tr>
<tr><td>1.</td><td>Thinking in systems - Donella Meadows, 2015</td></tr>
<tr><td>2.</td><td>Rapid Prototyping And Engineering Applications: A Toolbox For Prototype Development - Frank W.Liou, 2007</td></tr>
<tr><td>3.</td><td>Rapid Prototyping Technology: Selection and application - COOPER K. G, 2001</td></tr>
<tr><td colspan="2">Reference Books:</td></tr>
<tr><td>1.</td><td>https://thesystemsthinker.com/wp-content/uploads/2016/03/Introduction-to Systems-Thinking-IMS013Epk.pdf</td></tr>
<tr><td>2.</td><td>https://formlabs.com/blog/ultimate-guide-to-prototyping-tools-for-hardware-and product-design/</td></tr>
<tr><td>3.</td><td>https://docs.kicad-pcb.org/</td></tr>
<tr><td>4.</td><td>https://www.tinkercad.com/learn/circuits</td></tr>
<tr><td>5.</td><td>https://docs.github.com/en/free-pro- team@latest/actions/guides</td></tr>
</table>

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		1						2						2
CO2	2	3							2						2
CO3	3		1					1	2						2
CO4			3	2	3				2						2
CO5	2		2		1				2						2
Avg	**2.5**	**3**	**1.7**	**2**	**2**			**1**	**2**						**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**	**TH**
			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		1	3			3	1	1				1	2		1
CO2		1	3			3	1	1				1	2		1
Avg		**1**	**3**			**3**	**1**	**1**				**1**	**2**		**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 (45P) = 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						1	1	2
CO2	1	2	1	1	1	2	1						2	1	1
CO3	2	1	3	1	1	2	1						3	1	3
CO4															
CO5															
Avg	**2**	**1.7**	**1.7**	**1**	**1.7**	**1.7**	**1**						**2**	**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 (45P) = 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				1		1			1		1		1	
CO2		2			2	2	1	1				2		2	
CO3	3	1		1			2		1	1		1	2	1	3
CO4	3	3			2			2						2	
CO5		1							1	2			3		1
Avg	**2.6**	**1.7**		**1**	**1.7**	**2**	**1.3**	**1.5**	**1**	**1.3**		**1.3**	**2.5**	**1.5**	**2**

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

SEMESTER-V

22ME501	**DESIGN OF MACHINE ELEMENTS**		**SEMESTER V**			
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		1	1				1		3	2	1
CO2	2	2	1	2		1	1				1		3	2	1
CO3	2	2	1	2		1	1				1		3	2	1
CO4	2	2	1	2		1	1				1		3	2	1
CO5	2	2	1	2		1	1				1		3	2	1
Avg	**2.0**	**2.0**	**1.0**	**2.0**		**1.0**	**1.0**				**1.0**		**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. Basic laws and 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**
Basic Governing 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 (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 heat conduction under steady and unsteady conditions in solids.	Analyze
CO2	Describe the fundamentals of natural and forced convective heat transfer processes	Understand
CO3	Analyze the performance of heat exchangers by using the method of LMTD and NTU	Analyze
CO4	Evaluate the parameters of radiative heat exchange between surfaces	Evaluate
CO5	Relate the mass transfer concepts for various industrial applications.	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		1						3	3	1
CO2	3	3	3	3	2		1						3	3	1
CO3	3	3	3	3	2		1						3	3	1
CO4	3	3	3	3	2		1						3	2	1
CO5	2	2	2	2	1		1						3	1	
Avg	**2.8**	**2.8**	**2.8**	**2.8**	**1.8**		**1**						**3**	**2.4**	**1**

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 generalized measurement system-mechanical loading – static characteristics of instruments-factors considered in selection 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**

Surface finish – terminology and measurements – Optical measuring instruments – Acceptance test fo rmachines. Statistical Quality Control - Control charts - Sampling plans.

UNIT V	**SIX SIGMA**	**9**	**0**	**0**	**9**

Six sigma: define measure, analyse, improve and control phases. Analyze phase tools: Common Tools: Histogram, BoxPlot, Control chart, Scatter chart, Cause and effect diagram, Pareto analysis, interrelations diagram. 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							2	1	2				2	1	
CO2							3	1	2				1	2	
CO3							2	1					2	1	
CO4				3			2		1				1	2	
CO5				2				3	1				2	1	
Avg				**2.5**			**2.2**	**1.5**	**1.5**				**1.6**	**1.4**	

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(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 balancing of rotating and reciprocating masses.	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					1		3	2	1	2
CO2	2	2	3	2	1					1		3	2	1	2
CO3	2	2	3	2						1		3	2	1	2
CO4	2	2	3	2	1					1		3	2	1	2
CO5	1	2	3	2						1		3	2	1	1
Avg	**1.8**	**2.0**	**3.0**	**2.2**	**1**					**1.0**		**3.0**	**2.0**	**1.0**	**1.8**

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

<table>
<tr><td colspan="2">22ME505</td><td colspan="3">INSTRUMENTATION AND CONTROL SYSTEM</td><td colspan="4">SEMESTER V</td></tr>
<tr><td colspan="4">PREREQUISITE:</td><td>Category</td><td>PC</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="4" rowspan="2">Basics of measurements</td><td rowspan="2">Hours/Week</td><td>L</td><td>0</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="9">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="8">To make the students aware of the modern sensors and advanced measurement systems</td></tr>
<tr><td>2.</td><td colspan="8">To select the correct system of instrumentation and sensing as per the industrial requirements</td></tr>
<tr><td>3.</td><td colspan="8">To understand statistical signal processing</td></tr>
<tr><td>4.</td><td colspan="8">To provide adequate knowledge in the time response of systems and steady state error analysis</td></tr>
<tr><td>5.</td><td colspan="8">To introduce stability analysis and design of compensators</td></tr>
<tr><td colspan="3">UNIT I</td><td colspan="2">GENERAL CONCEPTS OF MEASUREMENT</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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</td></tr>
<tr><td colspan="3">UNIT II</td><td colspan="2">SIGNAL CONDITIONING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td colspan="3">UNIT III</td><td colspan="2">DATA ACQUISITION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td colspan="3">UNIT IV</td><td colspan="2">TIME RESPONSE ANALYSIS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td colspan="3">UNIT V</td><td colspan="2">FREQUENCY DOMAIN ANALYSIS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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</td></tr>
<tr><td colspan="9">Total(45L) = 45 Periods</td></tr>
<tr><td colspan="9">Text Books:</td></tr>
<tr><td>1.</td><td colspan="8">John G. Webster, “Measurement, Instrumentation, and Sensors Handbook”, CRC Press. 1998.</td></tr>
<tr><td>2.</td><td colspan="8">Murthy, D.V.S., Transducers and Instrumentation, 2nd Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2010</td></tr>
<tr><td colspan="9">Reference Books:</td></tr>
<tr><td>1.</td><td colspan="8">Patranabis, D, “Sensors and Transducers”, Wheeler Publishing Co, Ltd., New Delhi, 1997.</td></tr>
<tr><td>2.</td><td colspan="8">M.Gopal, ‘Control Systems, Principles and Design’, 4th Edition, Tata McGraw Hill, New Delhi, 2012</td></tr>
<tr><td>3.</td><td colspan="8">K.Ogata, Modern Control Engineering, 4th Edition, Prentice Hall, 2002</td></tr>
</table>

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				1			3	1		
CO2													2	1	
CO3	1	2	2	2	2	2	1		2		1	1		2	1
CO4		1	2	3	1		2					2			
CO5		2	3	3	1			1	2	1		3			2
Avg	**1**	**1.5**	**2.2**	**2.4**	**1.7**	**2**	**1.5**	**1**	**1.0**	**1.6**	**1**	**2.2**	**1.5**	**1.5**	**1.5**

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

<table>
<tr><td>22MCIN04</td><td colspan="2">IDEATION SPRINTS</td><td colspan="4">SEMESTER V</td></tr>
<tr><td colspan="2">PRE-REQUISITE:</td><td>Category</td><td>EE</td><td colspan="2">Credit</td><td>1</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>2</td><td>2</td></tr>
</table>

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**	**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 (30P) = 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**
PREREQUISITES		**Category**	**MC**	**Credit**		**0**
NIL		**Hours/Week**	**L**	**T**	**P**	**TH**
			2	**0**	**0**	**2**
Course Learning Objectives						
1	To learn the Fundamental Rights and Fundamental Duties of the Indian Constitution.					
2	To list the Union and Territories in our Nation					
3	To know the Finance, Trade and Commerce of our Nation					
4	To present a systematic analysis of all dimensions of Indian Political System					
5	To understand the power and functions of the Parliament, the Legislature and the Judiciary					
Unit I	**FUNDAMENTAL RIGHTS**		**6**	**0**	**0**	**6**
Union and its Territory– Citizenship– Fundamental Rights– Directive Principles of State Policy–Fundamental Duties						
Unit II	**UNION & TERRITORIES**		**6**	**0**	**0**	**6**
TheUnion–TheStates–TheUnionTerritories–ThePanchayats–TheMunicipalities						
Unit III	**FINANCE, TRADE & COMMERCE**		**6**	**0**	**0**	**6**
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	**ELECTIONS**		**6**	**0**	**0**	**6**
Services under the Union, the States–Tribunals–Elections–Special Provisions–Relating to certain Classes						
Unit V	**MISCELLANEOUS AMENDMENTS**		**6**	**0**	**0**	**6**
Languages– Emergency Provisions– Miscellaneous– Amendment of the Constitution.						
Total= 30 Periods						

Text 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	M.V.Pylee, Constitutional History of India, S.Chand publishing, 2010
4	Granville Austin, The Indian Constitution: Cornerstone of a Nation, Oxford UniversityPress,1999.
Reference Books:	
1	Indian Constitution And Indian Polity 3Rd Edition 2021 by Ganesha Subramanian, Pearson.
2	The Indian Constitution Oxford India Short Introductions 2012 Edition by Madhav Khosla , OUP India

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understanding the Fundamental Rights and Duties	Understand
CO2	Listing the agreement between the Union and the Territories	Remember
CO3	Analysing the role of the constitution in a democratic society.	Analyse
CO4	Explaining the key concepts of the Indian Political System.	Apply
CO5	Presenting the structure and functions of the Central and State Governments, the Legislature and the Judiciary	Understand

COURSE ARTICULATION MATRIX

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

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 (45P) = 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								3	1	2
CO2		2		3	1	1							1	2	3
CO3	3	1				2							2	3	1
CO4	2	3		1	3	1							3	2	1
Avg	**2**	**2.2**	**2**	**2**	**2.3**	**1.3**							**2.2**	**2.0**	**1.7**

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

22EN501	PLACEMENT AND CAREER SKILLS 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**	**3**	**3**

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(45P) = 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				1					2	3		1			1
CO2				2					2	3		1			2
CO3				2					1	3		1			1
CO4				1					2	3		1			2
Avg				**1.5**					**1.75**	**3.0**		**1.0**			**1.5**
3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)															

<table>
<tr><td>22ME507</td><td colspan="2">HEAT TRANSFER AND REFRIGERATION LABORATORY</td><td colspan="4">SEMESTER V</td></tr>
<tr><td colspan="2">PREREQUISITES:</td><td>Category</td><td>PC</td><td colspan="2">Credit</td><td>1.5</td></tr>
<tr><td colspan="2">1.Basic knowledge about the modes of heat transfer</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td colspan="2">2.Concept of psychrometry and refrigeration and air conditioning systems</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
</table>

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 (45P) = 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		2									3	1	2
CO2	1	2	1	1									2	1	1
CO3	1	3	1										3		2
CO4	1	2	1	1									2		1
CO5	1	2		1									1	1	1
Avg	**1**	**2.4**	**1**	**1.2**									**2.2**	**1**	**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 (90P) = 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		2		3	3	3
CO2	3	3	3	3	2	3	3		3		1		3	3	
CO3	2	2	2	2	2	1	1	1	3	1	2	3	3	3	
CO4	3	2	2	1	1	1	2	3	3	3		3	3	3	
CO5					2	2		1	3	3		2	3		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)															

PROTOSEM COURSES SYLLABUS

22PSPE01	**COMPUTATIONAL HARDWARE**		**Semester**			**VI**
PREREQUISITES		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To learn basic concepts of Embedded Systems by familiarizing the functionalities of embedded platforms with development boards.
2	To understand the core concepts of GPIO Pins, Functionality of peripherals, Selection of I/O devices , Usage of Internal functions, and Communication protocols.
3	To familiarize the current technologies and protocols used in the Internet of Things (IoT) and to learn the Cloud services.

Unit I	**BASICS OF EMBEDDED SYSTEM**	**9**	**0**	**0**	**9**

Embedded Platform: Architecture and working - Factors for Microcontroller/Microprocessor selection. Arduino - Boards and schematics – Toolchain - Setup and Configuration - Input/Output Configurations and Access - Libraries - Digital I/O - ADC - Analog I/O - Timers, Interrupts - Pulse Width Modulation - Display: 7-segment , LCD , OLED.

Unit II	**BASICS OF RASPBERRY PI**	**9**	**0**	**0**	**9**

Raspberry Pi: Raspberry pi Board - Processor - Setup and Configuration - Installing Python IDLE using Command Terminal - General Purpose I/O Pins - Protocol Pins - GPIO Access - Pulse Width Modulation - Network Libraries - Web services - Twitter APIs - Twitter Bot - Interfacing pi with camera modules.

Unit III	**SENSORS AND ACTUATORS**	**9**	**0**	**0**	**9**

Interfacing of Sensors and Actuators **-** Sensors: Introduction, Characteristics: Analog - Potentiometer, Temperature Sensor, Soil Moisture Sensor, LDR - Digital - PIR Sensor, Smoke Sensor, Infrared - Sensor, Ultra- Sonic Sensor. Actuators - Introduction, Characteristics and working with relay, DC motors, Servo motor, Stepper motor and its drivers.

Unit IV	**COMMUNICATION PROTOCOLS**	**9**	**0**	**0**	**9**

Protocols - Wired: RS232 Standard **-** UART, SPI, I2C - Comparative study of wired protocols - Implementation of wired Serial Communication protocols Wireless: Standards - Bluetooth, RF - Comparative study of wireless protocols - Implementation of wireless Serial Communication protocols.

Unit V	**INTERNET OF THINGS**	**9**	**0**	**0**	**9**

Definition and Architecture of IoT, Building blocks of IoT, Programming with IoT protocols - MQTT, CoAP - Connecting embedded target board to Web, Basics networking in IoT: creating a web page - Creating a server on target board - Controlling I/O peripherals from the webpage, Embedded Application Development, Creating communication between different nodes - Cloud platforms for IoT, Cloud data logging and monitoring, Interfacing with web services.

Total = 45 Periods

Text Books:

1	Raj Kamal, “ Embedded Systems - SoC, IoT, AI and Real-Time Systems”, 4th Edition, McGraw Hill, 2020.
2	Mohit Arora, “Embedded System Design”, 1st Edition, Learning Bytes Publishing, 2016.
3	Elecia White, “Making Embedded Systems”, 1st Edition, Shroff/ O’ Reilly, 2012.
4	Jack Ganssle, “ The Firmware Handbook”, 1st Edition, Newnes, 2004.

Reference Books:	
1	https://juniorfall.files.wordpress.com/2011/11/arduino-cookbook.pdf
2	https://drive.google.com/file/d/13s0m3lHPEFP2f2aCuVNRWeBZNKXWKTW5/view?ts=6231cab 3
3	https://ptolemy.berkeley.edu/books/leeseshia/releases/LeeSeshia_DigitalV2_2.pdf 4.
4	https://www.riverpublishers.com/pdf/ebook/RP9788793519046.pdf

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand and implement the functions & Capabilities of embedded platforms for easy prototyping.	L2: Understanding
CO2	Identify the type of sensors and actuators for required applications.	L3: Applying
CO3	Develop communication between devices using different protocols.	L3: Applying
CO4	Develop IoT based systems with wireless network connections and accessing devices over cloud.	L3: Applying

COURSE ARTICULATION MATRIX

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	2	3								3	2	2
CO2	3	3	2	2	2								3	2	2
CO3	3	2	3	2	3								3	3	3
CO4	3	2	3	2	3								3	3	3
AVG	**3**	**2.25**	**2.75**	**2**	**2.75**								**3**	**2.5**	**2.5**

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

22PSPE02	**CODING FOR INNOVATORS**		**Semester**			**VI**
PREREQUISITES		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**
Course Learning Objectives						
1	To learn and express creativity using coding skills.					
2	To gain knowledge of Python programming with hands-on experience.					
3	To demonstrate a problem solving using OOPs concepts.					
4	To learn basics of Linux by familiarizing the concepts of management and file structure.					
5	To practise full stack development using cloud platform.					
Unit I	**PROGRAMMING PARADIGMS**		**9**	**0**	**0**	**9**
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 II	**BASIC OF PROGRAMMING**		**9**	**0**	**0**	**9**
Introduction to Python: statements, variables, functions, operators, modules, conditional statements, loop statements, Lists: list operations, traversing a list, slicing a list - Text Handling: Strings, string functions, conversion functions, Dictionaries - File Operations: File open, close, read, copy, word frequency, creating word histograms from text file.						
Unit III	**OOPS 5**		**9**	**0**	**0**	**9**
OOPS- Why OOPS- verticals- implementation in python - Classes and Objects, Methods, Constructors and Destructors, Inheritance, Polymorphism, Abstraction, Encapsulation.						
Unit IV	**SOFTWARE DEVELOPMENT TO DELIVERY**		**9**	**0**	**0**	**9**
Software Engineering - Life Cycle (Tools), Agile Methodologies - Framework - Why Frameworks - Software Testing(Tool Based) - Data Structures - Database Management System - A case study to experiment from Development to Deployment(D2D) - Source code management and version control - GitHub - GitHub Actions - GitBash - Continuous Integration - Platform as service - Heroku - Build Packs AWS- Anaconda						
Unit V	**OPERATING SYSTEMS**		**9**	**0**	**0**	**9**
Introduction to Linux - Process Management - Process Scheduling - Memory Management - Storage Management - System calls - File System Structure - Multithreading - Multicore Programming - Deadlock Handling - Disk Structure - Disk Management - Dockers - Kubernetes						
						Total = 45 Periods

Text Books:	
1	Zed A. Shaw, “Learn Python 3 the Hard Way”, 3rd edition, Addison-Wesley Professional, 2013.
2	Silberschatz Abraham, “Operating System Concepts”, 9th edition, John Wiley & Sons Inc (Sea)Pte Ltd, 2016.
3	Paul Barry, "Head-First Python", 2nd edition, O'Reilly Media, Inc, 2016.
4	Anton Spraul, “Think Like a Programmer”, 1st edition, No Starch Press, 2012.

E-References :	
1	https://www.geeksforgeeks.org/python-programming-language/
2	https://www.guru99.com/python-tutorials.html
3	https://www.tutorialspoint.com/python/python_tutorial.pdf

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand the aspects of programming protocols	L2: Understanding
CO2	Develop optimized code for real-world problems	L3: Applying
CO3	Build full-stack development to deployment	L3: Applying
CO4	Demonstrate problem solving and continuous development	L2: Understanding

COURSE ARTICULATION MATRIX

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO 2**	**PSO 3**
CO1	2	2	2	1	3								2	1	1
CO2	3	3	3	2	3								3	2	2
CO3	3	2	3	1	3								3	2	2
CO4	2	3	2	1	2							3	2	1	1
AVG	**2.5**	**2.5**	**2.5**	**1.25**	**2.75**							**3**	**2.5**	**1.5**	**1.5**

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

22PSPE03	INDUSTRIAL AUTOMATION			Semester		VI
PREREQUISITES		Category	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives	
1	Acquire conceptual knowledge in Industrial Controllers by scaling of on-board devices and embedded board interfacing with various I/O peripherals.
2	Learn PLC by working on internal features and also interfacing with Sensors and actuators along HMI concept using SCADA and standard communication protocols.
3	To work with FPGA boards and RT controllers for reprogrammable embedded applications using LabVIEW
4	Understand the concepts and design electronics circuits

Unit I	INDUSTRIAL CONTROLLERS - I	9	0	0	9

Industrial Controllers - Introduction to RIO Controllers - Platform - Connection and Configuring controllers - Accessing onboard devices - Module SOM - Interfacing with Input and Output devices - Interfacing protocol based Analog and Digital sensors - Acquiring and Data Logging from sensors - Interfacing Actuators: Relay, DC Motor, Servo Motor - Creating standalone applications

Unit II	INDUSTRIAL CONTROLLERS - II	9	0	0	9

Industrial Controllers - II - PLC - Introduction - Mode of Operation - IEC 61131 Programming languages for PLC - Programming & sequence control - Instruction set - Scan Time - Timers - Counters - Interfacing with Input/Output devices - Interfacing with Sensors - Interfacing with Actuators - Interfacing with Human Machine Interface - Commissioning and operational safety of PLC - SCADA

Unit III	INDUSTRIAL COMMUNICATION PROTOCOLS	9	0	0	9

Serial Communication Protocols - I2C, SPI - Serial Field bus protocols CAN, PROFIBUS - Ethernet, HTTP, TCP/UDI, WiF, Cloud data logging. Multi-sensor communication, Data parsing between Embedded platforms. Comparative study of Industrial communication protocols - Implementation of Industrial Communication protocols.

Unit IV	FPGA AND RT CONTROLLER PROGRAMMING	9	0	0	9

Introduction to FPGA - Architecture - Operations in FPGA programming - FPGA Programming in LabVIEWand implementation in myRIO - Introduction to RT controllers - Architecture - Programming RT Controllers - Creating standalone applications.

Unit V	INDUSTRIAL CIRCUIT BOARD DESIGN	9	0	0	9

Designing basics circuits and to simulate in environment setup - Component selection - Creating libraries- Schematic design - Design rules, supply & communication track rules - Component and footprint editor -Understanding component package types - Test point creation for measurement - PCB Layout,placement rules - Footprint, 3D models, BoMs - Generating GERBER and output documentation

Total = 45 Periods

Text Books:	
1	Ed Doering, NI myRIO Project Essential Guide, National Instruments, 2016.
2	Willian Bolton, Programmable Logic Controllers, 6th edition, Newnes Publications, 2015
3	Richard Zurawski, Industrial Communication Technology Handbook, Second edition, CRC Press, 2014
4	Simon Monk, Make Your Own PCBs with EAGLE, McGraw Hill Education, 2014.

References Books:	
1	Jeffrey Travis, Jim Kring, LabVIEW for Everyone: Graphical Programming Made Easy and Fun,3rd edition, Prentice Hall
2	Mikell P. Groover, Automation, Production Systems, and Computer-integrated Manufacturing,Fourth edition, Pearson Education, 2016
3	Michael J. Hamill, Industrial Communications and Control Protocols, PDH centre, 2016
4	Ema Design Automation, The Hitchhiker's Guide to PCB Design, First edition, Blurb Publishers,December 2021

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand the usage of controllers in an industrial environment	L2: Understanding
CO2	Build Real-Time systems for Industrial embedded monitoring and controlling deterministic applications	L3: Applying
CO3	Communicate between devices at different levels using industrial protocols	L3: Applying
CO4	Understand the process involved in PCB design using EDA tools and fabricate it	L2: Understanding

COURSE ARTICULATION MATRIX

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO 2	PSO3
CO1	3	2	2	1	3								3	2	2
CO2	3	3	3	2	3								3	3	3
CO3	3	2	3	2	3								3	3	3
CO4	3	2	3	2	3								3	3	2
AV G	3	2.25	2.75	1.75	3								3	2.75	2.5

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

22PSOE01	**APPLIED DESIGN THINKING**			**Semester**		**VI**
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives	
1	The course enables product innovators and early-stage startup founders to learn the customer development process
2	To familiarize with the tools & techniques & validate the inherent risks by linking their progress to customer-motivation, customer-commitment & customer-acceptance.
3	To learn the system thinking concepts by reverse engineering technique.

Unit I	**DESIGN THINKING PRINCIPLES**	**9**	**0**	**0**	**9**
Exploring Human – Centered Design – Understanding the innovation process, discovering areas of opportunity, interviewing &empathy –building techniques, Mitigate validate risk with FIR(Forge Innovation Rubric) – Case Studies.					
Unit II	**CUSTOMER-CENTRIC INNOVATION**	**9**	**0**	**0**	**9**
Importance of customer-centric innovation – Problem Validation and Customer Discovery – Understanding problem significance and problem incidence- Customer Validation. Target user, User persona & user stories. Activity : Customer development process – Customer interviews and field visit.					
Unit III	**APPLIED DESIGN THINKING TOOLS**	**9**	**0**	**0**	**9**
Concept of Minimum Usable Prototype(MUP) – MUP challenge brief – Designing & Crafting the value proposition – Designing and Testing Value Proposition: Design a compelling value proposition: Process, tools and techniques of Value Proposition Design.					
Unit IV	**CONCEPT GENERATION**	**9**	**0**	**0**	**9**
Solution Exploration, Concepts Generation and MUP design – Conceptualize the solution concept: explore, iterate and learn; build the right prototype: Assess capability, usability and feasibility. Systematic concept generation; evaluation technology alternatives and the solution concepts.					
Unit V	**SYSTEM THINKING & REVERSE ENGINEERING**	**9**	**0**	**0**	**9**
System Thinking, Understanding Systems, Examples and Understandings, Complex Systems, Reverse Engineering Methodology, Identify building blocks/Components – Re-Engineering a complex system.					
Total = 45 Periods					

Text Books:	
1	Steve Blank, (2013), The four steps to epiphany: Successful strategies for products that win, Wiley.
2	Alexander Osterwalder, Yves Pigneur, Gregory Bernarda, Alan Smith, Trish Papadakos, (2014), Value
3	Proposition Design: How to Create Products and Services Customers Want, Wiley
4	Donella H. Meadows, (2015), “Thinking in Systems -A Primer”, Sustainability Institute.
5	Tim Brown,(2012) “Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation”, Harper Business.

Reference Books:	
1	https://www.ideou.com/pages/design-thinking#process
2	https://blog.forgeforward.in/valuation-risk-versus-validation-risk-in-product-innovations-49f253ca8624
3	https://blog.forgeforward.in/product-innovation-rubric-adf5ebdfd356
4	https://blog.forgeforward.in/evaluating-product-innovations-e8178e58b86e
5	https://blog.forgeforward.in/user-guide-for-product-innovation-rubric-857181b253dd6
6	https://blog.forgeforward.in/startup-failure-is-like-true-lie-7812cdfe9b85

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Define & treat various hypotheses to mitigate the inherent risks in product innovations	L1: Remembering
CO2	Design the solution concept based on the proposed value by exploring various alternate solutions to achieve value-price fit.	L6: Creating
CO3	Develop skills in empathizing, critical thinking, analyzing, storytelling & pitching.	L3: Applying
CO4	Apply system thinking to reverse engineer a product/prototype and understand its internal correlations.	L3: Applying

COURSE ARTICULATION MATRIX

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	3	2	3	2	1	1	1	1	1	1	1	2	2	3
CO2	2	2	3	2	2	1	1	1	1	1	1	1	3	3	2
CO3	1	2	2	1	1	3	1	1	3	3	1	1	1	1	1
CO4	2	3	3	3	3	2	2	1	2	2	1	1	3	3	3
AVG	**1.75**	**2.5**	**2.5**	**2.25**	**2**	**1.75**	**1.25**	**1**	**1.75**	**1.75**	**1**	**1**	**2.25**	**2.25**	**2.25**

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

22PSOE02	STARTUP FUNDAMENTALS		Semester			VI
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**
Course Learning Objectives						
1	Learn the science of to transforming an innovative idea into high-growth enterprises.					
2	To understand the basic concepts of IPR, and develop a patent draft for a potential IP					
Unit I	**ENTREPRENEURIAL MINDSET & METHOD**		**9**	**0**	**0**	**9**
Introduction to Innovation-led, tech-powered entrepreneurship - Understand from research the attributes of an expert entrepreneur - Effectuation principles - Dealing with the unknowns - Case studies of startup failures.						
Unit II	**IDEA TO ENTERPRISE**		**9**	**0**	**0**	**9**
Design and Planning of Product Concept - Business Model - Business Planning - Building Proof of Product and Value Testing - Target Market and Revenue Planning						
Unit III	**MINIMUM VIABLE BUSINESS**		**9**	**0**	**0**	**9**
Framework for Minimum Viable Business - Disruptive Innovation - Theory of Disruption - Competitive advantage - Building proof of viable business model - Demystifying Scalability - Funding Opportunities						
Unit IV	**INTELLECTUAL PROPERTY**		**9**	**0**	**0**	**9**
Introduction and the need for Intellectual Property Rights - IPR Genesis and Development - Copyright - Trademark - Trade Secret - Geographical Indicators - Industrial Designs - Types of Patent – Sample Patent Application - IPR in INDIA; Global trends - Patent fees						
Unit V	**PRIOR ART SEARCH AND PATENT DRAFTING**		**9**	**0**	**0**	**9**
Prior Art Search - IP Licensing – IP Commercialization - IP Infringement- Case Study on Apple vsSamsung, Case study on basmati rice. The invention as a concept - Keywords formation - Structure of patent - Key attributes in patent drafting -Drafting provisional specifications - Drafting complete specifications - Draft claims - Case studies onpatent drafting						
						Total = 45 Periods

Text Books:	
1	Steven Blank and Bob Dorf, (2012), The Startup Owner’s Manual: The Step-by-Step Guide for Building a Great Company, K&S Ranch
2	Dr Saras Sarasvathy, (2008), Effectuation: Elements of Entrepreneurial Expertise, New Horizons in Entrepreneurship series.
3	Elizabeth Verkey, (2005), Law of Patents, Eastern Book Company
4	Prabuddha Ganguli, (2017), Intellectual Property Rights: Unleashing the Knowledge Economy, McGraw Hill Education; 1st edition
Reference Books:	
1	WIPO Intellectual Property Handbook https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub_489.pdf
2	https://assets.entrepreneur.com/static/20220301113822-Marketing.pdf
3	https://www.deluxe.com/blog/startup-fundamentals-guide/
4	https://www.forbes.com/sites/allbusiness/2018/07/15/35-step-guide-entrepreneurs-starting-a-business/?sh=69a6031e184b

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Develop an entrepreneurial mindset to identify, assess, shape & act on opportunities.	L3: Applying
CO2	Demonstrate the potential of an innovative idea to create economic value, as a startup	L2: Understanding
CO3	Understand the scientific process to explore a viable business model	L2: Understanding
CO4	Demonstrate knowledge on the fundamental concepts of Intellectual Property	L2: Understanding

COURSE ARTICULATION MATRIX

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	2	2	1	1	2	1	2	2	2	3	3	1	1	2
CO2	2	2	3	1	1	1	1	2	2	1	3	2	2	2	2
CO3	1	2	2	2	1	1	1	1	1	1	3	2	1	1	1
CO4	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1
AVG	**1.25**	**1.75**	**2**	**1.25**	**1**	**1.25**	**1**	**2**	**1.5**	**1.25**	**2.5**	**2**	**1.25**	**1.25**	**1.5**

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

22PSOE03	PROTOTYPE DEVELOPMENT			Semester		VI
PREREQUISITES		Category	OE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives	
1	Learn to design a UI/UX design and develop an android application.
2	Provide working CAD model for prototype development.
3	Knowledge in hardware, 3D Printers and Laser cutters.
4	Acquire basic knowledge in designing electrical circuits and fabrication of electronic devices.

Unit I	UI/UX	9	0	0	9
Fundamental concepts in UI & UX - Tools - Fundamentals of design principles - Psychology and Human Factors for User Interface Design - Layout and composition for Web, Mobile and Devices - Typography - Information architecture - Colour theory - Design process flow, wireframes, best practices in the industry -User engagement ethics - Design alternatives					
Unit II	APP DEVELOPMENT	9	0	0	9
SDLC - Introduction to App Development - Types of Apps - web Development - understanding Stack - Frontend - backend - Working with Databases - Introduction to API - Introduction to Cloud services - Cloud environment Setup- Reading and writing data to cloud - Embedding ML models to Apps - Deploying application.					
Unit III	INDUSTRIAL DESIGN	9	0	0	9
Introduction to Industrial Design - Points, lines, and planes - Sketching and concept generation - Sketch to CAD - Introduction to CAD tools - Types of 3D modeling - Basic 3D Modeling Tools - Part creation - Assembly - Product design and rendering basics - Dimensioning & Tolerancing					
Unit IV	MECHANICAL RAPID PROTOTYPING	9	0	0	9
Need for prototyping - Domains in prototyping - Difference between actual manufacturing and prototyping - Rapid prototyping methods - Tools used in different domains - **Mechanical Prototyping:** 3DPrinting and classification - Laser Cutting and engraving - RD Works - Additive manufacturing					
Unit V	ELECTRICAL RAPID PROTOTYPING	9	0	0	9
Electronic Prototyping: Basics of electronic circuit design - lumped circuits - Electronic Prototyping - Working with simulation tool - simple PCB design with EDA					
Total = 45 Periods					

Text Books:	
1	Peter Fiell, Charlotte Fiell, Industrial Design A-Z, TASCHEN America Llc(2003)
2	Samar Malik, Autodesk Fusion 360 - The Master Guide.
3	Steve Krug, Don't Make Me Think, Revisited: A Common Sense Approach to Web Usability, Pearson,3rd edition (2014)
E - References:	
1	https://www.adobe.com/products/xd/learn/get-started.html
2	https://developer.android.com/guide
3	https://help.autodesk.com/view/fusion360/ENU/courses/
4	https://help.prusa3d.com/en/category/prusaslicer_204

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Create quick UI/UX prototypes for customer needs	L6: Creating
CO2	Develop web application to test product traction / product feature	L3: Applying
CO3	Develop 3D models for prototyping various product ideas	L3: Applying
CO4	Built prototypes using Tools and Techniques in a quick iterative methodology	L3: Applying

COURSE ARTICULATION MATRIX

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3	2	3				1	1			2	1	1
CO2	3	3	3	2	3				1	1			3	2	2
CO3	3	2	3	2	3				1	1			3	2	2
CO4	3	2	3	2	3				1	1			3	2	2
AVG	**2.75**	**2.25**	**3**	**2**	**3**				**1**	**1**			**2.75**	**1.75**	**1.75**

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

22PSEE01	**ROBOTICS**	**Semester**			**VI**
PREREQUISITES	**Category**	**EE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		0	**0**	**6**	**3**
Course Learning Objectives					
1	Learn the fundamentals of ROS				
2	Understand the requirements and choose the right sensors and actuators for the application development				
3	Create Bot in the virtual environment and simulate it to know the functionalities of the system developed				
4	Learn the basics of Robotics Vision System				
5	Integrate ROS and Computer Vision to build systems for various use cases				
Unit I	**INTRODUCTION TO ROBOT KINEMATICS**	**9**	**0**	**0**	**9**
Introduction to Robotics - Transformations - Forward Kinematics - Kinematics equations - Link transformations - Inverse Kinematics - Kinematic analysis - Numerical Inverse Kinematic Solutions - Analytical Inverse Kinematic Solutions					
Unit II	**SELECTION OF SENSORS AND ACTUATORS**	**9**	**0**	**0**	**9**
Introduction - Sensors & Actuators - Types - Selection criteria - Design considerations: Motor sizing - Selection of motors based on torque and speed characteristics - Hardware Interface & Assembly					
Unit III	**INTRODUCTION TO ROBOT OPERATING SYSTEM**	**9**	**0**	**0**	**9**
Introduction to ROS framework and prerequisites - Understanding communications in ROS - ROS Ecosystem - Introduction to ROS programming - ROS nodes, topics, messages - ROS services - ROS Tools and Utilities - URDF , Rviz - Simulation - Gazebo - ROS Motion					
Unit IV	**INTRODUCTION TO ROBOTICS VISION SYSTEM**	**9**	**0**	**0**	**9**
Image basics - Image Processing - Histograms - Gray scale, Color, Equalization - Smoothing andblurring/filtering - Averaging, Gaussian, Median, Bilateral - Thresholding - Simple, Adaptive, Otsu -Gradients and Edge detection - Laplacian, Sobel, Canny - Contours - Camera calibration					
Unit V	**INTEGRATION OF ROS AND COMPUTER VISION**	**9**	**0**	**0**	**9**
Introduction - Installation - CV Bridge - Image publisher node - Image subscriber node - Nodes buildingand launching - Building real world applications					
					Total = 45 Periods

Text Books:	
1	Introduction to Robotics: Mechanics and Control by John J Craig, Pearson Publishers.
2	Robot Operating System (ROS) for Absolute Beginners by Lentin Joseph, A press; Publishers (2018).
3	Learning OpenCV by Gary Bradski, Adrian Kaehler, O'Reilly Media, Inc.

Reference Books:	
1	https://www.intechopen.com/chapters/379
2	https://www.plantengineering.com/articles/eight-selection-criteria-for-actuation-components/
3	https://www.controleng.com/articles/tips-on-sensor-selection/
4	https://www.toptal.com/robotics/introduction-to-robot-operating-system
5	https://www.thomasnet.com/articles/automation-electronics/machine-vision-systems/
6	https://automaticaddison.com/working-with-ros-and-opencv-in-ros-noetic/

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand kinematics considerations of robot	L2: Understanding
CO2	Selection of sensors and actuators according to application	L3: Applying
CO3	Utilize the ROS environment to simulate and communicate between robot	L3: Applying
CO4	Develop algorithms to extract features and data from image	L3: Applying
CO5	Utilize the open CV for robotic applications	L3: Applying

COURSE ARTICULATION MATRIX

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	1	2								3	3	2
CO2	3	3	2	1	2								3	3	3
CO3	3	2	3	2	3								3	3	3
CO4	3	3	3	2	3								3	3	2
AVG	**3**	**2.5**	**2.75**	**1.5**	**2.5**								**3**	**3**	**2.5**

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

<table>
<tr><td>22ME701</td><td colspan="4">MECHATRONICS</td><td colspan="4">SEMESTER VII</td></tr>
<tr><td colspan="3">PREREQUISITE:</td><td colspan="2">Category</td><td>PC</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="3" rowspan="2">Basics of electronics and electrical engineering
Knowledge in instrumentation and sensors
Basics of Hydraulic and pneumatic systems</td><td colspan="2" rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="9">COURSE OBJECTIVES:</td></tr>
<tr><td>1.</td><td colspan="8">To impart knowledge about the elements and techniques involved in Mechatronics systems which are very much essential to understand the emerging field of automation.</td></tr>
<tr><td>2.</td><td colspan="8">To acquire adequate knowledge to model and simulate the physical systems.</td></tr>
<tr><td>3.</td><td colspan="8">To understand issues of implementation of different actuation systems in a Mechatronics system,</td></tr>
<tr><td>4.</td><td colspan="8">To gain practical experience in interfacing input and output devices to PLCs</td></tr>
<tr><td>5.</td><td colspan="8">To gain practical experience in applying knowledge in the real word systems.</td></tr>
<tr><td>UNIT I</td><td colspan="4">INTRODUCTION TO MECHATRONICS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">Definition, Introduction to Mechatronic Systems- Mechatronic Products and their functioning- Advanced applications in Mechatronics -Measurement systems- Control Systems- sequential controllers.</td></tr>
<tr><td>UNIT II</td><td colspan="4">PHYSICAL SYSTEM MODELING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td>UNIT III</td><td colspan="4">ACTUATION SYSTEMS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td>UNIT IV</td><td colspan="4">PROGRAMMING LOGIC CONTROLLERS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td>UNIT V</td><td colspan="4">MECHATRONICS SYSTEMS DESIGN</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td colspan="9" align="right">Total (45L) = 45 Periods</td></tr>
</table>

<table>
<tr><td colspan="2">Text Books:</td></tr>
<tr><td>1.</td><td>Bolton, W, Mechatronics, Pearson Education, 6th Edition, 2015.</td></tr>
<tr><td>2.</td><td>Ganesh S.Hegde, Mechatronics, Jones & Bartlett publishers, 1st Edition, 2010.</td></tr>
<tr><td colspan="2">Reference Books:</td></tr>
<tr><td>1.</td><td>Michael B. Histand and David G. Alciatore, Introduction to Mechatronics and Measurement Systems, McGraw Hill International Editions, 3rd Edition, 2007</td></tr>
<tr><td>2.</td><td>Bradley D. A., Dawson D., Buru N.C. and. Loader A.J, Mechatronics, Chapman and Hall, 1st Edition, 1993.</td></tr>
<tr><td>3.</td><td>Dan Necsulesu, Mechatronics, Pearson Education Asia, 1st Edition, 2002</td></tr>
<tr><td>4.</td><td>Brian Morriss, Automated Manufacturing Systems - Actuators, Controls, Sensors and Robotics, McGraw Hill International Edition, 1995</td></tr>
</table>

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		2								1	1		2
CO2	2	2	3	3	1							2	2	2	
CO3			2	2			2		2			2			
CO4		2	3	3	3				3		3	2		2	1
CO5	1	2	2	3	3	2	2	1	3	2	1	3			3
Avg	**1.3**	**2**	**2.5**	**2.6**	**2.3**	**2**	**2**	**1**	**2.6**	**2**	**2**	**2**	**1.5**	**2**	**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 (45L) = 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								3	1	
CO2	3	3	2	1	1								3	1	
CO3	3	3	2	1	1								3	1	
CO4	3	3	2	1	1								3	1	
CO5	3	3	2	1	1								3	1	
Avg	**3.0**	**3.0**	**2.0**	**1.0**	**1.0**								**3.0**	**1.0**	

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

<table>
<tr><td colspan="2">22HS701</td><td colspan="2">OPERATIONS RESEARCH</td><td colspan="4">SEMESTER VII</td></tr>
<tr><td colspan="3">PREREQUISITE:</td><td>Category</td><td>PC</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="3" rowspan="2">1. Knowledge of basic mathematics
2. Knowledge of probability distributions and statistics.</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="8">COURSE OBJECTIVES:</td></tr>
<tr><td>1.</td><td colspan="7">To make the students formulate linear programming problems and solve them with in the given constraints for optimization.</td></tr>
<tr><td>2.</td><td colspan="7">To equip the students solve transportation and production problems and optimize, interpret the results obtained and translate solutions into directives for action.</td></tr>
<tr><td>3.</td><td colspan="7">To equip the students solve replacement and sequencing problems and optimize, interpret the results obtained and translate solutions into directives for action.</td></tr>
<tr><td>4.</td><td colspan="7">To equip the students solve gaming theory and network models arising from a wide range of applications.</td></tr>
<tr><td>5.</td><td colspan="7">To familiarize the students about the procedures for queuing theory models and getting solutions using simulation.</td></tr>
<tr><td colspan="2">UNIT I</td><td colspan="2">INTRODUCTION AND LPP</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Development of OR – Definitions-Operation Research models– applications- Formation of linear programming model - Graphical method - Simplex algorithm - Big M method – Two phase method - Dual simplex method.</td></tr>
<tr><td colspan="2">UNIT II</td><td colspan="2">TRANSPORTATION AND ASSIGNMENT MODELS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Transportation models - Optimal solution by North West Corner method - Least Cost Method - Vogel’s Approximation Method - optimality test - MODI method - Assignment problem formulation - Hungarian method - Unbalanced and maximization assignment problems.</td></tr>
<tr><td colspan="2">UNIT III</td><td colspan="2">REPLACEMENT AND SEQUENCING MODELS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Replacement of items that deteriorate with time: value of money change with time, not change with time - Optimum replacement policy - Individual and group replacement - Sequencing problems – Problems with n jobs with 2 machines, n jobs with 3 machines, n jobs with k machines, 2 jobs with k machines.</td></tr>
<tr><td colspan="2">UNIT IV</td><td colspan="2">THEORY OF GAMES AND NETWORK MODELS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Introduction – Minimax (maximin) – Criterion and optimal strategy – Solution of games with saddle points – Rectangular games without saddle points – 2 X 2 games – dominance principle – m X 2 & 2 X n games -graphical method. Construction of project networks - Network optimization algorithms - Shortest route models, Minimal spanning tree models, Maximum flow models - CPM and PERT networks - Critical path scheduling.</td></tr>
<tr><td colspan="2">UNIT V</td><td colspan="2">QUEUING THEORY AND SIMULATION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Queuing systems and structures - Notations and parameters - Queuing models (Model I, Model II, Model III, Model IV) - Simulation- Random number generation - Application of simulation for queuing and maintenance.</td></tr>
<tr><td colspan="8" align="right">Total (45L) = 45 Periods</td></tr>
</table>

<table>
<tr><td colspan="2">Text Books:</td></tr>
<tr><td>1.</td><td>Hira and Gupta, “Introduction to Operations Research”, S. Chand and Co, 2011.</td></tr>
<tr><td>2.</td><td>Taha, H.A, “Operations Research”, 9th Edition, Pearson Education India, 2014.</td></tr>
<tr><td colspan="2">Reference Books:</td></tr>
<tr><td>1.</td><td>S.D.Sharma - Operations Research , Kedarnath, Ramnath 2015</td></tr>
<tr><td>2.</td><td>Hiller &Libermann - Introduction to O.R , Mc Graw Hill 2011</td></tr>
<tr><td>3.</td><td>Sharma J.K, “Operations Research”, 6th Edition Macmillan India Ltd, 2007.</td></tr>
<tr><td>4.</td><td>A.M.Natarajan, P.Balasubramani, A.Tamilarasi -Operations Research, Pearson Education.</td></tr>
<tr><td>5.</td><td>R.Pannerselvam - Operations Research ,PHI Publications 2006</td></tr>
<tr><td colspan="2">E-References:</td></tr>
<tr><td>1.</td><td>https://nptel.ac.in/courses/110106062</td></tr>
</table>

2.	https://onlinecourses.nptel.ac.in/noc19_ma29/preview
3.	https://nptel.ac.in/courses/110106059

COURSE OUTCOMES: **On completion of the course the student will be able to**		**Bloom's Taxonomy Mapped**
CO1	Formulate and solve linear programming problems for getting optimal solution under given constraints.	Apply
CO2	Solve transportation and production problems and optimize, interpret the results obtained and translate solutions into directives for action.	Analyze
CO3	Solve replacement and sequencing problems and optimize, interpret the results obtained and translate solutions into directives for action.	Analyze
CO4	Solve gaming theory and network models arising from a wide range of applications.	Analyze
CO5	Explain procedures for queuing theory models and getting solutions using simulation.	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										2	2	
CO2		2	2									1	1	2	2
CO3		2	2	2								1		2	
CO4		2	3			1						1	2	2	
CO5	1	2	2									1		2	
Avg	**1**	**2.0**	**2.2**	**2**		**1**						**1**	**1.6**	**2.0**	**2**

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

<table>
<tr><td>22ME703</td><td colspan="2">MECHATRONICS LABORATORY</td><td colspan="4">SEMESTER VII</td></tr>
<tr><td colspan="2">PREREQUISITE:</td><td>Category</td><td>PC</td><td colspan="2">Credit</td><td>1.5</td></tr>
<tr><td colspan="2" rowspan="2">1. Basics of electronics and electrical engineering
2. Knowledge in instrumentation and sensors
3. Basics of Hydraulic and pneumatic systems</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>3</td><td>3</td></tr>
</table>

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 “Hands On” 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 (45P) = 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 ARTICULATION MATRIX															
Cos/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	3											1	1	1
CO2			1	2									1	2	2
CO3			1				1	2					2	1	3
CO4				3							2	3	2	1	3
CO5			3						2	1	2		2	2	3
Avg	**1**	**3**	**1.5**	**2**			**1**	**2**	**2**	**1**	**2**	**3**	**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.,
The following exercises includes 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

Total(45P) = 45 Periods

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			3			1				1	1		
CO2	2	2			3			1				1	1		
CO3	2	2			3			1				1	2		
CO4	2	2			3			1				1	2		
CO5	2	2			3			1				1	2		
Avg	**2.0**	**2.0**			**3.0**			**1.0**				**1.0**	**1.6**		

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			2		2		2	2	1
CO2	1	1	1	1							3		1	1	1
CO3	1	2	1	2	2	3					3		2	2	1
CO4	1	2	1	1	1	3					3		2	2	1
CO5	1	2	1	1	1	3					3		2	2	1
Avg	**1.2**	**1.6**	**1.2**	**1.4**	**1.5**	**2.5**			**2**		**2.8**		**1.8**	**1.8**	**1.0**

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

22ME801	**PROJECT WORK**		**SEMESTER VIII**			
PREREQUISITE:		**CATEGORY**	**EE**	**Credit**		**10**
		Hours/Week	**L**	**T**	**P**	**TH**
			0	**0**	**20**	**20**

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		2		3	3	3
CO2	3	3	3	3	2	3	3		3		1		3	3	
CO3	2	2	2	2	2	1	1	1	3	1	2	3	3	3	
CO4	3	2	2	1	1	1	2	3	3	3		3	3	3	
CO5					2	2		1	3	3		2	3		3
Avg	**2.75**	**2.5**	**2.5**	**2.2**	**1.8**	**2**	**2.2**	**1.5**	**3**	**2.3**	**1.6**	**2.6**	**3**	**3**	**3**

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

PROFESSIONAL ELECTIVE COURSES

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	**POWER TRAIN 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 suspension systems for a vehicle**.**	Analyze
CO4	Discuss various types of braking and steering 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		1				2	2		3	
CO2	3	3	3	3	2		1				2	2		3	
CO3	3	3	3	3	2		1				2	2		3	
CO4	3	3	3	3	2		1				2	2		3	
CO5	3	3	3	3	2		1				2	2		3	
Avg	**3**	**3**	**3**	**3**	**2**		**1**				**2**	**2**		**3**	
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

22MEPE12	**COMPOSITE MATERIALS**					**SEMESTER VI**
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
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		2		1			1		2	2	1
CO2	2	1	1	1			1				1		2	1	
CO3	2	1	1	1			1				1		2	1	
CO4	2	1	1	1		1	1	1			1		2	1	
CO5	2	2	1	1		1	1	1			1		2	2	1
Avg	**2.0**	**1.4**	**1.2**	**1.0**		**1.3**	**1**	**1**			**1**		**2.0**	**1.4**	**1**

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									1		1	1	1	2	3
CO2									1		1		1	2	2
CO3			1						1		1		1	2	2
CO4		1	1	1	3				3	2	1		1	1	3
CO5			1	3	2				2	2	1	1	1	2	2
Avg		**1**	**1**	**2**	**2.5**				**1.6**	**2**	**1.0**	**1**	**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		1	1				1		3	2	1
CO2	2	2	1	2		1	1				1		3	2	1
CO3	2	2	1	2		1	1				1		3	2	1
CO4	2	2	1	2		1	1				1		3	2	1
CO5	2	2	1	2		1	1				1		3	2	1
Avg	**2**	**2**	**1**	**2**		**1**	**1**				**1**		**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, 2ndEdition, 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		1						2	1	1
CO2	3	2	2	1	1	1							2	1	1
CO3	3	3	3	1	1	1	1						2	1	1
CO4	2	2	3	1	1	1	1						2	1	1
CO5	2	2	2	2	1	1	1						2	1	1
Avg	**2.6**	**2.2**	**2.4**	**1.2**	**1.0**	**1**	**1**						**2**	**1**	**1**
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

<table>
<tr><td>22MEPE16</td><td colspan="5">GAS DYNAMICS AND JET PROPULSION</td><td colspan="4">SEMESTER VI</td></tr>
<tr><td colspan="5">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="5">1.Basic knowledge in laws and principles of thermodynamics</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td colspan="5">2.Fundamental concepts about turbo machines and compressible flow</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="10">COURSE OBJECTIVES:</td></tr>
<tr><td>1.</td><td colspan="9">Studying the basic concepts of compressible fluid flow and isentropic flow.</td></tr>
<tr><td>2.</td><td colspan="9">Learning about the flow through ducts and various flow parameters.</td></tr>
<tr><td>3.</td><td colspan="9">Discussing various flow parameters of normal and oblique shocks.</td></tr>
<tr><td>4.</td><td colspan="9">Understanding the concept of jet propulsion and its performance analysis.</td></tr>
<tr><td>5.</td><td colspan="9">Studying about space propulsion concept and evaluating its performance parameters.</td></tr>
<tr><td>UNIT I</td><td colspan="5">BASIC CONCEPTS OF FLUID FLOW</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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</td></tr>
<tr><td>UNIT II</td><td colspan="5">ISENTROPIC FLOW</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>UNIT III</td><td colspan="5">NORMAL AND OBLIQUE SHOCKS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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</td></tr>
<tr><td>UNIT IV</td><td colspan="5">JET PROPULSION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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</td></tr>
<tr><td>UNIT V</td><td colspan="5">SPACE PROPULSION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">Types of rocket engines – Propellants – Ignition and combustion – Theory of rocket propulsion – Performance study – Staging – Terminal and characteristic velocity – Applications – Space flights</td></tr>
<tr><td colspan="10">TOTAL (45L) = 45 Periods</td></tr>
</table>

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			1	1		1	1			1					
CO2	1	1			1			1					1	1	1
CO3															
CO4			1	1											
CO5			1	1		1	1					1			
Avg	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**		**1**		**1**	**1**	**1**	**1**
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

<table>
<tr><td>22MEPE17</td><td colspan="2">RENEWABLE ENERGY SYSTEM</td><td colspan="4">SEMESTER VI</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2">Basic idea about solar radiation and other renewable energy that exists.</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td colspan="2">Understanding about various chemical reactions occur in the process</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
</table>

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) = 45 Periods

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		2	2	3	1	1	2	2	1	3
CO2	1	2	3	2	1		2	2	3	1	1	2	2	1	3
CO3		2	3	2	1		2	2	3	1	1	2	2	1	3
CO4	1	2	3	2			2	2	3	1	1	2	2	1	3
CO5	1	2	3	2	1		2	2	3	1	1	2	2	1	3
Avg	**1**	**2.0**	**3.0**	**2.0**	**1**		**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**
Engineering Mechanics and Strength of Materials		**Hours/Week**	**L**	**T**	**P**	**TH**
			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				1					3	2	1
CO2	2	3	3	1				0					3	2	1
CO3	2	3	3	2				1					2	3	1
CO4	2	2	2	2	2		1	1			1		3	2	1
CO5	2	2	2	2	2			1					3	2	1
Avg	**2.2**	**2.4**	**2.2**	**1.6**	**0.8**		**0.2**	**0.8**			**0.2**		**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		2							2	1	1
CO2			3	2			1						1	1	
CO3			1	1			1								
CO4	1	1	1	1			1	1					1	1	1
CO5						1	1		1	1					
Avg	**1.5**	**1**	**1.5**	**1.2**		**1.5**	**1**	**1**	**1**	**1**			**1.3**	**1**	**1**

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								2	1	
CO2		1	3	2	1								2	3	
CO3	1	2	2	1	1								2	3	
CO4	1	2	3	2	1								1	3	
CO5		2	2	2										2	
Avg	**1**	**1.8**	**2.4**	**1.6**	**1.2**								**1.7**	**2.4**	

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

22MEPE24	**INDUSTRIAL ENGINEERING AND MANAGEMENT**					**SEMESTER VI**
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
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									2	2	
CO2	1	2	3	1									1	2	1
CO3		2	2		3	1							1	2	3
CO4									3			1			2
CO5						2		2			1	1	2		
Avg	**2**	**2**	**2**	**1**	**3**	**1.5**		**2**	**3**		**1**	**1**	**2**	**2**	**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									3	2	1
CO2	3	2	2	1									3	2	1
CO3	3	1	2	2	2	2	3						2	3	1
CO4	2	1	2	1	2	2	3						2	3	1
CO5	3	1	1	1	2	2	2						2	3	1
Avg	**2.8**	**1.4**	**1.8**	**1.2**	**2**	**2**	**2.6**						**2.4**	**2.6**	**1.0**

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

<table>
<tr><td>22MEPE26</td><td colspan="2">MACHINE DRAWING</td><td colspan="4">SEMESTER VI</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">1.Engineering Drawing</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>1</td><td>0</td><td>4</td><td>5</td></tr>
</table>

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**	**3**	**0**	**12**	**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**	**3**	**0**	**12**	**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**	**9**	**0**	**36**	**45**

The assembly drawing of the following machine tool parts are to be drawn from the given detailed drawing.

Couplings – Flange, Universal, Oldham’s, Muff and gear couplings.

Joints – Knuckle, Gib & cotter, strap, sleeve & cotter joints.

Engine parts – Piston, connecting rod, cross-head (vertical and horizontal), stuffing box, multi-plate clutch.

Miscellaneous machine components – Screw jack, machine vice.

Total (15L + 60P) = 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		1	1				1		2	2	1
CO2	2	1	2	1		1	1				1		2	2	1
CO3	2	2	2	2			2				1		2	2	1
CO4	1	1	2	2		1					1		2	2	1
CO5	1	1	1	2		2	2	1			0		1	1	1
Avg	**1.6**	**1.2**	**1.8**	**1.6**		**1.2**	**1.5**	**1**			**1**		**1.8**	**1.8**	**1.0**
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

<table>
<tr><td>22MEPE27</td><td colspan="2">POWER PLANT ENGINEERING</td><td colspan="4">SEMESTER VI</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2">1.Having sufficient knowledge on basics of power plant</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td colspan="2">2. Basic unit calculation for consumption of power</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">COURSE OBJECTIVES:</td></tr>
<tr><td>1.</td><td colspan="6">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.</td></tr>
<tr><td>2.</td><td colspan="6">Location of hydro power plant and its components to generate power.</td></tr>
<tr><td>3.</td><td colspan="6">Complete knowledge about diesel and gas power plant.</td></tr>
<tr><td>4.</td><td colspan="6">Basic knowledge of nuclear reaction and types of nuclear power plant.</td></tr>
<tr><td>5.</td><td colspan="6">Basic knowledge of power plant economics and various tariff methods.</td></tr>
<tr><td>UNIT I</td><td colspan="2">STEAM POWER PLANT</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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</td></tr>
<tr><td>UNIT II</td><td colspan="2">HYDRO ELECTRIC POWER PLANT</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Layout of hydel power plant- classification –working – components – layout of pumped storage power plant - Plant equipment for Pumped Store Schemes.</td></tr>
<tr><td>UNIT III</td><td colspan="2">DIESEL AND GAS POWER PLANT</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>UNIT IV</td><td colspan="2">NUCLEAR, MHD POWER GENERATION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>UNIT V</td><td colspan="2">ECONOMICS AND SAFETY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7">Total(45L): 45 Periods</td></tr>
</table>

<table>
<tr><td colspan="2">TEXT BOOKS:</td></tr>
<tr><td>1.</td><td>S. Domkundwar, A.V. Domkundwar, S.C. Arora “A Course in Power Plant Engineering”, Dhanpat Rai Publications. 2016.</td></tr>
<tr><td>2.</td><td>P.K. Nag, Power Plant Engineering, Tata McGraw Hill, Laxmi Publications Pvt. Ltd New Delhi, 5th Edition, 2014.</td></tr>
<tr><td colspan="2">REFERENCES:</td></tr>
<tr><td>1</td><td>R.K. Rajput. A Text of Power Plant Engineering, Laxmi publications, New Delhi 5th Edition, 2016.</td></tr>
<tr><td>2</td><td>G.R. Nagpal, Power Plant Engineering, Khanna Publications 1998.</td></tr>
<tr><td>3</td><td>Bernhardt G. Askrotzki and William A. Vopat, “Power Station Engineering and Economy”, Tata McGraw Hill Publishing Co. Ltd., 1972.</td></tr>
<tr><td>4</td><td>Frederick T. Mores, “Power Plant Engineering”, Affiliated East-West Press Private Ltd., 1953.</td></tr>
<tr><td>5</td><td>Joel Weisman and Roy Eckart, “Modern Power Plant Engineering”, Prentice Hall International Inc., 1985.</td></tr>
<tr><td colspan="2">E-REFERENCES:</td></tr>
</table>

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	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	2	3	2	1		1	1	2		2	2	2	1	2
CO2	1	2	3	2	1		1	1	2		2	2	2	1	2
CO3	1	2	3	2	1		1	1	2		2	2	2	1	2
CO4	1	2	3	2	1		1	1	2		2	2	2	1	2
CO5	2		1	2				2	2	1	1	1	2		
Avg	**1.2**	**2**	**2.6**	**2.0**	**1**		**1**	**1.2**	**2.0**	**1**	**1.8**	**1.8**	**2.0**	**1**	**2**
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

PROFESSIONAL ELECTIVES – III

<table>
<tr><td>22MEPE31</td><td colspan="5">FUELS AND COMBUSTION</td><td colspan="4">SEMESTER VI</td></tr>
<tr><td colspan="4">PREREQUISITES</td><td colspan="2">CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="4">1. Basic chemical reactions between various components</td><td colspan="2" rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td colspan="4">2. Fundamental about various types of fuels and its nature</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="10">COURSE OBJECTIVES:</td></tr>
<tr><td>1.</td><td colspan="9">To impart the acquaintance about characterize of the different types of fuels.</td></tr>
<tr><td>2.</td><td colspan="9">To enhance the understanding of Classification, Composition & Properties of various fuels</td></tr>
<tr><td>3.</td><td colspan="9">Understanding of thermodynamics and kinetics of combustion.</td></tr>
<tr><td>4.</td><td colspan="9">Understand and analyze the combustion mechanisms of various fuels.</td></tr>
<tr><td>UNIT I</td><td colspan="5">CHARACTERIZATION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>UNIT II</td><td colspan="5">SOLID FUELS AND LIQUID FUELS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>UNIT III</td><td colspan="5">GASEOUS FUELS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>UNIT IV</td><td colspan="5">COMBUSTION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>UNIT V</td><td colspan="5">COMBUSTION EQUIPMENT’S</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td colspan="10">Total (45L) = 45Periods</td></tr>
</table>

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

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		1	2	1	2	1	1	2	1
CO2	1	2	3	1	1	1		1	2	1	2	1	2	2	1
CO3	1	1	2	2	1	1		1	2	1	2	1	2	3	1
CO4	1	3	2	3	1	1		1	2	1	2	1	3	2	1
CO5	1	3	1	2	1	1		1	2	1	2	1	2	1	1
Avg	**1.0**	**2.4**	**2.0**	**2.0**	**1.0**	**1.0**		**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		2	3	3	2		1	1	1	3	2	3	3
CO2	1	2		2	2	2	1		1		1	3	2	3	3
CO3		3	1	1	2	1			1			2	2	2	2
CO4	3	2	1	2	2								.3	2	1
CO5	3	2		2	2								3	2	1
Avg	**2**	**2.4**	**1**	**1.8**	**2.2**	**2**	**1.5**		**1**	**1**	**1**	**2.6**	**2.4**	**2.4**	**2.0**

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

<table>
<tr><td>22MEPE33</td><td colspan="6">NON-TRADITIONAL MACHINING PROCESSES</td><td colspan="4">SEMESTER VI</td></tr>
<tr><td colspan="5">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td colspan="2">3</td></tr>
<tr><td colspan="5">1.Manufacturing Technology</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td colspan="2">TH</td></tr>
<tr><td colspan="5">2.Engineering Chemistry</td><td>3</td><td>0</td><td>0</td><td colspan="2">3</td></tr>
<tr><td colspan="11">COURSE OBJECTIVES:</td></tr>
<tr><td>1.</td><td colspan="10">To understand the various Non-Traditional machining processes and its applications</td></tr>
<tr><td>2.</td><td colspan="10">To decide the appropriate process among various electro chemical processes</td></tr>
<tr><td>3.</td><td colspan="10">To justify the appropriate Thermo - electric process based on the application and limitations</td></tr>
<tr><td>4.</td><td colspan="10">To understand the working principle and applications of Laser machining processes</td></tr>
<tr><td>5.</td><td colspan="10">To understand the working principle and applications of Micro-electro Mechanical processes</td></tr>
<tr><td>UNIT I</td><td colspan="6">INTRODUCTION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="11">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.</td></tr>
<tr><td>UNIT II</td><td colspan="6">ELECTRO - CHEMICAL PROCESSES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="11">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.</td></tr>
<tr><td>UNIT III</td><td colspan="6">THERMO - ELECTRICAL PROCESSES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="11">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.</td></tr>
<tr><td>UNIT IV</td><td colspan="6">LASER MACHINING PROCESSES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="11">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.</td></tr>
<tr><td>UNIT V</td><td colspan="6">MICRO ELECTRO - MECHANICAL PROCESSES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="11">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.</td></tr>
<tr><td colspan="11">Total(45L) = 45 Periods</td></tr>
</table>

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		1							1		2	2	1
CO2	3	2			1								2	2	1
CO3	3	2			1								2	2	1
CO4	2	1			1								2	2	1
CO5	2	1			1								2	2	1
Avg	**2.6**	**1.6**		**0.2**	**1**						**1**		**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							3	1	3			2	1		
CO2							2	2	3			2	1	2	
CO3							3	2	3			2	1	2	
CO4							3	3	2			2	1	2	
CO5							2	2	3			2	1		
Avg							**2.6**	**2**	**2.8**			**2.0**	**1.0**	**2**	

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

<table>
<tr><td>22MEPE35</td><td colspan="2">RAPID PRODUCT DEVELOPMENT TECHNOLOGIES</td><td colspan="4">SEMESTER VI</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2">1. Design of Machine elements and transmission systems, CAD software</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td colspan="2">2. Material science, Tool Design, Engineering physics</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
</table>

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.

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		1	1	1	1	2					1	1	3	2	1
CO2		2	1	1	1				1		1	1	1	2	2
CO3		2	1	1	1				1		1	1	1	2	2
CO4		2	3	1	1				1		1	1	1	2	2
CO5		1	0	1	3				1		1		3	2	3
Avg		**1.6**	**1.5**	**1.0**	**1.4**	**2**			**1**		**1.0**	**1**	**1.8**	**2.0**	**2.0**
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

<table>
<tr><td>22MEPE36</td><td colspan="2">REFRIGERATION AND AIR CONDITIONING</td><td colspan="4">SEMESTER VI</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2">1. Engineering Thermodynamics</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td colspan="2">2.Fluid Mechanics and Machinery</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">COURSE OBJECTIVES:</td></tr>
<tr><td>1.</td><td colspan="6">To understand the basic concepts and processes in refrigeration.</td></tr>
<tr><td>2.</td><td colspan="6">To understand the components of vapour compression refrigerating system and its effects.</td></tr>
<tr><td>3.</td><td colspan="6">To understand the other refrigeration systems and their applications.</td></tr>
<tr><td>4.</td><td colspan="6">To solve the problems using psychrometric charts and psychrometric properties.</td></tr>
<tr><td>5.</td><td colspan="6">To calculate the cooling load for designing air conditioning systems.</td></tr>
<tr><td>UNIT I</td><td colspan="2">INTRODUCTION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>UNIT II</td><td colspan="2">VAPOUR COMPRESSION REFRIGERATION SYSTEM</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>UNIT III</td><td colspan="2">OTHER REFRIGERATION SYSTEMS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Working principle of vapour absorption refrigeration system – Steam jet refrigeration, Ejector refrigeration system-Thermoelectric refrigeration, Pulse tube refrigeration system, low temperature refrigeration – Cascade systems.</td></tr>
<tr><td>UNIT IV</td><td colspan="2">PSYCHROMETRY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>UNIT V</td><td colspan="2">AIR CONDITIONING SYSTEMS AND LOAD ESTIMATION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7" align="right">Total (45L) = 45 Periods</td></tr>
</table>

<table>
<tr><td colspan="2">TEXT BOOKS:</td></tr>
<tr><td>1.</td><td>Arora, C.P., “Refrigeration and Air Conditioning”, 3rd edition, McGraw Hill, New Delhi, 2017.</td></tr>
<tr><td>2.</td><td>Arora S. C. and Domkundwar, “Refrigeration and Air-Conditioning”, Dhanpat Rai and Co. (P) Ltd., 2010.</td></tr>
<tr><td colspan="2">REFERENCES:</td></tr>
<tr><td>1</td><td>Roy J. Dossat, “Principles of Refrigeration”, 4th Edition, Pearson Education Asia, 2009.</td></tr>
<tr><td>2</td><td>Stoecker, W.F. and Jones J. W., “Refrigeration and Air Conditioning”, McGraw Hill, New Delhi, 1986.</td></tr>
<tr><td>3</td><td>Ballaney P. L, Refrigeration and Air-Conditioning, Khanna Publishers, New Delhi, 2014.</td></tr>
<tr><td>4</td><td>Manohar Prasad, Refrigeration and Air-Conditioning, New Age International, 2011.</td></tr>
<tr><td>5</td><td>ASHRAE Hand book, Fundamentals, 2010.</td></tr>
<tr><td colspan="2">E-REFERENCES:</td></tr>
<tr><td>1.</td><td>NPTEL courses: http://nptel.iitm.ac.in/courses.php - web and video sources on Refrigeration and Air Conditioning.</td></tr>
</table>

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					1	2						2	2	1
CO2	2	3		2		1	1						2	2	1
CO3	2	3		1							1		2	2	1
CO4	2	1								1			2	2	1
CO5	2	2	1	2	1	2	1				1		2	2	1
Avg	**2.2**	**2.2**	**1**	**1.6**	**1**	**1.3**	**1.3**			**1**	**1**		**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**	**TH**
			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 CONDITIONING SYSTEM**	**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 Berlin and Heidel berg GmbH &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				2	1						2	1	2
CO2	3	2	1	2		1					1		2	2	2
CO3	3	2		2	3	2					1		2	2	1
CO4	3	3	1	2	2	2					1		3	2	2
CO5	3	2	3	2	3	2					1		2	3	2
Avg	**3**	**2**	**1.6**	**2**	**2.6**	**1.8**	**1**				**1**		**2.2**	**2**	**1.8**

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

PROFESSIONAL ELECTIVES – IV

<table>
<tr><td>22MEPE41</td><td colspan="5">ADVANCED DECISION MODELING TECHNIQUES</td><td colspan="4">SEMESTER VII</td></tr>
<tr><td colspan="5">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="5" rowspan="2">1. Students are expected to have a background knowledge in probability.
2. Students are expected to have a basic understanding in the concepts of Calculus, and Algebra.
3. Basic knowledge in python programming.</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="10">COURSE OBJECTIVES:</td></tr>
<tr><td>1.</td><td colspan="9">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.</td></tr>
<tr><td>2.</td><td colspan="9">To make the student explain the concepts of Convolutional Neural Network (CNN) architecture, training and implementation of different CNN models using Python.</td></tr>
<tr><td>3.</td><td colspan="9">To make the student explain the concepts of Recurrent Neural Network (RNN) architecture, training and implementation of different CNN models using Python.</td></tr>
<tr><td>4.</td><td colspan="9">To familiarize the need, methods and concepts for ensemble learning and apply with Python implementation of ensemble learning approaches.</td></tr>
<tr><td>5.</td><td colspan="9">To identify alternate deep learning models for the listed use cases, identify a suitable algorithm by apprehend the differences between standard deep learning models.</td></tr>
<tr><td>UNIT I</td><td colspan="5">INTRODUCTION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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</td></tr>
<tr><td>UNIT II</td><td colspan="5">CONVOLUTIONAL NEURAL NETWORKS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>UNIT III</td><td colspan="5">RECURRENT NEURAL NETWORKS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>UNIT IV</td><td colspan="5">ENSEMBLE LEARNING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>UNIT V</td><td colspan="5">CASE STUDIES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td colspan="10" align="right">Total(45L) = 45 Periods</td></tr>
</table>

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. (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 – Machine Curve.
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	Study the 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					1	1		1	1	
CO2	3	2		3	2					1	1		1	1	
CO3	3	2		3	2					1	1		1	1	
CO4	3	2		3	2					1	1		1	1	
CO5	3	2	2	3	1					1	1		1	1	
Avg	**3.0**	**2.2**	**2**	**3.0**	**1.8**					**1.0**	**1.0**		**1.0**	**1.0**	
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

22MEPE42	**AUTOMATION IN MANUFACTURING**					**SEMESTER VII**
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			1	1	1	2	2
CO2	1	2	2	1	1	2	1		2		1	1	1	2	2
CO3	1	2	2	2	2	2	1		2		1	1	1	2	2
CO4			1	1	3	2	2	1		2	1	1	1	2	2
CO5				1	3	2	2	1		2	1	1	1	2	2
Avg	**1**	**1.6**	**1.7**	**1.2**	**2.0**	**2.0**	**1.6**	**1**	**2**	**2**	**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 VII**	
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	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	3	1									2	1	
CO2	2	2	2	1									3	1	
CO3	2	2	3	1									3	1	
CO4	2	2	2	1									1	1	
CO5	2	1	1	1									1	1	
Avg	**2.0**	**1.8**	**2.2**	**1.0**									**2.0**	**1.0**	
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

22MEPE44	FRACTURE MECHANICS AND FAILURE ANALYSIS	SEMESTER VII

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 – in static loading.	Create
CO3	Solve the problems related to deformation and related theories for fatigue fracture.	Evaluate
CO4	Formulate the empirical relations for creep 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		2	1						3	1	1
CO2	2	2	1	1		2	1						3	1	1
CO3	2	2	1	1		2	1						3	1	1
CO4	2	2	1	1		2	1						3	1	1
CO5	2	2	1	1		2	1						3	1	1
Avg	**2**	**2**	**1**	**1**		**2**	**1**						**3**	**1**	**1**

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

<table>
<tr><th>22MEPE45</th><th colspan="5">FUNDAMENTALS OF TRIBOLOGY</th><th colspan="3">SEMESTER VII</th></tr>
<tr><td colspan="2">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">1.Engineering Mechanics</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
</table>

COURSE OBJECTIVES:

1.	To provide broad 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						1	2	1
CO2		1	2	2	1	1	1						1	1	1
CO3	1	2	2	2	1	1							2	1	1
CO4		1	2	2	1								2	1	1
CO5		2	2	2									1	2	1
Avg	**1**	**1.6**	**2.2**	**2.2**	**1**	**1**	**1.5**						**1.4**	**1.4**	**1.0**

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

22MEPE46	METAL FORMING PROCESSES					SEMESTER VII
PREREQUISITES		CATEGORY	PE	Credit		3
1.Manufacturing processes			L	T	P	TH
2.Strength of materials		Hours/Week	3	0	0	3

COURSE OBJECTIVES:

1.	To familiarize the students about principle, procedure and applications of bulk metmal 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	State the principles of rolling and stresses developed under rolling loads.	Evaluate
CO3	Brief various forging techniques and defects in forging.	Understand
CO4	Analyze Extrusion and drawing processes and associated stresses developed.	Understand
CO5	Know various process parameters and applied loads in sheet metal working.	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1		1							1	1			1		2
CO2	1	2		2						1			1	1	2
CO3		1	2			2				1			1	1	2
CO4	1	1		1						1			1	1	2
CO5	1	3		1	1		2					1	1	1	2
Avg	**1**	**1.6**	**2**	**1.3**	**1**	**2**	**2**		**1**	**1**		**1**	**1.0**	**1**	**2.0**

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

22MEPE47	**MICRO AND NANO MACHINING**		**SEMESTER VII**			
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.	To introduce 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	Understand the various techniques in micro and nano manufacturing.	Understand
CO2	To know about the conventional techniques used in micro manufacturing.	Understand
CO3	To know about the non-conventional techniques used in micro manufacturing.	Understand
CO4	To know about the finishing and joining process used in micro manufacturing.	Understand
CO5	Find the applications of all the areas in industries.	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	1		2		1
CO2		1	1	1						1	1	1	1	2	3
CO3			1	1						1	1	1	1	1	1
CO4	1	2	1	1						1	1	1	1	1	1
CO5	1	1		1						2	2	1	2	2	2
Avg	**1.3**	**1.6**	**1**	**1**						**1.2**	**1.2**	**1**	**1.4**	**1.5**	**1.6**

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

PROFESSIONAL ELECTIVES – V

<table>
<tr><td>22MEPE51</td><td colspan="5">ANALYSIS AND SYNTHESIS OF MECHANISMS</td><td colspan="4">SEMESTER VIII</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2">1.Kinematics of Machinery</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td colspan="2">2. Dynamics of Machinery.</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
</table>

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			1	1			1		2	2	1
CO2	2	2	2	2			1	1			1		2	2	1
CO3	1	1	1	1									1	1	
CO4	2	2	2	2			1	1			1		2	2	1
CO5	2	2	2	2			1	1			1		2	2	1
Avg	**1.8**	**1.8**	**1.8**	**1.8**			**1**	**1**			**1**		**1.8**	**1.8**	**1**

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

<table>
<tr><td>22MEPE52</td><td colspan="3">DESIGN OF JIGS, FIXTURES AND PRESS TOOLS</td><td colspan="4">SEMESTER VIII</td></tr>
<tr><td colspan="3">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="3" rowspan="2"></td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="8">COURSE OBJECTIVES:</td></tr>
<tr><td>1.</td><td colspan="7">To understand the functions and design principles of Jigs and fixtures.</td></tr>
<tr><td>2.</td><td colspan="7">To know the importance of work piece location and its design.</td></tr>
<tr><td>3.</td><td colspan="7">To know the importance of work piece clamping and its design.</td></tr>
<tr><td>4.</td><td colspan="7">To know about the importance of jigs bushings and drill jig.</td></tr>
<tr><td>5.</td><td colspan="7">To know about the design of fixtures.</td></tr>
<tr><td>UNIT I</td><td colspan="3">BASICS OF JIGS AND FIXTURES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">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.</td></tr>
<tr><td>UNIT II</td><td colspan="3">PRINCIPLES OF LOCATING AND CLAMPING DEVICES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">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.</td></tr>
<tr><td>UNIT III</td><td colspan="3">DESIGN OF JIGS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">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.</td></tr>
<tr><td>UNIT IV</td><td colspan="3">JIG BUSHINGS AND DRILL JIGS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">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.</td></tr>
<tr><td>UNIT V</td><td colspan="3">PRINCIPLE OF FIXTURE DESIGN</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">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.</td></tr>
<tr><td colspan="8" align="right">Total (45L) = 45 Periods</td></tr>
</table>

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 Hill Publisher.

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		2	1	1		1		2	2	1
CO2	1	2	2	1	1		1	1	1		1		2	2	1
CO3	1	2	2	2	2		1	1	1		1		2	2	1
CO4	1	2	1	1	3		2	1	1		1		2	2	1
CO5	1	2	1	1	3		2	1	1		1		2	2	1
Avg	**1**	**2**	**1.6**	**1.2**	**2.0**		**1.6**	**1**	**1**		**1**		**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:	
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		1			2					1	1	1
CO2	3	2						1					2	1	1
CO3	3	3			1			2					3	3	2
CO4	3	2			2			1					3	1	1
CO5			1	1		1	1					1			
Avg	**2.2**	**2.25**	**1**	**1**	**1.3**	**1**	**1**	**1.5**				**1**	**2.2**	**1.5**	**1.2**

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, Metal Organic MBE (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.
3.	A Textbook of Nanoscience and Nanotechnology – T.Pradeep, Tata McGraw Hill edition.
REFERENCES:	
1	G Timp, “Nanotechnology”, AIP press/Springer, 1999.
2	Akhlesh Lakhtakia, “The Hand Book of Nano Technology, Nanometer Structure, Theory, Modeling and Simulations”. Prentice-Hall of India (P) Ltd, New Delhi, 2007.
3	Mark Ratner and Daniel Ratner, “Nano Technology”, Pearson Education, New Delhi, 2003.
4	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		2		1			1		2	2	1
CO2	2	1	1	1			1				1		2	1	
CO3	2	1	1	1			1				1		2	1	
CO4	2	1	1	1		1	1	1			1		2	1	
CO5	2	2	1	1		1	1	1			1		2	2	1
Avg	**2.0**	**1.4**	**1.2**	**1.0**		**1.3**	**1**	**1**			**1**		**2.0**	**1.4**	**1**

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.a	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						1	1	1
CO2	1	1	2	1	2	1	2						2	3	3
CO3	1	1	1	1	1	1	1						1	2	1
CO4	3	1	1	1	1	2	1						3	1	1
CO5	1	1	2	1	1	1	1						1	3	1
Avg	**1.4**	**1.2**	**1.6**	**1.0**	**1.2**	**1.2**	**1.2**						**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						1	2	2
CO2	1	3	1	1	2	1	1						1	1	3
CO3	2	1	3	1	1	2	1						1	1	2
CO4	2	1	1	1	3	1	1						1	1	2
CO5	2	1	1	3	1	2	1						2	3	1
Avg	**1.6**	**1.6**	**1.4**	**1.4**	**2.0**	**1.4**	**1.0**						**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 Rashmi Urdhwareshe, “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			2		1		2			2	1	2	1
CO2	1	2							2			2			
CO3	1	2	2		1			1				2	1		1
CO4	1	2			2	3		2		3		2	2	2	1
CO5	1	2	2		2	2	1	2	2	3		2	2	2	1
Avg	**1**	**2.2**	**2**		**1.7**	**2.5**	**1**	**1.7**	**2**	**3**		**2**	**1.5**	**2**	**1**

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**		**3**
		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 and 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 and 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 and Box Jigs – design and 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 and Compound dies – die design for simple components. Drawing dies – blank development – estimation of drawing force – blank holders and blank holding pressure – design and sketching of drawing dies for simple components – Bending dies and 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 for 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											1	1	
CO2		1											1	1	
CO3		1	2										1	1	
CO4	1	2	3										1	2	
CO5	1	1	1	3											
Avg	**1.3**	**1.2**	**2**	**3**									**1**	**1**	

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									1	1	
CO2	1	2	1										1	1	
CO3	2	1	1	1									1	1	
CO4	2	2	1											1	
CO5	1	1	1		3								1	2	
Avg	**1.6**	**1.4**	**1**	**1**	**3**								**1**	**1.2**	

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 and 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			1	1		1	1						1	1	1
CO2		3							1		1	1	1	1	1
CO3									1		3		1	1	2
CO4			1				1								2
CO5						1	1			1			1	1	1
Avg		**3**	**1**	**1**		**1**	**1**		**1**	**1**	**2**	**1**	**1**	**1**	**1.4**
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			2	3			1				2	2	1
CO2	3	1	1			2	2	1					2	2	1
CO3	2		1		2	2	2						2	2	1
CO4	2	1	1			2							2	2	1
CO5	2	1			2	2	2		1				2	2	1
Avg	**2**	**1**	**1**		**2**	**2.2**	**2**	**1**	**1**				**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 knowledge in 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	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1			1			1								
CO2			1				1								
CO3	1	1	1			1	1	1							
CO4	2	2			1			1					2	2	1
CO5	2	1						2					2	2	1
Avg	**1.5**	**1.7**	**1**	**1**	**1**	**1**	**1**	**1.7**					**2**	**2**	**1**

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									2	2	1
CO2	2	1	1	1	1								2	2	1
CO3	2	2	3	1	1								2	2	1
CO4	2		3			3	2			2		1	2	2	1
CO5	1	1	2	1		3	2			1			2	2	1
Avg	**2.0**	**1.25**	**2.0**	**1**	**1**	**3**	**2**			**1.5**		**1**	**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**		**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.

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, 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) = 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		1				2		2	2	1
CO2	2	1	1	1		1	2	1			1		2	2	1
CO3	1	1	1	1		1	1	1			1		2	2	1
CO4	1	1	1	2	2	2	1				2		1	1	1
CO5	1	1	1	1	2	1	1				1		2	2	1
Avg	**1.4**	**1**	**1.2**	**1.2**	**2**	**1.25**	**1.2**	**1**			**1.4**		**1.8**	**1.8**	**1**

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

OPEN ELECTIVE COURSES

22MAOE01	SAMPLING THEORY AND NUMERICAL METHODS				
PREREQUISTIES	**CATEGORY**	**L**	**T**	**P**	**C**
Basic 12th level knowledge of Probability, Statistics, Matrices, ODE and PDE.	**BS**	**3**	**0**	**0**	**3**

Course Objectives:

1.	To gain the knowledge of tests of significance for large and small samples.
2.	To find the numerical solution of linear, non-linear equations and to obtain the knowledge about fitting of curves by the method of least squares.
3.	To obtain the knowledge about numerical interpolation, differentiation and integration.
4.	To acquire the knowledge about numerical solutions to first order ordinary differential equations using single step and multi-step methods.
5.	To gain the knowledge about numerical solutions to second order partial differential equations by using explicit and implicit methods.

UNIT I	**SAMPLING THEORY**	**9**	**0**	**0**	**9**

Test of significance: Large Sample tests for Single proportion, difference of proportions, single mean and difference of means-Small Sample test for single mean, difference of means, test for ratio of variances - Chi-square test for goodness of fit and independence of attributes.

UNIT II	**SOLUTION OF EQUATIONS**	**9**	**0**	**0**	**9**

Solutions of nonlinear equations by Newton Raphson Method-Solutions of linear system of equations by Gauss Elimination, Gauss Jacobi and Gauss Seidel methods, Curve fitting by the Method of Least Squares – Fitting of straight lines, second degree parabolas.

UNIT III	**INTERPOLATION, NUMERICAL DIFFERENTIATION AND INTEGRATION**	**9**	**0**	**0**	**9**

Interpolation using Newton’s Forward and Backward formula- Interpolation with unequal intervals: Newton’s divided difference and Lagrange’s formula -Numerical Differentiation and Integration: Trapezoidal rule, Simpson’s 1/3 rule and Simpson’s 3/8 rule.

UNIT IV	**NUMERICAL SOLUTION FOR ORDINARY DIFFERENTIAL EQUATIONS**	**9**	**0**	**0**	**9**

Ordinary differential equations: Taylor series method- Euler and modified Euler’s method- Runge-Kutta method of fourth order for solving first order differential- Milne’s and Adam’s predictor - corrector methods.

UNIT V	**NUMERICAL SOLUTION FOR PARTIAL DIFFERENTIAL EQUATIONS**	**9**	**0**	**0**	**9**

Partial differential equations: Finite difference solution of two-dimensional Laplace and Poisson equations- Implicit and Explicit methods for one dimensional heat equation (Bender Schmidt and Crank-Nicholson methods) - Finite difference explicit method for wave equation.

Total (45 L + 0T) = 45 Periods

Text Books:

1.	Veerarajan T, “Probability and Random Process (With Queuing theory)”, 4th Edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2016.
2.	Kandasamy.P, Thilagavathy.K, Gunavathi.K, “Numerical Methods”, S. Chand & Co., New Delhi, 2005.
3.	Gupta, S.C. and Kapoor, V.K., “Fundamentals of Mathematical Statistics”, S. Chand and Sons, New Delhi, 11th Edition, 2014.

Reference Books:

1.	Freund John, E. and Miller Irwin, “Probability and Statistics for Engineers”, 8th Edition, Prentice Hall India (P) Ltd, 2010.
2.	Gerald, C. F. and Wheatley, P.O., “Applied Numerical Analysis”, Sixth Edition, Pearson Education Asia, New Delhi, 2002.
3.	M.K. Venkataraman, “Numerical Methods in Science and Engineering”, 5th Edition, National Publishing Company, 2000.
4.	Jain M.K, Iyengar K & Jain R.K., “Numerical Methods for Scientific and Engineering Computation”, New Age International (P) Ltd, Publishers, 2003.
5.	Manish Goyal, “Numerical Methods and Statistical techniques Using ‘C”, 1st Edition, Laxmi Publications (P) Ltd, 2009.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Learn about the concept of sampling theory and testing of hypotheses.	L2: Understanding
CO2	:	Find the numerical solution of equations and fitting the curves by Least Square Method.	L2: Understanding
CO3	:	Appreciate the numerical techniques of interpolation in various intervals and apply the numerical techniques of differentiation and integration for engineering problems.	L3: Applying
CO4	:	Solve the initial value problems for ordinary differential equations.	L3: Applying
CO5	:	Find the numerical solution of the partial differential equation by using the Finite difference method.	L2: Understanding

COURSE ARTICULATION MATRIX

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

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

22MAOE02	**NUMERICAL METHODS**				
PREREQUISTIES	**CATEGORY**	**L**	**T**	**P**	**C**
Basic 12th level knowledge of solution of equations, differentiation, integration, ODE and PDE.	**BS**	**3**	**0**	**0**	**3**

Course Objectives:

1.	To familiarize the numerical solution of the linear system of equations.
2.	To understand the concept of interpolation and approximation.
3.	To obtain the knowledge about numerical differentiation, integration.
4.	To familiarize the students on solving first order ordinary differential equations using single step and multi-step methods
5.	To enable them to solve boundary value problems associated with engineering applications using numerical methods.

UNIT I	**SOLUTION OF EQUATIONS**	**9**	**0**	**0**	**9**
Solutions of nonlinear equations by Newton Raphson Method-Solutions of linear system of equations by Gauss Elimination, Gauss Jordan, Gauss Jacobi and Gauss Seidel Methods.					
UNIT II	**INTERPOLATION AND APPROXIMATION**	**9**	**0**	**0**	**9**
Interpolation with Equal Intervals-Newton's Forward and Backward interpolations- Unequal intervals-Newton's divided difference formula and Lagrangian Polynomials.					
UNIT III	**NUMERICAL DIFFERENTIATION AND INTEGRATION**	**9**	**0**	**0**	**9**
Newton's Forward and Backward Differences to compute derivatives-Trapezoidal rule-Simpson's 1/3 rule, Simpson's 3/8 rule –Two- and three-point Gaussian quadrature formulas.					
UNIT IV	**INITIAL VALUE PROBLEMS FOR ORDINARY DIFFERENTIAL EQUATIONS**	**9**	**0**	**0**	**9**
Solving first order ODE – Single step method: Taylor series method-Euler and modified Euler Method-Fourth order Runge-Kutta method- Multistep method: Milne's and Adam's predictor and corrector methods.					
UNIT V	**BOUNDARY VALUE PROBLEMS IN ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS**	**9**	**0**	**0**	**9**
Finite difference solution of second order ordinary differential equations-Finite difference solutions of one-dimensional heat equation by explicit and implicit methods-One dimensional wave equation and two-dimensional Laplace and Poisson equations.					

Total (45 L + 0 T) = 45 Periods

Text Books:

1.	Veerarajan. T and Ramachandran, "Numerical methods with Programs in C and C^{++}", Tata McGraw Hill, New Delhi, 2006.
2.	Kandasamy.P, Thilagavathy.K, Gunavathi.K, "Numerical Methods", S. Chand & Co., New Delhi, 2005.

Reference Books:

1.	Gerald, C. F. and Wheatley, P.O.," Applied Numerical Analysis", Sixth Edition, Pearson Education Asia, New Delhi, 2002.
2.	M.K. Venkataraman, "Numerical Methods in Science and Engineering", 5th Edition, National Publishing Company, 2000.
3.	Jain M.K. Iyengar, K & Jain R.K., "Numerical Methods for Scientific and Engineering Computation", New Age International (P) Ltd, Publishers, 2003.
4.	Manish Goyal, "Numerical Methods and Statistical Techniques Using 'C'", 1st Edition, Laxmi Publications (P) Ltd, 2009.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Obtain the numerical solutions of linear and nonlinear equations.	L2: Understanding
CO2	:	Acquired the techniques of interpolation and approximations.	L2: Understanding
CO3	:	Familiarize with numerical differentiation and integration.	L2: Understanding
CO4	:	Solve the initial value problems for ordinary differential equations.	L3: Applying
CO5	:	Acquire the techniques of solving Boundary value problems.	L2: Understanding

COURSE ARTICULATION MATRIX

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

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

22MAOE03	**PROBABILITY AND QUEUING THEORY**				
PREREQUISTIES	**CATEGORY**	**L**	**T**	**P**	**C**
Basic 12th level knowledge of Probability and Statistics.	**BS**	**3**	**0**	**0**	**3**

Course Objectives:

1.	To understand the basic concepts of one-dimensional random variables and to introduce some standard distributions applicable to engineering which can describe real life phenomenon.
2.	To understand the concept of two-dimensional random variables, Correlation and linear regression.
3.	To provide necessary basic concepts in random processes for applications such as random signals, linear systems in communication engineering.
4.	To understand the concept of queueing models and apply in engineering.
5.	To understand the significance of advanced queueing models and develop probabilistic models which can be used in several areas of science and engineering

UNIT I	**RANDOM VARIABLES**	**9**	**0**	**0**	**9**

Discrete and continuous random variables – Moments – Moment generating functions – Binomial, Poisson, Uniform, Exponential and Normal distributions.

UNIT II	**TWO - DIMENSIONAL RANDOM VARIABLES**	**9**	**0**	**0**	**9**

Joint distributions – Marginal and conditional distributions – Covariance – Correlation and linear regression – Transformation of random variables .

UNIT III	**RANDOM PROCESSES**	**9**	**0**	**0**	**9**

Classification – Stationary process – Markov process - Poisson process – Discrete parameter Markov chain – Chapman Kolmogorov equations .

UNIT IV	**QUEUEING MODELS**	**9**	**0**	**0**	**9**

Markovian queues – Birth and death processes – Single and multiple server queueing models – Little’s formula - Queues with finite waiting rooms.

UNIT V	**ADVANCED QUEUEING MODELS**	**9**	**0**	**0**	**9**

Finite source models - M/G/1 queue – Pollaczek Khinchin formula - M/D/1 and M/E_K /1 as special case – Series queues – Open Jackson networks.

Total (45 L + 0 T) = 45 Periods

Text Books:

1.	Gross, D., Shortle, J.F, Thompson, J.M and Harris, C.M., “Fundamentals of Queueing Theory”, Wiley, Student 4th Edition, 2014.
2.	Ibe, O.C., “Fundamentals of Applied Probability and Random Processes”, Elsevier, 1st Indian Reprint, 2007.

Reference Books:

1.	Hwei Hsu, “Schaum‘s Outline of Theory and Problems of Probability, Random Variables and Random Processes”, Tata McGraw Hill Edition, New Delhi, 2004.
2.	Taha, H.A., “Operations Research”, 9th Edition, Pearson India Education Services, Delhi, 2016.
3.	Trivedi, K.S., “Probability and Statistics with Reliability, Queueing and Computer Science Applications”, 2nd Edition, John Wiley and Sons, 2002.
4.	Yates, R.D. and Goodman. D. J., “Probability and Stochastic Processes”, 2nd Edition, Wiley India Pvt. Ltd., Bangalore, 2012.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the fundamental knowledge of the standard distributions which can describe real life phenomenon.	L2: Understanding
CO2	:	Understand the concepts of two-dimensional random variables, Correlation and linear regression.	L2: Understanding
CO3	:	Apply the concept of random processes in engineering disciplines.	L3: Applying
CO4	:	Acquire skills in analysing queueing models.	L2: Understanding
CO5	:	Understand and characterize phenomenon which evolve with respect to time in a probabilistic manner.	L2: Understanding

COURSE ARTICULATION MATRIX

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

22CEOE01	**ENVIRONMENTAL MANAGEMENT**		**Semester**			**VI**
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
NIL		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To study the variable natures of our environmental resources and to understand their importance associated with our societic life.
2	To study the variable categories of pollutants and their controlling measures
3	To impart an understanding of systems approach to Environmental Management as per ISO 14000 and to evaluate the management plan using gis tools
4	To impart skills for environmental performance in terms of legal compliance, pollution prevention and continual improvement.
5	To impart skills for managing the usage of our natural resources without disrupting balance and stability of the natural system.

Unit I	**ENVIRONMENTAL RESOURCES**	**9**	**0**	**0**	**9**

Non-renewable resources-Mineral use and exploitation; fossil fuels. Renewable resources: Water resources-supply, demand, dams-benefits and problems; Soil and Land resources- Structure, formation, erosion, conservation of soil, agricultural practices, land use,degradation and desertification; Fisheries- Inland and marine fisheries, aquaculture, overharvesting; Forest resources- Timber, Medicinal plants, fuel-wood, deforestation, forest management- Management of renewable and non-renewable resources; Sustainable use

Unit II	**ENVIRONMENTAL POLLUTION**	**9**	**0**	**0**	**9**

Definition of pollution and pollutants; types of pollution-Air, Water ,Soil, Noise, thermal, nuclear; causes of pollution, effects of pollution and control measures; Liquid and Solid waste management, nuclear holocausts. Case studies: leather industry, fly ash, thermal stations, nuclear power plants

Unit III	**ENVIRONMENTAL MANAGEMENT SYSTEM**	**9**	**0**	**0**	**9**

Environmental Management Systems; ISO14000 series; Environmental auditing: Environmental Impact Assessment; Life cycle assessment; Human health risk assessment. Management plans using GIS and RS tools

Unit IV	**ENVIRONMENTAL LAW AND POLICY**	**9**	**0**	**0**	**9**

Environmental Law and Policy – Objectives; Polluter pays principle, Precautionary principle; The Water and Air Acts with amendments; The Environment (Protection) Act (EPA) 1986; National Green Tribunal Act, 2010; National Environment Policy; Principles of International Law and International treaties.

Unit V	**ENERGY-ENVIRONMENT AND SUSTAINABLE DEVELOPMENT**	**9**	**0**	**0**	**9**

Energy and Environment: Energy sources – overview of resources and reserves; Renewable and non-renewable energy sources; Energy-Environment nexus Sustainable Development: Definition and concepts of sustainable development; Sustainable development goals; Hurdles to sustainability; Environment and economics.

Total= 45 Periods

Text Books:

1	“Natural Resources Conservation & Management” , K.K.SINGH -MD PUBLICATIONS PVT LTD
2	“Environmental Pollution “ by N.MANIVASAKAM,2021
3	ISO 14001/14004: Environmental management systems –Requirements and Guidelines – International Organisation for Standardisation, 2004.
4	Fundamental Concepts in Environmental Studies by Dr.D.D Mishra

Reference Books:

1	ISO 19011: 2002, “Guidelines for quality and/or Environmental Management System auditing, Bureau of Indian Standards, New Delhi, 2002.
2	Paul LBishop „Pollution Prevention: Fundamentals and Practice‟, McGraw -Hill International, Boston,2000.

3	Environmental Management Systems: An Implementation Guide for Small and Medium-Sized Organizations, Second Edition, NSF International, Ann Arbor, Michigan, January 2001
4	Christopher Sheldon and Mark Yoxon, “Installing Environmental management Systems –a step by step guide” Earthscan Publications Ltd, London, 1999.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom’s Taxonomy Mapped**
CO1	Understand the importance of variable natural resources	Understand
CO2	Understand the necessity of environmental management that will be caused by projects or industries.	Understand
CO3	Develop, Implement, maintain and Audit Environmental Management systems for Organizations.	Understand /Evaluate
CO4	Gain the Knowledge about the legal requirements of Environmental management and auditing	Remembering
CO5	Understand eco-friendly business in order to achieve sustainable development	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	1	1	1	-	1	3	3	-	2
CO2	-	1	3	-	-	3	1	1	1	-	1	3	3	-	2
CO3	1	1	1	2	2	3	1	-	2	2	3	2	3	-	3
CO4	-	1	1	-	-	3	1	1	2	2	1	2	1	-	2
CO5	1	1	3	2	1	3	3	-	2	-	3	3	3	-	2
Avg	1	1	2	2	0.6	3	1.4	0.6	1.6	2	1.8	2.6	2.6	-	2.2
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

<table>
<tr><td>22CEOE02</td><td colspan="2">DISASTER MITIGATION AND MANAGEMENT</td><td colspan="3">Semester</td><td>VI</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>Category</td><td>OE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">NIL</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
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Course Learning Objectives

1	To provide students an exposure to disasters, their significance and types
2	To ensure that students begin to understand the relationship between vulnerability disasters, disaster prevention and risk reduction
3	To gain a preliminary understanding of approaches of Disaster Risk Reduction (DRR)
4	To enhance the institutional processes in the country
5	To evaluate the various case studies in disaster management

Unit I	**INTRODUCTION TO DISASTERS**	**9**	**0**	**0**	**9**

Definition: Disaster, Hazard, Vulnerability, Resilience, Risks – Disasters: Types of disasters –Earthquake, Landslide, Flood, Drought, Fire etc – Classification, Causes, Impacts including social, economic, political, environmental, health, psychosocial, etc.- Differential impacts- in terms of caste, class, gender, age, location, disability- Global trends I n disasters: urban disasters, pandemics, complex emergencies, Climate change- Dos and Don‟ts during various types of Disasters.

Unit II	**APPROACHES TO DISASTER RISK REDUCTION (DRR)**	**9**	**0**	**0**	**9**

Disaster cycle – Phases, Culture of safety, prevention, mitigation and preparedness community based DRR, Structural-nonstructural measures, Roles and responsibilities of- community, Panchayat Raj Institutions/Urban Local Bodies (PRIs/ULBs), States, Centre, and other stake-holders- Institutional Processes and Framework at State and Central Level- State Disaster Management Authority(SDMA)– Early Warning System – Advisories from Appropriate Agencies.

Unit III	**INTER-RELATIONSHIP BETWEEN DISASTERS AND DEVELOPMENT**	**9**	**0**	**0**	**9**

Factors affecting Vulnerabilities, differential impacts, impact of Development projects such as dams, embankments, changes in Land-use etc.- Climate Change Adaptation- IPCC Scenario and Scenarios in the context of India – Relevance of indigenous knowledge, appropriate technology and local resources.

Unit IV	**DISASTER RISK MANAGEMENT IN INDIA**	**9**	**0**	**0**	**9**

Hazard and Vulnerability profile of India, Components of Disaster Relief: Water, Food, Sanitation, Shelter, Health, Waste Management, Institutional arrangements (Mitigation, Response and Preparedness, Disaster Management Act and Policy – Other related policies, plans, programmes and legislation – Role of GIS and Information Technology Components in Preparedness, Risk Assessment, Response and Recovery Phases of Disaster – Disaster Damage Assessment.

Unit V	**DISASTER MANAGEMENT: APPLICATIONS AND CASE STUDIES AND FIELD WORKS**	**9**	**0**	**0**	**9**

Landslide Hazard Zonation: Case Studies, Earthquake Vulnerability Assessment of Buildings and Infrastructure: Case Studies, Drought Assessment: Case Studies, Coastal Flooding: Storm Surge Assessment, Floods: Fluvial and Pluvial Flooding: Case Studies; Forest Fire: Case Studies, Man Made disasters: Case Studies, Space Based Inputs for Disaster Mitigation and Management and fieldworks related to disaster management

Total= 45 Periods

Text Books:	
1	Singhal J.P. “Disaster Management”, Laxmi Publications, 2010. ISBN-10: 9380386427 ISBN-13:978-9380386423
2	Tushar Bhattacharya, “Disaster Science and Management”, McGraw Hill India Education Pvt.Ltd., 2012. ISBN-10: 1259007367, ISBN-13: 978-1259007361]
Reference Books:	
1	Govt. of India: Disaster Management Act , Government of India, New Delhi, 2005
2	Government of India, National Disaster Management Policy, 2009.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom’s Taxonomy Mapped**
CO1	Differentiate the types of disasters, causes and their impact on environment and society	Analyze
CO2	Assess vulnerability and various methods of risk reduction measures as well as mitigation	Understand
CO3	Draw the hazard and vulnerability profile of India, Scenarios in the Indian context, Disaster damage assessment and management.	Create
CO4	Use the GIS softwares for disaster risk management in india	Evaluate
CO5	Gain knowledge on various case studies of disaster management	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**	**1**	**1**	**2**	**1**		**1**	**1**	**1**	**1**	**1**		**1**
CO2	**1**	**1**	**1**	**2**	**1**	**1**	**1**		**1**	**1**	**2**	**1**	**1**		**1**
CO3	**2**	**1**	**2**	**2**	**1**	**-**	**1**		**2**	**1**	**2**	**1**	**1**		**1**
CO4	**1**	**1**	**2**	**1**	**3**	**3**	**2**	**1**	**3**	**2**	**3**	**2**	**2**	**2**	**3**
CO5	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**2**	**2**		**2**
Avg	**1.4**	**1.2**	**1.6**	**1.6**	**1.6**	**1.6**	**1.4**	**1**	**1.8**	**1.4**	**2**	**1.4**	**1.4**	**2**	**1.6**
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

22CEOE03	**REPAIR AND REHABILITATION OF BUILDING ELEMENTS**		**Semester**			**VI**
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
Construction materials and Technology & Concrete Technology		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To get the knowledge on causes of deterioration of structure
2	To know about the assessment of distressed structures
3	To get the knowledge on maintenance of building systems
4	To know about the repairing of structures
5	To gain knowledge about the techniques involved in the demolition procedure

Unit I	**MAINTENANCE AND REPAIR STRATEGIES**	**9**	**0**	**0**	**9**
Maintenance, repair and rehabilitation, Facts of Maintenance, importance of Maintenance various aspects of inspection, assessment procedure for evaluating a damaged structure, causes of deterioration.					
Unit II	**MAINTENANCE OF ELECTRICITY AND DOMESTIC WATER PUMP SYSTEMS**	**9**	**0**	**0**	**9**
Load rating of lighting devices and usual household appliances, electric supply from street line to building, devices for alternate supply during power failure, importance of earth leakage circuit breaker (ELCB), Maintenance of electric system in buildings. General specifications of water pumps, centrifugal pumps, jet pumps and submersible pumps, general rules in operation of water pumps. Maintenance of the sump.					
Unit III	**MATERIALS AND TECHNIQUES FOR REPAIR**	**9**	**0**	**0**	**9**
Materials for Repair: Special concretes and mortar concrete chemicals construction chemicals Expansive cement polymer concrete sulphur infiltrated concrete Ferro cement Fibre reinforced concrete Rust eliminators and polymers coating for rebar foamed concrete dry pack vacuum concrete asphalt sheeting Techniques for Repairs Gunniting, grouting and Shotcrete Epoxy injection					
Unit IV	**REPAIRS,REHABILITATION AND RETROFITTING OF BUILDING SYSTEMS**	**9**	**0**	**0**	**9**
Repairs of RC beams and columns damaged by steel corrosion, repair of rising dampness in walls, repair of efflorescence effect, repair of cracks in concrete structures, repair of rain water, groundwater leakage in buildings.					
Unit V	**DEMOLITION TECHNIQUES**	**9**	**0**	**0**	**9**
Engineered demolition techniques for dilapidated structures- case studies					
					Total= 45 Periods

Text Books:	
1	Varghese P.C., Maintenance Repair Rehabilitation and Minor Works of Buildings, PHI Learning pvt.ltd.,NewDelhi,2014
Reference Books:	
1	Santhakumar A.R, Training Course notes on Damage Assessment and Repair in Low cost housing, “RHDC.NBO” Anna University, July 1992.
2	Shetty, M.S., Concrete Technology-Theory and Practice, S. Chand and company, NewDelhi,1992
3	RaikarR.N., Learning from failures- deficiencies in design, construction and services– R &D centre (SDCPL), raikar bhavan, Bombay,1987
4	Palaniyappan, N., Estate management, Anna Institute of Management, Chennai, 1992.
5	Lakshmipathy, M. et al., Lecture notes of workshop on Repairs and Rehabilitation of structures, 29-30thoctober 1999.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom’s Taxonomy Mapped**
CO1	Carry out the damage assessment and Rapid Visual inspection of a building showing signs of deterioration and thus should be able to detect the possible cause /source of deterioration	Analyse
CO2	Know how to Maintain and repair the building systems like electricity, plumbing etc.	Remember
CO3	Know how of the Concrete repair industry equipped with variety of repair materials and techniques	Remember
CO4	Know the various repair works in building systems.	Remember
CO5	Demonstrate the dismantling and demolishing structures	Apply

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	-	-	-	-	1	1	1	1	1	1	2	1	1	-	1
CO2	-	-	-	-	2	1	1	1	1	1	2	1	1	-	1
CO3	-	-	-	-	2	1	1	1	1	1	1	1	2	-	1
CO4	-	-	-	-	2	1	1	1	1	-	-	-	1	-	1
CO5	-	-	-	-	1	2	1	2	2	2	1	1	1	-	1
Avg	-	-	-	-	1.6	1.2	1	1.2	1.2	1.25	1.5	1	1.2	-	1
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

22CEOE04	**MECHANICS OF DEFORMABLE BODIES**		**Semester**			**VI**
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
Mechanics of Solids and Strength of Materials		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives	
1	To learn the fundamental concepts of stress, strain and their relations based on linear elasticity with applications to bars and beams.
2	Analyze the bending of various types of beams under static loading conditions and compute the shear-moment diagrams of a beam and find the Maximum moment/shear and their locations for different cross sections of beams.
3	Understand the basic concept of theory of flexure and torsion, springs and strain energy.
4	To learn the principles of mechanics applied to different materials under static conditions and to develop problem solving skills through application of these principles to basic engineering problems.
5	To learn the principles of mechanical behavior of engineering materials, various tests under dynamics conditions and parametric studies.

Unit I	**SIMPLE STRESSES, BEHAVIOUR OF COMPOSITE SECTIONS, THERMAL STRESSES**	**9**	**0**	**0**	**9**
Mechanical properties of solids –Hooke’s law, principle of superposition, Bars of varying sections –Elastic constants – composite sections – determination of stress, strain , deformation –Temperature stress ,strain					
Unit II	**BENDING AND SHEAR**	**9**	**0**	**0**	**9**
Types of beams – shear force and bending moment. Theory of simple bending - Analysis of stress-load carrying capacity. Shear stress distribution of simple beams of different cross sections					
Unit III	**TORSION AND SPRINGS**	**9**	**0**	**0**	**9**
Torsion of circular shaft – Hollow and solid circular section, torsional rigidity-stepped shaft-Twist and torsional stiffness-compound shaft-shafts springs-Stiffness and deflection of helical springs, leaf spring					
Unit IV	**MECHANICAL BEHAVIOUR OF MATERIALS UNDER STATIC LOADS**	**9**	**0**	**0**	**9**
Tension tests – stress – strain diagram, Elastic and plastic regions – True stress – strain properties in tension – fracture under tensile loads – compression and Torsion tests – stress concentration –Residual stresses					
Unit V	**MECHANICAL BEHAVIOUR OF MATERIALS UNDER DYNAMIC LOADS**	**9**	**0**	**0**	**9**
Fatigue loading and Fatigue fracture – Fatigue tests – Empirical relations between variable stress and mean stress – Fatigue stress concentration Factors – Cumulative Damage – Endurance limit –Impact – notched – Bar Impact tests, Charpy Impact tests – Izod Impact tests – Elevated temperature – Creep tests – Isochronous curves – stress Relaxation – Parametric methods					
					Total= 45 Periods

Text Books:	
1	James M.Gere, Mechanics of Materials, Brooke/Cole Thomson Learning, 5 Ed., 2001.
2	Dr.R.Vaithiyanathan, Dr. P. Perumal &Lingeswari", Mechanics of Solids and StructuresVolume-I" Sci- tech publications, India(Pvt) Chennai-17.
3	Srinath L.S; - Strength of materials – Macmillan India Limited – New Delhi,2017

Reference Books:	
1	Popov.E.P., "Engineering Mechanics of solids", Prentice- Hall of India, New Delhi
2	Beer F.P and Johnston R, "Mechanics of Materials", McGraw- Hill book Co, Third Edition
3	Timoshenko S.P., "Elements of Strength of Materials", Tata McGraw- Hill, New Delhi
4	Nash W.A., "Theory and Problems in Strength of Materials", Schuam outline Series, McGraw- Hill Book Co., New York.
5	Rajput. R.K., "Strength of Materials", S. Chand & Co, Delhi, Third Edition, 2003.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	To acquire basic knowledge of stress strain and deformation of structures of varying cross sections of bars.	Knowledge
CO2	To draw Shear Force and Bending Moment Diagram for transverse loading under various types of loadings and beams.	Analyse
CO3	To solve problems of Torsional shear stress for shaft and stiffness and deflection of springs	Apply
CO4	Describe the mechanical behaviour of engineering materials subjected to various types of stresses	Understand
CO5	Understand the concept of mechanical behaviour under dynamic loading of various tests to find the stresses induced in the materials.	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	-	-	-
CO2	1	1	-	-	-	-	-	-	-	-	-	1	-	-	-
CO3	1	1	-	1	-	-	-	-	-	-	-	1	-	-	-
CO4	1	1	-	1	-	-	-	-	-	-	1	1	-	-	-
CO5	1	1	-	1	-	-	-	-	-	-	1	1	-	-	-
Avg	1	1	-	1.25	-	-	1	-	-	-	1	1	-	-	-

22CSOE01	**OBJECT ORIENTED PROGRAMMING USING CONCEPTS**					
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
Problem Solving and C Programming		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:	
1.	To understand object oriented programming concept
2.	To apply object oriented concept for problem solving
3.	To design solutions to the real world problems using object oriented concept.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Procedure oriented programming paradigm - Object oriented programming paradigm - Basic concepts of object oriented programming, benefits of OOP, application of OOP - C++ fundamentals –structure of C++ program, tokens, data types - Operators and expressions - Control structures - Functions.					
UNIT II	**CLASSES AND OBJECTS**	**9**	**0**	**0**	**9**
Classes and objects - friend functions- constructors and destructors- Operator overloading – binary and unary operator overloading using member function and friend function - Type conversions.					
UNIT III	**INHERITANCE AND VIRTUAL FUNCTIONS**	**9**	**0**	**0**	**9**
Inheritance – defining derived classes, types, virtual base classes, abstract classes, constructor in derived classes - Pointers-pointers to objects, this pointer, pointer to derived classes - Virtual functions.					
UNIT IV	**TEMPLATES AND EXCEPTION HANDLING**	**9**	**0**	**0**	**9**
Generic Classes – class template, class templates with multiple parameters - Generic Functions - function templates, function templates with multiple parameters, member function templates - Exception handling – basics, exception handling mechanism, rethrowing an exception .					
UNIT V	**CONSOLE I/O AND FILE HANDLING**	**9**	**0**	**0**	**9**
C++ Stream Classes – unformatted I/O operations, formatted console I/O operations, manipulators - Files-classes for file operation, opening and closing a file, detecting end of file, files modes, sequential file operations, random file operations.					
					Total (45 L) =45 Periods

Text Books:	
1.	E. Balagurusamy “Object Oriented Programming with C++”, Eighth Edition, Tata McGraw-Hill, 2020.
Reference Books:	
1.	Herbert Schildt, "The Complete Reference C++", Fifth Edition, Tata McGraw Hill, 2015.
2.	Bjarne Stroustrup, “The C++ programming language”, Fourth Edition Addison Wesley, 2013.
3.	K.R.Venugopal, Rajkumar Buyya, T.Ravishankar , Mastering in C++, Second Edition, Tata McGraw Hill,2013.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom’s Taxonomy Mapped**
CO1	Familiarize the object oriented programming concepts, Generic Programming and handling exceptions.	Understand
CO2	Build Object Oriented Programming concepts for problem solving.	Apply
CO3	Develop solutions to real world problems using Object Oriented Concepts.	Apply

22CSOE02	OPERATING SYSTEMS PRINCIPLES					
PREREQUISITES		CATEGORY	OE	Credit		3
NIL		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	To understand the structure and functions of Operating systems
2.	To understand the process concepts and scheduling algorithms
3.	To understand the concept of process synchronization and deadlocks
4.	To learn various memory management schemes
5.	To illustrate various file systems and disk management strategies

UNIT I	INTRODUCTION AND OPERATING SYSTEM STRUCTURES	9	0	0	9
Main frame Systems, Desktop Systems, Multiprocessor Systems, Distributed Systems, Clustered Systems, Real Time systems, Hand held Systems; Operating Systems Structures - System Components, Operating System Services, System calls, System Programs, System Design and Implementation.					
UNIT II	**PROCESS MANAGEMENT**	**9**	**0**	**0**	**9**
Processes-Process Concepts, Process Scheduling, Operation on Processes, Co-Operating Processes, InterProcess Communication; Threads- Multithreading Models, Threading Issues; CPU Scheduling-Basic Concepts, Scheduling Criteria, Scheduling Algorithms.					
UNIT III	**PROCESS SYNCHRONIZATION AND DEADLOCKS**	**9**	**0**	**0**	**9**
Process Synchronization- The Critical Section Problem, Semaphores, Classical Problem of Synchronization, Monitors; Deadlocks- Deadlock Characterization, Methods for handling Deadlocks, Deadlock Prevention, Deadlock Avoidance ,Deadlock Detection, Recovery from Deadlock.					
UNIT IV	**MEMORY MANAGEMENT AND VIRTUAL MEMORY**	**9**	**0**	**0**	**9**
Memory Management- Background, Swapping, Contiguous Memory Allocation, Paging, Segmentation, Segmentation with paging; Virtual Memory - Demand paging, Page Replacement, Thrashing.					
UNIT V	**FILE SYSTEM AND MASS-STORAGE STRUCTURE**	**9**	**0**	**0**	**9**
File System Interface - File Concepts, Access methods, Directory Structure, File Sharing, File Protection; File System Implementation - File System Structure and Implementation, Directory Implementation, Allocation Methods, Free Space Management; Mass-Storage Structure - Disk Structure, Disk scheduling, Disk Management, RAID Structure.					
Total (45 L) =45 Periods					

Text Books:

1.	Abraham Silberschatz, P.B.Galvin, G.Gagne —Operating System Concepts 6th edition, John Wiley & Sons, 2003.

Reference Books:

1.	Andrew S. Tanenbaum, —Modern Operating Systems, PHI , 2nd edition, 2001
2.	D.M.Dhamdhere, “Systems Programming and Operating Systems ", 2nd edition, Tata McGraw Hill Company, 1999.
3.	Maurice J. Bach, —The Design of the Unix Operating System, 1st edition, PHI, 2004.

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom’s Taxonomy Mapped
CO1	Interpret the components and functionalities of the operating system	Understand
CO2	Apply various services and concepts of operating system to real time applications	Apply
CO3	Analyze the issues related to operating system and provide suitable solutions.	Analyze

22CSOE03	COMPUTER COMMUNICATIONS AND NETWORKS					
PREREQUISITES		CATEGORY	OE	Credit		3
NIL		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	To study the concepts of data communications and functions of different ISO/OSI reference architecture
2.	To understand the error detection and correction methods and also the types of LAN
3.	To study the concepts of subnetting and routing mechanisms
4.	To understand the different types of protocols and congestion control
5.	To study the application protocols and network security

UNIT I	DATA COMMUNICATIONS AND PHYSICAL LAYER	9	0	0	9

Data Communication; Networks- Physical Structures (Types of Connections, Physical Topology),Categories of Networks, Interconnection of Networks: Internetwork; Protocols and Standards; Network Models-The OSI Model, Layers in the OSI Model, Addressing; Transmission media-Guided Media, Unguided Media.

UNIT II	DATA LINK LAYER	9	0	0	9

Introduction-Types of errors, Redundancy, Detection versus Correction; Block Coding-Error Detection and Correction (VRC, LRC, CRC, Checksum, Hamming Code);Data link Control- Flow Control (Stop- and-Wait, Sliding Window),Error Control (Automatic Repeat Request, Stop-and-wait ARQ, Sliding Window ARQ), HDLC; Local Area Networks- Ethernet, Token Bus, Token Ring.

UNIT III	NETWORK LAYER	9	0	0	9

Network Layer services-Packet Switching-Network Layer Performance-IPv4 addresses-IPv6 addressing- Subnetting-Bridges-Gateways- Routers-Routing Algorithm-Distance Vector Routing, Link State Routing.

UNIT IV	TRANSPORT LAYER	9	0	0	9

Duties of the Transport layer-User Datagram Protocol-Transmission Control Protocol- Congestion Control and Quality of Service-Congestion, Congestion Control, Quality of Service, Techniques to improve QoS.

UNIT V	APPLICATION LAYER	9	0	0	9

Domain Name System - Domain Name Space, DNS in the Internet; Electronic Mail-FTP- HTTP- World Wide Web.

Total (45 L) =45 Periods

Text Book:

1.	Behrouz A. Ferouzan, "Data Communications and Networking", 4th Edition, Tata McGraw-Hill, 2007.

Reference Books:

1.	Andrew S. Tanenbaum, "Computer networks "PHI, 4th edition 2008
2.	William Stallings," Data and computer communications", 10th edition,PHI, 2012
3.	Douglas E. comer," Internetworking with TCP/IP-Volume-I", 6th edition,PHI, 2008

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the fundamental concepts of networking and working principles of various communication protocols.	Understand
CO2	Apply the various functionalities of OSI layers in real time applications	Apply
CO3	Analyze the various network issues in different layers and provide suitable solutions.	Analyze

22CSOE04	**PYTHON PROGRAMMING**				
PREREQUISITES	**Category**	**OE**	**Credit**		**3**
NIL	**Hours/Week**	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Learning Objectives

1	To Learn the basic concepts of python programming.
2	To write simple programs using python programming concepts.
3	To build simple real world applications using python.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Introduction - Features- The Basics - Numbers, Sequence: Strings, Lists, Tuples, Mapping and set types. Variables- Operators- Expressions- Precedence of operators – Comments - Input and output functions - Formatting numbers and strings- Implicit/explicit type conversion.					
UNIT II	**CONDITIONS,CONTROL STRUCTURES AND FILES**	**9**	**0**	**0**	**9**
Conditionals and loops-if statement-else statement – elif-Conditional Expressions-while statement-for statement – break-continue –pass; Files and Input/ Output.					
UNIT III	**PYTHON EXCEPTIONS, MODULES AND PACKAGES**	**9**	**0**	**0**	**9**
Errors and Exceptions – Introduction-Detecting and handling Exceptions- Raising Exceptions – Assertions-Standard Exceptions – Modules: user defined modules, random and o s modules - Packages.					
UNIT IV	**FUNCTIONS**	**9**	**0**	**0**	**9**
Functions-Calling functions-Creating functions-Passing Functions-Formal Arguments-Variable length arguments- Variable scope – Recursion- Map, Filter, Reduce and List Comprehensions-Iterators -Generator Expressions.					
UNIT V	**OBJECT ORIENTED PROGRAMMING AND REGULAR EXPRESSION**	**9**	**0**	**0**	**9**
Introduction – Classes- Class Attributes – Instances-Instances attributes-Building and Method Invocation-Static methods and Class Methods – Inheritance-Operator overloading-Regular Expression.					
					Total (45 L) =45 Periods

Text Books:

1.	Wesley J.Chun-“Core Python Programming” –Prentice Hall, Third Edition, 2012.

Reference Books:

1.	Swaroop C N, “ A Byte of Python “, ebshelf Inc., 1st Edition, 2013
2.	“A Practical Introduction to python programming”, Brian Heinold,MountSt.Mary’s University,2012
3.	Learning to Program with Python,” Richard L. Halterman”., Southern Adventist University

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	To understand the basic concepts of python programming.	Understand
CO2	To design simple programs using python programming concepts.	Apply
CO3	To apply python programming concepts in the real world application.	Analyze

22CSOE05	**INTRODUTION TO PROGRAMMING IN JAVA**					
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
C Programming		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1. To familiarize and apply the Object Oriented concepts and java features
2. To write the standalone applications and applet applications
3. To build simple chart application and Database Connectivity

UNIT I	**INTRODUCTION TO JAVA**	**9**	**0**	**0**	**9**

Fundamentals of object oriented programming- java features, comparing JAVA with C and C++, JAVA environment; Overview of java language - java program structure, java tokens, java statements, implementing java program, java virtual machine, command line arguments; constants, variables and data types - Operators and expressions - Decision making – branching and looping.

UNIT II	**JAVA FEATURES**	**9**	**0**	**0**	**9**

Classes, objects methods – arrays, Strings and Vectors– Interfaces – Packages - Multithreaded programming- Exception handling.

UNIT III	**APPLET**	**9**	**0**	**0**	**9**

Applet programming- build applet code, applet life cycle, creating executable applet, designing a web page, applet tag, running the applet ,passing parameters to Applet; Graphics programming – graphics class, lines, rectangles, circles, ellipses, arcs and polygons

UNIT IV	**AWT CONTROLS**	**9**	**0**	**0**	**9**

Event handling – event handling Mechanisms, delegation event model, event classes, sources of events, event listener interfaces; AWT - AWT controls, Layout Managers, Menu Bars and Menus, Dialog Boxes, FileDialogs;

UNIT V	**I/O FILES AND JDBC**	**9**	**0**	**0**	**9**

I/O Files- concepts of stream, stream classes, byte stream classes, character stream classes, file classes, creation of files, reading and writing characters and bytes; Design of JDBC - JDBC drivers; JDBC programming concepts - Database concepts, making connection, executing SQL commands, managing connections, statements, and result sets; Query execution - Prepared Statements.

Total(45L)=45Periods

Text Books:

1. E. Balaguruswamy, “Programming with java”, Sixth, TMH 2019 (Unit- I-III)
2. Patrick Naughton , Herbert Schildt, “The Complete Reference Java 2” , Twelfth edition Tata McGraw Hills , 2021 (Unit IV - V)

Reference Books:

1. Cay S. Horstmann, Gary Cornell “ Core Java 2” Eighth Edition, Pearson Education, 2008
2. Graham Hamilton , Rick Cattell, Maydene Fisher ,”JDBC Database access with java”.1997
3. PaulDeitel and Harvey Deitel, “Java How to Program”, Eleventh Edition, Pearson Prentice Hall 2017.

COURSEOUTCOMES: Upon completion of the course ,the students will be able to:		**Bloom’s Taxonomy Mapped**
CO1	Familiarize the Object Oriented concepts and java features	Understand
CO2	Build the simple standalone applications and web applications	Create
CO3	Develop simple application using files and Database	Create

<table>
<tr><td colspan="2">22CSOE06</td><td colspan="2">COMPUTER ORGANIZATION</td><td colspan="4">SEMESTER VI</td></tr>
<tr><td colspan="3">PREREQUISITES</td><td>CATEGORY</td><td>OE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="3" rowspan="2">Digital Principles and System Design</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="8">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="7">To understand the basic structure and operations of digital computer and to learn the working of different arithmetic operations.</td></tr>
<tr><td>2.</td><td colspan="7">To expose different types of processor control and the concept of pipelining and to familiarize hierarchical memory system including cache memory and virtual memory</td></tr>
<tr><td>3.</td><td colspan="7">To expose the different ways of communicating with I/O devices and standard I/O interfaces</td></tr>
<tr><td colspan="2">UNIT I</td><td colspan="2">INTRODUCTION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Functional units ,Basic Operational Concepts, Bus Structure ,Memory Locations and Addresses, MemoryOperations, Instruction and Instruction Sequencing, Addressing modes.</td></tr>
<tr><td colspan="2">UNIT II</td><td colspan="2">ARITHMETIC UNIT</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Addition and Subtraction of Signed Numbers, Design of Fast Adders, Multiplication of Positive Numbers, BoothAlgorithm, Fast Multiplication, Integer Division, Floating point number operations.</td></tr>
<tr><td colspan="2">UNIT III</td><td colspan="2">PROCESSOR UNIT AND PIPELINING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Fundamental Concepts, Execution of Instruction, Multi Bus Organization, Hardwired control, Micro programmed control, Basic Concepts of pipelining, Data Hazards, Instruction Hazards, Data path & Control Considerations.</td></tr>
<tr><td colspan="2">UNIT IV</td><td colspan="2">MEMORY SYSTEMS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Basic Concepts, Semiconductor RAM, ROM, Cache memory, Improving Cache Performance, Virtual memory, Memory Management requirements, Secondary Storage Device.</td></tr>
<tr><td colspan="2">UNIT V</td><td colspan="2">INPUT AND OUTPUT ORGANIZATION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Accessing I/O devices, Programmed I/O, Interrupts, Direct Memory Access, Interface circuits, Standard I/OInterfaces (PCI, SCSI, USB).</td></tr>
<tr><td colspan="8" align="right">Total (45 L)= 45 Periods</td></tr>
</table>

Text Books:	
1.	Carl Hamacher V.,Zvonko G.Vranesic, Safwat G. Zaky, " Computer organization ", Tata McGraw Hill,5th Edition, 2008.
Reference Books:	
1.	Patterson and Hennessey, “Computer Organization and Design ". The Hardware/Software interface,Harcourt Asia Morgan Kaufmann, 3rd Edition, 2007
2.	Hayes, “Computer Architecture and Organization ", 3rd edition,Tata McGraw Hill, 2006
3.	Heuring V.P., Jordan H.F., " Computer System Design and Architecture ", 6th edition ,Addison Wesley,2008

COURSE OUTCOMES Upon completion of the course, the students will be able to:		**Bloom’s Taxonomy Mapped**
CO1	Understand the working principles of computer components	Understand
CO2	Design the arithmetic and processing units	Create
CO3	Analyze the various computer components	Analyze

<table>
<tr><td>22CSOE07</td><td colspan="2">DATA STRUCTURES USING C++</td><td colspan="4">SEMESTER VI</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>Category</td><td>OE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">C Programming</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="6">To comprehend the fundamentals of object oriend programming, particularly in C++</td></tr>
<tr><td>2</td><td colspan="6">To design linear and non linear data structure using object programming concepts</td></tr>
<tr><td>3</td><td colspan="6">To apply various sorting and searching alogorithims.</td></tr>
<tr><td>UNIT I</td><td colspan="2">DATA ABSTRACTION & OVERLOADING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Overview of C++ – Structures – Class Scope and Accessing Class Members – Reference Variables – Initialization – Constructors – Destructors – Member Functions and Classes – Friend Function – Dynamic Memory Allocation – Static Class Members – Container Classes and Integrators – Overloading: Function overloading and Operator Overloading.</td></tr>
<tr><td>UNIT II</td><td colspan="2">INHERITANCE AND POLYMORPHISM</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Base Classes and Derived Classes – Protected Members – Casting Class pointers and Member Functions – Overriding – Public, Protected and Private Inheritance – Constructors and Destructors in derived Classes – Implicit Derived – Class Object to Base – Class Object Conversion – Virtual functions – this Pointer – Abstract Base Classes and Concrete Classes – Virtual Destructors – Dynamic Binding.</td></tr>
<tr><td>UNIT III</td><td colspan="2">LINEAR DATA STRUCTURES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Abstract Data Types (ADTs) – List ADT – array-based implementation – linked list implementation –Singly Linked lists –Polynomial Manipulation – Stack ADT – Queue ADT – Evaluating arithmetic expressions.</td></tr>
<tr><td>UNIT IV</td><td colspan="2">NON-LINEAR DATA STRUCTURES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Trees – Binary Trees – Binary tree representation and traversals – Application of trees – Binary Search Tree - Heaps - Operations of Heaps - Binary Heap - Max Heap - Min Heap - Graph and its representations – Graph Traversals – Representation of Graphs – Breadth-first search – Depth-first search.</td></tr>
<tr><td>UNIT V</td><td colspan="2">SORTING AND SEARCHING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Sorting algorithms: Insertion sort – Quick sort – Merge sort – Searching: Linear search –Binary Search</td></tr>
<tr><td colspan="7">Total (45 L) =45 Periods</td></tr>
</table>

Text Books:	
1	Deitel and Deitel, “C++, How To Program”, Tenth Edition, Pearson Education, 2017.
2	Mark Allen Weiss, “Data Structures and Algorithm Analysis in C++”, Fourth Edition, Addison Wesley, Copyright 2014.
Reference Books:	
1	Bhushan Trivedi, “Programming with ANSI C++, A Step-By-Step approach”, Oxford University Press,2010.
2	Goodrich, Michael T., Roberto Tamassia, David Mount, “Data Structures and Algorithms in C++”, 7thEdition, Wiley. 2004.
3	Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, “Introduction to Algorithms”, Second Edition, Mc Graw Hill, 2002.
4	Bjarne Stroustrup, “The C++ programming language”, Fourth Edition Addison Wesley, 2013.
5	Ellis Horowitz, Sartaj Sahni and Dinesh Mehta, “Fundamentals of Data Structures in C++”, Galgotia Publications, 2007.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand the concepts of Object oriented programming	Understand
CO2	Design linear and non-linear data structure using object oriented programming concepts	Apply
CO3	Apply various sorting and searching Alogarithms.	Analyze

22CSOE08	**CLOUD COMPUTING FUNDAMENTALS**				
PREREQUISITES:	**CATEGORY**	**OE**	**Credit**		**3**
Computer Networks	**Hours/Week**	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives:

1.	To introduce the broad perceptive of Parallel Computing, Distributed Computing and Cloud Computing.
2.	To understand the concept of Virtualization, Cloud Architecture and Storage.
3.	To understand the Cloud Platforms in Industry and Software Environments.
4.	To understand the concept of Cloud Security and Applications.

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

The vision of Cloud Computing – Defining a Cloud – The Cloud Computing reference model –Characteristics and Benefits; Historical developments: Distributed systems – Virtualization - Web 2.0 - Service-oriented computing - Utility-oriented computing.
Principles of Parallel and Distributed Computing: Parallel vs. distributed computing - Elements of parallel and distributed computing - Technologies for distributed computing.

UNIT II	**VIRTUALIZATION**	**9**	**0**	**0**	**9**

Introduction - Characteristics of Virtualized environments - Virtualization techniques: Machine Reference Model – Hardware Level Virtualization - Programming Language Level Virtualization –Application Level Virtualization - Other types of Virtualization - Pros and cons of Virtualization.

UNIT III	**CLOUD ARCHITECTURE AND STORAGE**	**9**	**0**	**0**	**9**

The cloud reference model: IaaS, PaaS, SaaS; Types of clouds: Public clouds – Private clouds – Hybrid clouds – Community clouds ;Architectural design challenges.
Cloud Storage: Storage as a Service – Advantages of cloud storage – Cloud Storage Provider: Amazon Simple Storage Service (S3).

UNIT IV	**CLOUD INDUSTRIAL PLATFORMS AND SOFTWARE ENVIRONMENTS**	**9**	**0**	**0**	**9**

Cloud Platforms in Industry: Amazon Web Service - Google App Engine - Microsoft Azure; Cloud Software Environments -Hadoop –Map Reduce -Eucalyptus – Open Nebula;

UNIT V	**CLOUD SECURITY AND APPLICATIONS**	**9**	**0**	**0**	**9**

Security in the cloud: Cloud Security challenges – Software as a Service Security: Security Management – Security governance – Security Architecture Design -Virtual Machine Security – Identity Access Management.
Cloud Scientific Applications: Healthcare: ECG analysis in the cloud- Geo science: Satellite Image Processing.

Total (45 L)=45 Periods

Text Books:

1.	Rajkumar Buyya, Christian Vecchiola, S.TamaraiSelvi, ‘Mastering Cloud Computing-Foundations and Applications Programming”, TMGH,2013.
2.	Rittinghouse, John W., and James F. Ransome – Cloud Computing: Implementation, Management and Security. CRC Press, 2017.

Reference Books:

1.	Kai Hwang.GeoffreyC.Fox.JackJ.Dongarra, “ Distributed and Cloud Computing ,From Parallel Processing to The Internet of Things”, 2012 Elsevier
2.	Barrie Sosinsky, “Cloud Computing Bible”, Wiley Publisher, 2011

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the main concepts and architecture of Parallel computing, Distributed Computing and Cloud Computing.	Understand
CO2	Analyze the concept of Virtualization, Cloud Architecture and Storage.	Analyze
CO3	Analyze the Cloud Platforms in Industry and Software Environments.	Analyze
CO4	Identify the security issues in scientific and real time applications.	Apply

22CSOE09	**ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING**				
PREREQUISITES:	**CATEGORY**	**OE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives:

1. To learn the various characteristics of Intelligent agents, different search strategies and represent knowledge in solving AI problems
2. To understand the need for machine learning for various problem solving
3. To study the various supervised, semi-supervised and unsupervised learning algorithms in machine learning

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

Introduction–Definition – Future of Artificial Intelligence – Characteristics of Intelligent Agents–Typical Intelligent Agents – Problem Solving Approach to Typical AI problems.

UNIT II	**PROBLEM SOLVING METHODS**	**9**	**0**	**0**	**9**

Problem solving Methods – Search Strategies- Uninformed – Informed – Heuristics – Local Search Algorithms and Optimization Problems – Searching with Partial Observations – Constraint Satisfaction Problems – Constraint Propagation – Backtracking Search – Game Playing – Optimal Decisions in Games – Alpha – Beta Pruning.

UNIT III	**KNOWLEDGE REPRESENTATION**	**9**	**0**	**0**	**9**

First Order Predicate Logic – Forward Chaining-Backward Chaining – Resolution – Knowledge Representation – Ontological Engineering-Categories and Objects – Events – Mental Events and Mental Objects – Reasoning Systems for Categories – Reasoning with Default Information.

UNIT IV	**LEARNING PROBLEMS**	**9**	**0**	**0**	**9**

Perspectives and Issues – Concept Learning – Version Spaces and Candidate Eliminations – Inductive bias – Decision Tree learning – Representation – Algorithm – Heuristic Space Search.

UNIT V	**NEURAL NETWORKS AND GENETIC ALGORITHMS**	**9**	**0**	**0**	**9**

Neural Network Representation – Problems – Perceptrons – Multilayer Networks and Back Propagation Algorithms – Advanced Topics – Genetic Algorithms – Hypothesis Space Search – Genetic Programming – Models of Evaluation and Learning.

Total (45 L)=45 Periods

Text Books:

1. S. Russell and P. Norvig, “Artificial Intelligence: A Modern Approach‖, Prentice Hall, Third Edition, 2009
2. I. Bratko, ―Prolog: Programming for Artificial Intelligence, Fourth edition, Addison-Wesley Educational Publishers Inc., 2011
3. Tom M. Mitchell, ―Machine Learning, McGraw-Hill Education (India) Private Limited, 2013.

Reference Books:

1. M. Tim Jones, ―Artificial Intelligence: A Systems Approach(Computer Science)‖, Jones and Bartlett Publishers, Inc.; First Edition, 2008
2. Nils J. Nilsson, ―The Quest for Artificial Intelligence‖, Cambridge University Press, 2009
3. William F. Clocksin and Christopher S. Mellish,‖ Programming in Prolog: Using the ISO Standard‖, Fifth Edition, Springer, 2003

E-References:	
1.	https://builtin.com/artificial-intelligence
2.	https://science.howstuffworks.com/robot6.htm
3.	https://onlinecourses.nptel.ac.in/noc18_cs40/preview, (Prof. Sudeshna Sarkar,IIT KHARAGPUR)
4.	Shai Shalev-Shwartz, Shai Ben-David, Understanding Machine Learning From Theory to Algorithms, Cambridge University Press, 2014
5.	Machine Learning. Tom Mitchell. First Edition, McGraw- Hill, 1997

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Use appropriate search algorithms for any AI problem	Apply
CO2	Represent a problem using first order and predicate logic	Understand
CO3	Differentiate between supervised, unsupervised, semi-supervised machine learning approaches	Analyze
CO4	Discuss the decision tree algorithm and identity and overcome the problem of over fitting	Apply

22ECOE01	**FUNDAMENTALS OF ELECTRON DEVICES**	**OPEN ELECTIVE**			
PREREQUISITES	**CATEGORY**	**OE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives:	
1.	To understand the fundamentals of electron devices and apply the knowledge of these devices in electronic circuits.
2.	To design and analyse single stage and multistage amplifier circuits.
3.	To understand and classify different kinds of power and feedback amplifiers.

Unit I	**SEMICONDUCTOR DIODE**	**9**	**0**	**0**	**9**
PN junction diode, Current equations, Energy Band diagram, Diffusion and drift current densities, forward and reverse bias characteristics, Transition and Diffusion Capacitances, Switching Characteristics, Breakdown in PN Junction Diodes.					
Unit II	**BIPOLAR JUNCTION TRANSISTORS**	**9**	**0**	**0**	**9**
NPN -PNP -Operations-Early effect-Current equations — Input and Output characteristics of CE, CB, CC – Hybrid - p model – h-parameter model, Multi Emitter Transistor.					
Unit III	**FIELD EFFECT TRANSISTORS**	**9**	**0**	**0**	**9**
JFETs — Drain and Transfer characteristics,-Current equations-Pinch off voltage and its significance- MOSFET-Characteristics- Threshold voltage, D-MOSFET, E-MOSFET- Characteristics — Comparison of MOSFET with JFET.					
Unit IV	**SPECIAL SEMICONDUCTOR DEVICES**	**9**	**0**	**0**	**9**
Metal-Semiconductor Junction- MESFET, FINFET, PINFET, CNTFET, DUAL GATE MOSFET, Schottky barrier diode-Zener diode-Varactor diode –Tunnel diode, LASER diode.					
Unit V	**POWER DEVICES AND DISPLAY DEVICES**	**9**	**0**	**0**	**9**
UJT, SCR, Diac, Triac, Power BJT- Power MOSFET- DMOS-VMOS, LED, LCD, Photo transistor, Opto Coupler, Solar cell, CCD.					
					Total (45L) = 45 periods

Text Books:	
1.	Millman and Halkias, “Electronic Devices and Circuits”, 4th Edition, McGraw Hill, 2015.
2.	Salivahanan. S, Suresh Kumar. N, Vallavaraj.A, “Electronic Devices and circuits”, Fourth Edition, Tata McGraw- Hill, 2016.
Reference Books:	
1.	Robert L. Boylestad and Louis Nashelsky, “Electronic Devices and Circuit Theory” Pearson Prentice Hall, 11th Edition, 2014.
2.	Bhattacharya and Sharma, “Solid State Electronic Devices”, 2nd Edition, Oxford University Press, 2014.
3.	R.S.Sedha, “A Textbook of Electronic Devices and Circuits”, 2nd Edition, S.Chand Publications, 2008.
4.	David A. Bell, “Electronic Devices and Circuits”, 5th Edition, Oxford University Press, 2008.

E-References:	
1.	https://archive.nptel.ac.in/courses/108/108/108108122/
2.	https://www.youtube.com/watch?v=qqQ8wO-lNmI
3.	https://slideplayer.com/slide/12438044/

Course Outcomes: Upon completion of this course, the students will be able to		Bloom's Taxonomy Mapped
CO1	Analyze the characteristics of semiconductor diodes.	Understanding
CO2	Describe the problems of Transistor circuits using model	Analysing
CO3	Analyze the knowledge of various types of FET.	Analysing
CO4	Gain a knowledge on special semiconductor devices	Understanding
CO5	Understand the knowledge on Power and Display devices.	Understanding

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	3	1	-	-	-	-	-	-	-	-	-	1	-	-
CO2	2	3	1	2	-	-	-	-	-	-	-	-	2	-	-
CO3	2	3	1	3	-	-	-	-	-	-	-	-	3	-	-
CO4	1	2	1	-	-	-	1	-	-	-	1	3	3	-	1
CO5	1	3	1	1	1	-	1	-	-	-	2	3	3	1	2
Avg	1.6	2.8	1	2	2	-	2	-	-	-	1.5	3	2.4	1	1.5
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

22ECOE02	**PRINCIPLES OF MODERN COMMUNICATION SYSTEMS**		**OPEN ELECTIVE**			
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:	
1.	To have the knowledge of the basic concepts of AM, FM and PM.
2.	To gain knowledge about different pulse modulation and digital modulation techniques.
3.	To gain knowledge about technical information on satellite communication and wireless communication

Unit I	**FUNDAMENTALS OF ANALOG COMMUNICATION**	**9**	**0**	**0**	**9**
Modulation: Introduction - Amplitude modulation: Modulator and demodulator with waveforms - Angle Modulation: Frequency modulation: Modulator and demodulator with waveforms - Phase modulation - Equivalence between PM and FM - FM transmitters and receivers (Block diagram approach only) - Comparison of various Analog Communication System (AM – FM – PM).					
Unit II	**BASICS OF DIGITAL COMMUNICATION AND PULSE MODULATION**	**9**	**0**	**0**	**9**
Pulse Amplitude Modulation (PAM) – Pulse Width Modulation (PWM) – Pulse code Modulation (PCM)–Differential Pulse Code Modulation - Pulse Position modulation: Generation and detection - Comparison of various Pulse Communication System (PAM – PWM – PCM - PPM).					
Unit III	**DIGITAL MODULATION TECHNIQUES**	**9**	**0**	**0**	**9**
Amplitude Shift Keying (ASK) – Frequency Shift Keying (FSK) - Minimum Shift Keying (MSK) –Binary Phase Shift Keying (BPSK) – QPSK –M- ary PSK- Comparison of various Digital Communication System (ASK – FSK – PSK).					
Unit IV	**SATELLITE COMMUNICATION**	**9**	**0**	**0**	**9**
History of Satellites- Kepler's laws - Satellite Orbits-Geo synchrous Satellites - Satellite Classification - Footprints - Satellite system link models: Uplink model and down link model - Multiple Access Techniques: TDMA - FDMA-CDMA-SDMA - Comparison of Multiple Access Schemes - various satellite services.					
Unit V	**CELLULAR MOBILE COMMUNICATION**	**9**	**0**	**0**	**9**
Cellular concept - Frequency reuse-Channel Assignment Strategy - Hand off mechanism - Basic propagation models: Reflection - diffraction and scattering - Bluetooth-WLAN-Global System for Mobile Communications (GSM) –GPRS.					
					Total (45L)= 45 Periods

Text Books:	
1.	Rappaport T.S, "Wireless Communications: Principles and Practice", 2nd Edition, Pearson Education, 2007
2.	Simon Haykin, "Communication Systems", 4th Edition, John Wiley & Sons, 2010
Reference Books:	
1.	Dennis Roddy, John Coolen, "Electronic Communications", Prentice Hall of India, 4th Edition.,2016
2.	H.Taub, D L Schilling and G Saha, "Principles of Communication", 3rd Edition, Pearson Education, 2007.
3.	B. P.Lathi, "Modern Analog and Digital Communication Systems", 3rd Edition, Oxford University Press, 2007.
4.	AnokhSingh , "Principles of Communication Engineering" ,S.CHAND Publication, 2002

E-References:	
1.	http://www.nptelvideos.in/2012/11/communication-engineering.html
2.	https://www.tutorialspoint.com/analog_communication/analog_communication_introduction.htm
3.	https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-973-communication-system-design-spring-2006/lecture-notes/

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom’s Taxonomy Mapped
CO1	Understand the need for modulation and how analog modulation takes place	Understanding
CO2	Understand the features of digital communication and pulse modulation.	Understanding
CO3	Analyse various digital modulation schemes.	Analysing
CO4	Have the knowledge about satellite communication.	Remembering
CO5	Have the basics of wireless and mobile communication.	Remembering

COURSE ARTICULATION MATRIX

COs/POs	PO 1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	1	2	1	-	-	-	-	-	-	-	3	2	2
CO2	2	2	1	1	1	-	-	-	-	-	-	-	2	1	2
CO3	1	3	2	2	1	-	-	-	-	-	-	-	3	1	2
CO4	2	2	1	1	1	-	-	-	-	-	-	-	3	2	2
CO5	1	2	2	1	1	-	-	-	-	-	-	-	3	2	2
Avg	1.6	2.2	1.4	1.4	1	-	-	-	-	-	-	-	2.8	1.6	2

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

22ECOE03	**MICROCONTROLLERS AND ITS APPLICATIONS**	**OPEN ELECTIVE**			
PREREQUISITES	**CATEGORY**	**OE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives:

1.	To learn microcontroller basics and get exposure to 8051 architectures
2.	To embed and program with 8051 microcontrollers
3.	To introduce the advanced features in microcontrollers and its applications

Unit I	**INTRODUCTION TO 8051 MICROCONTROLLER**	**9**	**0**	**0**	**9**

Introduction to the concepts of microprocessors, microcontrollers, RISC, CISC, Harvard and Von Neumann architectures. Selection of microcontrollers, variants of MCS-51 family and their features. Applications of microcontrollers. 8051 architecture - Registers in 8051 - Pin description - 8051 parallel I/O ports - memory organization.

Unit II	**ASSEMBLY LANGUAGE PROGRAMMING**	**9**	**0**	**0**	**9**

Features of machine language, assembly language, middle-level and high-level languages. 8051 Addressing modes. Instruction set: Classification, syntax and function of instructions, example programs.

Unit III	**I/O PORT AND INTERRUPTS PROGRAMMING**	**9**	**0**	**0**	**9**

Features of I/O ports. Byte size I/O, bit addressability and configuring I/O ports, interface I/O devices such as LED, buzzer, push-button switch, relay, example programs with assembly. Polling & interrupt methods, executing an interrupt, different types, IE and IP registers, enabling, disabling and priority setting, example programs in assembly.

Unit IV	**PIC MICROCONTROLLERS**	**9**	**0**	**0**	**9**

Main characteristics of PIC microcontrollers – PIC microcontroller families-12-bit instruction word-14-bit instruction word-16-bit instruction word-Inside a PIC microcontroller.

Unit V	**APPLICATIONS**	**9**	**0**	**0**	**9**

Multiplexed seven-segment display, LCD module, ADC 0804, wave form generation using DAC 0808, DC motor-PWM for speed control, Stepper motor, appropriate program.

Total (45L)= 45 Periods

Text Books:

1.	A.Mazidi , J.C. Mazidi&R.D.McKinlay,” The 8051 Microcontroller & Embedded systems using assembly and C” (2ndEdition)
2.	Lucio Di Jasio et.al., “PIC Microcontrollers: Know It All”, Elsevier Science,2007

Reference Books:

1.	Microcontrollers & applications, Ramani Kalpathi, & Ganesh Raja
2.	Embedded C - Michael .J.Pont - Pearson Education -2002
3.	I. Scott MacKenzie, Raphael C.-W. Phan “The 8051 Microcontroller” , Pearson/Prentice Hall Publishers, 2008.
4.	M. Mahalakshmi, “8051 Microcontroller Architecture, Programming and Application”, Laxmi Publications , 2008.

E-References:

1.	https://nptel.ac.in/courses/108105102
2.	https://www.youtube.com/playlist?list=PLm_MSClsnwm9hEIDpFfDnOEu-6kVnF4ug
3.	http://www.satishkashyap.com/2012/02/video-lectures-on-microprocessors-and.html

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand the basics of microcontroller and 8051 architectures.	Understanding
CO2	Develop programs for control applications using assembly language	Applying
CO3	Illustrate the use of interrupts service routines	Applying
CO4	Understand the PIC microcontroller architecture.	Understanding
CO5	Design microcontroller based simple real-world applications	Applying

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	2	-	2	-	2	-	-	-	-	-	-	3	-	2
CO2	1	2	-	-	-	2	-	-	-	-	-	-	-	-	1
CO3	2	2	-	3	-	1	-	-	-	-	-	-	2	-	3
CO4	1	3	-	2	-	2	-	-	-	-	-	-	2	-	1
CO5	2	3	-	1	-	2	-	-	-	-	-	-	2	-	2
Avg	1.4	2.4	-	2	-	1.8	-	-	-	-	-	-	2.25	-	1.8
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

<table>
<tr><td>22ECOE04</td><td colspan="2">COMPUTER NETWORKS</td><td colspan="4">OPEN ELECTIVE</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>CATEGORY</td><td>OE</td><td colspan="2">Credit</td><td>3</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>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="6">To introduce the basic concept in modern data communication and computer networking.</td></tr>
<tr><td>2.</td><td colspan="6">To introduce the students the functions of different layers and in - depth knowledge of data link layer.</td></tr>
<tr><td>3.</td><td colspan="6">To make students to get familiarized with different protocols and network layer components.</td></tr>
<tr><td>4.</td><td colspan="6">To introduce the basic functions of transport layer and congestion in networks.</td></tr>
<tr><td>5.</td><td colspan="6">To understand the concepts of various network Applications and Data security.</td></tr>
<tr><td>Unit I</td><td colspan="2">NETWORK FUNDAMENTALS AND PHYSICAL LAYER</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Components – networks – Topologies – The OSI reference model - layers and duties. TCP/IP reference model – layers and duties, Physical Layer: Transmission Media – Guided media & unguided media - EIA 232, SONET</td></tr>
<tr><td>Unit II</td><td colspan="2">DATA LINK LAYER</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Logical link control Functions: - Framing, Flow control, Error control: CRC, LLC protocols -HDLC, P to P- Medium access layer: - Random access, Controlled access, Channelization - Wired LANs: Ethernet IEEE 802.3, IEEE 802.4, and IEEE 802.5. Internetworking, Interconnection issues, Interconnection devices: - Repeaters, Hubs, Routers/switches and Gateways.</td></tr>
<tr><td>Unit III</td><td colspan="2">NETWORK LAYER</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Switching-Circuit switching, packet switching, message switching. Internet protocols; IPV4, IPV6, ARP, RARP, VPN. Network Routing Algorithms - Unicast routing protocol: Distance Vector Routing – Link State Routing.</td></tr>
<tr><td>Unit IV</td><td colspan="2">TRANSPORT LAYER</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Transport Services, Elements of Transport protocols, Connection management, – User Datagram Protocol (UDP) – Transmission Control Protocol (TCP) – Congestion Control and Quality of services (QoS) – Integrated Services</td></tr>
<tr><td>Unit V</td><td colspan="2">APPLICATION LAYER</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Domain Name Space (DNS) – Electronic mail (SMTP, MIME, POP3, IMAP4) - Application protocols: WWW, HTTP, FTP and TELNET, Network management protocol: SNMP.</td></tr>
<tr><td colspan="7" align="right">Total (45L)= 45 Periods</td></tr>
</table>

Text Books:	
1.	Behrouz A. Foruzan, “Data communication and Networking”, TMH, 4th edition, 2014.
2.	James. F. Kurouse& W. Ross, “Computer Networking: A Top down Approach Featuring”, Pearson, 2020.
Reference Books:	
1.	LarryL.Peterson&PeterS.Davie,“ComputerNetworks”,HarcourtAsiaPvt.Ltd.,SecondEdition.
2.	AndrewS.Tanenbaum,“ComputerNetworks”,PHI,FourthEdition,2003.
3.	An Engineering Approach to Computer Networks-S. Keshav, 2nd Edition, Pearson Education
4.	AjitPal,“DataCommunicationandComputerNetworks”,PHI,2014.
E-References:	
1.	https://nptel.ac.in/courses/106105183
2.	https://www.mbit.edu.in/wp-content/uploads/2020/05/Computer-Networks-5th-Edition.pdf
3.	https://www.tutorialspoint.com/data_communication_computer_network/index.htm

Course Outcomes: Upon completion of this course, the students will be able to:			Bloom's Taxonomy Mapped
CO1	:	Explain the basic concept in modern data communication and different level of layers in the protocol	Understanding
CO2	:	Analyse the functions and services of data link layer	Analysing
CO3	:	Categorize the functions and services of network layer	Understanding
CO4	:	Examine the basic functions of transport layer and congestion in networks	Understanding
CO5	:	Analyse the concepts of various network applications and data security	Analysing

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	1	-	1	-	-	-	-	-	-	-	2	-	1
CO2	2	1	2	-	1	-	-	-	-	-	-	-	2	1	1
CO3	2	1	1	-	-	-	-	-	-	-	-	-	3	1	2
CO4	3	2	1	-	2	-	-	-	-	-	-	-	2	-	2
CO5	2	1	1	-	1	-	-	-	-	-	-	-	1	1	1
Avg	2.2	1.2	1.2	-	1.25	-	-	-	-	-	-	-	2	1	1.4
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

22ECOE05	**BASICS OF EMBEDDED SYSTEMS**		**OPEN ELECTIVE**			
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:	
1.	To impart knowledge on embedded system architecture and embedded development Strategies
2.	To understand the bus Communication in processors and peripheral interfacing
3.	To understand basics of Real Time Operating System

Unit I	**BASICS OF EMBEDDED SYSTEMS**	**9**	**0**	**0**	**9**
Introduction - Fundamental Components of Embedded Systems - Challenges for Embedded Systems - Examples - Programming Languages - Recent Trends in Embedded Systems - Architecture of Embedded Systems - Embedded Design Life Cycle - Selection Process - Hardware Software Partitioning - Development Environment.					
Unit II	**MEMORY MANAGEMENT AND INTERRUPTS**	**9**	**0**	**0**	**9**
Memory Access Procedure - Types of Memory - Memory Management Methods - DMA – Memory Interfacing - Polling Vs Interrupts - Types of Interrupts - Interrupt Latency - Interrupt Priority – Programmable Interrupt Controllers - Interrupt Service Routines.					
Unit III	**COMMUNICATION INTERFACES**	**9**	**0**	**0**	**9**
Interfacing Buses - Serial Interfaces - RS232/UART - RS422/RS485 - I2C Interface - SPI Interface - USB – CAN - IRDA - Ethernet - IEEE 802.11 – Bluetooth					
Unit IV	**REAL TIME OPERATING SYSTEMS**	**9**	**0**	**0**	**9**
Real-Time Concepts - Task Management - Task Scheduling - Classification of Scheduling Algorithms - Clock Driven Scheduling - Event Driven Scheduling - Resource Sharing - Priority Inheritance Protocol - Priority Ceiling Protocol - Inter Task Communication - Mutex - Semaphores - Message Queues - Timers - Commercial RTOS.					
Unit V	**VALIDATION AND DEBUGGING**	**9**	**0**	**0**	**9**
Host and Target Machines - Validation Types and Methods - Host Testing - Host-Based Testing Setup - Target Testing - Remote Debuggers and Debug Kernels - ROM Emulator - Logical Analyzer – Background Debug Mode - InCircuit Emulator CASE STUDY: RFID Systems - GPS Navigation System – Development of Protocol Converter.					
					Total (45L)= 45 Periods

Text Books:	
1.	Sriram VIyer and Pankaj Gupta, ―Embedded Real-time Systems Programming‖, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2006.
2.	Arnold S Berger, ―Embedded Systems Design - An Introduction to Processes, Tools and Techniques, Elsevier, New Delhi, 2011.
Reference Books:	
1.	Prasad K V K K, ―Embedded/Real-Time Systems: Concepts, Design and Programming – The Ultimate Reference, Himal Impressions, New Delhi, 2003
2.	Heath, "Embedded Systems Design‖", Newnes an Imprint of Elsevier, Massachusetts, 2003.
3.	Tammy Noergaard, "Embedded Systems Architecture‖, Newnes an Imprint of Elsevier, Massachusetts, 2006.
4.	Raj Kamal, 'Embedded System-Architecture, Programming, Design', McGraw Hill, 2013
E-References:	
1.	https://lecturenotes.in/subject/225/embedded-system-es
2.	https://nptel.ac.in/courses/108102045/19
3.	https://www.coursera.org/learn/introduction-embedded-systems.

Course Outcomes: Upon completion of this course, the students will be able to		**Bloom's Taxonomy Mapped**
CO1	Outline the concepts of embedded systems	Remembering
CO2	Understand the concept of memory management system and interrupts.	Understanding
CO3	Know the importance of interfaces.	Understanding
CO4	Understand real time operating system concepts.	Understanding
CO5	To realize the applications of validation and debugging.	Applying

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	1	3	3	3	2	-	-	-	3	3	3	-	2
CO2	3	3	2	3	3	3	2	-	-	-	3	3	3	-	2
CO3	3	3	3	3	3	3	2	-	-	-	3	3	3	-	2
CO4	3	3	2	3	3	3	2	-	-	-	2	3	3	-	2
CO5	3	3	2	3	3	3	2	-	-	-	3	3	3	-	2
Avg	3	3	2	3	3	3	2	-	-	-	2.8	3	3	-	2
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

22ECOE06	**BASICS OF INTERNET OF THINGS**	**OPEN ELECTIVE**

PREREQUISITES	**CATEGORY**	**OE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives:	
1.	To understand the vision of M2M to IOT.
2.	To gain an understanding of IOT market perspective.
3.	To acquire knowledge on Io T Technology Fundamentals and applications
4.	To build small system using Raspberry Pi.

Unit I	**M2M TO IOT – THE VISION**	**9**	**0**	**0**	**9**

Introduction - From M2M to Io T- M2M towards Io T: M2M Communication - The global context - A use case example – Differing Characteristics.

Unit II	**M2M TO IOT – A MARKET PERSPECTIVE**	**9**	**0**	**0**	**9**

Introduction - Some Definitions - M2M Value Chains – Io T Value Chains - An emerging industrial structure for Io T- International driven global value chain and global information monopolies - M2M to Io T-An Architectural Overview – Building an architecture - Main design principles and needed capabilities - An Io T architecture outline - Standards considerations.

Unit III	**IOT TECHNOLOGY FUNDAMENTALS**	**9**	**0**	**0**	**9**

Io T Enabling technologies – Io T levels and deployment templates - Devices and gateways - Data management - Business processes in Io T - Everything as a Service (XaaS) - M2M and Io T Analytics.

Unit IV	**BUILDING IOT WITH HARDWARE PLATFORMS**	**9**	**0**	**0**	**9**

Io T Systems-Logical Design using Python –Io T Physical Devices and End Points- Io T Device - Raspberry Pi - Interfaces – Programming – Other Io T devices – Io T Reference Model - Real World Design Constraints.

Unit V	**IOT USE CASES AND APPLICATIONS**	**9**	**0**	**0**	**9**

Home automation-Automatic lighting-Home intrusion detection- Cities-Smart parking – Environment - Weather monitoring system-Air pollution Monitoring-Forest Fire Detection- Agriculture- Smart irrigation. Commercial Building Automation – Introduction - Case study (Phase one) : Commercial building automation today - Case study (Phase two) - Commercial building automation in the future.

Total (45L)= 45 Periods

Text Books:	
1.	Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stefan Avesand, StamatisKarnouskos, David Boyle, “From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence”, 1st Edition, Academic Press, 2014.
2.	Arshdeep Bahga, Vijay Madisetti, “Internet of Things-A hands-on approach”, Universities Press, 2015
Reference Books:	
1.	Olivier Hersent, davidBoswarthick, Omar Elloumi, ‘The Internet of Things Applications to the smart grid building automation’, John Wiley & Sons, 2012
2.	Francis daCosta, “Rethinking the Internet of Things : A Scalable Approach to Connecting Everything”, 1st Edition, Apress Publications, 2013
3.	HakimaChaouchi, ‘The Internet of Things Connecting Objects’, John Wiley & Sons, 2010.
4.	FabriceTheoleyr, Ai-Chun Pang, ‘Internet of Things and M2M Communications’, River Publishers, 2013.
E-References:	
1.	https://nptel.ac.in/courses/106105166
2.	https://onlineitguru.com/IoT-online-training.html
3.	https://onlinecourses.nptel.ac.in/noc22_cs53/preview

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the vision of IoT from a global context.	Understanding
CO2	:	Determine the Market perspective of IoT.	Remembering
CO3	:	Understand the IoT technology fundamentals.	Understanding
CO4	:	Build small system using Raspberry Pi.	Applying
CO5	:	Analyse applications of IoT and case studies	Analysing

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	-	1	-	-	2	-	-	-	-	-	-	-	-	-	-
CO2	2	2	2	2	2	-	-	-	-	-	-	1	1	-	-
CO3	2	2	2	2	2	-	-	-	-	-	-	1	1	-	-
CO4	2	2	2	2	2	-	-	-	-	-	2	2	2	-	-
CO5	2	2	2	2	2	-	-	-	-	-	2	-	2	-	2
Avg	2	1.8	2	2	2	-	-	-	-	-	2	1.3	1.5	-	2
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

22ECOE07	BASICS OF ARTIFICIAL INTELLIGENCE	OPEN ELECTIVE			
PREREQUISITES	**CATEGORY**	**OE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives:	
1.	Study about uninformed and Heuristic search techniques.
2.	To Learn techniques for reasoning under uncertainty
3.	Introduce Machine Learning and supervised learning algorithms
4.	Study about ensemble and unsupervised learning algorithms.
5.	Learn the basics of deep learning using neural networks.

Unit I	**PROBLEM SOLVING**	**9**	**0**	**0**	**9**
Introduction to AI - AI applications – problem solving agents – search algorithms – Uninformed search strategies – Heuristic search strategies – local search and optimization problems –adversarial search – constraing satisfaction problems(CSP) .					
Unit II	**PROBABILISTIC REASONING**	**9**	**0**	**0**	**9**
Acting under uncertainty – Bayesian inference – naïve bayes models. Probabilistic reasoning – Bayesian networks – exact inference in BN – approximate inference in BN – causal networks.					
Unit III	**SUPERVISED LEARNING**	**9**	**0**	**0**	**9**
Introduction to machine learning – Linear Regression Models: Least squares, single & multiple variables, Bayesian linear regression, gradient descent, Linear Classification Models: Discriminant function – Probabilistic discriminative model - Logistic regression, Probabilistic generative model – Naive Bayes, Maximum margin classifier – Support vector machine, Decision Tree.					
Unit IV	**ENSEMBLE TECHNIQUES AND UNSUPERVISED LEARNING**	**9**	**0**	**0**	**9**
Combining multiple learners: Model combination schemes, Voting, Ensemble Learning - bagging, boosting, stacking, Unsupervised learning: K-means, Instance Based Learning: KNN					
Unit V	**NEURAL NETWORKS**	**9**	**0**	**0**	**9**
Perceptron - Multilayer perceptron, activation functions, network training – gradient descent optimization – stochastic gradient descent, error backpropagation, from shallow networks to deep networks –Unit saturation (aka the vanishing gradient problem) –batch normalization, regularization, dropout.					
					Total (45L)= 45 Periods

Text Books:	
1.	Stuart Russell and Peter Norvig, “Artificial Intelligence – A Modern Approach”, Fourth Edition, Pearson Education, 2021
2.	Christopher M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2006
Reference Books:	
1.	Ethem Alpaydin, “Introduction to Machine Learning”, MIT Press, Fourth Edition, 2020.
2.	Kevin Night, Elaine Rich, and Nair B., “Artificial Intelligence”, McGraw Hill, 2008
3.	Patrick H. Winston, "Artificial Intelligence", Third Edition, Pearson Education, 2006
4.	Tom Mitchell, “Machine Learning”, McGraw Hill, 3rd Edition,1997.
E-References:	
1.	https://machinelearningmastery.com/
2.	https://ai.google/education/
3.	https://in.coursera.org/learn/machine-learning

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom’s Taxonomy Mapped
CO1	Use appropriate search algorithms for problem solving	Understanding
CO2	Apply reasoning under uncertainty	Applying
CO3	Build supervised learning models	Applying
CO4	Build ensembling and unsupervised models	Applying
CO5	Build deep learning neural network models	Applying

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	2	1	1	-	-	-	-	-	1	1	2	2	2
CO2	2	1	2	1	1	-	-	-	-	-	1	1	2	2	2
CO3	2	2	3	2	1	-	-	-	-	-	3	2	2	2	2
CO4	2	2	2	1	1	-	-	-	-	-	3	2	2	2	2
CO5	2	2	3	2	1	-	-	-	-	-	3	2	2	2	2
Avg	2	1.6	2.4	1.4	1	-	-	-	-	-	2.2	1.6	2	2	2
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

22EEOE01	**RENEWABLE ENERGY SOURCES**		**SEMESTER**			**VI / VII**
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
Basic Electrical and Electronics Engineering		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**
Course Objectives:						
1.	To impart knowledge on the different renewable energy sources and technologies.					
UNIT I	**INTRODUCTION**		**9**	**0**	**0**	**9**
World Energy Use – Reserves of Energy Resources – Environmental Aspects of Energy Utilisation – Renewable Energy Scenario in Tamil Nadu, India and around the World – Potentials – Achievements / Applications – Economics of Renewable Energy Systems.						
UNIT II	**SOLAR ENERGY**		**9**	**0**	**0**	**9**
Solar Radiation – Measurements of Solar Radiation – 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 PV Applications.						
UNIT III	**WIND ENERGY**		**9**	**0**	**0**	**9**
Wind Data and Energy Estimation – Types of Wind Energy Systems – Performance – Site Selection – Details of Wind Turbine Generator – Safety and Environmental Aspects.						
UNIT IV	**BIO – ENERGY**		**9**	**0**	**0**	**9**
Biomass Direct Combustion – Biomass Gasifiers – Biogas Plants – Digesters – Ethanol Production – Bio Diesel – Cogeneration – Biomass Applications.						
UNIT V	**OTHER RENEWABLE ENERGY SOURCES**		**9**	**0**	**0**	**9**
Tidal Energy – Wave Energy – Open and Closed Ocean Thermal Energy Conversion(OTEC) Cycles – Small Hydro-Geothermal Energy – Hydrogen and Storage – Fuel Cell Systems – Hybrid Systems.						
						Total (45L+0T) = 45 Periods

Text Books:	
1.	Rai. G.D., “Non-Conventional Energy Sources”, Khanna Publishers, New Delhi, 2011.
2.	Twidell, J.W. & Weir, A., “Renewable Energy Sources”, EFN Spon Ltd., UK, 2006.
3.	Godfrey Boyle, “Renewable Energy, Power for A Sustainable Future”, Oxford University Press, U.K., 1996.
Reference Books:	
1.	Chetan Singh Solanki, Solar Photovoltaics, “Fundamentals, Technologies and Applications”, PHI Learning Private Limited, New Delhi, 2009.
2.	Tiwari. G.N., Solar Energy – “Fundamentals Design, Modelling & Applications”, Narosa Publishing House, New Delhi, 2002.
3.	Freris. L.L., “Wind Energy Conversion Systems”, Prentice Hall, UK, 1990.
4.	Johnson Gary, L. “Wind Energy Systems”, Prentice Hall, New York, 1985
5.	David M. Mousdale – “Introduction to Biofuels”, CRC Press, Taylor & Francis Group, USA 2010

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Recall the available renewable Energy Sources	L1: Remembering
CO2	:	Illustrate the types of generators.	L4: Analysing
CO3	:	Apply different types of mechanism for energy conversion.	L3: Applying
CO4	:	Analyze the benefits and challenges in harnessing renewable Energy.	L4: Analysing
CO5	:	Recognize and apply appropriate renewable energy sources.	L2: Understanding

COURSE ARTICULATION MATRIX														
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2	1	1	1	2	1	1	1	1	1	1	1	1	1	1
CO2	3	1	1	3	1	1	1	1	1	1	1	1	2	1	1
CO3	1	2	2	1	1	1	1	1	1	1	1	1	2	1	1
CO4	3	1	1	3	2	1	1	1	1	1	1	1	2	1	1
CO5	2	1	1	2	1	1	2	1	1	1	1	1	2	1	1
Avg	**2.2**	**1.2**	**1.2**	**2**	**1.4**	**1**	**1.2**	**1**	**1**	**1**	**1**	**1**	**1.7**	**1.2**	**1**
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

22EEOE02	**INDUSTRIAL DRIVES**			**SEMESTER**			**VI / VII**
PREREQUISITES			**CATEGORY**	**OE**	**Credit**		**3**
Power Electronics, and Electrical Machines			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To understand the basic components of electric drive system,
2.	To analyze the operation and performance of the chopper fed DCdrive,
3.	To understand the operation and performance of AC motor drives
4.	To understand the advanced techniques in the control of industrial drives.

Unit I	**BASICS OF ELECTRIC DRIVE**	**9**	**0**	**0**	**9**

Electric drive - introduction and advantages, types and choice of electric drive, components of electric drive system, motor duty class classification continuous, short time and intermittent duty, speed-torque characteristics of DC and Induction motor drive.

Unit II	**DC DRIVES**	**9**	**0**	**0**	**9**

Review of dc chopper and duty ratio control, chopper fed dc motor for speed control, steady state operation of a chopper fed drive, armature current waveform and ripple, calculation of losses in dc motor and chopper, efficiency of dc drive, smooth starting,

Review of motoring and generating modes operation of a separately excited dc machine, four quadrant operation of dc machine; single-quadrant, two-quadrant and four-quadrant choppers; steady-state operation of multi-quadrant chopper fed dc drive, regenerative braking

Unit III	**AC DRIVES**	**9**	**0**	**0**	**9**

Review of induction motor equivalent circuit and torque-speed characteristic, variation of torque speed curve with applied voltage, applied frequency and applied voltage and frequency, typical torque-speed curves of fan and pump loads, operating point, constant flux operation, flux weakening operation.

Unit IV	**CONTROL OF DC AND AC DRIVES**	**9**	**0**	**0**	**9**

Control structure of DC drive, inner current loop and outer speed loop, dynamic model of dc motor dynamic equations and transfer functions, modeling of chopper as gain with switching delay, plant transfer function, for controller design, current controller specification and design, speed controller specification and design.

Generation of three-phase PWM signals, sinusoidal modulation, space vector theory, conventional space vector modulation; constant V/f control of induction motor. Operation of slip-ring induction motor with external rotor resistance, power electronic based rotor side control of slip ring motor, slip power recovery schemes.

Unit V	**ADVANCED TECHNIQUES**	**9**	**0**	**0**	**9**

Microcontroller based control of DC drive, Phase locked loop control of DC motor, AC/DC drive using microprocessor. Synchronous motor drives, Stepper motor - ratings, specifications, stepper motor drive employing microcontroller.

Total (45L+0T) = 45 Periods

Text Books:

1.	G. K. Dubey, “Fundamentals of Electrical Drives”, CRC Press, 2002.
2.	Subrahmanyam, Vedam “Electrical Drives Concepts and Applications”, Mc-Graw Hill Publishing, New Delhi, 2016
3.	S.K.Pillai, “A first course on Electric Drives”, Wiley Eastern Ltd., New Delhi, 2016

Reference Books:

1.	G. K. Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall, 1989.
2.	W. Leonhard, “Control of Electric Drives”, Springer Science & Business Media, 2001.
3.	Jai P.Agrawal, “Power Electronics Systems - Theory and Design”, Pearson Education, Inc., New Delhi, 2016

Course Outcomes:

Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Identify the electric drive for the required speed-torque characteristics	L1: Remembering
CO2	:	Understand the functioning of DC drive using converters	L2: Understanding
CO3	:	Understand the functioning of AC drive using converters	L2: Understanding
CO4	:	Analyse the various control schemes for AC and DC drive	L4: Analyzing
CO5	:	To use microcontroller based system for motor control	L6: Creating

COURSE ARTICULATION MATRIX

COs/ POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	1	1	2	1							1	1	2	
CO2	2	2	2	3	2		1					1	1	2	
CO3	2	2	2	3	2		1					1	2	3	
CO4	2	3	3	3	3	1	2	2				3	2	3	2
CO5	1	2	2	3	3		2					3	1	2	2
Avg	**1.6**	**2**	**2**	**2.8**	**2.2**	**1**	**1.5**	**2**	**-**	**-**	**-**	**1.8**	**1.4**	**2.4**	**2**
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

22EEOE03	ENERGY CONSERVATION AND MANAGEMENT				SEMESTER			VI / VII
PREREQUISITES				**CATEGORY**	**OE**	**Credit**		**3**
Basic Electrical and Electronics Engineering or Principles of Electrical Engineering or Basic Electrical Engineering for Metallurgy				**Hours/Week**	**L**	**T**	**P**	**C**
					3	**0**	**0**	**3**
Course Objectives:								
1.	To understand basics of energy.							
2.	To familiarize the energy scenario in India.							
3.	To understand the energy conservation approaches.							
4.	To get knowledge on energy management approaches.							
5.	To update the knowledge in energy efficient technologies.							
UNIT I	**ENERGY SCENARIO**				**9**	**0**	**0**	**9**
Energy scenario of India – Present non-renewable energy scenario – Gross domestic product- Energy intensity – Current energy production and pricing – Energy security - Energy strategy for the future, air pollution, climate change. Energy Conservation Act-2001 and its features.								
UNIT II	**BASICS OF ENERGY**				**9**	**0**	**0**	**9**
Introduction – Work, power and energy – Electricity basics – Thermal energy basics – Energy units and conversions – Energy performance – Matching energy usage to requirement.								
UNIT III	**ENERGY CONSERVATION APPROACHES**				**9**	**0**	**0**	**9**
Energy saving opportunities in electric motors, Benefits of Power factor improvement and its techniques-Shunt capacitor, Synchronous Condenser etc., Energy conservation by industrial drives, Methods and techniques of energy conservation in ventilation and air conditioners, compressors pumps, fans and blowers. Energy conservation in electric furnaces, ovens and boilers., lighting techniques – Natural , CFL, LED lighting sources and fittings.								
UNIT IV	**ENERGY MANAGEMENT**				**9**	**0**	**0**	**9**
Demand side management (DSM)– DSM planning – DSM Techniques – Load management as a DSM strategy – energy conservation – tariff options for DSM - Energy audit – instruments for energy audit – Energy audit for generation, distribution and utilization systems – economic analysis.								
UNIT V	**ENERGY EFFICIENT TECHNOLOGIES**				**9**	**0**	**0**	**9**
Maximum demand controllers - Automatic power factor controllers - Energy efficient motors -Softstarters with energy saver - Variable speed drives - Energy efficient transformers - Electronic ballast - Occupancy sensors - Energy efficient lighting controls - Energy saving potential of each technology.								
Total (45 L+0 T)= 45 Periods								

Text Books:	
1.	Sonal Desai, “Handbook of Energy Audit”, McGraw Hill, 2015.
2.	Tripathy, S. C, “Utilization of Electrical Energy and Conservation”, McGraw Hill, 1991.
Reference Books:	
1.	Guide books for National Certification Examination for Energy Manager / Energy AuditorsBook-1, General Aspects (available online).
2.	Guide books for National Certification Examination for Energy Manager / Energy AuditorsBook-3, Electrical Utilities (available online)
3.	Murphy. W.R and McKay. G, “Energy Management”, Butterworths Publications, London, 1982.
4.	Wayne C Tuner, “Energy Management Hand Book”, John Wiley and Sons, 1982.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Identify the present energy scenario.	L2: Understanding
CO2	:	Recognize the various form of energy.	L2: Understanding
CO3	:	Interpret the process of energy conservation.	L3: Applying
CO4	:	Categorize the methods improving energy management.	L4: Analysing
CO5	:	Examine the role of energy efficient devices in energy conservation	L4: Analysing

COURSE ARTICULATION MATRIX														
CO/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	1	2	3	2	2		3				2	2	2	2	1
CO 2	1	2	2	2	2		3				3	3	2	2	1
CO 3	2	2	2	3	2		3				2	3	1	3	1
CO 4	2	3	2	2	3		3				3	3	3	3	1
CO 5	2	2	3	1	2		3				2	1	3	2	1
Avg	**1.6**	**2.2**	**2.4**	**2**	**2.2**	**-**	**3**	**-**	**-**	**-**	**2.4**	**2.4**	**2.2**	**2.4**	**1**
3/ 2/ 1 – indicates strength of correlation (3- High, 2-Medium, 1-Low)															

22EEOE04	**ELECTRIC VEHICLES**			**SEMESTER**			**VI / VII**
PREREQUISITES			**CATEGORY**	**OE**	**Credit**		**3**
Electrical Machines			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:	
1.	To learn the components of Electric Vehicle, configurations and its architectural design
2.	To study the energy storage options for Electric vehicle.

UNIT I	**ELECTRIC VEHICLES**	**9**	**0**	**0**	**9**
Configurations of Electric Vehicles (EV), Performance of Electric Vehicles: Traction Motor Characteristics, Tractive Effort and Transmission Requirement and Vehicle Performance, Tractive Effort in Normal Driving , Energy Consumption					
UNIT II	**HYBRID ELECTRIC VEHICLES**	**9**	**0**	**0**	**9**
Concept of Hybrid Electric Drive Trains, Classification of hybrid electric vehicles , Architectures of Hybrid Electric Drive Trains: Series Hybrid Electric Drive Trains, Parallel Hybrid Electric Drive Trains, Torque-Coupling Parallel Hybrid Electric Drive Trains, Speed-Coupling Parallel Hybrid Electric Drive Trains, Torque-Coupling and Speed-Coupling Parallel Hybrid Electric Drive Trains					
UNIT III	**PLUG-IN HYBRID ELECTRIC VEHICLES (PHEV)**	**9**	**0**	**0**	**9**
Functions And Benefits Of PHEV, Components of PHEV, Operating Principles of Plug-In Hybrid Vehicle, Plug-In Hybrid Vehicular Architecture, Compound PHEV Architecture, Control Strategy of PHEV, Charging of PHEV					
UNIT IV	**FUEL CELL ELECTRIC VEHICLE**	**9**	**0**	**0**	**9**
Operating Principles of Fuel Cells, Fuel Cell System Characteristics, Fuel Cell Technologies, Hydrogen Storage, Configuration of a Fuel cell hybrid Electric Vehicle, Control Strategy of Fuel cell Electric Vehicle					
UNIT V	**ENERGY STORAGE SYSTEM**	**9**	**0**	**0**	**9**
Status of Battery Systems for Automotive Applications, Battery Technologies: Nickel–Metal Hydride (Ni–MH) Battery, Lithium–Polymer (Li–P) Battery, Lithium-Ion (Li-Ion) Battery, Ultracapacitors: Features, operation and performance, Hybridization of Energy Storages					
Total (45L+0T)= 45 Periods					

Text Books:	
1.	Iqbal Hussain, “Electric and Hybrid Vehicles: Design Fundamentals”, CRC Press, Taylor & Francis Group, Second Edition ,2011.
2.	Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, AliEmadi,, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles” CRC Press, 2016
Reference Books:	
1.	Ali Emadi, Mehrdad Ehsani, John M.Miller ,“Vehicular Electric Power Systems”, Ali Emadi, Mehrdad Ehsani, John M.Miller, Special Indian Edition, Marcel dekker, Inc 2010
E-Reference	
1	https://archive.nptel.ac.in/courses/108/106/108106170/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Level**
CO1	:	Recall the concept of Electric Vehicle technology	L1: Remembering
CO2	:	Draw the configuration of different types of Electric Vehicle	L4: Analyzing
CO3	:	Describe the selection and sizing of Fuel cell for hybrid electric vehicle.	L2: Understanding
CO4	:	Select control strategy and control for Plug In Hybrid Electric vehicle	L4: Analyzing
CO5	:	Use the battery management system for electric vehicle	L3: Applying

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	1		1	3	1	2	1		1	2	1	1	1	2	1
CO2	1	2	3	1		1	2	1	1		1	2	1	2	
CO3	1	1			2		3	2	1	2	1		1	1	1
CO4	3	1	2	1	2	1	1				3	2	1	2	1
CO5	1	2	1	2	1	2		1	2	1		1	1	2	1
Avg	**1.4**	**1.5**	**1.75**	**1.75**	**1.50**	**1.5**	**1.75**	**1.33**	**1.25**	**1.67**	**1.5**	**1.5**	**1**	**1.8**	**1**

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

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.

UNIT I	**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.

UNIT II	**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

UNIT III	**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.

UNIT IV	**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)

UNIT V	**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

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		1	1				1		3	2
CO2	2	2	1	2		1	1				1		3	2
CO3	2	2	1	2		1	1				1		3	2
CO4	2	2	1	2		1	1				1		3	2
CO5	2	2	1	2		1	1				1		3	2
Avg	**2**	**2**	**1**	**2**		**1**	**1**				**1**		**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.

UNIT I	FORECASTING	9	0	0	9

Characteristics and Principles - Qualitative Methods, Delphi Technique, Market Research -Time Series Methods- Moving Average, Exponential Smoothing- Box Jenkins Method – Auto Regressive Moving Average (ARMA) or Auto Regressive Integrated Moving Average (ARIMA) models – Fitting Regression Models - Measurement of Forecast Errors, Coefficient of Correlation - Problem solving.

UNIT II	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 – Line Balancing - 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.

UNIT III	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 Minute Exchange of Die (SMED) 5S concept - Concurrent Engineering- Cellular Manufacturing – Enablersof Agile Manufacturing – Rapid Manufacturing - Business Process Re-engineering (BPR) - Basics of Supply Chain Management, Supply chain and “Keiretsu” – Enterprises Resources Planning (ERP) - Role of KAIZEN, Quality Circles and POKA YOKE in Modern Manufacturing – Seven wastes in Lean Manufacturing.

UNIT IV	AGGREGATE PRODUCTION PLANNING	9	0	0	9

Objectives of Aggregate Planning - Capacity Requirement Planning (CRP) Process - Types of Capacity 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).

UNIT V	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 Loading Charts - Priority Sequencing -Dynamic Sequencing Rules - Batch Scheduling – Economic Batch Quantity (EBQ) or Economic Run Length (ERL) – Scheduling in Repetitive, Batch and Job Shop Manufacturing – Allocation of units for a single resource, allocation of multiple resources – Resource balancing - Flexible Manufacturing System.

Total (45L) = 45 Periods

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			2	2									3
CO2			3											2
CO3						3	2		3	2	3	2	3	
CO4	3	3		2	3	3						2		3
CO5						3	2	3					3	
Avg	**3**	**3**	**3**	**2**	**2.5**	**3**	**2**	**3**	**3**	**2**	**3**	**2**	**3**	**2.6**

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

<table>
<tr><td>22MEOE03</td><td colspan="2">INDUSTRIAL ROBOTICS</td><td colspan="4">SEMESTER VI/VII</td></tr>
<tr><td colspan="2" rowspan="3"></td><td>CATEGORY</td><td>OE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
</table>

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			1							1	1
CO2			1		1	1							1	1
CO3		1	0										1	1
CO4			1			3								1
CO5		2											1	2
Avg	**3**	**1.7**	**1**		**1**	**1.7**							**1**	**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 operations and its components.
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 and 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	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	2	3	2	1		1	1	2		2	2	2	1	2
CO2	1	2	3	2	1		1	1	2		2	2	2	1	2
CO3	1	2	3	2	1		1	1	2		2	2	2	1	2
CO4	1	2	3	2	1		1	1	2		2	2	2	1	2
CO5	2		1	2				2	2	1	1	1	2		
Avg	**1.2**	**2**	**2.6**	**2.0**	**1**		**1**	**1.2**	**2.0**	**1**	**1.8**	**1.8**	**2.0**	**1**	**2**

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 - AN INTRODUCTION AND OVERVIEW**	**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	Herald knootz and Heinz weihrich, Essentials of Management ‖, McGraw-Hill Publishing Company, Singapore International Edition, 2007
2	Joseph L, Massie, Essentials of Management. Prentice Hall of IndiaPvt., Ltd (Pearson) Fourth Edition, 2003.
3	Stephen A. Robbins & David A. Decenzo & Mary Coulter, “Fundamentals of Management” 7th Edition, Pearson Education, 2011.
4	Robert Kreitner & Mamata Mohapatra, “Management”, Biztantra, 2008.
5	Harold Koontz & Heinz Weihrich “Essentials of management” Tata McGraw Hill, 1998.
6	Tripathy PC & Reddy PN, “Principles of Management”, Tata McGraw Hill, 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 of 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							1	3	1		2	2	1	1
CO2							1	1	2		3	2	1	1
CO3								1	2		1	1	1	1
CO4							2	1	2		2	1	1	1
Avg							**1.3**	**1.5**	**1.75**		**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.

UNIT I	**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.

UNIT II	**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.

UNIT III	**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.

UNIT IV	**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.

UNIT V	**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**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1						2	1	3	2		1				1
CO2						1	1	3	1		1				1
CO3						2	1	3	1		1				1
Avg						**1.66**	**1**	**3**	**1.33**		**1**				**1**

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

<table>
<tr><td>22MEOE07</td><td colspan="2">RENEWABLE SOURCES OF ENERGY</td><td colspan="4">SEMESTER VI/VIII</td></tr>
<tr><td colspan="2" rowspan="3">PRE-REQUISITE:
1. Basic idea about solar radiation and other renewable energy that exists.
2. Understanding about various chemical reactions occur in the energy conversion process</td><td>CATEGORY</td><td>OE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td rowspan="2">Horus/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>1</td><td>4</td></tr>
<tr><td colspan="7">COURSE OBJECTIVES</td></tr>
<tr><td>1.</td><td colspan="6">To recognize the consciousness of energy conservation in scholars</td></tr>
<tr><td>2.</td><td colspan="6">To identify the employ of renewable energy sources for electrical power generation</td></tr>
<tr><td>3.</td><td colspan="6">To collect different energy storage methods</td></tr>
<tr><td>4.</td><td colspan="6">To detect about environmental effects of energy conversion</td></tr>
<tr><td>UNIT I</td><td colspan="2">SOLAR RADIATION AND ITS MEASUREMENTS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Alternative energy sources, Global and Indian energy scenario. Solar Energy: Introduction – Solar Radiation Measurement and Instruments – Data and estimation.</td></tr>
<tr><td>UNIT II</td><td colspan="2">SOLAR ENERGY COLLECTORS, SOLAR ENERGY STORAGE AND APPLICATIONS OF SOLAR ENERGY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>UNIT III</td><td colspan="2">BIOMASS AND ITS CONVERSION TECHNOLOGIES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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;</td></tr>
<tr><td>UNIT IV</td><td colspan="2">WIND, GEOTHERMAL AND TIDAL ENERGY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>UNIT V</td><td colspan="2">CHEMICAL ENERGY, HYDROGEN ENERGY AND MAGNETO HYDRO DYNAMIC</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7">Total (45L) = 45Periods</td></tr>
</table>

<table>
<tr><td colspan="2">REFERENCE BOOKS:</td></tr>
<tr><td>1</td><td>G.D. Rai, "Non-Conventional Energy Sources", Khanna Publishers, New Delhi, 2014.</td></tr>
<tr><td>2</td><td>Suhas P. Sukhatme, “Solar Energy”, Tata McGraw Hill Publishing Company Ltd., 2007.</td></tr>
<tr><td>3</td><td>Khan, B.H., "Non-Conventional Energy Resources", The McGraw Hill Companies, 2009.</td></tr>
<tr><td>4</td><td>Twidell, J.W. & Weir, A., "Renewable Energy Resources", EFN Spon Ltd., UK, 2005.</td></tr>
<tr><td>5</td><td>Solanki: Renewable Energy Technologies: Practical Guide for Beginners, PHI Learning Pvt.Ltd., 2008</td></tr>
<tr><td>6</td><td>D. Mukherjee: Fundamentals of Renewable Energy Systems, New Age International publishers, 2007.</td></tr>
<tr><td>7</td><td>Gilbert M. Masters: Renewable and Efficient Electric Power Systems, John Wiley & Sons, 2004.</td></tr>
<tr><td colspan="2">E-REFERENCES:</td></tr>
<tr><td>1.</td><td>https://en.wikipedia.org/wiki/Renewable_energy</td></tr>
</table>

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 of solar 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		2	2	3	1	1	2	2	1
CO2	1	2	3	2	1		2	2	3	1	1	2	2	1
CO3		2	3	2	1		2	2	3	1	1	2	2	1
CO4	1	2	3	2			2	2	3	1	1	2	2	1
CO5	1	2	3	2	1		2	2	3	1	1	2	2	1
Avg	**1**	**2**	**3**	**2**	**1**		**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**
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

UNIT I	**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.					
UNIT II	**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					
UNIT III	**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.					
UNIT IV	**KINEMATICS AND PATH PLANNING**	**9**	**0**	**0**	**9**
Solution of inverse kinematics problem – multiple solution jacobian work envelop – Hill Climbing Techniques – robot programming languages					
UNIT V	**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) = 45 Periods					

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		2					1		2	2	2
CO2	1	3	2	1	1							2	1	3
CO3		2	2	1	1							2	1	3
CO4		1	1	2	3			1	3	2	1	2		
CO5		1	2	2	2	1	2	2	3	2	1	2		
Avg	**1**	**1.6**	**1.8**	**1.5**	**2**	**1**	**2**	**1.5**	**3**	**1.7**	**1**	**2**	**1.3**	**2.7**

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**

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) = 45Periods

REFERENCE BOOKS:	
1	Dale H.Besterfiled, Carol B.Michna,Glen H. Bester field, MaryB.Sacre, Hemant Urdhwareshe and Rashmi Urdhwareshe, “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			2		1		2			2	1	2
CO2	1	2							2			2		
CO3	1	2	2		1			1				2	1	
CO4	1	2			2	3		2		3		2	2	2
CO5	1	2	2		2	2	1	2	2	3		2	2	2
Avg	**1**	**2.2**	**2**		**1.75**	**2.5**	**1**	**1.7**	**2**	**3**		**2**	**1.5**	**2**

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

22MTOE01	FOUNDRY AND WELDING TECHNOLOGY				
PREREQUISITES: **Manufacturing Technology**	**Category**	**OE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives:

1.	To know the basic concepts of metal casting technology and to apply them to produce of new materials.
2.	To know the concepts of different materials joining technology and emphasis on underlying science and engineering principle of every processes.

UNIT I	**MOULDING MATERIALS AND PATTERNS**	**9**	**0**	**0**	**9**
Introduction to foundry operations, patterns - functions, types, allowances, selection of pattern materials, colourcodes, core boxes, moulding practice, ingredients of moulding sand and core sand, Testing of Moulding sands. Sand preparation, Sand reclamation in foundries.					
UNIT II	**MOULDING AND CASTING TECHNIQUES**	**9**	**0**	**0**	**9**
Sand moulding: green sand moulding, dry sand moulding, skin dry sand moulding, shell moulding, carbon- di-oxide process, permanent mould casting, die casting, centrifugal casting, investment casting, squeeze casting, full mould process, Rheocasting, Thixo casting.					
UNIT III	**MELTING PRACTICE**	**9**	**0**	**0**	**9**
Melting practice and special precautions for steels, alloy steels, cast irons, aluminium alloys, copper alloysand magnesium alloys, Cleaning and repair of castings. Casting defects and remedies					
UNIT IV	**WELDING AND OTHER JOINING PROCESSES**	**9**	**0**	**0**	**9**
Classification of welding processes- oxy-acetylene welding, arc welding-manual, submerged arc welding, gas tungsten arc and gas metal arc welding, electro slag and electro gas welding. Brazing, soldering and cutting processes					
UNIT V	**SPECIAL WELDING PROCESSES**	**9**	**0**	**0**	**9**
Principle, equipment, process variables, merits, limitations and applications of Electron beam, plasma arc andlaser beam welding processes. Friction, friction stir welding, ultrasonic explosive and diffusion welding.					
					Total (45+0) = 45 Hours

Text Books:

1.	Heine R W., Loper, C.R.Rosenthal, P.C.,"Principles of Metal Casting",Tata-McGraw Hill PublishingCo Ltd, New Delhi, 2008.
2.	Srinivasan N K.,"Foundry Engineering", Khanna Tech Publications, New Delhi, 2005.
3.	Parmar, R.S., –Welding Processes and Technology‖, 2nd edn. Khanna Publishers, New Delhi, 2001
4.	Srinivasan N K ,"Welding Technology", Khanna Publications, Delhi, 2000

Reference Books:

1.	Beeley P R., "Foundry Technology", Butterworths, London, 1982.
2.	Howard B. Cary, "Modern Welding Technology", Prentice Hall, New Jersey, USA, 1998.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Discuss the alloying element effect on the steels and mention the precaution to be taken in mouldingand melting of steels.	L2: Understanding
CO2	:	Distinguish different moulding and casting techniques.	L3:Applying
CO3	:	Apply the melting procedure for the various alloys like steels, stainless steels,discuss the slag-metal reactions	L3:Applying
CO4	:	Illustrate the conventional welding processes and allied joining processes.	L2: Understanding
CO5	:	Compare the various special welding processes.	L3:Applying

COURSE ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	1	1										2			
CO2	1	1		1	1								1			1
CO3	2	1	1				1						2			
CO4	1	1	1	1	1	1							1			1
CO5	2	1		1	1								1			
Avg.	1.6	1.0	1.0	1.0	1.0	1.0	1.0						1.4			1.0

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

<table>
<tr><td>22MTOE02</td><td colspan="2">ADVANCED SURFACE ENGINEERING</td><td colspan="4"></td></tr>
<tr><td colspan="2" rowspan="3">PREREQUISITES:
Manufacturing Technology</td><td>Category</td><td>OE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="6">Analyze the various concepts of surface engineering and comprehend the design difficulties</td></tr>
<tr><td>UNIT I</td><td colspan="2">TRIBOLOGY AND PLATING PROCESSES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Introduction to tribology, Wear: Types of wear - adhesive, abrasive, oxidative, corrosive, erosive and trotting wear, roles of friction and lubrication and wear testing. Plating Processes: Fundamentals of electrode position, plating of nickel, chromium, tin and copper, pulsed plating, hydrogen embrittlement, plating adhesion, electroless plating, electrochemical conversion coating, selective plating for repair, plating properties, hard anodizing.</td></tr>
<tr><td>UNIT II</td><td colspan="2">HARD FACING PROCESSES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">SMAW, GTAW, GMAW, FCAW, SAW, PAW, Oxy-Acetylene Welding, Furnace fusing, Thermal-spray, Flamespray processes - HVOF, Detonation gun and Jet kote processes, Hard facing consumables.</td></tr>
<tr><td>UNIT III</td><td colspan="2">SPECIAL DIFFUSION PROCESSES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Principle of diffusion processes - Boriding, Aluminising, Siliconising, Chromising - Selection of diffusion processes - Characteristics of diffused layer - micro structure and micro hardness evaluation - properties andapplications.</td></tr>
<tr><td>UNIT IV</td><td colspan="2">THIN FILM COATINGS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Physical vapour deposition processes - Thermal evaporation - sputter coating - Ion plating - Chemical vapour deposition - reactive sputtering - TiC, TiN, Alumina, CBN, Diamond and DLC coatings. Structure, properties and applications.</td></tr>
<tr><td>UNIT V</td><td colspan="2">HIGH ENERGY MODIFICATION AND SPECIAL PROCESSES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Electron beam hardening, glazing, Laser beam hardening glazing ion implantation, Composite surface created by laser and Electron beam. Surface cements, Wear tiles, Electro spark deposition, fused carbide cloth,thermal / chemical. Ceramic coatings, centrifugal cast wear coatings, Wear sleeves and Wear plates.</td></tr>
<tr><td colspan="7">Total (L+T) = 45 Hours</td></tr>
</table>

<table>
<tr><td colspan="2">Text Books:</td></tr>
<tr><td>1.</td><td>Chattopadhyay R., Surface Wear: Analysis, Treatment, Prevention, ASM International, USA, 2001</td></tr>
<tr><td>2.</td><td>Kenneth G. Budinski, Surface Engineering for Wear Resistance, Prentice Hall, Englewood Cliff, 1990.</td></tr>
<tr><td colspan="2">Reference Books:</td></tr>
<tr><td>1.</td><td>ASM Metals Handbook, Vol 5: Surface Engineering, ASM International, Ohio, 1994.</td></tr>
<tr><td>2.</td><td>Ernest Rabinowicz, Friction and Wear of Materials, 2nd ed., John Wiley & Sons, NY, 1995.</td></tr>
<tr><td>3.</td><td>Davis J.R., Surface Engineering for Corrosion and Wear resistance, ASM International, 2001.</td></tr>
</table>

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Discuss the influence of the tribological characteristics.	L2: Understanding
CO2	:	Discuss the various hard facing processes.	L3:Applying
CO3	:	Demonstrate the surface properties with diffusion of foreign atoms into the outer surface of thematerial such as boriding, aluminizing, etc.	L2: Understanding
CO4	:	Demonstrate the various vapour deposition processes of different materials on the surface of native materials using the Chemical, Physical and Thermal vapour deposition processes.	L2: Understanding
CO5	:	Describe the Modern processes and high energy processes like electron beam hardening, laser beamhardening.	L3:Applying

COURSE ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	1		1	1								1	1		1
CO2	2	1			1	1						1	1			1
CO3	1	1		1	1		1					1	2			1
CO4	2	1	1		1									2		1
CO5	1			1	1								1			1
Avg.	1.4	1.0	1.0	1.0	1.0	1.0	1.0					1.0	1.3	1.5		1.0

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

22MTOE03	**DESIGN AND SELECTION OF MATERIALS**					
PREREQUISITES: **Manufacturing Technology**		**Category**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To know different types of materials and properties and to select better materials forDifferent applications.

UNIT I	**DESIGN PROCESS**	**9**	**0**	**0**	**9**
Materials in Design, Evolution of Engineering Materials, Design process, Types of design, Design flow chart-tools and material data, Interaction between Function, Material, Shape and Process.					
UNIT II	**MATERIAL PROPERTIES**	**9**	**0**	**0**	**9**
Revision of engineering materials and properties, Material properties inter-relationship charts such as Young"s modulus-density, Strength-density, Young"s modulus-Strength, wear rate-hardness, Young‘s modulus– relative cost, strength relative cost and others.					
UNIT III	**MATERIAL SELECTION**	**9**	**0**	**0**	**9**
Materials selection, selection strategy: material attributes, attribute limits, selection procedure, computer aided selection, structural index; Case studies: table legs, flywheel, springs, pressure vessels, bearings, heat exchangers, airframes, ship structures, automobile structures.					
UNIT IV	**PROCESSES AND PROCESS SELECTION**	**9**	**0**	**0**	**9**
The processes: shaping, joining and finishing, Process selection, ranking processes, cost, computer based process selection, Case studies: fan, pressure vessel, optical table, economical casting.					
UNIT V	**MULTIPLE CONSTRAINTS AND OBJECTIVES**	**9**	**0**	**0**	**9**
Selection under multiple constraints, conflicting objectives, penalty-functions, exchange constants, Case studies: connecting rods for high performance engines, windings of high field magnets.					
Total (L+T) = 45 Hours					

Text Books:	
1.	Michael F. Ashby, Materials Selection in Mechanical Design, third edition, Butterworth-Heinemann,2005
2.	J. Charles, F.A.A. Crane, J. A.G. Furness, Selection and Use of Engineering Materials, third edition,Butterworth-Heinemann, 2006
Reference Books:	
1.	ASM Metals Handbook, Vol.20: Materials Selection and Design, ASM International,1997
2.	Myer Kutz, Handbook of Materials Selection, John Wiley & Sons, Inc., New York, 2002

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the design process and design flow chart tools for the materials selection criterion.	L2: Understanding
CO2	:	Apply the materials for corrosion and wear resistance processes.	L3:Applying
CO3	:	Apply the materials for auto and aero industry.	L3:Applying
CO4	:	Classify the process selection criterion for high temperature materials.	L2: Understanding
CO5	:	Suggest the process selection criterion for high performance materials..	L3:Applying

COURSE ARTICULATION MATRIX																
CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	1	1		1	1								1		1	
CO2	2	1	1			1	1							2		
CO3	1	1		1	1								1	1		
CO4	2	1	1		1									2		
CO5	1	1		1	1											1
Avg.	1.4	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.7	1.0	1.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MTOE04	**NANOSCIENCE AND TECHNOLOGY**				
PREREQUISITES: **Engineering material and metallurgy**	**Category**	**OE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**
Course Objectives:					
1. To study about nanomaterials and its application					
UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Definition, Length scales, surface area/volume ratio of micron to nanoscale materials, Importance of Nanoscale and Technology, Top down and bottom up approaches, Classification of nanomaterials, Properties of selected nanomaterials including carbon nanotubes (CNT), graphene, metal nanoparticles, clays, nanowires, quantum dots (QDs), effect of size on thermal, mechanical and electrical properties of nanomaterials.					
UNIT II	**SYNTHESIS OF NANOMATERIALS**	**9**	**0**	**0**	**9**
Fabrication of Nanomaterials: Top-down approaches-lithography, Mechanical alloying milling, Severe PlasticDeformation, Bottom-up approaches-chemical vapour deposition, physical vapour deposition, atomic layer deposition (ALD), and Sol-gel method, Synthesis and purification of CNT, synthesis of expanded graphite (EG) orgraphene.					
UNIT III	**NANOCOMPOSITES**	**9**	**0**	**0**	**9**
Fabrication of nanocomposites: Fabrication of Clay-rubber, Clay-polymer, CNT-polymer, EG-polymer, magnetic particle-polymer, CNT-metal, trade off between the composites and nanocomposites etc. Consolidation of nanomaterials.					
UNIT IV	**CHARACTERIZATION OF NANOMATERIALS**	**9**	**0**	**0**	**9**
Characterization of Nanomaterials:, X-ray diffraction (XRD), Dynamic Light Scattering, Scanning electron microscope (SEM), Transmission Electron Microscope (TEM), UV-Visible spectroscopy, Scanning probe microscopy- Atomic force microscope (AFM) and scanning tunneling microscope (STM). Nanoindentation.					
UNIT V	**APPLICATIONS OF NANOMATERIALS**	**9**	**0**	**0**	**9**
Applications of nanomaterials: Electronics, structural, biomedical, sensors nanofluids, optical, magnetic, biomedicalfields, solar cells, LED, LCD, electrically conducting polymers, batteries, fuel cells, SMART Materials. Environmental and health issues related to nanomaterials.					
					Total (L+T) = 45 Hours

Text Books:	
1.	B.S. Murty, P. Shankar, Baldev Raj, B BRath, James Murday, Textbook of Nanoscience and Nanotechnology,University Press (I) Pvt. Ltd., 2013.
2.	Bharat Bhushan (Ed), Springer Handbook of Nanotechnology, Springer-Verlag Berlin Heidelberg, 2004
Reference Books:	
1.	Charles P Poole and Frank J Owens, –Introduction to Nanotechnology‖, John Wiley and Sons, New York, 2003.
2.	Michael Wilson, KamaliKannagara and Geoff Smith, ―Nanotechnology: Basic Science and Emerging Technology‖, Chapman and Hall, New York, 2002.
3.	Pradeep T, –Nano: The Essentials‖, Tata McGraw Hill, New Delhi, 2007.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Define and differentiate engineering materials on the basis of structure and properties for engineeringapplications.	L2: Understanding
CO2	:	Explain the various applications of nanomaterials.	L3:Applying
CO3	:	Discuss the fabrications of composites and nano composites.	L2: Understanding
CO4	:	Describe the charactrization of nanomaterials using SEM & TEM.	L4: Analyzing
CO5	:	Apply the applications of nanomaterials.	L3:Applying

COURSE ARTICULATION MATRIX																
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	2		1	1								1			1
CO2	2	2		1	1		1						1			1
CO3	3	2	1		1									1	1	
CO4	1	1		1	1	1							1	2		
CO5	1	1		1	1									1		
Avg.	1.6	1.6	1.0	1.0	1.0	1.0	1.0						1.0	1.3	1.0	1.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MTOE05	**MATERIALS FOR AUTOMOTIVE COMPONENTS**				
PREREQUISITES: **Engineering material and metallurgy**	**Category**	**OE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives:

1.	To give an overview of material properties, use of materials selection chart and considerations for material selection
2.	To impart knowledge about the basis of materials selection
3.	To give insight about the factors that influence materials selection for engines and transmission system
4.	To instill the knowledge required for the selection of materials for automotivestructures
5.	To render the basis of material selection for electronics devices in the automobile.

UNIT I	**ENGINEERING MATERIALS AND THEIR PROPERTIES**	**9**	**0**	**0**	**9**
Classes of engineering materials - the evolution of engineering materials, Definition of materials properties, Displaying material properties using materials selection charts, Forces for change in materials selection and design, Materials and the environment. Selection of materials for automotive, aerospace, marine and defence applications.					
UNIT II	**BASIS OF MATERIAL SELECTION**	**9**	**0**	**0**	**9**
Selection strategy, Attribute limits and Material indices, structural index Selection procedure: Design process - types of design, design requirements, Function, Material attributes, Shape and Manufacturing processes - Materials processing and design processes and their influence on design, Process attributes, Systematic process selection, Process selection diagrams, Process cost, Energy consumption for production, Material costs, Availability, Recyclability, Environmental consideration. Computer aided selection.					
UNIT III	**MATERIALS FOR ENGINES AND TRANSMISSION SYSTEMS**	**9**	**0**	**0**	**9**
Materials selection for IC engines: Piston, piston rings, cylinder, Engine block, Connecting rod, Crank shaft, Fly wheels, Gear box, Gears, Splines, Clutches.					
UNIT IV	**MATERIALS FOR AUTOMOTIVE STRUCTURES**	**9**	**0**	**0**	**9**
Materials selection for bearings, leaf springs, chasis& frames, Bumper, shock absorbers, Damping fluid, wind screens, panels, brake shoes, Disc, wheels, differentials , damping and Antifriction fluids, Tyres and tubes.					
UNIT V	**ELECTRONIC MATERIALS FOR AUTOMOTIVE APPLICATIONS**	**9**	**0**	**0**	**9**
Materials for electronic devices meant for engine control, ABS, Steering, Suspension, Sensors, Temperature sensors forclimate control, anti-collision, Anti-fog, Head lamps.					
					Total (L+T) = 45 Hours

Text Books:

1.	Charles J A and Crane. F A. A., –Selection and Use of Engineering Materials‖, 3rd Edition, Butterworths, London UK, 1996.
2.	Jason Rowe, ―Advanced Materials in Automotive Engineering‖, Wood Head Publishing, 2012.

Reference Books:

1.	Ahmed E, ―Advanced composite materials for Automotive applications, Wiley, 2013
2.	Don H Wright,‖ Testing Automotive Materials and Components‖, SAE 1993.

3.	Geoff Davis, ― Materials for Automobile bodies‖, Butter Worth Heinemann, 2012
4.	Hiroshi Yamagata, –The Science and Technology of Materials in Automotive Engines‖, Elsvier, 2005
5.	Mstislav A M, Valentin N A, Gleb V M, ―Automotive materials: a handbook for the mechanical engineer‖, NTIS, 1972.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Identify the criteria and forces that cause the changes in materials selection.	L3:Applying
CO2	:	Investigate the influence of structural index, manufacturing process, design and Functional requirements on selection strategies.	L4:Analysing
CO3	:	Recognize the temperature regime, nature of load and property requirements of materials for engines and transmission system.	L4:Analysing
CO4	:	Analyse the various stresses acting on the structural members of automobile underDynamic loading and select suitable material.	L4:Analysing
CO5	:	Prepare the apt material for electronic devices used in automobiles	L3:Applying

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	1		1	1									2		1
CO2	3	2		1		1								2	1	
CO3	2	3	1		1								1			1
CO4	2	1		1	1								2			
CO5	1	1			1		1							1		
Avg.	1.8	1.6	1.0	1.0	1.0	1.0	1.0						1.5	1.7	1.0	1.0

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

ELECTIVES FOR HONOURS

PROFESSIONAL ELECTIVE COURSES – VERTICALS

VERTICAL 1 – CLEAN AND GREEN ENERGY TECHNOLOGY

22MEH101	**HYDROGEN AND FUEL CELL TECHNOLOGIES**					
		CATEGORY	**PE**	**Credit**		**3**
		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 a typical fuel cell and its types. To elaboration its thermodynamics and kinetics.
3	To study the cost effectiveness and eco-friendliness of Fuel Cells.

UNIT I	**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.					
UNIT II	**HYDROGEN STORAGE**	**9**	**0**	**0**	**9**
Hydrogen storage options – compressed gas – liquid hydrogen – Hydride – chemical Storage – comparisons, safety and management of hydrogen.					
UNIT III	**FUEL CELLS**	**9**	**0**	**0**	**9**
History – principle – working – thermodynamics and kinetics of fuel cell process – performance evaluation of fuel cell – comparison on battery Vs fuel cell.					
UNIT IV	**FUEL CELL–TYPES**	**9**	**0**	**0**	**9**
Types of fuel cells–AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – Relative merit sand demerits.					
UNIT V	**APPLICATION OF FUEL CELL AND ECONOMICS**	**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 trends in fuel cells.					
Total (45L) = 45Periods					

REFERENCE BOOKS:	
1	Viswanathan B. and Aulice Scibioh.M, Fuel Cells – Principles and Applications, Universities Press, 2006
2	RebeccaL.and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma, 2005
3	Bent Sorensen (Sorensen), Hydrogen and Fuel Cells: Emerging Technologies and Applications, Elsevier, UK2005
4	Kordesch K.and G.Simader, Fuel Cell and their Applications,Wiley-Vch, Germany 1996
5	Hart A.B.and G.J.Womack, Fuel Cells: Theory and Application, Prentice Hall, New York Ltd., London 1989
6	Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA 2002
7	Barclay F.J., Fuel Cells, Engines and Hydrogen, 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 process.	Understand
CO4	Comprehend the different types of fuel cells compare their merits and demerits.	Understand
CO5	Identify the potential application of a fuel cells for domestic, automotive, space craft 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**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2			1									1	1
CO2	3	2			1									1	1
CO3	3	2	1	1	1		1							1	1
CO4	3	3	1	2	1	1	1							1	1
CO5	3	2	1	1	2	2	1						1	1	1
Avg	**3**	**2.2**	**1**	**1.3**	**1.2**	**1.5**	**1**						**1**	**1**	**1**

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

22MEH102	**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 PCM in thermal management.
3	To investigate the thermal behaviors in electric vehicle battery systems through simulation and experimental.
4	To calculate the energy and exergy analyses of battery TMSs.
5	To obtain solutions for case studies on Thermal Management Solutions of Electric batteries.

UNIT I	**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.					
UNIT II	**PHASE CHANGE MATERIALS FOR THERMAL MANAGEMENT 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 INVESTIGATION 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					
UNIT IV	**ENERGY AND EXERGY ANALYSES OF BATTERY TMS**	**9**	**0**	**0**	**9**
TMS Comparison, Modeling of Major TMS Components, Energy and Exergy Analyses, Illustrative Example: Liquid Battery Thermal Management Systems					
UNIT V	**CASE STUDIES ON THERMAL MANAGEMENT SOLUTIONS OF ELECTRIC BATTERIES**	**9**	**0**	**0**	**9**
Case Study1: Experimental and Theoretical Investigation of Temperature Distributions in a Prismatic Lithium- Ion Battery. Case Study2: Thermal Management Solutions for Electric Vehicle Lithium-Ion Batteries based on Vehicle Charge and Discharge Cycles					
Total (45L) = 45Periods					

REFERENCE BOOKS:

1	Ibrahim Dinçer, Halil S.Hamut, Nader Javani, Thermal Management of Electric Vehicle Battery Systems, 2017
2	Halil S.Hamut, Nader Javani, Ibrahim Dinçer, Thermal Management of ElectricVehicle Battery Systems, Wiley, 2016
3	Weixiang Shen, Rui Xiong, Advanced Battery Management Technologies for Electric Vehicles, John Wiley and sons, First edition 2019.
4	Chitra A., Sanjeevi kumar Padmanaban, Jens BoHolm - Nielsen, Artificial Intelligent Techniques for Electric and Hybrid Electric Vehicles, John Wiley and sons, First edition 2020.

5	Bruno Scrosati, Jurgen Garche, Werner Tillmetz, Advances in Battery Technologies for Electric Vehicles, Wood head Publishing, 2015

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Describe and analyse the techniques of thermal management of electric vehicle battery systems	Analyze
CO2	Describe and classify various applications of PCM in 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	Identify the solutions for case studies on thermal management solutions of electric batteries.	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		1						1		
CO2	3	2	1		1		1				1		2		
CO3	3	2	2	3	1		1				1		2		
CO4	3	2	1	2	1	1					1		2		
CO5	3	3			1	2	1	1	1	1	1		2		
Avg	**2.8**	**2.2**	**1.3**	**2.5**	**1.2**	**1.5**	**1**	**1**	**1**	**1**	**1**		**1.8**		

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

22MEH103	**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	To elaborate on the types and utilization of hybrid and electric drive trains.
3	To expose on 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 hybrid traction, introduction to various hybrid drive-train topologies, power flow control, fuel efficiency analysis in hybrid drive-train topologies. Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train.					
UNIT III	**CONTROL OF AC & DC DRIVES**	**9**	**0**	**0**	**9**
Introduction to electric components used in hybrid and electric vehicles, Configuration and control– DC Motor drives, Induction Motor drives, Permanent Magnet Motor drive, and Switch Reluctance Motor drives, drive system efficiency					
UNIT IV	**ENERGY STORAGE AND DRIVE SIZING**	**9**	**0**	**0**	**9**
Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Energy storage and its analysis, Hybridization of different energy storage devices, Sizing the drive system: Matching the electric machine and the Internal Combustion Engine (ICE), Sizing the propulsion motor, sizing the power electronics, selection of appropriate energy storage technology					
UNIT V	**ENERGY MANAGEMENT STRATEGIES**	**9**	**0**	**0**	**9**
Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification and comparison of energy management strategies, implementation issues.					
					Total (45L) = 45 Periods

REFERENCE BOOKS:

1	Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC press, 2003.
2	James Larminie, john lowry, Electric Vehicle Technology Explained, Wiley, 2003.
3	Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, AliEmadi, Modern Electric, Hybrid Electric and fuel cell vehicles: Fundamentals, theory and design, CRC press, 2004.
4	Randd.A.J, Woods, R & dell rm Batteries for electric vehicles, john wiley & 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 trains in a 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 strategies to ensure 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		1	1	1								1
CO2	3	2	2		1	1		1	1						2
CO3	3	1	3	1	2	1	1	2		1					2
CO4	2	3	1	1	1	1	1	1		1	2			1	1
CO5	3	2			1	1	1			2	1	2		1	1
Avg	**2.8**	**2**	**2**	**1**	**1.2**	**1**	**1**	**1.3**	**1**	**1.3**	**1.5**	**2**		**1**	**1.4**

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

22MEH104	**ALTERNATE FUELS FOR IC ENGINES**				
	CATEGORY	**PE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

COURSE OBJECTIVES	
1	To expose potential alternate fuels and their characteristics.
2	To use appropriate synthetic fuels and fuel additives for better combustion characteristics.
3	To utilize alcohol fuels effectively for low emissions.
4	To elaborate on the utilization of Bio-Diesel and its types as a suitable fuel in CI engines.
5	To utilize different gaseous fuels and predict their performance and combustion characteristics.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Availability, need, suitability, properties, merits and demerits of potential alternative fuels– Alcohols, Bio-Diesel, Hydrogen, Liquefied Petroleum Gas, Natural Gas, Biogas, 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–as fuel and fuel additives, properties and characteristics.					
UNIT III	**ALCOHOL FUELS**	**9**	**0**	**0**	**9**
Alcohols–Properties, Production methods and usage in engines. Performance, combustion and emission Characteristics in engines. Issues and 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, Transesterification and emulsification – 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 and limitation in Gaseous fuels.					
					Total (45L) = 45 Periods

REFERENCE BOOKS:	
1	Keith Owen and trevoreoley, Automotive Fuels Handbook, SAE publications, 1990.
2	Pundir B.P, I.C.Engines Combustion and Emission, 2010, Narosa publishing house.
3	PundirB.P, Engine Combustion and Emission, 2011, Narosa publishing house, Keith.
4	Richard l.Bechtold, Automotive Fuels guide book, 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	Use appropriate synthetic fuels and fuel additives for better combustion characteristics.	Understand
CO3	Describe the properties of alcohol fuel and estimate the performance of alcohol fuels and its emissions.	Understand
CO4	Explain the properties and combustion and emission characteristics of bio-diesel.	Understand
CO5	Explain different gaseous fuels and predict their performance and combustion characteristics.	Understand

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3		1	1	1								3	2
CO2	3	2	1	1		1					1			2	2
CO3	2	3	2	1	1		1			1				2	2
CO4	2	1	1	1	1	1	1		1		2				2
CO5	1					2				2	1				
Avg	**2.2**	**2.25**	**1.3**	**1**	**1**	**1.25**	**1**		**1**	**1.5**	**1.3**			**2.3**	**2**

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

22MEH105	**ADVANCED ENERGY STORAGE TECHNOLOGIES**					
		CATEGORY	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES	
1	To understand the various types of energy storage technologies and its applications.
2	To study the various modelling techniques of energy storage systems using TRNSYS.
3	To learn the concepts and types of batteries.
4	To make the students to get understand the concepts of Hydrogen and Biogas storage.
5	To provide the insights on flywheel and compressed energy storage systems.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Necessity of energy storage– types of energy storage – comparison of energy storage technologies – 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**
Fundamental concept of batteries – measuring of battery performance, charging and discharging of a battery, storage density, energy density, and safety issues. Types of batteries – Lead Acid, Nickel – Cadmium, Zinc Manganese-di-oxide and Lithium Battery.					
UNIT IV	**HYDROGEN AND BIOGAS STORAGE**	**9**	**0**	**0**	**9**
Hydrogen storage options – compressed gas – liquid hydrogen – Metal Hydrides, chemical Storage, Biogas storage-comparisons. Safety and management of hydrogen and Bio gas storage – Applications.					
UNIT V	**ALTERNATE ENERGY STORAGE TECHNOLOGIES**	**9**	**0**	**0**	**9**
Flywheel, Super capacitors, Principles and Methods –Applications, Compressed air energy storage, Concept of Hybrid Storage – Applications.					
Total (45L) = 45 Periods					

REFERENCE BOOKS:	
1	Ibrahim Dincer and Mark A.Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002
2	James Larminie and Andrew Dicks, Fuel cell systems Explained, Wiley publications, 2003
3	LuisaF. Cabeza, Advances in Thermal Energy Storage Systems: Methods and Applications, Elsevier Wood head Publishing, 2015.
4	Robert Huggins, Energy Storage: Fundamentals, Materials and Applications, 2nd edition, Springer, 2015.
5	Ru-shiliu, Leizhang, Xueliangsun, Electro-chemical technologies for energy storage and conversion, Wiley publications, 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**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2			1	1		1						3	1
CO2	2	3	1	1	1		1		1						
CO3	3	2		1			1	1			1			3	
CO4	3	1	2	1	1	2	1			2				1	1
CO5	2	3	1	1					1						1
Avg	**2.6**	**2.2**	**1.3**	**1**	**1**	**1.5**	**1**	**1**	**1**	**2**	**1**			**2.3**	**1**

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

22MEH106	**SOLAR POWER PLANTS**				
	CATEGORY	**PE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

COURSE OBJECTIVES	
1	To explain concept of various power cycles involved in the solar power plants.
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.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Power Plant Scenario - Classification, Basic Principles and Features – Comparison and selection criteria					
UNIT II	**SOLAR POWER CYCLES**	**9**	**0**	**0**	**9**
Vapour cycles – Organic cycles – Combined Cycles – Binary Cycles – Stirling Cycle – Brayton Cycle – 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**
International PV Power Programmes – Photovoltaic Power Systems – System Integration – Energy Storage – 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.), Energy from the Desert –Feasibility of very large-scale photo-voltaic power generation systems, James and James 2003.
3	Sukhatme S.P., SolarEnergy, Tata McGraw Hills Pvt Co., 3rdEdition, 2008.
4	C.J.Winter, R.L.Sizmann, L.L.Vant-Hull, Solar Power Plants, Springer-Verlag Berlin and Heidel berg GmbH & Co.K, 2001.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Describe the concept of various power cycles involved in the solar power plants were learnt.	Understand
CO2	Analyze different cycle for solar power generation.	Analyze
CO3	Describe the construction and working of component solar thermal power plant.	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	PO12	PSO1	PSO2	PSO3
CO1	3	1	1		1	2	1							2	2
CO2	3	2	1	1	2		1							2	2
CO3	2	1			1		1							1	
CO4	3	2	1	2				1						1	
CO5	1	2			2									1	
Avg	**2.4**	**1.6**	**1**	**1.5**	**1.5**	**2**	**1**	**1**						**1.4**	**2**

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

22MEH107	**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 to its cost.

UNITI	**MATERIALS FOR SOLAR 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 impurities on 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**
Functional requirements of other materials for components like Invertors, Charge Controllers, Wires, Pipes,Valves etc.and identification of suitable materials – Simple Cost Analysis for 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 McGraw Hill, 2008.
3	Nelson.J, The Physics of Solar Cells, Imperial College Press, 2003.
4	Jef Poortmans and Vladimir Arkhipov, Thin Film Solar Cells, John Wiley and Sons, 2008.
5	Thomas Markvart, Solar Electricity, John Wiley and Sons, 2007.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Describe the fundamental principles of materials best suited for making solar collectors, their reliability, characteristics and possibility of using plastics.	Understand
CO2	Explore the materials for solar cells, principles, doping and fabrication and optimizations of solar cells.	Analyze
CO3	Explore the novel materials for the fabrication of solar cell, their efficiency and organic solar cells.	Analyze

CO4	Explain the concept and the diverse materials used for solar energy devices for diverse applications.	Understand
CO5	Describe the requirements of system balance and analysis with reference to its cost.	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					1					1	1	1
CO2	3	2	1				1						1	1	2
CO3	2	3			1								2	2	2
CO4	2	1			2	1			1				1	1	1
CO5	3	2		1			1					1	1	1	2
Avg	**2.6**	**2**	**1**	**1**	**1.5**	**1**	**1**	**1**	**1**			**1**	**1.2**	**1.2**	**1.6**

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

22MEH108	**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	To understand PV technology principles and techniques of various solar cells / materials for energy conversion.
3	To understand the fundamentals of wind energy and its conversion system.
4	To understand the aerodynamics and types of loads, generators in wind turbines.
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-n junction- Solar cell array system analysis and performance prediction - solar cell array design concepts – PV system design – design process and optimization – detailed array design – storage autonomy - 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, Blade element theory, 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 generator drive systems.					
Total (45L) = 45 Periods					

REFERENCE BOOKS:

1	Sukhatme S.P., Nayak.J.P, 'Solar Energy –Principle of Thermal Storage and collection", Tata McGraw Hill, 2008.
2	Solar Energy International, "Photovoltaic – Design and Installation Manual" –New Society Publishers, 2006.
3	DuffieA.and Beckann W.A., "Solar Engineering of Thermal Processes, JohnWiley, 1991.
4	John D S orensen and Jens N S orensen, "Wind Energy Systems", Wood head Publishing

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										3	1	
CO2	3	1	2	1									3	2	
CO3	3	2	2		1					1			3	2	2
CO4	3	2		1		1							3	2	
CO5	3	2			1	1							3	2	
Avg	**3**	**1.8**	**1**	**1**	**1**	**1**				**1**			**3**	**1.8**	**2**
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

22MEH109	**FIRE ENGINEERING AND EXPLOSION CONTROL**					
		CATEGORY	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES	
1	To understand and learn the fundamentals of fire, explosion and theory of combustion.
2	To know various classes of fires and 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.

UNIT I	**FIRE AND EXPLOSIONS**	**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 – jet fires – 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 of fires– 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 PROTECTION SYSTEM COMPONENTS**	**9**	**0**	**0**	**9**

Sprinkler – hydrants – stand pipes – special fire suppression systems like deluge and emulsifier, selection criteria of the above installations, reliability, maintenance, evaluation and standards – alarm and detection systems, suppression systems – CO_2 system, foam system – smoke venting – fire fighting 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, explosion relief of large enclosure - explosion venting - inert gases, suppression system based on carbon-di-oxide (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., “Hand Book of Fire Technology” Orient Longman, Bombay 1977.
2	“Accident Prevention manual for industrial operations” N.S.C., Chicago, 1982.
3	DinkoTuhtar, “Fire and explosion protection”.
4	Davis Daniel etal, “Hand Book of fire technology”.
5	“Fire fighters hazardous materials reference book” Fire Prevention in Factories”, An Nostrand ReinHold, 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	Explain various industrial fire protection systems components and their working.	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		1		1							2		
CO2	3	2				1	2						2		
CO3	3	2		1	2	1	2						2		
CO4	2	1	3	2		1	2				1		2		
CO5	3	2		1	2	2	1				1		2		
Avg	**2.8**	**1.8**	**3**	**1.25**	**2**	**1.2**	**1.75**				**1**		**2**		

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

22MEH110	**ENERGY MANAGEMENT AND ENVIRONMENTAL BENEFITS**					
		CATEGORY	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES

1	To create awareness on 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	To study the different techniques adopted for financial appraisal of a project.
5	To comprehend the impact of energy on environment.

UNIT I	**ENERGY SCENARIO**	**9**	**0**	**0**	**9**

Comparison of energy scenario – India and World (energy sources, generation mix, consumption pattern, T&D losses, energy demand, per capita energy 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- Steps in 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, Return on investment, Net present value, Internal rate of return - Cashflows, Risk and sensitivity analysis: micro and macro factors.

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 (4 Volumes) 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 of India.2004.
2	L.C.Witte, P.S.Schmidt, D.R.Brown, “Industrial Energy Management and Utilisation” Hemisphere Publ, Washington, 1988.
3	W.C.turner, “Energy Management Handbook” Wiley, NewYork, 1982.
4	W.R.Murphy and G.McKay “Energy Management” Butterworths, London1987.
5	Eastop.T.D & Croft D.R, Energy Efficiency for Engineers and Technologists, Logman Scientific &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 fuels used in industries.	Analyze
CO3	Apply Gantt Chart, CPM and PERT in energy conservation projects.	Apply
CO4	Evaluate the techno-economics of a project adopting discounting and non-discounting cashflow 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		1				1	1			2	2
CO2	3	2				1						2		2	
CO3	3	1	1	1		1								2	3
CO4	3	2					1					1			2
CO5	2	1			1	2	1								
Avg	**2.8**	**1.6**	**1**	**1**	**1**	**1.25**	**1**		**1**	**1**	**1**	**1.5**		**2**	**2.3**
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

VERTICAL 2 - COMPUTATIONAL ENGINEERING

22MEH201	**NUMERICAL METHODS IN MECHANICAL ENGINEERING**					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
		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
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.	Evaluate

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								2	1	
CO2	3	3	1	2	1								2	1	
CO3	3	3	1	2	1								2	1	
CO4	3	3	1	2	1								2	1	
CO5	3	3	1	2	1								2	1	
Avg	**3**	**3**	**1**	**2**	**1**								**2**	**1**	

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

22MEH202	**ADVANCED FLUID MECHANICS**					
		CATEGORY	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

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 equation in integral form stream function and velocity potential.

UNIT II	**VISCOUS FLUID FLOW**	**9**	**0**	**0**	**9**

Euler equation for invpiscid 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. (1964) “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.,.

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 equation 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								1	2	2	
CO2	3	3	2	3								1	2	2	
CO3	3	3	2	3	3							1	2	2	
CO4	3	3	2	3								1	2	2	
CO5	3	3	2	3	3							1	2	2	
Avg	**3**	**3**	**2**	**3**	**3**							**1**	**2**	**2**	

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

22MEH203	**FUNDAMENTALS OF BIO-MECHANICS**					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Basic knowledge of physics and biology which includes kinetics and 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							1		2	2	
CO2	2	2	2	2							1		2	2	
CO3	2	2	2	2							1		2	2	
CO4	2	2	2	2							1		2	2	
CO5	2	2	2	2	2						1		2	2	
Avg	**2**	**2**	**2**	**2**	**2**						**1**		**2**	**2**	

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

22MEH204	**INTRODUCTION TO MACHINE LEARNING**				
PREREQUISITES	**CATEGORY**	**PE**	**Credit**		**3**
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		1	3							1	2	2	
CO2	2	2		1	3		3					1	2	2	
CO3	2	2		1	3							1	2	2	
CO4	2	2		1	3		3					1	2	2	
CO5	2	2		1	3		3					1	2	2	
Avg	**2**	**2**		**1**	**3**		**3**					**1**	**2**	**2**	
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

22MEH205	DESIGN OPTIMIZATION AND DESIGN THEORY					
		CATEGORY	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES:

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	PROGRAMMING	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							2	2	2	
CO2	2	2	3	3	1							2	2	2	
CO3	2	2	2	3	1							2	2	2	
CO4	2	2	2	3	1							2	2	2	
Avg	**2**	**2**	**2.5**	**3**	**1**							**2**	**2**	**2**	

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

22MEH206	**ADVANCED FINITE ELEMENT METHODS**					
		CATEGORY	**PE**	**Credit**		**3**
		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 AND 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				1	1				1	2	
CO2	3	1	3	3	3			1	1						3
CO3	3	1	3	3	2			1	1						
CO4	3	2	3	3	2		2	2	1				1	2	
CO5	3	1	1	1	1				1				1	1	
Avg	**3.0**	**1.2**	**2.6**	**2.2**	**1.6**		**0.4**	**1.25**	**1.0**				**0.6**	**1.7**	**3**

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

22MEH207	**ADVANCED COMPUTATIONAL FLUID DYNAMICS**					
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								2	2	
CO2	2	2	1	3	2								2	2	
CO3	2	2	1	3	2								2	2	
CO4	2	2	1	1	2								2	2	
CO5	2	2	1	3	2								2	2	
Avg	**2**	**2**	**1**	**2.2**	**2**								**2**	**2**	

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

22MEH208	**SMART MATERIALS AND STRUCTURES**					
		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.

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	**SENSORS AND ACTUATORS**	**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 and materials.	Create
CO3	Perform simulations of smart structures and 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								2	2	
CO2	2	2	1	1	2								2	2	
CO3	2	2	1	1	2								2	2	
CO4	2	2	1	1	2								2	2	
Avg	**2**	**2**	**1**	**1**	**2**								**2**	**2**	

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

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22MEH209	**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**

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 II	**DESIGN OF VESSELS USING CODES**	**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 III	**SUPPORTS FOR VERTICAL AND HORIZONTAL VESSELS**	**9**	**0**	**0**	**9**

Design of base plate and support lugs. Types of anchor bolt, its material and allowable stresses. Design of saddle suppors.

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									3	3	
CO2	2	3	3	3									3	3	
CO3	2	3	3	3									3	3	
CO4	3	1	1	1									3	3	
CO5	2	3	3	3									3	3	
Avg	**2**	**2.4**	**2.4**	**2.4**									**3**	**3**	

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

<table>
<tr><td>22MEH210</td><td colspan="5">MECHANICAL VIBRATIONS</td><td colspan="4"></td></tr>
<tr><td colspan="5">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="5" rowspan="2"></td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="10">COURSE OBJECTIVES:</td></tr>
<tr><td>1.</td><td colspan="9">To understand the Fundamentals of Vibration and its practical applications.</td></tr>
<tr><td>2.</td><td colspan="9">To understand the characteristics of free and forced vibration.</td></tr>
<tr><td>3.</td><td colspan="9">To understand the Single and Multi DOF of vibration system.</td></tr>
<tr><td>4.</td><td colspan="9">To understand the working principle and operations of various vibration measuring instruments</td></tr>
<tr><td>5</td><td colspan="9">To understand about the vibration analysis methods.</td></tr>
<tr><td>UNIT I</td><td colspan="5">FUNDAMENTALS OF VIBRATIONS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>UNIT II</td><td colspan="5">FREE VIBRATION OF SINGLE DEGREE OF FREEDOM SYSTEMS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>UNIT III</td><td colspan="5">FORCED VIBRATION OF SINGLE DEGREE OF FREEDOM SYSTEMS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>UNIT IV</td><td colspan="5">VIBRATION OF MULTI DEGREE OF FREEDOM SYSTEMS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>UNIT V</td><td colspan="5">VIBRATION MEASURING INSTRUMENTS AND VIBRATION ANALYSIS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td colspan="10">Total (45L) = 45 Periods</td></tr>
</table>

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	Explain basics of sound, noise and vibration; as well as their control strategies.	Evaluate
CO2	Derive equations of motion for undamped one-dimensional vibrations, and solve problems of damped free vibrations.	Create
CO3	Analyse and solve problems of forced vibrations involving frequency response curves, phase angle plots, vibration isolation and transmissibility.	Analyze
CO4	Analyse and solve problems involving vibrations of systems having more than one degree of freedom.	Analyze
CO5	Recall and explain concepts involving vibrations measuring instruments.	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									2	2	
CO2	3	3	2	2									2	2	
CO3	3	3	2	2									2	2	
CO4	3	3	2	2									2	2	
CO5	1	1	2	2									2	2	
Avg	**2.2**	**2.4**	**2**	**1.8**									**2**	**2**	

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

VERTICALS -3 PRODUCT AND PROCESS DEVELOPMENT

22MEH301	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 design requirements of precision machine tools.
4.	To know about the mechanical and thermal errors in measurement.
5.	To understand about laser devices, machine vision, 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, Ultra-precision Processes and Nanotechnology

UNIT II	PRECISION MACHINING AND UNCONVENTIONAL MICROMACHING TECHNIQUES	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. Micro electrical discharge machining, Photochemical machining, Electro chemical micromachining, Laser beam micromachining, Electron beam micromachining, Focused Ion Beam micromachining, etc

UNIT III	MACHINE DESIGN FOR PRECISION MANUFACTURING	9	0	0	9

Philosophy of Precision machine design -Ultra-Precision machine elements: Guide ways – Drive Systems – Friction Drive - Linear Motor drive – Spindle drive. Bearings: Principle – Construction and application of bearings – Hydrodynamic and Hydrostatic Bearings – Aerostatic Bearings – Magnetic Bearings.

UNIT IV	MECHANICAL AND THERMAL ERRORS	9	0	0	9

Sources of error – Principle of measurement – Errors die to machine elements – Bearings – Spindles – Kinematic Design – Stuctural Compliance – Vibration – Thermal Effects – Environmental control of precision machinery. Error Mapping and Error budgets.

UNIT V	MEASUREMENT AND CHARACTERISATION	9	0	0	9

Machine Vision – Laser tracking systems – Laser scanners – White light Interference 3D microscopes – Focus based optical metrology – Fringe projection method. 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.
4.	Jain V.K, “Micro-manufacturing Prrocesses”, 1st Edition, CRC press, Taylor and Francis group, 2012.

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.	Apply
CO3	Choose the basic design requirements for the construction of precision machine tools.	Apply
CO4	Identify various errors affecting the accuracy of precision manufacturing.	Apply
CO5	Define the uses of laser devices and machine vision, apply the 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		1			1					2	1	2	2
CO2	1	3	1	1			1					2		1	1
CO3	3	3	1	1	2		1					3		1	3
CO4	3	2	1	2	2		1					3	2	1	3
CO5	2	3		3	1		1					3		1	2
Avg	**2.2**	**2.6**	**1**	**1.6**	**1.7**		**1.0**					**2.6**	**1.5**	**1.2**	**2.2**

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

22MEH302	ADVANCED MATERIALS TECHNOLOGY					
PREREQUISITES		CATEGORY	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES:	
1.	To understand the causes of crack and failure in metals.
2.	To know different types of surface coatings in metals.
3.	To know about different composite materials.
4.	To understand the properties of modern alloys
5.	To know about the 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**
Iron Carbon phase diagram; TTT diagram; different microstructures; transformations; Annealing, Stress relieving; Spherodizing; Normalizing; Hardening; Tempering; Austemepring; Martempering; Quenching; Quenchants; Quenching media; Surface hardening; Harden ability; Sub-zero treatment; Thermo-mechanical treatment; Chemical Treatment; Tool steel and their heat treatment; cast Iron and their heat treatment. Aluminum and its alloys; Classification of heat treatment of aluminum alloys; Heat treatment of Magnesium and its alloys; Heat treatment of Titanium and its alloys; Heat treatment of Copper and its alloys; Heat treatment of Nickel and its alloys, Energy Economy in heat treatment.					
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 – Advanced materials and their treatment for automobile applications – Materials for aerospace (Al6061, Al7075), 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	Impart the knowledge of crack and failure of metals.	Understand
CO2	Identify the different types of surface coatings to improve the property of material.	Understand
CO3	Impart the knowledge of advanced heat treatment method for various materials.	Understand
CO4	Define the properties of modern materials and 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		1			1					2	1	2	2
CO2	1	3	1	1			1					2		1	1
CO3	3	3	1	1	2		1					3		1	3
CO4	3	2	1	2	2		1					3	2	1	3
CO5	2	3		3	1		1					3		1	2
Avg	**2.2**	**2.6**	**1**	**1.6**	**1.7**		**1.0**					**2.6**	**1.5**	**1.2**	**2.2**
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

22MEH303	**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						1	2		1		2	1	1	1
CO2	2	1	1	1	1		2	1		1		2	1	2	1
CO3	2	1					1			1		2	1	1	1
CO4	2	1					1			1		2	1	1	1
CO5	2	1					1			1		2	1	1	1
Avg	**2.0**	**1**	**1**	**1**	**1**		**1.2**	**1.5**		**1**		**2.0**	**1.0**	**1.2**	**1.0**

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

<table>
<tr><td>22MEH304</td><td colspan="5">NON DESTRUCTIVE TESTING AND FAILURE ANALYSIS</td><td colspan="4"></td></tr>
<tr><td colspan="5">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="5" rowspan="2"></td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="10">COURSE OBJECTIVES:</td></tr>
<tr><td>1.</td><td colspan="9">To develop the fundamental knowledge about non-destructive and destructive analysis, in order to control the quality in manufacturing and production engineering components.</td></tr>
<tr><td>UNIT I</td><td colspan="5">INTRODUCTION AND SURFACE NDT</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>UNIT II</td><td colspan="5">RADIOGRAPHY AND ACOUSTIC EMISSION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">Radiography- basic principle, electromagnetic radiation sources, radiographic imaging, inspection techniques, applications, limitations and safety. Acoustic emission testing- procedures and its importance.</td></tr>
<tr><td>UNIT III</td><td colspan="5">EDDY CURRENT AND ULTRASONIC TESTING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">Eddy current testing – principle, application, limitation; Ultrasonic testing – basic properties of sound beam, transducers, inspection methods, flaw characterization techniques, immersion testing, advantage and limitations.</td></tr>
<tr><td>UNIT IV</td><td colspan="5">LEAK TESTING AND THERMOGRAPHY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">Leak testing, Holography and Thermography – principles, procedures and applications; Comparison and selection of Non destructive testing methods; Defects in casting, forging, rolling and welding.</td></tr>
<tr><td>UNIT V</td><td colspan="5">FAILURE ANALYSIS METHODOLOGY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td colspan="10">Total (45L) = 45 Periods</td></tr>
</table>

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

<table>
<tr><td colspan="2">COURSE OUTCOMES:
Upon completion of this course, the students will be able to:</td><td>Bloom Taxonomy Mapped</td></tr>
<tr><td><i>CO1</i></td><td>Understand the concept of destructive and Non-destructive testing methods.</td><td>Understand</td></tr>
<tr><td><i>CO2</i></td><td>Explain the working principle and application of die penetrant test and magnetic particle inspection.</td><td>Remember</td></tr>
<tr><td><i>CO3</i></td><td>Understand the working principle of eddy current inspection, Ultrasonic testing and applications.</td><td>Understand</td></tr>
<tr><td><i>CO4</i></td><td>Apply radiographic techniques for testing and acoustic emission testing.</td><td>Apply</td></tr>
<tr><td><i>CO5</i></td><td>Define tools and techniques of failure analysis, procedural steps for investigation of failure.</td><td>Remember</td></tr>
</table>

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									2	2	
CO2	2	2	1	3									2	2	
CO3	2	2	1	3	1								2	2	
CO4	2	2	1	3	1								2	2	
CO5	2	2	1	3	3								2	2	
Avg	**1.8**	**2**	**1**	**2.6**	**1.7**								**2**	**2**	
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

22MEH305	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.	Antti Saaksvuori and AnselmiImmonen, “Product Lifecycle Management”, Springer Publisher, 2008 (3rd Edition)
2.	Ivica Crnkovic, Ulf Asklund and Annita Persson Dahlqvist, “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, CAD & 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									2	2	1	1	
CO2	1	1									2	2	1	1	
CO3	1	1			1						2	2	1	1	
CO4	1	1			2				2		2	2	1	1	
CO5	1	1			3				2		2	2	1	1	
Avg	**1**	**1**			**2**				**2**		**2**	**2**	**1**	**1**	
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

22MEH306	**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					3	2	2				2	1	2	1
CO2	1					3	2	2				2	1	2	1
CO3	1					3	2	2				2	1	2	1
CO4	1					3	2	2				2	1	2	1
CO5	1					3	2	2				2	1	2	1
Avg	**1**					**3**	**2**	**2**				**2**	**1**	**2**	**1**
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

22MEH307	**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 Gougingoabrasion, 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, Non-fusion 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 and 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, and wear plates.	Understand
CO5	Study about shielded metal arc welding, gas tungsten arc welding and non-fusion 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		1								2	1	
CO2	1	1	2		1								2	1	
CO3	1	1	2		1								2	1	
CO4	1	1	2		1								2	1	
CO5	1	1	2		1								2	1	
Avg	**1**	**1**	**2**		**1**								**2**	**1**	
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

22MEH308	**INDUSTRIAL LAYOUT DESIGN AND SAFETY**				
PREREQUISITES	**CATEGORY**	**PE**	**Credit**		**3**
1. Knowledge in basic manufacturing systems. 2. Knowledge in operations research 3. Knowledge in safety regulations.	**Hours/Week**	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To get the basics of process layout and 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 and investigation procedure.
5.	To assimilate knowledge on workplace hazards and 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 and 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		1	2	3		1		1	2		2		1	2	1
CO3		2	2	1	3	1	1	1	1		1	2	2	3	2
CO4		2	1	1	2			1	1	1	2		2	1	1
CO5	1	2	2	1	2			1	1	1	2	1	3	2	1
Avg	**1**	**1.8**	**1.6**	**1.6**	**2.5**	**1.3**	**1**	**1.0**	**1.4**	**1.3**	**1.8**	**1.0**	**1.7**	**2**	**1.4**

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

22MEH309	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 AND 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 and 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 Cyber security					
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 and 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					2				2	2	2	2	2
CO2	1	1					2				2	2	2	2	2
CO3	1	1					2				2	2	2	2	2
CO4	1	1					2				2	2	2	2	2
CO5	1	1					2				2	2	2	2	2
Avg	**1**	**1**					**2**				**2**	**2**	**2**	**2**	**2**
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

22MEH310	**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 and 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		2	1					1	2	2	2	
CO2	2	2	2		2	1					1	2	2	2	
CO3	2	2	2		2	1					1	2	2	2	
CO4	2	2	2		2	1					1	2	2	2	
CO5	2	2	2		2	1					1	2	2	2	
Avg	**2**	**2**	**2**		**2**	**1**					**1**	**2**	**2**	**2**	

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

ELECTIVES FOR MINOR

22CEM01	**CONSTRUCTION MATERIALS**		**Semester**			
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
NIL		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**
Course Learning Objectives						
1	To study the characteristics and Properties of Stones and Brick					
2	To impart knowledge on Cement, Aggregate and Mortar					
3	To understand the behaviour of concrete and seasoning timber					
4	To study the Parts and types of flooring and roofing					
5	To study carpentry, arches, lintels and finishing works.					
Unit I	**STONES, BRICKS**		**9**	**0**	**0**	**9**
Building Stone –classification of rocks-characteristics of good building stone – deterioration and preservation of stone work – tests on stones - Bricks- manufacture of clay bricks -classification - tests on bricks- bricks for special use- refractory bricks.						
Unit II	**CEMENT, AGGREGATES, MORTAR**		**9**	**0**	**0**	**9**
Cement- composition- manufacturing process-wet and dry processes. Aggregates –coarse and fine aggregates-characteristics and function. Mortar- properties- uses- types of mortars- selection of mortars for various Civil Engineering construction.						
Unit III	**CONCRETE, TIMBER AND OTHER MATERIALS**		**9**	**0**	**0**	**9**
Concrete- ingredients - principles of hardened concrete- Special concrete- types. Timber- characteristics- seasoning-preservation- Panels of laminates. Glass- properties- uses. Steel- Uses - market forms. Aluminum and other metallic materials for construction. Paints, Varnishes and Distempers-types-properties.						
Unit IV	**FLOORING AND ROOFING**		**9**	**0**	**0**	**9**
Components of floor- selection of flooring materials- suitability of floors for various applications. damp proof course, causes of dampness- effect of dampness - requirements of good stairs - classification of stairs -Roofs - types of roofs- requirements - pitched roof - lean to roof-gable roof-hip roof-flat roof-RCC roof.						
Unit V	**CARPENTARY, ARCHES, LINTELS AND FINISHING WORKS**		**9**	**0**	**0**	**9**
Location of doors and windows - size of doors - types of doors - fixture and fastenings for doors and windows - arches - classification - stability of an arch - lintels - classification of lintels - steel lintel. scaffolding - component parts - shoring - methods of plastering - defects in plastering - pointing - objectives- methods of pointing						
						Total= 45 Periods

Text Books:	
1	B.C. Punmia, Building Construction, Laxmi Publications; Eleventh edition -2021
2	S.C.Rangwala, Building Construction,CharotarPublishing House Pvt. Ltd, 34th Edition - 2022
3	P. Purushothama Raj., Building Construction Materials and Techniques, Pearson Education India, First Edition - 2017

Reference Books:	
1	Shetty M.S., Concrete Technology (Theory and Practice), S.Chand& Company Ltd.,2021.
2	Rangwala S.C., Engineering Materials (Material Science) revised and enlarged by Rangwala K.S. and Rangwala P.S., Charotar Publishing House, 2010.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify and characterize and properties of Stone and brick	Remember
CO2	Understand the manufacturing process of cement and functions of mortar	Understand
CO3	Identify the age of timber and preservation methods of timber	Remember
CO4	Differentiate the types of roofing and flooring	Understand
CO5	Understand the miscellaneous works such as carpentry, lintels, Arch, etc.	Understand

COURSE ARTICULATION MATRIX

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

<table>
<tr><td>22CEM02</td><td colspan="2">BUILDING CONSTRUCTION & EQUIPMENT</td><td colspan="3">Semester</td><td></td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>Category</td><td>OE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">NIL</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="6">Able to gain basic knowledge in construction methods.</td></tr>
<tr><td>2</td><td colspan="6">Able to gain basic knowledge in equipment.</td></tr>
<tr><td>3</td><td colspan="6">Able to gain basic knowledge in machineries.</td></tr>
<tr><td>4</td><td colspan="6">Able to gain basic knowledge in fire safety principles.</td></tr>
<tr><td>5</td><td colspan="6">Able to gain basic knowledge in green technology.</td></tr>
<tr><td>Unit I</td><td colspan="2">CLASSIFICATION OF BUILDINGS, FOUNDATIONS AND TYPES OF MASONRY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Component parts of a building -Their functions. Classification of buildings according to National building code.
Site investigation for foundation as per N.B.C, Types of foundation and prevention of dampness at basement level,Classification of stone masonry</td></tr>
<tr><td>Unit II</td><td colspan="2">DOORS, WINDOWS, LINTELS, SCAFFOLDING AND STAIRCASES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Doors and windows – parts of door and window – Types of Door and windows–Ventilators – fixed, swinging type and louvered. Lintels – Functions, Scaffolding – Purpose and types –Location of stairs.Types of stairs</td></tr>
<tr><td>Unit III</td><td colspan="2">ROOFS, FLOORINGS, PROTECTIVE AND DECORATIVE FINISHES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Roof Beams and Roof Slabs – Types of Roofing Systems – Methods of Termite Proofing – Methods of Damp proofing.
Types of floors- Plastering (Interior and Exterior) – Pointing for Walls and Floors using Grouts – White Washing, Color Washing with different Color Shades available in the Markets – Painting – Types of Painting for Interior and Exterior application.</td></tr>
<tr><td>Unit IV</td><td colspan="2">CONSTRUCTION EQUIPMENTS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Selection of equipment for earthwork excavation, drilling, blasting, tunnelling, erection and dewatering and pumping, concreting, material handling and erection of structures</td></tr>
<tr><td>Unit V</td><td colspan="2">GREEN BUILDING TECHNOLOGY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Introduction to green technology – types and importance; zero waste and r concept, green materials – green concrete (purpose and limitations), green buildings, green engineering.</td></tr>
<tr><td colspan="7">Total= 45 Periods</td></tr>
</table>

Text Books:	
1	Building Construction by S.C.Rangawala
2	Construction Technology by Sarkar Oxford University Press
3	Building Material & Construction by S.P. Arora& S. P. Bindra

Reference Books:	
1	Hopkinson And Kay J.D., The Lighting of Building, Faber and Faber, London.
2	Koerner, R.M, Construction & Geotechnical Methods in Foundations Engineering, McGraw Hill, 1984
3	Varna M., Construction Equipment and Its Planning & Applications, Metropolitan Books Co, 1979

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Organize the construction technique to be followed in brick and stone masonry, concreting, flooring, roofing and plastering etc.	Create
CO2	Select safe practices in building construction activities	Evaluate
CO3	Clarify the different types of roofs, floor and productive materials of buildings	understand
CO4	Select the relevant equipment for building construction	Evaluate
CO5	Apply the Principles of green building technology.	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**	**2**	**1**	**1**	**-**	**-**	**-**	**-**	**1**
CO2	**-**	**-**	**-**	**-**	**3**	**2**	**2**	**2**	**2**	**2**	**-**	**-**	**-**	**-**	**1**
CO3	**-**	**-**	**-**	**-**	**2**	**3**	**2**	**2**	**2**	**1**	**-**	**-**	**-**	**-**	**1**
CO4	**-**	**-**	**-**	**-**	**2**	**2**	**3**	**1**	**1**	**2**	**-**	**-**	**-**	**-**	**1**
CO5	**-**	**-**	**-**	**-**	**2**	**3**	**2**	**2**	**2**	**2**	**-**	**-**	**-**	**-**	**1**
Avg	**-**	**-**	**-**	**-**	**2.4**	**2.4**	**2.2**	**1.8**	**1.6**	**1.6**	**-**	**-**	**-**	**-**	**1**
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

22CEM03	**CONCRETE TECHNOLOGY**		**Semester**			
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
NIL		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To understand the properties of ingredients of concrete.
2	To study the behavior of concrete at its fresh and hardened state.
3	To study about the concrete design mix.
4	To know about the procedures in concrete at different stage.
5	To understand special concrete and their uses.

Unit I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Concrete materials, Cement: Field and laboratory tests on cement, Types of cement and their uses, different tests for aggregates. Methods for manufacturing of cement- Wet and dry process. Hydration of cement, Bogue’s compound.

Unit II	**ADMIXTURES**	**9**	**0**	**0**	**9**

Accelerating admixtures, Retarding admixtures, water reducing admixtures, Air entraining admixtures, coloring agent, Plasticizers. Batching, Mixing, Transportation, placing of concrete, curing of Concrete

Unit III	**MIX DESIGN**	**9**	**0**	**0**	**9**

Factors influencing mix proportion, Mix design by ACI method and I.S. code method, Design of high strength concrete.

Unit IV	**BEHAVIOUR OF CONCRETE**	**9**	**0**	**0**	**9**

Strength of concrete, Shrinkage and temperature effects, creep of concrete, permeability of concrete, durability of concrete, Corrosion, Causes and effects, remedial measures, Thermal properties of concrete, Micro cracking of concrete.

Unit V	**SPECIAL CONCRETE**	**9**	**0**	**0**	**9**

Light-weight concrete, Fibre reinforced concrete, Polymer modified concrete, Ferro cement, Mass concrete, Ready-mix concrete, Self-compacting concrete, Quality control, Sampling and testing, Acceptance criteria.

Total= 45 Periods

Text Books:

1	Neville A.M Properties of Concrete, Pearson publication, 2012.
2	Shetty M.S Concrete technology, S.Chand and Company Ltd, New Delhi 2022.
3	Santha Kumar A.R Concrete Technology, Oxford university Press, NewDelhi, 2022.
4	Mehta K.P Concrete Technology, Chand & Co, NewDelhi, 2006.
5	Robert RatayForensic Structural Engineering Handbook, McGraw Hill LLC, 2009

Reference Books:	
1	Indian Standard Recommended Guide lines for Concrete Mix Design, IS:10262 – 2019, Bureau of Indian Standards, NewDelhi.
2	Indian Standard Specification for Coarse and Fine Aggregates from Natural Sources for Concrete IS:383-1970 R2011, Bureau of Indian Standards, NewDelhi.
3	Gambhir.M.L,Concrete Technology, Volume I & II, Tata McGraw-HillBookCompany,Third print, 2003
4	Krishna Raju N. Design of Concrete Mixes, CBS publishers. NewDelhi, 2002.
5	Stephen E. Petty,Forensic Engineering: Damage Assessments for Residential and Commercial Structures,CRCpress,Taylor& Francis,2013.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	To identify suitable materials to be used in the cement concrete by conducting various tests as per BIS code.	Evaluate
CO2	To know about the specific applications and uses of admixtures.	Understand
CO3	Design the concrete mix using ACI and BIS code methods.	Create
CO4	Determine the properties of fresh and hardened of concrete.	Evaluate
CO5	Design special concretes and to Ensure quality control while testing/ sampling and acceptance criteria for pre and post construction work.	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	1	2	1	1	1	-	1
CO2	-	-	-	-	3	-	3	-	1	1	-	-	2	-	1
CO3	-	-	-	-	3	-	3	-	-	1	-	-	1	-	1
CO4	-	-	-	-	3	2	1	-	-	-	-	-	-	-	1
CO5	-	-	-	-	3	3	3	1	1	3	1		3	-	1
Avg	-	-	-	-	3	2.5	2.2	1	1	1.75	1	1	1.75	-	1
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

22CEM04	**ENVIRONMENTAL ENGINEERING**		**Semester**			
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
NIL		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To evaluate the sources of water and analyse its characteristics and processes in water treatment, express the analysis of distribution network
2	To design sewer system, basic design of the biological treatment processes, gain knowledge on sludge treatment and its disposal
3	To predict the sources, effects, dispersion of air pollutants air quality management and its control measures
4	To identify the characteristics and sources of municipal solid wastes, its collection methods, off-site processing of municipal solid wastes and its recovery, disposal methods
5	To assess the sources, effects and control measures of noise pollution

Unit I	**WATER TREATMENT**	**9**	**0**	**0**	**9**

Water Quality and its Treatment: Basics of water quality standards – Physical, chemical and biological parameters; Water quality index; Unit processes and operations; Water requirement; Water distribution system; Drinking water treatment.

Unit II	**WASTEWATER TREATMENT**	**9**	**0**	**0**	**9**

Sewerage system design, quantity and quality of domestic wastewater, primary and secondary treatment. Effluent discharge standards; Sludge disposal; Reuse of treated sewage for different applications.

Unit III	**AIR POLLUTION**	**9**	**0**	**0**	**9**

Air Pollution: Types of pollutants, their sources and impacts, air pollution control, air quality standards, Air quality Index and limits.

Unit IV	**SOLID WASTE MANAGEMENT**	**9**	**0**	**0**	**9**

Municipal Solid Wastes: Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse/ recycle, energy recovery, treatment and disposal).

Unit V	**NOISE POLLUTION**	**9**	**0**	**0**	**9**

Noise pollution: Sources; Health effects; Standards; Measurement and control methods

Total= 45 Periods

Text Books:

1	Garg, S.K. Water supply Engineering, Khanna Publishers, New Delhi, 2010.
2	Garg, S.K. Sewage water disposal and Air pollution, Khanna Publishers, New Delhi, 2010.
3	George Tchobanoglous et.al., Integrated Solid Waste Management, McGraw-Hill, Publishers, 1993.
4	Rao, C.S., Environmental Pollution Control Engineering, Wiley Eastern Ltd., New Delhi, 1996.

Reference Books:	
1	Manual on Water Supply and Treatment, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013.
2	Peavy S.W., Rowe D.R. and Tchobanoglous G. Environmental Engineering, McGraw Hill, NewDelhi, 1985.
3	Metcalf and Eddy,M.C., Wastewater Engineering – Treatment &Reuse,TataMcGraw-Hill Publications, New Delhi,2003.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify the sources of water supply, analyze the characteristics of water with its standards and various unit operations and processes in water treatment, express the analysis of distribution network	Remember
CO2	Expertise design sewer system, basic design of the biological treatment processes, gain knowledge on sludge treatment and disposal and justify the methods for disposal of sewage	Analyze
CO3	Predict the sources, effects, dispersion of air pollutants air quality management and its control measures	Apply
CO4	Aware about the characteristics, types and sources of municipal solid wastes, Learn the collection methods, Know about off-site processing of municipal solid wastes and its recovery, disposal methods	Remember
CO5	Understand the sources, effects and control methods of noise pollution	Understand

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**2**	**1**	**3**	**2**	**1**	**3**	**2**	**1**	**1**	**2**	**1**	**1**	**3**	**-**	**2**
CO2	**2**	**1**	**3**	**1**	**1**	**3**	**1**	**-**	**1**	**2**	**2**	**1**	**3**	**-**	**2**
CO3	**2**	**1**	**3**	**1**	**1**	**3**	**1**	**-**	**1**	**2**	**2**	**1**	**3**	**-**	**2**
CO4	**2**	**1**	**3**	**1**	**1**	**3**	**1**	**-**	**-**	**2**	**2**	**1**	**3**	**-**	**2**
CO5	**2**	**-**	**3**	**-**	**-**	**3**	**-**	**-**	**-**	**2**	**1**	**1**	**3**	**-**	**2**
Avg	**2**	**1**	**3**	**1.3**	**1**	**3**	**1.3**	**1**	**1**	**2**	**1.6**	**1**	**3**	**-**	**2**
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

22CEM05	**BASICS OF TRANSPORTATION ENGINEERING**		**Semester**			
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
NIL		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	The objective of the course is to educate the students on various components of highway engineering.
2	To educate the geometric design concepts of highway engineering
3	To develop skills on construction and maintenance of highway.
4	Ability to plan various civil engineering aspects of railways and educate various components of railways
5	The course enables the students to develop skill on evaluation and maintenance of railway track.

Unit I	**CROSS SECTIONAL ELEMENTS OF HIGHWAYS**	**9**	**0**	**0**	**9**
Classification of Highways - Classification and Cross Section of Urban and Rural Roads (IRC), Highway Cross Sectional Elements- Right of Way, Carriage Way, Camber, Kerbs, Shoulders and Footpaths (IRC Standards), Sight Distances - Stopping Sight Distance (SSD), Overtaking Sight Distance (OSD), Sight Distance at Intersections, Intermediate Sight Distance and Illumination Sight Distance - Cross Sections of Different Class of Roads -					
Unit II	**GEOMETRIC DESIGN OF HIGHWAYS**	**9**	**0**	**0**	**9**
Horizontal Alignments – Superelevation, Widening of Pavements on Horizontal Curves, Vertical Alignments - Rolling. Limiting, Exceptional and Minimum Gradients, Summit and Valley Curves -Geometric Design of Hill Roads (IRC Standards Only)					
Unit III	**CONSTRUCTION AND MAINTENANCE OF HIGHWAY**	**9**	**0**	**0**	**9**
Construction of Flexible and Rigid Pavements – Defects in Flexible and Rigid Pavements -Highway Drainage – Evaluation and Maintenance of Pavements.					
Unit IV	**RAILWAY PLANNING AND DESIGN**	**9**	**0**	**0**	**9**
Permanent Way, its Components and Functions of Each Component: Rails - Types of Rails, Rail Fastenings, Concept of Gauges, Coning of Wheels, Creeps Sleepers - Functions, Materials, Density. Ballasts - Functions, Materials, Ballast less Tracks Geometric Design of Railway Tracks Gradients and Grade Compensation, Super-Elevation, Widening of Gauges in Curves, Transition Curves, Horizontal and Vertical Curves.					
Unit V	**RAILWAY TRACK CONSTRUCTION MAINTENANCE AND OPERATION**	**9**	**0**	**0**	**9**
Points and Crossings – Turnouts, Track circuiting, Signaling, Interlocking, Lay Outs of Railway Stations and Yards, Rolling Stock, Tractive Power, Track Resistance, Level Crossings.					
					Total= 45 Periods

Text Books:

1	Khanna K., Justo C.E.G., Highway Engineering Revised 10th Edition Khanna Publishers, Roorkee, 2014
2	Kadiyalil. R, Engineering Traffic and Transport Planning, Khanna Publishers, New Delhi, 2019.
3	Chandola S.P. Transportation Engineering-2019

Reference Books:	
1	Sharma S.K., Principles Practice and Design of Highway Engineering, S. Chand & Co Ltd. New Delhi, 2006
2	Guidelines Of Ministry of Road Transport and Highways, Government of India.
3	Agarwal M.M., Indian Railway Track, 14th Edition, Prabha and Co., New Delhi, 2002.
4	Saxena S.C. Highway & Traffic Engineering, 2014.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Classify roads as per Indian Road Congress and describe the principles of highway alignment	Understand
CO2	Determine the highway geometric elements	Analyse
CO3	Differentiate between types of pavements, their construction and design principles	Analyse
CO4	Explain the functions of components of Railways	Understand
CO5	Carry out the various methods for track alignment & procedure for construction of railway & maintenance of track	Apply

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	-	-	-	-	2	2	3	1	2	-	-	-	1	-	-
CO2	2	3	2	2	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	2	2	3	1	3	-	-	-	1	-	-
CO4	-	-	-	-	2	2	3	1	2	-	-	-	-	-	-
CO5	-	-	-	-	2	2	3	1	2	-	-	-	1	-	-
Avg	2	3	2	2	2	2	3	1	2.25	-	-	-	1	-	-
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

<table>
<tr><td>22CEM06</td><td colspan="2">REPAIR AND REHABILITATION OF STRUCTURES</td><td colspan="3">Semester</td><td></td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>Category</td><td>OE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">NIL</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="6">Study the various types and properties of repair materials</td></tr>
<tr><td>2</td><td colspan="6">Learn various distress and damages to concrete structures</td></tr>
<tr><td>3</td><td colspan="6">Understand the importance of maintenance of structures</td></tr>
<tr><td>4</td><td colspan="6">Assess the damage to structures using various tests</td></tr>
<tr><td>5</td><td colspan="6">Learn various repair techniques of damaged structures, corroded structures</td></tr>
<tr><td>Unit I</td><td colspan="2">MAINTENANCE AND REPAIR STRATEGIES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Maintenance, repair and rehabilitation, Facts of Maintenance, importance of Maintenance various aspects of inspection, assessment procedure for evaluating a damaged structure, causes of deterioration.</td></tr>
<tr><td>Unit II</td><td colspan="2">SERVICEABILITY AND DURABILITY OF CONCRETE</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Quality assurance for concrete construction, concrete properties- strength, permeability, thermal properties and cracking-effects due to climate, temperature, chemical, corrosion- Design and construction errors-effects of cover thickness and cracking.</td></tr>
<tr><td>Unit III</td><td colspan="2">MATERIALS AND TECHNIQUES FOR REPAIR</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Special concretes and mortar, concrete chemical, special elements for accelerated strength gain, expansive cement, polymer concrete, Sulphur infiltrated concrete, ferro cement, fibre reinforced concrete, rust eliminators and polymers coating for rebars during repair, foamed concrete, mortar and dry pack, vacuum concrete, gunite and shotcrete, epoxy injection, mortar repair for cracks, shoring and underpinning. Methods of corrosion protection, corrosion inhibitors, corrosion resistant steels, coatings and cathodic protection.</td></tr>
<tr><td>Unit IV</td><td colspan="2">REPAIRS, REHABILITATION AND RETROFITTING OF STRUCTURES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Strengthening of Structural elements, deflection, cracking, chemical disruption, weathering corrosion, wear, fire, leakage and marine exposure.</td></tr>
<tr><td>Unit V</td><td colspan="2">DEMOLITION TECHNIQUES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Demolition methods by machines, explosives, Advanced techniques-Demolition sequences, dismantling techniques, safety precautions in dismantling and demolition, Engineered demolition techniques for dilapidated structures- case studies</td></tr>
<tr><td colspan="7" align="right">Total= 45 Periods</td></tr>
</table>

Text Books:	
1	Shetty, M.S, Concrete Technology- Theory and Practice, S. Chand and company, New Delhi,2019
2	Repair and protection of concrete structures by Noel P. Mailvaganam, CRC Press,1991.
3	CPWD: Handbook on Repair & Rehabilitation of R.C.C. Buildings, CPWD, Govt. of India, 2002, updated reprint 2011

Reference Books:	
1	Santhakumar A.R, Training Course notes on Damage Assessment and Repair in Low-cost housing, “RHDC.NBO” Anna University, July 1992.
2	Raikar R.N.,Learning from failures- deficiencies in design, construction and services – R&D Centre (SDCPL), Raikar bhavan, Bombay,1987
3	Palaniyappan, N., Estate management, Anna Institute of Management, Chennai,1992.
4	Lakshmipathy, M. etal., Lecture notes of workshop on Repairs and Rehabilitation of structures, 29-30th October 1999.
5	https://nptel.ac.in/courses/114106035/38

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom’s Taxonomy Mapped**
CO1	Demonstrate the condition of structures	Understand
CO2	Inspect and evaluate the damaged structure	Analyze
CO3	Implement the repairing techniques of a structure	Analyze
CO4	Identify and Use different materials for repairing works	Apply
CO5	Demonstrate the dismantling and demolishing structures	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**	**2**	**2**	**3**	**2**	**-**	**-**	**-**	**1**	**2**	**-**	**-**
CO2	**1**	**-**	**2**	**2**	**2**	**2**	**3**	**2**	**-**	**-**	**-**	**1**	**2**	**-**	**-**
CO3	**1**	**-**	**2**	**2**	**2**	**2**	**3**	**2**	**-**	**-**	**-**	**1**	**2**	**-**	**-**
CO4	**1**	**-**	**2**	**2**	**2**	**2**	**3**	**2**	**-**	**-**	**-**	**1**	**2**	**-**	**-**
CO5	**1**	**-**	**2**	**2**	**2**	**2**	**3**	**2**	**-**	**-**	**-**	**1**	**2**	**-**	**-**
Avg	**1**	**-**	**2**	**2**	**2**	**2**	**3**	**2**	**-**	**-**	**-**	**1**	**2**	**-**	**-**
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

<table>
<tr><td colspan="2">22CEM07</td><td colspan="2">GREEN BUILDING TECHNOLOGY</td><td colspan="3">Semester</td><td></td></tr>
<tr><td colspan="3">PREREQUISITES</td><td>Category</td><td>OE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="3" rowspan="2">NIL</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="8">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="7">To Know various aspects of green buildings</td></tr>
<tr><td>2</td><td colspan="7">To Learn the principles of planning and orientation of buildings.</td></tr>
<tr><td>3</td><td colspan="7">To Relate the construction of green building with prevailing energy conservation policy and regulations.</td></tr>
<tr><td>4</td><td colspan="7">To Know and identify different green building construction materials.</td></tr>
<tr><td>5</td><td colspan="7">To Learn different rating systems and their criteria</td></tr>
<tr><td colspan="2">Unit I</td><td colspan="2">INTRODUCTION TO GREEN BUILDING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Introduction, Necessity, Definition & concept of Green Building, Issues and strategies of Green Building, Principles and Benefits of Green Building, Components/ features of Green Building, Energy Efficiency, Water efficiency, Material Efficiency, Indoor Air Quality.</td></tr>
<tr><td colspan="2">Unit II</td><td colspan="2">SITE SELECTION AND PLANNING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Site selection, Site selection strategies, Landscaping, building form, orientation, building envelope and fenestration, material and construction techniques, roofs, walls, fenestration and shaded finishes, Environmental design (ED) strategies for building construction, Rainwater harvesting methods for roof & non-roof, reducing landscape water demand by proper irrigation systems, recycle and reuse systems, Waste Management.</td></tr>
<tr><td colspan="2">Unit III</td><td colspan="2">ENERGY AND ENERGY CONSERVATION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Introduction, Environmental impact of building constructions, present scenario, Need of energy conservation, Concepts of embodied energy,
operational energy and life cycle energy, Methods to reduce operational energy, Energy efficient building, zero ozone depleting potential (ODP) materials, wind and solar energy harvesting, energy metering and monitoring, concept of net zero buildings.</td></tr>
<tr><td colspan="2">Unit IV</td><td colspan="2">BUILDING MATERIALS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Green building materials and products- Bamboo, Rice husk ash concrete, plastic bricks, Bagasse particle board, Insulated concrete forms. use of materials with recycled content such as blended cements, pozzolana cements, flyash bricks, vitrified tiles, materials from agro and industrial waste, reuse of waste material-Plastic, rubber, Newspaper wood, Nontoxic paint, green roofing.</td></tr>
<tr><td colspan="2">Unit V</td><td colspan="2">RATING SYSTEM</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Introduction to Leadership in Energy and Environmental Design (LEED) criteria, Indian Green Building council (IGBC) Green rating, Green Rating for Integrated Habitat Assessment. (GRIHA) criteria, National Productivity council (NPC) Ministry of New and Renewable Energy (MNRE) Bureau of Energy efficiency (BEE) -BER (Building Energy Rating) – Certificates.</td></tr>
<tr><td colspan="8">Total= 45 Periods</td></tr>
</table>

<table>
<tr><td colspan="2">Text Books:</td></tr>
<tr><td>1</td><td>Kibert, C.J., Sustainable construction: Green Building design and Delivery, John Wiley Hobouken, NewJersey, 3rd Edition, 2012.</td></tr>
<tr><td>2</td><td>Chauhan, D S Sreevasthava, S K., Non-conventional Energy Resources, New Age International Publishers, NewDelhi, 4th Edition, 2021</td></tr>
</table>

Reference Books:	
1	O.P. Gupta, Energy Technology, Khanna Publishing House, NewDelhi
2	Jagadeesh, K S, Reddy Venkatta Rama &Nanjunda Rao, K S., Alternative Building Materials and Technologies, New Age International Publishers,Delhi.
3	Sam Kubba., Handbook of Green Building Design and Construction, Butterworth- Heinemann.
4	Means R S, Green Building - Project Planning and Cost Estimating, John Wiley &Sons
5	Sharma K V, Venkataseshaiah P., Energy Management and Conservation, IK International.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the concepts of Green Building	Understand
CO2	Discuss the Planning of Green Building.	Understand
CO3	Explain the concept of Energy and Energy Conservation.	Understand
CO4	Select appropriate green building material and technique.	Understand
CO5	Summarize the Green Building Functions in various organizations.	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**	**2**	-	-
CO2	**1**	**1**	**1**	**2**	**1**	-	-	-	-	-	-	-	**2**	-	-
CO3	-	**1**	**3**	-	**2**	-	-	-	-	-	-	-	**2**	-	-
CO4	-	**1**	**2**	-	**3**	-	-	-	-	-	**2**	-	**2**	-	-
CO5	**1**	**1**	**2**	**3**	**2**	-	-	-	-	-	**2**	-	**2**	-	-
Avg	**1**	**1**	**2**	**2**	**2**	**2**	**3**	-	-	-	**2**	**1**	**2**	-	-
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

22CSM01	**PROGRAMMING IN C++**					
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**
Course Learning Objectives						
1	To understand and develop the object oriented programming concepts.					
2	To familiarize and design the template functions and classes					
3	To disseminate and apply exception handling mechanisms.					
4	To learn and exploit stream classes.					
Unit I	**INTRODUCTION**		**9**	**0**	**0**	**9**
Procedure oriented programming paradigm - Object oriented programming paradigm - Basic concepts of object oriented programming, benefits of OOP, application of OOP - C++ fundamentals –structure of C++ program, tokens, data types - Operators and expressions - Control structures - Functions.						
Unit II	**INHERITANCE AND VIRTUAL FUNCTIONS**		**9**	**0**	**0**	**9**
Classes and objects - friend functions- constructors and destructors- Operator overloading – binary and unary operator overloading using member function and friend function - Type conversions.						
Unit III	**INHERITANCE AND VIRTUAL FUNCTIONS**		**9**	**0**	**0**	**9**
Inheritance – defining derived classes, types, virtual base classes, abstract classes, constructor in derived classes - Pointers- pointers to objects, this pointer, pointer to derived classes - Virtual functions.						
Unit IV	**TEMPLATES AND EXCEPTION HANDLING**		**9**	**0**	**0**	**9**
Generic Classes – class template, class templates with multiple parameters - Generic Functions - function templates, function templates with multiple parameters, member function templates - Exception handling – basics, exception handling mechanism, rethrowing an exception – Exception handling options – understanding terminate() and unexpected() – the uncaught_exception() function – bad_exception().						
Unit V	**CONSOLE I/O AND FILE HANDLING**		**9**	**0**	**0**	**9**
C++ Stream Classes – unformatted I/O operations, formatted console I/O operations, manipulators - Files-classes for file operation, opening and closing a file, detecting end of file, files modes, sequential file operations, random file operations.						
						Total (45 L) =45 Periods

Text Books:	
1	E. Balagurusamy “Object –Oriented Programming with C++” Sixth Edition Tata McGraw-Hill
Reference Books:	
1	Herbert Schildt, "The Complete Reference C++", Fifth Edition, Tata McGraw Hill
2	Bjarne Stroustrup, “The C++ programming language”, Fourth Edition Addison Wesley
3	K.R.Venugopal, Rajkumar Buyya, T.Ravishankar , Mastering in C++, Second Edition, Tata McGraw Hill

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom’s Taxonomy Level**
CO1	Build the object oriented programming concepts.	Apply
CO2	Familiarize and build the template functions and classes	Understand
CO3	Disseminate and apply exception handling mechanisms.	Apply
CO4	Depict and exploit steam classes.	Understand

22CSM02	**ADVANCED DATA STRUCTURES AND ALGORITHMS**					
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To understand the concepts of ADTs
2	To Learn linear data structures – lists, stacks, and queues
3	To have knowledge about non-linear data structures like trees and graphs
4	To understand concepts about searching and sorting and hashing techniques

Unit I	**LINEAR DATA STRUCTURES – LIST**	**9**	**0**	**0**	**9**

Abstract Data Types (ADTs) – List ADT - Array based Implementation - Linked List Implementation – Singly Linked Lists - Circularly Linked Lists - Doubly-Linked Lists - Applications of Lists – Polynomial Manipulation – All operations (Insertion, Deletion, Merge, Traversal).

Unit II	**LINEAR DATA STRUCTURES –STACKS AND QUEUES**	**9**	**0**	**0**	**9**

Stack ADT - Operations - Applications of Stacks - Evaluating Arithmetic Expression - Conversion of infix to postfix Expression - Queue ADT - Operations - Circular Queue - DeQueue - Applications of Queue

Unit III	**NON LINEAR DATA STRUCTURES – TREES**	**9**	**0**	**0**	**9**

Tree ADT – Tree traversals – Binary Tree ADT – Expression Trees – Applications of Trees – Binary Search Tree ADT – Threaded Binary Trees- AVL Trees – B-Tree – Heaps - Operations of Heaps - Priority Queues - Binary Heap - Max Heap - Min Heap - Applications of Heap.

Unit IV	**NON LINEAR DATA STRUCTURES – GRAPHS**	**9**	**0**	**0**	**9**

Definition – Representation of Graphs –Types of Graphs - Graph Traversals - Breadth First Search - Depth First Search - Application of Graph Structures: Shortest Path Problem: Dijkstra's Algorithm - Minimum Spanning Trees: Prim's Algorithm - Kruskal's Algorithms

Unit V	**SEARCHING, SORTING AND HASHING TECHNIQUES**	**9**	**0**	**0**	**9**

Searching: Linear Search - Binary Search - Sorting Algorithms - Insertion Sort - Selection Sort - Shell Sort - Bubble Sort - Quick Sort - Merge Sort - Radix Sort - Hashing: Hash Functions – Separate Chaining – Open Addressing – Rehashing – Extendible Hashing.

Total (45 L) =45 Periods

Text Books:

1	Mark Allen Weiss, " Data Structures and Algorithm Analysis in C ", 4/E Pearson Education, 2013.

Reference Books:

1	Seymour Lipschutz, "Data Structures With C ",(Schaum`s Outline Series) Published by Tata McGraw-Hill Education Pvt. Ltd., 2015
2	Ellis Horowitz, Sartaj Sahni, Dinesh Mehta, "Fundamentals of Data Structures In C", Second Edition, Silicon Press, 2008.
3	Richard F.Gilberg & Behrouz A.Forouzan, "Data Structures: A Pseudo code Approach With C", Second Edition, Cengage Learning Publishers,2005.
4	Classic Data Structures", Second Edition by Debasis Samanta, PHI Learning, 2009.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Implement various abstract data types to solve real time problems by using Linear Data Structures	Apply
CO2	Apply the different Non-Linear Data Structures to solve problems	Apply
CO3	Analyze and implement graph data structures to solve various computing problems.	Analyze
CO4	Critically analyze the various sorting and searching algorithms	Analyze

22CSM03	**COMPUTER ORGANIZATION AND DESIGN**					
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To understand the basic structure and operations of digital computer
2	To learn the working of different arithmetic operations
3	To understand the different types of control and the concept of pipelining
4	To study the hierarchical memory system including cache memory and virtual memory
5	To understand the different ways of communication with I/O devices and standard I/O interfaces

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Functional units ,Basic Operational Concepts, Bus Structure ,Memory Locations and Addresses, MemoryOperations, Instruction and Instruction Sequencing, Addressing modes.					
UNIT II	**ARITHMETIC UNIT**	**9**	**0**	**0**	**9**
Addition and Subtraction of Signed Numbers, Design of Fast Adders, Multiplication of Positive Numbers, BoothAlgorithm, Fast Multiplication, Integer Division, Floating point number operations.					
UNIT III	**PROCESSOR UNIT AND PIPELINING**	**9**	**0**	**0**	**9**
Fundamental Concepts, Execution of Instruction, Multi Bus Organization, Hardwired control, Micro programmed control, Basic Concepts of pipelining, Data Hazards, Instruction Hazards ,Data path & Control Considerations.					
UNIT IV	**MEMORY SYSTEMS**	**9**	**0**	**0**	**9**
Basic Concepts, Semiconductor RAM, ROM, Cache memory, Improving Cache Performance, Virtual memory,Memory Management requirements, Secondary Storage Device.					
UNIT V	**INPUT AND OUTPUT ORGANIZATION**	**9**	**0**	**0**	**9**
Accessing I/O devices, Programmed I/O, Interrupts, Direct Memory Access, Interface circuits, Standard I/O Interfaces (PCI, SCSI, USB).					
Total (45 L) =45 Periods					

Text Books:

1	Carl Hamacher V.,Zvonko G.Vranesic, Safwat G. Zaky, " Computer organization ", Tata McGraw Hill,5th Edition, 200

Reference Books:

1	Patterson and Hennessey, “Computer Organization and Design ". The Hardware/Software interface,Harcourt Asia Morgan Kaufmann, 3rd Edition, 2007
2	Hayes, “Computer Architecture and Organization ", 3rd edition,Tata McGraw Hill, 2006
3	Heuring V.P., Jordan H.F., " Computer System Design and Architecture ", 6th edition ,Addison Wesley,2008

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand the working principles of computer componets	Understand
CO2	Design the arithmetic and processing units	Create
CO3	Analyze the various computer components	Analyze

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22CSM04	ADVANCED OPERATING SYSTEMS		Semester			
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To understand the structure and functions of Operating systems
2	To understand the process concepts and scheduling algorithms
3	To understand the concept of process synchronization and deadlocks
4	To learn various memory management schemes
5	To illustrate various file systems and disk management strategies

UNIT I	INTRODUCTION AND OPERATING SYSTEM STRUCTURES	9	0	0	9

Main frame Systems, Desktop Systems, Multiprocessor Systems, Distributed Systems, Clustered Systems, Real Time systems, Hand held Systems; Operating Systems Structures - System Components, Operating System Services, System calls, System Programs, System Design and Implementation.

UNIT II	PROCESS MANAGEMENT	9	0	0	9

Processes-Process Concepts, Process Scheduling, Operation on Processes, Co-Operating Processes, InterProcess Communication; Threads- Multithreading Models, Threading Issues; CPU Scheduling-Basic Concepts, Scheduling Criteria, Scheduling Algorithms.

UNIT III	PROCESS SYNCHRONIZATION AND DEADLOCKS	9	0	0	9

Process Synchronization- The Critical Section Problem, Synchronization Hardware, Semaphores, Classical Problem of Synchronization, Monitors; Deadlocks- Deadlock Characterization, Methods for handling Deadlocks, Deadlock Prevention, Deadlock Avoidance ,Deadlock Detection, Recovery from Deadlock.

UNIT IV	MEMORY MANAGEMENT AND VIRTUAL MEMORY	9	0	0	9

Memory Management- Background, Swapping, Contiguous Memory Allocation, Paging, Segmentation, Segmentation with paging; Virtual Memory - Demand paging, Page Replacement, Thrashing.

UNIT V	FILE SYSTEM AND MASS-STORAGE STRUCTURE	9	0	0	9

File System Interface - File Concepts, Access methods, Directory Structure, File Sharing, File Protection; File System Implementation- File System Structure and Implementation, Directory Implementation, Allocation Methods, Free Space Management; Mass-Storage Structure - Disk Structure, Disk scheduling, Disk Management, RAID Structure; Case study: Linux system.

Total (45 L) =45 Periods

Text Books:

1	Abraham Silberschatz, P.B.Galvin, G.Gagne —Operating System Concepts 6th edition, John Wiley & Sons, 2003.

Reference Books:

1	Andrew S. Tanenbaum, —Modern Operating Systems, PHI , 2nd edition, 2001
2	D.M.Dhamdhere, “Systems Programming and Operating Systems ", 2nd edition, Tata McGraw Hill Company, 1999.
3	Maurice J. Bach, —The Design of the Unix Operating System, 1st edition, PHI, 2004.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Identify the components and their functionalities in the operating system	Apply
CO2	Apply various CPU scheduling algorithms to solve problems	Apply
CO3	Analyze the needs and applications of process synchronization and deadlocks	Analyze
CO4	Apply the concepts of memory management including virtual memory and page replacement to the issues that occur in real time applications	Apply
CO5	Solve issues related to file system implementation and disk management	Apply

<table>
<tr><td colspan="2">22CSM05</td><td colspan="2">DATA COMMUNICATION AND COMPUTER NETWORKS</td><td colspan="3">Semester</td><td></td></tr>
<tr><td colspan="3">PREREQUISITES</td><td>Category</td><td>OE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="3" rowspan="2"></td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="8">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="7">To study the concepts of data communications and functions of different ISO/OSI reference architecture</td></tr>
<tr><td>2</td><td colspan="7">To understand the error detection and correction methods and also the types of LAN</td></tr>
<tr><td>3</td><td colspan="7">To study the concepts of subnetting and routing mechanisms</td></tr>
<tr><td>4</td><td colspan="7">To understand the different types of protocols and congestion control</td></tr>
<tr><td>5</td><td colspan="7">To study the application protocols and network security</td></tr>
<tr><td colspan="2">UNIT I</td><td colspan="2">DATA COMMUNICATIONS AND PHYSICAL LAYER</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Data Communication; Networks- Physical Structures (Types of Connections, Physical Topology),Categories of Networks, Interconnection of Networks: Internetwork; Protocols and Standards; Network Models-The OSI Model, Layers in the OSI Model, Addressing; Transmission media-Guided Media, Unguided Media.</td></tr>
<tr><td colspan="2">UNIT II</td><td colspan="2">DATA LINK LAYER</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Introduction-Types of errors, Redundancy, Detection versus Correction, Modular Arithmetic; Block Coding-Error Detection and Correction (VRC,LRC,CRC, Checksum, Hamming Code);Data link Control- Flow Control (Stop- and-Wait, Sliding Window),Error Control (Automatic Repeat Request, Stop-and-wait ARQ, Sliding Window ARQ), HDLC; Local Area Networks-Ethernet, Token Bus, Token Ring, FDDI.</td></tr>
<tr><td colspan="2">UNIT III</td><td colspan="2">NETWORK LAYER</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Network Layer services-Packet Switching-Network Layer Performance-IPv4 addresses-IPv6 addressing- Subnetting-Bridges-Gateways- Routers-Routing Algorithm-Distance Vector Routing, Link State Routing.</td></tr>
<tr><td colspan="2">UNIT IV</td><td colspan="2">TRANSPORT LAYER</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Duties of the Transport layer-User Datagram Protocol-Transmission Control Protocol- Congestion Control and Quality of Service-Congestion, Congestion Control, Quality of Service, Techniques to improve QoS, Integrated Services.</td></tr>
<tr><td colspan="2">UNIT V</td><td colspan="2">PRESENTATION LAYER AND APPLICATION LAYER</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Domain Name System - Domain Name Space, DNS in the Internet; Electronic Mail-FTP- HTTP- World Wide Web.</td></tr>
<tr><td colspan="8">Total (45 L) =45 Periods</td></tr>
</table>

Text Books:	
1	Behrouz A.Ferouzan, “Data Communications and Networking”, 4th Edition, Tata McGraw-Hill, 2007.

Reference Books:	
1	Andrew S. Tanenbaum, “Computer networks “PHI, 4th edition 2008
2	William Stallings,” Data and computer communications”, 10th edition,PHI, 2012
3	Douglas E. comer,” Internetworking with TCP/IP-Volume-I”, 6th edition,PHI, 2008

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Classify the fundamentals of data communications and functions of layered architecture	Understand
CO2	Apply the error detection and correction methods and also identify the different network technologies	Apply
CO3	Analyze the requirements for a given organizational structure and select the most appropriate networking architecture and routing technologies	Analyze
CO4	Illustrate the transport layer principles and reliable data transfer using protocols	Apply
CO5	Analyze the application layer protocols and also the use of network security	Analyze

22CSM06	**PROGRAMMING ESSENTIALS IN PYTHON**		**Semester**			
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives	
1	To learn Python data structures, conditional and control structures and files
2	To study Python Modules, packages, Functions and Exceptions.
3	To describe Object oriented programming features and Regular Expressions.
4	To learn about Web programming, GUI Programming and Database programming

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Python: Features - The Basics-Python Objects-Numbers-Sequences-Mapping and set types- Conditionals and loops-if statement-else statement-elif-Conditional Expressions-while statement-for statement-break-continue.					
UNIT II	**FUNCTIONS, MODULES AND PACKAGES**	**9**	**0**	**0**	**9**
Functions-Calling functions-Creating functions-Passing Functions-Formal Arguments-Variable length arguments-variable scope-Recursion, Modules-Packages.					
UNIT III	**FILES AND EXCEPTIONS**	**9**	**0**	**0**	**9**
Files and Input/ Output –Errors and Exceptions-Introduction-Detecting and handling Exceptions-Context Management-Raising Exceptions-Assertions-Standard Exceptions.					
UNIT IV	**OBJECT ORIENTED PROGRAMMING AND REGULAR EXPRESSIONS**	**9**	**0**	**0**	**9**
Object Oriented Programming Introduction-Classes-class Attributes-Instances-Instances attributes-Building and Method Invocation-Static methods and class Methods-Inheritance-Operator overloading - Regular Expressions-Network Programming – Multithreaded Programming					
UNIT V	**ADVANCED TOPICS**	**9**	**0**	**0**	**9**
GUI Programming- Web Programming-Database Programming					
Total (45 L) =45 Periods					

Text Books:	
1	Wesley J.Chun-“Core Python Programming” –Prentice Hall, Second Edition, 2006.
Reference Books:	
1	Swaroop C N, “ A Byte of Python “, ebshelf Inc., 1st Edition, 2013
2	“A Practical Introduction to python programming”, Brian Heinold,Mount St.Mary’s University,2012
3	Learning to Program with Python,” Richard L. Halterman”., Southern Adventist University

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom’s Taxonomy Level**
CO1	Develop programs using control structures and files. .	Create
CO2	Create own Python Modules, packages, functions and Exceptions. .	Create
CO3	Illustrate Object oriented Programming features and Regular Expressions.	Apply
CO4	Create own Web programs, GUI and database programs.	Create

22CSM07	**ADVANCED DATABASE SYSTEM CONCEPTS**		**Semester**			
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To understand the fundamentals of data models ,SQL queries and relational databases
2	To make a study of database design using ER Diagram and normalize
3	To impart knowledge in transaction processing.
4	To make the students to understand the file operations and indexing
5	To familiarize the students with advanced databases

UNIT I	**RELATIONAL DATABASES**	**9**	**0**	**0**	**9**

Purpose of Database System – Views of data – Data Models – Database System Architecture – Introduction to relational databases – Relational Model – Keys – Relational Algebra – SQL fundamentals – Advanced SQL features – Embedded SQL– Dynamic SQL.

UNIT II	**DATABASE DESIGN**	**9**	**0**	**0**	**9**

Entity-Relationship model – E-R Diagrams – Enhanced-ER Model – ER-to-Relational Mapping – Functional Dependencies – Non-loss Decomposition – First, Second, Third Normal Forms, Dependency Preservation – Boyce/Codd Normal Form – Multi-valued Dependencies and Fourth Normal Form – Join Dependencies and Fifth Normal Form.

UNIT III	**TRANSACTION**	**9**	**0**	**0**	**9**

Transaction Concepts – ACID Properties – Schedules – Serializability – Concurrency Control – Need for Concurrency – Locking Protocols – Two Phase Locking – Deadlock – Transaction Recovery – Save Points – Isolation Levels – SQL Facilities for Concurrency and Recovery.

UNIT IV	**IMPLEMENTATION TECHNIQUES**	**9**	**0**	**0**	**9**

RAID – File Organization – Organization of Records in Files – Indexing and Hashing –Ordered Indices – B+ tree Index Files – B tree Index Files – Static Hashing – Dynamic Hashing – Query Processing Overview – Algorithms for SELECT and JOIN operations – Query optimization using Heuristics and Cost Estimation.

UNIT V	**ADVANCED TOPICS**	**9**	**0**	**0**	**9**

Distributed Databases: Architecture, Data Storage, Transaction Processing – Object-based Databases: Object Database Concepts, Object-Relational features, ODMG Object Model, ODL, OQL – XML Databases: XML Hierarchical Model, DTD, XML Schema, XQuery – Data Warehousing and Data Mining - information Retrieval:
IR Concepts, Retrieval Models, Queries in IR systems.

Total (45 L) =45 Periods

Text Books:

1	Abraham Silberschatz, Henry F.Korth and S.Sundarshan “Database System Concepts”, Sixth Edition,Tata McGraw Hi 2011.

Reference Books:

1	Ramez Elamassri and Shankant B-Navathe, “Fundamentals of Database Systems”, Sixth Edition,Pearson Education, 2011.
2	C.J. Date, “An Introduction to Database Systems”, Eighth Edition, Pearson Education Delhi, 2008.
3	Raghu Ramakrishnan, ―Database Management Systems, Fourth Edition, McGraw-Hill CollegePublications, 2015.
4	G.K.Gupta,”Database Management Systems”, Tata McGraw Hill, 2011.

E-References:	
1.	Lecture Series on Database Management System by Dr.S.Srinath, IIIT Bangalore, nptl

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand the basic concepts of the database and data models.	Understand
CO2	Design a database using ER diagrams and map ER into Relations and normalize the relations.	Create
CO3	Develop a simple database for applications	Create

22CSM08	**VIRTUALIZATION AND CLOUD COMPUTING**		**Semester**			
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To introduce the broad perceptive of Parallel Computing, Distributed Computing and Cloud Computing.
2	To understand the concept of Virtualization
3	To identify the approaches of SLA and programming model in Cloud
4	To understand the Cloud Platforms in Industry and Software Environments.
5	To learn to design the trusted Cloud Computing system

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

Principles of Parallel and Distributed Computing – Elements of Parallel and Distributed Computing, Technologies for Distributed Computing; Vision of Cloud, Defining a Cloud, characteristics and benefits; Cloud Computing Architecture- Cloud Reference Model, Types of Clouds, Open Challenges.

UNIT II	**VIRTUALIZATION**	**9**	**0**	**0**	**9**

Introduction, Characteristics of Virtualized environments, Virtualization techniques-Machine Reference Model, Hardware-Level Virtualization, Programming Language-Level Virtualization, Application-Level Virtualization ,Other types of Virtualization, Virtualization and Cloud computing, Pros and cons of Virtualization, Technology examples-Xen: Para virtualization, VMware: Full Virtualization.

UNIT III	**SLA MANAGEMENT IN CLOUD COMPUTING AND PROGRAMMING MODEL**	**9**	**0**	**0**	**9**

Traditional Approaches to SLA Management, Types of SLA, Life Cycle of SLA, SLA Management in Cloud; Data Intensive Computing - Technologies for Data Intensive Computing, MapReduce Programming Model.

UNIT IV	**CLOUD INDUSTRIAL PLATFORMS AND SOFTWARE ENVIRONMENTS**	**9**	**0**	**0**	**9**

Cloud Platforms in Industry - Amazon Web Service, Google App Engine; Cloud Software Environments –Eucalyptus, OpenNebula; Aneka Cloud Application Platform-Aneka Framework Overview, Anatomy of Aneka Container.

UNIT V	**CLOUD SECURITY AND APPLICATIONS**	**9**	**0**	**0**	**9**

An Introduction to the Idea of Data Security, The Current State of Data Security in the Cloud, Cloud Computing and Data Security Risk, Cloud Computing and Identity; The Cloud, Digital Identity, and Data Security, Content Level Security, Pros and Cons; Cloud Scientific Applications.

Total (45L) = 45 Periods

Text Books:

1	Rajkumar Buyya, Christian Vecchiola, S.Tamarai Selvi, 'Mastering Cloud Computing-Foundations and Applications Programming", TMGH,2013.(Unit- I,II & IV)
2	RajKumar Buyya, James Broberg, Andrezei M.Goscinski, "Cloud Computing: Principles and paradigms",2011(Unit-III & V)

Reference Books:

1	Kai Hwang.GeoffreyC.Fox.JackJ.Dongarra, " Distributed and Cloud Computing ,From Parallel Processing to The Internet of Things", 2012 Elsevier
2	Barrie Sosinsky, "Cloud Computing Bible", Wiley Publisher, 2011

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Explain the main concepts and architecture of Parallel computing, Distributed Computing and Cloud Computing.	Understand
CO2	Analyze the concept of Virtualization	Analyze
CO3	Identify the approaches of SLA and programming model in Cloud	Apply
CO4	Analyze the Cloud Platforms in Industry and Software Environments.	Analyze
CO5	Identify the security issues in scientific and real time applications.	Apply

22ECM01	**ELECTRON DEVICES**					
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1. To introduce components such as diodes, BJTs and FETs, their characteristics and applications
2. To understand, analyse and design of simple diode and transistor circuits.
3. To know the switching characteristics of components and the concept of rectifiers and power supplies

Unit I	**EXTRINSIC SEMICONDUCTOR AND PN JUCTIONS**	**9**	**0**	**0**	**9**

N and P type semiconductor and their energy band structures- Law of electrical neutrality-calculation of location of Fermi level and free electron and hole densities in extrinsic semiconductors-Mobility, drift current and conductivity-diffusion current-continuity equation- Hall effect and its applications. Band structure of PN junction – current component in a PN junction- derivation of diode equation-temperature dependence of diode characteristics and equivalent models.

Unit II	**SWITCHING CHARACTERISTICS OF PN JUNTION AND SPECIAL DIODES**	**9**	**0**	**0**	**9**

Calculation of transition and diffusion capacitance- varactor diode-charge control description of diode-switching characteristics of diode- mechanism of avalanche and Zener breakdown-temperature dependence of breakdown voltages-backward diode-tunneling effect in thin barriers - tunnel diode-photo diode-light emitting diodes.

Unit III	**BIPOLAR JUNCTION TRANSISTORS**	**9**	**0**	**0**	**9**

Construction of PNP and NPN transistors- BJT current components-emitter to collector and base to collector current gains-base width modulation CB, CE and CC characteristics- breakdown characteristics- Ebers-Moll model - transistor switching times- Photo translator.

Unit IV	**FIELD EFFECT TRANSISTORS**	**9**	**0**	**0**	**9**

Construction and characteristics of JFET-relation between pinch off voltage and drain current derivation. MOSFETS - enhancement and depletion types. CMOS circuits. MOS capacitance, BICMOS, SOI CMOS.

Unit V	**RECTIFIERS AND POWER SUPPLIES**	**9**	**0**	**0**	**9**

Half-wave, full-wave and bridge rectifiers with resistive load. Analysis for Vdc and ripple voltage with C, CL, L-C and C-L-C filters. Voltage multipliers Zener diode regulator. Electronically regulated d.c power supplies. Line regulation, output resistance and temperature coefficient.

Total (45L)= 45 Periods

Text Books:

1. JaconMillman& Christos C. Halkias, " Electronic Devices and Circuits" Tata McGraw-Hill, 1991.
2. Robert L. Boylestad and Louis Nashelsky, "Electronic Devices and Circuit Theory 8th edition.", PHI, 2002

Reference Books:

1. Donald A. Neaman. " Semiconductor Physics and Devices" 3rd Ed., Tata McGraw-Hill 2002
2. S. Salivahanan, N. Suresh kumar and A. Vallavaraj, Electronic Devices and Circuits, TMH, 1998.
3. Ben, G. Streetman and Sanjay Banerjee, Solid State Electronic Devices, Pearson Education 2000
4. Floyd, "Electronic Devices", Sixth edition, Pearson Education, 2003.

E-References:

1. https://archive.nptel.ac.in/courses/108/108/108108122/
2. https://www.youtube.com/watch?v=qqQ8wO-lNmI
3. https://slideplayer.com/slide/12438044/

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Interpret various applications of diode.	Applying
CO2	Classify various configurations and biasing technique of BJT	Applying
CO3	Apply the knowledge of using special devices for various applications	Understanding
CO4	Discuss operation, biasing and applications of JFET.	Analysing
CO5	Design power supplies and rectifiers	Applying

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	2	2	1	-	-	-	-	-	-	-	-	-	1	-	-
CO2	2	2	1	-	-	-	-	-	-	-	-	-	2	-	-
CO3	2	2	1	-	-	-	-	-	-	-	-	-	3	-	-
CO4	2	2	1	-	-	-	-	-	-	-	-	-	2	2	1
CO5	2	2	1	-	-	-	-	-	-	-	-	-	3	2	2
Avg	2	2	1	-	-	-	-	-	-	-	-	-	2.2	2	1.5
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

22ECM02	DIGITAL ELECTRONICS					
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives	
1	To introduce basic postulates of boolean algebra and show the correlation between expressions
2	To Introduce the methods for Simplifying Boolean expressions
3	To Outline the formal procedures for the analysis and design of combinational circuits and sequential circuits
4	To introduce the Concept of Memories and programmable logic devices
5	To illustrate the concept of synchronous and Asynchronous sequential circuits

Unit I	**NUMBER SYSTEMS AND LOGIC GATES**	**9**	**0**	**0**	**9**
Number Systems - signed Binary numbers - Binary Arithmetic - Binary codes -conversion from one code to another - Boolean Algebra and Minimization Techniques - Canonical forms – Conversion between canonical forms – Simplifications of Boolean expressions using Karnaugh map - LOGIC GATES - Implementations of Logic Functions using gates.					
Unit II	**COMBINATIONAL CIRCUITS**	**9**	**0**	**0**	**9**
Design procedure – Adders/Subtractor – Serial adder/ Subtractor - Parallel adder/ Subtractor- BCD adder- Multiplexer/ Demultiplexer - encoder / decoder – code converters.					
Unit III	**SEQUENTIAL CIRCUITS**	**9**	**0**	**0**	**9**
Design Procedure - Flip flops: SR, JK, T, D and JKMS – Triggering of Flip-flop - Realization of flip flops – Moore and Mealy – Counters: Asynchronous / Ripple counters – Synchronous counters – Modulo n counter. Register: shift registers- Universal shift register.					
Unit IV	**ASYNCHRONOUS SEQUENTIAL CIRCUITS**	**9**	**0**	**0**	**9**
Design of fundamental mode circuits – primitive state / flow table – Minimization of primitive state table –state assignment. Problems in Asynchronous Circuits: Cycles – Races – Hazards. Design of Hazard Free Circuits: Static, Dynamic Hazards elimination					
Unit V	**PLD AND MEMORY DEVICES**	**9**	**0**	**0**	**9**
Classification of memories –RAM organization –ROM organization. Programmable Logic Devices: Programmable Logic Array (PLA) - Programmable Array Logic (PAL). Implementation of combinational logic using MUX, ROM, PAL and PLA.					
Total (45 L) = 45 Periods					

Text Books:	
1	M. Morris Mano, Digital Design, 4.ed.,Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2008
2	R.P.Jain, Modern Digital Electronics, 4th edition, TMH, 2010.
Reference Books:	
1	S. Salivahanan and S. Arivazhagan, Digital Circuits and Design, 2nd ed., Vikas Publishing House Pvt. Ltd, New Delhi, 2004
2	Charles H.Roth. “Fundamentals of Logic Design”, Thomson Publication Company, 2003.
3	Donald P.Leach and Albert Paul Malvino, Digital Principles and Applications, 5 ed., Tata McGraw Hill Publishing Company Limited, New Delhi, 2003.
4	John F.Wakerly, Digital Design: Principles and practices, PHI, 2006

E-Reference:	
1	http://nptel.ac.in/noc/individual_course.php?id=noc15-ec01
2	https://nptel.ac.in/courses/117105080/6

3	https://nptel.ac.in/courses/117105080/12

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Minimize Boolean expressions and implement using logic gates	Applying
CO2	Design and analyse combinational logic circuits.	Analysing
CO3	Design and analyse synchronous and asynchronous sequential logic circuits	Analysing
CO4	Understand the concepts of memories and PLDs	Understanding
CO5	Implement circuits using memory and PLDs.	Applying

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	2	3	2	3	2	-	-	-	-	2	1	-
CO2	3	3	2	2	3	3	2	1	1	-	-	-	3	2	-
CO3	2	2	3	3	2	1	2	1	1	-	-	-	2	2	-
CO4	2	1	2	1	2	2	3	1	-	-	-	-	2	1	-
CO5	2	1	2	1	3	2	1	2	-	-	-	-	3	2	-
Avg	2.4	1.8	2.2	1.8	2.6	2	2.2	1.4	1	-	-	-	2.4	1.6	-
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

22ECM03	**ELECTRONIC CIRCUITS**				
PREREQUISITES	**CATEGORY**	**OE**	**Credit**		**3**
Electron Devices	**Hours/Week**	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**
Course Objectives					
1	To perform analysis on Small signal amplifiers and large signal amplifiers.				
2	To give a comprehensive exposure to all types of discrete amplifiers and oscillators.				
3	To understand the various linear and non-linear applications of op-amp				
Unit I	**MIDBAND ANALYSIS OF SMALL SIGNAL AMPLIFIERS**	**9**	**0**	**0**	**9**
BJT – Need for biasing - Fixed bias circuit - Load line and quiescent point. Different types of biasing circuits. Use of Self bias circuit as a constant current circuit. CE, CB and CC amplifiers. Method of drawing small-signal equivalent circuit. Mid-band analysis of various types of single stage amplifiers to obtain gain - input impedance and output impedance. Miller's theorem. Darlington connection using similar and Complementary transistors. Methods of increasing input impedance using Darlington connection and bootstrapping. CS, CG and CD (FET) amplifiers. Multistage amplifiers-Basic emitter coupled differential amplifier circuit. Differential gain - CMRR. Use of constant current circuit to improve CMRR.					
Unit II	**LARGE SIGNAL AMPLIFIERS**	**9**	**0**	**0**	**9**
Low frequency & High frequency analysis of amplifiers -Hybrid – pi equivalent circuit of BJTs.-High frequency equivalent circuit of FETs. Gain-bandwidth product of FETs. General expression for frequency response of multistage amplifiers. Calculation of overall upper and lower cut off frequencies of multistage amplifiers. Amplifier rise time and sag time and their relation to cut off frequencies. Classification of amplifiers (Class A, B, AB, C&D), Efficiency of class A, RC coupled and transformer-coupled power amplifiers. Class B complementary-symmetry, push-pull power amplifiers. Calculation of power output, efficiency and power dissipation. Crossover distortion and methods of eliminating it. Calculation of actual power handling capacity of transistors with and without heat sink. Heat sink design.					
Unit III	**OSCILLATORS**	**9**	**0**	**0**	**9**
Feedback Amplifier: Block diagram - Gain with feedback - Barkhausen Criterion - Mechanism for start of oscillation and stabilization of amplitude - Analysis of Oscillator using Cascade connection of RC and LC filters - RC phase shift Oscillator - Wien bridge Oscillator and Twin-T Oscillators - Analysis of LC Oscillators: Colpitts – Hartley – Clapp - Miller and Pierce oscillators - Frequency range of RC Oscillators - Electrical equivalent circuit of Crystal.					
Unit IV	**TUNED AMPLIFIERS AND MULTIVIBRATORS**	**9**	**0**	**0**	**9**
Analysis of single tuned and synchronously tuned amplifiers - Class C tuned amplifiers and their applications - Efficiency of Class C tuned Amplifier- Collector coupled and Emitter coupled Astable Multi vibrator – Mono stable Multi vibrator – Bistable Multi vibrator - Triggering methods – Mono stable and Astable Blocking Oscillators using Emitter and base timing.					
Unit V	**OPERATIONAL AMPLIFIERS AND ITS APPLICATIONS**	**9**	**0**	**0**	**9**
Basic structure and principle of operation - Calculation of differential gain - Common Mode gain, CMRR - OP-AMP design - DC and AC characteristics of OP-AMP. Applications: Inverting and non-inverting amplifiers - Integrator and Differentiator - Summing amplifier - Precision rectifier - Schmitt trigger and its applications - Active filters: Low pass, high pass, band pass and band stop filters - Sine wave oscillators – Comparator – Multi vibrator.					
					Total (45 L) = 45 Periods

Text Books:	
1	B.Visvesvara Rao, K.Raja Rajeswari, P.Chalam Raju Pantulu, K.Bhaskara Rama Murthy, "Electronic Circuits-II", Pearson Education,2012
2	D.Roy Choudhry, Shail Jain, "Linear Integrated Circuits", New Age International Pvt. Ltd., 2011.
Reference Books:	
1	Millman J. and Taub H., "Pulse Digital and Switching waveform", 3rd Edition, McGraw-Hill International , 2011.
2	Sedera& Smith, "Micro Electronic Circuits", 4 th Edition, Oxford University Press, Chennai.

3	Michael Jacob, 'Applications and Design with Analog Integrated Circuits', Prentice Hall of India, 1996.
4	K.R.Botkar, 'Integrated Circuits', 10th edition, Khanna Publishers, 2010.
e-Reference:	
1	http://nptel.ac.in/courses/117105080/40
2	http://nptel.ac.in/courses/117108038/1
3	https://freevideolectures.com/course/2915/linear-integrated-circuits

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	To analyze small signal amplifiers and Large signal Amplifiers.	Applying
CO2	Analyze the frequency response characteristics of amplifiers	Applying
CO3	Develop insight of on oscillator design.	Applying
CO4	Construct and analyse tuned amplifiers and multivibrators.	Applying
CO5	Develop competence in linear and nonlinear Op amp circuit analysis.	Applying

COURSE ARTICULATION MATRIX

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	1	2	-	-	-	-	-	-	-	-	1	2	1
CO2	3	2	1	2	-	-	-	-	-	-	-	-	1	2	1
CO3	3	2	1	2	-	-	-	-	-	-	-	-	1	2	1
CO4	3	2	1	2	-	-	-	-	-	-	-	-	1	2	1
CO5	1	2	1	2	-	-	-	-	-	-	-	-	1	2	1
Avg	2.4	2	1	2	-	-	-	-	-	-	-	-	1	2	1

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

22ECM04	SIGNAL PROCESSING				
PREREQUISITES	**CATEGORY**	**OE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives:	
1.	To understand and perform Fourier and Laplace analysis on signals and systems respectively.
2.	To analyse the Discrete Fourier Transform, Fast Fourier Transform algorithms.
3.	To design and realize IIR, FIR filters.

Unit I	**INTRODUCTION TO SIGNALS AND SYSTEMS**	**9**	**0**	**0**	**9**

Classification of Signals: Even and Odd Signal - Energy and power signals - Continuous time (CT) and Discrete time (DT) signals - Continuous and Discrete amplitude signal -. System properties and representation: linearity - Tme-invariance – Causality – Stability - Realizability. - Linear Time-Invariant (LTI) systems: Impulse response and step response – Convolution – Correlation - System representation through differential equations and difference equations.

Unit II	**ANALYSIS OF SIGNAL AND SYSTEMS**	**9**	**0**	**0**	**9**

Introduction to Fourier Transform, Fourier Series, Relating the Laplace Transform to Fourier Transform, Frequency response of continuous time systems. Introduction to z- Transform.

Unit III	**DISCRETE FOURIER TRANSFORM**	**9**	**0**	**0**	**9**

Introduction to DFT – Properties of DFT - Circular convolution - FFT algorithms – Radix-2 FFT algorithms – Decimation in Time and Decimation in Frequency algorithms.

Unit IV	**INFINITE IMPULSE RESPONSE FILTER DESIGN**	**9**	**0**	**0**	**9**

Characteristics of Analog Butterworth filter - Chebyshev filter - Low pass filter, High pass filter, Band pass filter and Band stop filter - Transformation of analog filters in to equivalent digital filters using bilinear transformation method - Realization structure for IIR filters-Direct form - Cascade form - Parallel form.

Unit V	**FINITE IMPULSE RESPONSE FILTER DESIGN**	**9**	**0**	**0**	**9**

Linear phase response of FIR filter - FIR design using window method: Rectangular, Hamming, Hanning and Blackmann Windows - Park-McClellan's method - Realization structures for FIR filters - Linear phase structures and Direct form structure - Comparison of FIR and IIR filters.

Total (45L)= 45 Periods

Text Books:	
1.	A.Anand Kumar, “Signals and Systems” , 3rd Edition, PHI, 2013.
2.	John G Proakis and Manolakis, “Digital Signal Processing Principles, Algorithms and Applications”, 4th Edition, Pearson Education, 2009.
Reference Books:	
1.	Alan V Oppenheim, Alan S Willsky and S Hamid Nawab, “Signals and Systems”, 2nd edition, PHI Learning Private Limited, New Delhi, 2010.
2.	B.P. Lathi, "Principles of Signal Processing and Linear Systems", Oxford University Press, 2009.
3.	Emmanuel C. Ifeacher, Barry W. Jervis, “Digital Signal Processing: A Practical Approach”, 2nd Edition, Pearson Education, 2004.
4.	S.K. Mitra, “Digital Signal Processing, A Computer Based approach”, 4th Edition, McGraw-Hill, 2010.
E-References:	
1.	http://nptel.ac.in/courses/117104074/
2.	https://www.coursera.org/learn/dsp
3.	https://ocw.mit.edu/resources/res-6-008-digital-signal-processing-spring-2011/

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Analyse and understands different types of signals.	Analysing
CO2	Represent continuous signals and systems in time and frequency domain using different transforms.	Analysing
CO3	Analyse the need for Discrete Fourier Transform, Fast Fourier Transform algorithms in digital signals & systems.	Analysing
CO4	Design and realize IIR filters.	Applying
CO5	Design and realize FIR filters.	Applying

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	-	-	-	-	-	-	-	2	2	2
CO2	3	2	2	3	3	2	-	-	-	-	-	-	2	2	2
CO3	3	2	2	2	1	-	1	-	-	-	-	-	1	1	1
CO4	3	2	2	2	1	-	1	-	-	-	-	-	1	1	1
CO5	1	1	1	1	1	-	-	-	-	-	-	-	2	2	1
Avg	2.6	1.8	2	2.2	1.8	2	1						1.6	1.6	1.4
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

22ECM05	**FUNDAMENTALS OF MICROPROCESSORS AND MICROCONTROLLERS**					
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:	
1.	To familiarise with 8086 and 8051 architectures.
2.	To interface 8086 microprocessor and 8051 microcontrollers with peripherals by programming.
3.	To gain basic knowledge of PIC microcontrollers.

Unit I	**8086 MICROPROCESSOR ARCHITECTURE**	9	0	9
Overview of Microcomputer systems-8086 Architecture – Pin Assignments – Internal Architecture – Addressing modes-Instruction Formats- Directives and Operators-Assembly process.				
Unit II	**PROGRAMMING AND INTERFACING OF 8086**	9	0	9
Fundamental I/O considerations- Programmed I/O- Interrupt I/O- Basic 8086 Configurations- Minimum Mode-Maximum Mode-System Bus timing- I/O Interfaces-Peripheral Interfacing using 8255 PPI - 8279 Keyboard/Display controller - 8251 USART.				
Unit III	**8051 ARCHITECTURE**	9	0	9
8051 architecture - Registers in 8051 - Pin description - 8051 parallel I/O ports - memory organization - Instruction set — Addressing modes				
Unit IV	**PROGRAMMING AND INTERFACING OF 8051**	9	0	9
Assembly language programming.8051Timers - Serial Port Programming - Interrupts Programming - LCD and Keyboard Interfacing - ADC, DAC and Sensor Interfacing - Motor Control.				
Unit V	**PIC MICROCONTROLLERS**	9	0	9
Main characteristics of PIC microcontrollers – PIC microcontroller families-Memory-Program Memory – RAM Data Memory - Instruction set and timers in PIC				
				Total (L+T) = 45 periods

Text Books:	
1.	Yu-Cheng Liu, Glenn A. Gibson,” Microcomputer Systems, The 8086/8088 Family”, Pearson, 2e, 2019.
2.	Muhammad Ali Mazidi, Janice GillispieMazidi, RolinD.McKinlay, “The 8051 Microcontroller and Embedded Systems using Assembly and C”, 2e, 2022.
Reference Books:	
1.	Mohamed Ali Mazidi, Janice GillispieMazidi, RolinMcKinlay, “The 8051 Microcontroller and Embedded Systems: Using Assembly and C”, 2nd Edition, Pearson education, 2011.
2.	Martin Bates,”PIC Microcontrollers-An Introduction to Microelectronics”, 3e, Elsevier, 2011.
3.	Mathur Sunil,”Microprocessor 8086: Architecture, Programming and Interfacing” PHI Learning Pvt. Ltd. 2011.
4.	Salvador PinillosGimenez,” 8051 Microcontrollers Fundamental Concepts, Hardware, Software and Applications in Electronics”, Springer 2019.
E-References:	
1.	Ashraf Almadhoun,”A Detailed Look Into PIC Microcontroller and Its Architecture”, Amazon 2020.
2.	https://nptel.ac.in/courses/108105102
3.	http://www.satishkashyap.com/2012/02/video-lectures-on-microprocessors-and.html

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom’s Taxonomy Mapped**
CO1	Describe and analyse the architecture of 8086 microprocessor and 8051 architectures.	Remembering
CO2	Develop assembly language programs and Interface peripherals with 8086.	Applying
CO3	Develop assembly language programs and Interface peripherals with 8051.	Applying
CO4	Determine application specific circuit for real-time applications.	Understanding
CO5	Associate appropriate PIC microcontroller for a given application.	Understanding

COURSE ARTICULATION MATRIX														
COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO3
CO1	2	2	-	-	-	-	-	-	-	-	2	-	1	-	-
CO2	2	2	2	2	-	-	-	-	-	-	-	-	2	2	-
CO3	2	2	2	2	-	-	-	-	-	-	-	-	2	2	-
CO4	2	2	2	2	-	-	-	-	-	-	-	-	2	2	2
CO5	2	2	-	2	-	-	-	-	-	-	-	-	2	2	-
Avg	2	2	2	2	-	-	-	-	-	-	2	-	1.8	2	2

22ECM06	**ANALOG AND DIGITAL COMMUNICATION**				
PREREQUISITES	**CATEGORY**	**OE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives:

1. Understand analog and digital communication techniques.
2. Learn data and pulse communication techniques.
3. Be familiarized with source and Error control coding.

Unit I	**INFORMATION THEORY**	**9**	**0**	**0**	**9**

Uncertainty, information and entropy – Source coding theorem – Shannon Fano coding – Huffman coding – Discrete memoryless channels – Mutual information – Channel capacity – Channel coding theorem.

Unit II	**ANALOG COMMUNICATION**	**9**	**0**	**0**	**9**

Noise: Source of Noise – External Noise- Internal Noise- Noise Calculation. Introduction to Communication Systems: Modulation – Types – Need for Modulation. Theory of Amplitude Modulation – Evolution and Description of SSB Techniques – Theory of Frequency and Phase Modulation – Comparison of various Analog Communication System (AM – FM – PM).

Unit III	**DIGITAL COMMUNICATION**	**9**	**0**	**0**	**9**

Amplitude Shift Keying (ASK) – Frequency Shift Keying (FSK) Minimum Shift Keying (MSK) –Phase Shift Keying (PSK) – BPSK – QPSK – 8 PSK – 16 PSK – Quadrature Amplitude Modulation (QAM) – 8 QAM – 16 QAM – Bandwidth Efficiency– Comparison of various Digital Communication System (ASK – FSK – PSK – QAM).

Unit IV	**PULSE COMMUNICATION AND MULTIPLE ACCESS TECHNIQUES**	**9**	**0**	**0**	**9**

Pulse Communication: Pulse Amplitude Modulation (PAM) – Pulse Time Modulation (PTM) – Pulse code Modulation (PCM) – Comparison of various Pulse Communication System (PAM – PTM – PCM). Multiple access techniques: FDMA, CDMA, TDMA, SDMA.

Unit V	**ERROR CONTROL CODING**	**9**	**0**	**0**	**9**

Linear block codes - Cyclic codes - Convolution codes – Maximum likelihood decoding of convolutional codes – Sequential decoding of convolutional codes – Trellis codes – Applications.

Total (45L)= 45 Periods

Text Books:

1. Simon Haykin, “Communication Systems”, 4th Edition, John Wiley & Sons, 2014.
2. J.G.Proakis, M.Salehi, ―Fundamentals of Communication Systems‖, Pearson Education 2014.

Reference Books:

1. B.P.Lathi, ―Modern Digital and Analog Communication Systems‖, 4th Edition, Oxford University Press, 2013.
2. D.Roody, J.Coolen, ―Electronic Communications, 4th edition PHI 2015.
3. B.Sklar, ―Digital Communications Fundamentals and Applications‖, 5th Edition Pearson Education 2017
4. H P Hsu, Schaum Outline Series - ―Analog and Digital Communications‖ TMH, 5th edition 2006

E-References:

1. https://onlinecourses.nptel.ac.in/noc21_ee74/preview
2. https://nptel.ac.in/courses/117101051
3. https://www.digimat.in/nptel/courses/video/117105143/L51.html

Course Outcomes: Upon completion of this course, the students will be able to:			Bloom's Taxonomy Mapped
CO	:	Apply the concepts of Random Process to the design of Communication	Applying
CO	:	Apply analog and digital communication techniques.	Applying
CO	:	Understand the use of data and pulse communication techniques.	Understanding
CO	:	Analyze Source and Error control coding.	Analysing
CO	:	Design AM communication systems and Angle modulated communication	Applying

COURSE ARTICULATION MATRIX															
COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO1 2	PSO 1	PSO 2	PSO 3
CO1	2	3	2	1	1	-	-	-	-	-	-	-	3	-	-
CO2	3	2	2	1	1	-	-	-	-	-	-	-	3	2	1
CO3	2	2	2	3	1	-	-	-	-	-	-	-	3	2	-
CO4	1	1	2	1	2	-	-	-	-	-	-	-	2	3	-
CO5	1	1	2	2	2	-	-	-	-	-	-	-	2	3	1
Avg	1.8	1.8	2	1.6	1.4	-	-	-	-	-	-	-	2.6	2.5	1
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

22ECM07	COMMUNICATION NETWORKS					
PREREQUISITES		CATEGORY	OE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:	
1.	Understand the division of network functionalities into layers.
2.	Be familiar with the components required to build different types of networks
3.	Be exposed to the required functionality at each layer
4.	Learn the flow control and congestion control algorithms

Unit I	**FUNDAMENTALS & LINK LAYER**	9	0	0	9
Overview of Data Communications- Networks – Building Network and its types– Overview of Internet - Protocol Layering - OSI Mode – Physical Layer – Overview of Data and Signals - introduction to Data Link Layer - Link layer Addressing- Error Detection and Correction					
Unit II	**MEDIA ACCESS & INTERNETWORKING**	9	0	0	9
Overview of Data link Control and Media access control - Ethernet (802.3) - Wireless LANs – Available Protocols – Bluetooth – Bluetooth Low Energy – WiFi – 6LowPAN–Zigbee - Network layer services – Packet Switching – IPV4 Address – Network layer protocols (IP, ICMP, Mobile IP)					
Unit III	**ROUTING**	9	0	0	9
Routing - Unicast Routing – Algorithms – Protocols – Multicast Routing and its basics – Overview of Intradomain and interdomain protocols – Overview of IPv6 Addressing – Transition from IPv4 to IPv6					
Unit IV	**TRANSPORT LAYER**	9	0	0	9
Introduction to Transport layer –Protocols- User Datagram Protocols (UDP) and Transmiision Control Protocols (TCP) –Services – Features – TCP Connection – State Transition Diagram – Flow, Error and Congestion Control - Congestion avoidance (DECbit, RED) – QoS – Application requirements					
Unit V	**APPLICATION LAYER**	9	0	0	9
Application Layer Paradigms – Client Server Programming – World Wide Web and HTTP - DNS- Electronic Mail (SMTP, POP3, IMAP, MIME) – Introduction to Peer to Peer Networks – Need forCryptography and Network Security – Firewalls.					
Total (45L)= 45 Periods					

Text Books:	
1.	Behrouz A Forouzan, Data Communications and Networking, 4th Edition, 2020
2.	James F. Kurose, Keith W. Ross, Computer Networking - A Top-Down Approach Featuring the Internet, Seventh Edition, Pearson Education, 2016.
Reference Books:	
1.	Nader. F. Mir,“ Computer and Communication Networks”, Pearson Prentice Hall Publishers, 2nd Edition, 2014.
2.	Alberto Leon-Garcia, IndraWidjajaCommunication Networks 2nd Edition McGraw-Hill Education, 2003
3.	Ying-Dar Lin, Ren-Hung Hwang, Fred Baker, “Computer Networks: An Open Source Approach”, McGraw Hill Publisher, 2011.
4.	Larry L. Peterson, Bruce S. Davie, “Computer Networks: A Systems Approach”, Fifth Edition, Morgan Kaufmann Publishers, 2011.
E-References:	
1.	https://onlinecourses.nptel.ac.in/noc22_ee61/preview
2.	https://www.ee.iitb.ac.in/~sarva/courses/EE706/2012/EE706LecNotes.pdf
3.	http://www.cs.kent.edu/~farrell/net01/lectures/

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the basic concept in modern data communication and different level of layers in the protocol	Understanding
CO2	Analyse the functions and services of data link layer	Analysing
CO3	Categorize the functions and services of network layer	Understanding
CO4	Examine the basic functions of transport layer and congestion in networks	Understanding
CO5	Analyse the concepts of various network applications and data security	Analysing

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	2	1	1	-	1	-	-	-	-	-	-	-	2	-	1
CO2	2	1	2	-	1	-	-	-	-	-	-	-	2	1	1
CO3	2	1	1	-	-	-	-	-	-	-	-	-	3	1	2
CO4	3	2	1	-	2	-	-	-	-	-	-	-	2	-	2
CO5	2	1	1	-	1	-	-	-	-	-	-	-	1	1	1
Avg	2.2	1.2	1.2	-	1.25	-	-	-	-	-	-	-	2	1	1.4
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

22ECM08	**FUNDAMENTALS OF IOT**					
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives	
1	To understand Smart Objects and IoT Architectures
2	To learn about various IOT-related protocols
3	To build simple IoT Systems using Arduino and Raspberry Pi
4	To understand data analytics and cloud in the context of IoT
5	To develop IoT infrastructure for popular applications

Unit I	**FUNDAMENTALS OF IOT**	**9**	**0**	**0**	**9**
Evolution of Internet of Things - Enabling Technologies – IoT Architectures: oneM2M, IoT World Forum (IoTWF) and Alternative IoT models – Simplified IoT Architecture and Core IoT Functional Stack -– Fog, Edge and Cloud in IoT – Functional blocks of an IoT ecosystem – Sensors, Actuators, Smart Objects and Connecting Smart Objects					
Unit II	**IoT PROTOCOLS**	**9**	**0**	**0**	**9**
IoT Access Technologies: Physical and MAC layers, topology and Security of IEEE 802.15.4, 802.15.4g, 802.15.4e, 1901.2a, 802.11ah and LoRaWAN – Network Layer: IP versions, Constrained Nodes and Constrained Networks – Optimizing IP for IoT: From 6LoWPAN to 6Lo, Routing over Low Power and Lossy Networks – Application Transport Methods: Supervisory Control and Data Acquisition – Application Layer Protocols: CoAP and MQTT					
Unit III	**DESIGN AND DEVELOPMENT**	**9**	**0**	**0**	**9**
Design Methodology - Embedded computing logic - Microcontroller, System on Chips - IoT system building blocks - Arduino - Board details, IDE programming - Raspberry Pi - Interfaces and Raspberry Pi with Python Programming.					
Unit IV	**DATA ANALYTICS AND SUPPORTING SERVICES**	**9**	**0**	**0**	**9**
Structured Vs Unstructured Data and Data in Motion Vs Data in Rest – Role of Machine Learning – No SQL Databases – Hadoop Ecosystem – Apache Kafka, Apache Spark – Edge Streaming Analytics and Network Analytics – Xively Cloud for IoT, Python Web Application Framework – Django – AWS for IoT – System Management with NETCONF-YANG					
Unit V	**CASE STUDIES/INDUSTRIAL APPLICATIONS**	**9**	**0**	**0**	**9**
Cisco IoT system - IBM Watson IoT platform – Manufacturing - Converged Plantwide Ethernet Model (CPwE) – Power Utility Industry – Grid Blocks Reference Model - Smart and Connected Cities: Layered architecture, Smart Lighting, Smart Parking Architecture and Smart Traffic Control					
Total (45 L) = 45 Periods					

Text Books:	
1	David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, ―IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, Cisco Press, 2017
2	ArshdeepBahga, Vijay Madisetti, ―Internet of Things – A hands-on approach‖, Universities Press, 2015
Reference Books:	
1	Olivier Hersent, David Boswarthick, Omar Elloumi , ―The Internet of Things – Key applications and Protocols, Wiley, 2012 (for Unit 2).
2	Jan Ho¨ ller, VlasiosTsiatsis , Catherine Mulligan, Stamatis , Karnouskos, Stefan Avesand. David Boyle, "From Machine-to-Machine to the Internet of Things - Introduction to a New Age of Intelligence", Elsevier, 2014.

3	Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), ―Architecting the Internet of Things‖, Springer, 2011.
4	Michael Margolis, Arduino Cookbook, Recipes to Begin, Expand, and Enhance Your Projects, 2nd Edition, O'Reilly Media, 2011.

E-References:

1	https://online.stanford.edu/courses/xee100-introduction-internet-things
2	https://www.udemy.com/topic/internet-of-things/
3	https://www.netacad.com/courses/iot

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the concept of IoT.	Understanding
CO2	Analyze various protocols for IoT.	Applying
CO3	Design a PoC of an IoT system using Rasperry Pi/Arduino	Applying
CO4	Apply data analytics and use cloud offerings related to IoT.	Applying
CO5	Analyze applications of IoT in real time scenario	Analysing

COURSE ARTICULATION MATRIX

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	2	1	1	-	-	-	-	-	1	-	2	2	2
CO2	2	1	2	1	1	-	-	-	-	-	1	-	2	2	2
CO3	2	2	3	2	1	-	-	-	-	-	2	-	2	2	2
CO4	2	2	2	1	1	-	-	-	-	-	1	-	2	2	2
CO5	2	2	3	2	1	-	-	-	-	-	2	-	2	2	2
Avg	2	1.6	2.4	1.4	1	-	-	-	-	-	1.4	-	2	2	2
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

22ECM09	**WIRELESS SENSORS AND NETWORKING**					
PREREQUISITE:		**CATEGORY**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:					
1.	Learn fundamental of Ad hoc network and architecture				
2.	Understand the MAC and routing protocols.				
3.	Have an in-depth knowledge on QoS, security and sensor network platforms				
Unit I	**ROUTING PROTOCOLS**	9	0	0	9
Elements of Ad hoc Wireless Networks, Issues in Ad hoc wireless networks, Example commercial applications of Ad hoc networking, Ad hoc wireless Internet, Issues in Designing a Routing Protocol for Ad Hoc Wireless Networks, Classifications of Routing Protocols, Table Driven Routing Protocols – Destination Sequenced Distance Vector (DSDV), On–Demand Routing protocols –Ad hoc On–Demand Distance Vector Routing (AODV).					
Unit II	**ARCHITECTURES OF WSN**	9	0	0	9
WSN application examples, Types of applications, Challenges for Wireless Sensor Networks, Enabling Technologies for Wireless Sensor Networks, Single-Node Architecture: Hardware Components, Energy Consumption of Sensor Nodes, Operating systems and execution environments Network Architecture: Sensor Network Scenarios, Optimization goals and figures of merit, Design principles of WSN, Service interfaces of WSNs, gateway concepts.					
Unit III	**MAC PROTOCOLS AND ROUTING PROTOCOLS**	9	0	0	9
Image compression: Predictive techniques – PCM – DPCM - DM - Transform coding - Introduction to JPEG - JPEG-2000 - JBIG standards - Study of EZW. Video compression: Video signal representation – ITU-T Recommendation H.261 – Model based coding – The MPEG-1 Video Standard - The MPEG-2 Video Standard: H.262 - ITU-T Recommendation H.263.					
Unit IV	**QUALITY OF SERVICE AND ADVANCED APPLICATION SUPPORT**	9	0	0	9
Quality of Service: Coverage and deployment, Reliable data transport, Single packet delivery, Block delivery, Congestion control and rate control - Advanced application support: Advanced in-network processing, Security and Application-specific support.					
Unit V	**SENSOR NETWORK PLATFORMS AND TOOLS**	9	0	0	9
Sensor Node Hardware – Berkeley Motes, Programming Challenges, Node-level software platforms – TinyOS, nesC, CONTIKIOS, Node-level Simulators – NS2 and its extension to sensor networks, COOJA, TOSSIM, Programming beyond individual nodes – State centric programming.					
					Total (45L) = 45 Periods

Text Books:	
1.	C. Siva Ram Murthy, and B. S. Manoj, "AdHoc Wireless networks ", Pearson Education – 2008
2.	Holger Karl and Andreas Willig, "Protocols And Architectures for Wireless Sensor Networks", John Wiley, 2007.
Reference Books:	
1.	Feng Zhao and LeonidesGuibas, "Wireless sensor networks ", Elsevier publication - 2004.
2.	Charles E. Perkins, ―Ad Hoc Networking‖, Addison Wesley, 2000.
3.	William Stallings, "Wireless Communications and Networks ", Pearson Education – 2004
4.	I.F. Akyildiz, W. Su, Sankarasubramaniam, E. Cayirci, “Wireless sensor networks: a survey”, Computer Networks, Elsevier, 2002, 394 - 422.
E-References:	
1.	https://nptel.ac.in/courses/106105183
2.	https://nptel.ac.in/courses/106105183
3.	https://archive.nptel.ac.in/courses/106/105/106105160/

Course Outcomes: Upon completion of this course, the students will be able to		**Bloom's Taxonomy Mapped**
CO1	Know the basics of Ad hoc networks and Wireless Sensor Networks	Understanding
CO2	Have a knowledge on architecture of Wireless Sensor Networks	Applying
CO3	Apply the knowledge to identify MAC and routing protocols	Applying
CO4	Understand the transport layer and security issues possible in Ad hoc and sensor networks	Understanding
CO5	Be familiar with the OS used in Wireless Sensor Networks and build basic modules	Remembering

COURSE ARTICULATION MATRIX

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	3	3	1	3	3	3	2	-	-	-	3	3	3	-	2
CO2	3	3	2	3	3	3	2	-	-	-	3	3	3	-	2
CO3	3	3	3	3	3	3	2	-	-	-	3	3	3	-	2
CO4	3	3	2	3	3	3	2	-	-	-	2	3	3	-	2
CO5	3	3	2	3	3	3	2	-	-	-	3	3	3	-	2
Avg	3	3	2	3	3	3	2	-	-	-	2.8	3	3	-	2

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

22ECM10	**FUNDAMENTALS OF EMBEDDED SYSTEMS**				
PREREQUISITES	**CATEGORY**	**OE**	**Credit**		**3**
Microprocessors and Mmicrocontrollers	**Hours/Week**	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives	
1	To impart knowledge on embedded system architecture and embedded development Strategies
2	To understand the bus Communication in processors and peripheral interfacing
3	To understand basics of Real Time Operating System

UNIT I	**BASICS OF EMBEDDED SYSTEMS**	9	0	0	9

Introduction - Fundamental Components of Embedded Systems - Challenges for Embedded Systems - Examples - Programming Languages - Recent Trends in Embedded Systems - Architecture of Embedded Systems - Embedded Design Life Cycle - Selection Process - Hardware Software Partitioning - Development Environment.

UNIT II	**MEMORY MANAGEMENT AND INTERRUPTS**	9	0	0	9

Memory Access Procedure - Types of Memory - Memory Management Methods - DMA – Memory Interfacing - Polling Vs Interrupts - Types of Interrupts - Interrupt Latency - Interrupt Priority – Programmable Interrupt Controllers - Interrupt Service Routines

UNIT III	**COMMUNICATION INTERFACES**	9	0	0	9

Interfacing Buses - Serial Interfaces - RS232/UART - RS422/RS485 - I2C Interface - SPI Interface - USB – CAN - IRDA - Ethernet - IEEE 802.11 – Bluetooth

UNIT IV	**REAL TIME OPERATING SYSTEMS**	9	0	0	9

Real-Time Concepts - Task Management - Task Scheduling - Classification of Scheduling Algorithms - Clock Driven Scheduling - Event Driven Scheduling - Resource Sharing - Priority Inheritance Protocol - Priority Ceiling Protocol - Inter Task Communication - Mutex - Semaphores - Message Queues - Timers - Commercial RTOS.

UNIT V	**VALIDATION AND DEBUGGING**	9	0	0	9

Host and Target Machines - Validation Types and Methods - Host Testing - Host-Based Testing Setup - Target Testing - Remote Debuggers and Debug Kernels - ROM Emulator - Logical Analyzer – Background Debug Mode - InCircuit Emulator CASE STUDY: RFID Systems - GPS Navigation System – Development of Protocol Converter.

Total (45 L) = 45 Periods

Text Books:	
1	Sriram V Iyer and Pankaj Gupta, ―Embedded Real-time Systems Programming‖, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2006.
2	Arnold S Berger, ―Embedded Systems Design - An Introduction to Processes, Tools and Techniques, Elsevier, New Delhi, 2011.

Reference Books:	
1	Prasad K V K K, ―Embedded/Real-Time Systems: Concepts, Design and Programming – The Ultimate Reference, Himal Impressions, New Delhi, 2003
2	Heath, “Embedded Systems Design‖”, Newnes an Imprint of Elsevier, Massachusetts, 2003.
3	Tammy Noergaard, “Embedded Systems Architecture‖, Newnes an Imprint of Elsevier, Massachusetts, 2006.
4	Raj Kamal, ‘Embedded System-Architecture, Programming, Design’, McGraw Hill, 2013

E-References:	
1	https://lecturenotes.in/subject/225/embedded-system-es
2	https://nptel.ac.in/courses/108102045/19
3	https://www.coursera.org/learn/introduction-embedded-systems.

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Course Outcomes: Upon completion of this course, the students will be able to		**Bloom's Taxonomy Mapped**
CO1	Outline the concepts of embedded systems	Understanding
CO2	Understand the concept of memory management system and interrupts.	Understanding
CO3	Know the importance of interfaces.	Understanding
CO4	Understand real time operating system concepts.	Understanding
CO5	To realize the applications of validation and debugging.	Applying

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	3	3	1	3	-	-	-	-	-	-	3	3	3	-	2
CO2	3	3	2	3	-	-	-	-	-	-	3	3	3	-	2
CO3	3	3	3	3	-	-	-	-	-	-	3	3	3	-	2
CO4	3	3	2	3	-	-	-	-	-	-	2	3	3	-	2
CO5	3	3	2	3	-	-	-	-	-	-	3	3	3	-	2
Avg	3	3	2	3	-	-	-	-	-	-	2.8	3	3	-	2
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

22EEM01	**LINEAR AND DIGITAL ELECTRONICS CIRCUITS**	**SEMESTER**			
PREREQUISITES	**CATEGORY**	**PE**	**Credit**		**3**
Electron Devices and Circuits	**Hours/Week**	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives:

1. To impart knowledge on the characteristics& applications of Operation Amplifier, functional diagram and applications of linear ICs.
2. To simplify the switching functions
3. To design the combinational logic circuits and sequential logic circuits

Unit I	**OPERATIONAL AMPLIFIERS**	**9**	**0**	**0**	**9**

Operational amplifiers - Equivalent circuit, voltage transfer curve - Open loop Op-amp configurations –Voltage series, Voltage shunt feedback amplifiers configurations, closed loop differential amplifiers for single and differential outputs.

Output offset voltage, minimizing output offset voltage due to input bias current and input offset current, factors affecting off set parameters, CMRR - Open loop and closed loop frequency response of op-amps, circuit stability, slew rate and its effects in applications.

Unit II	**APPLICATION OF OPERATIONAL AMPLIFIER AND LINEAR ICS**	**9**	**0**	**0**	**9**

DC & AC amplifiers- Summing, Scaling and Averaging amplifiers-Instrumentation amplifier- Voltage to Current converter for floating and grounded loads - Current to voltage converter - Integrator, Differentiator. Voltage comparators - Zero Crossing Detector - Schmitt trigger with voltage limiter- Precision Rectifier Circuits-Peak Detector-Sample and Hold circuit, Active Filters - Frequency response characteristics of major active filters, first and higher order low pass and high pass filters, all pass filters.

Functional block diagram and Applications of Linear ICs: IC 555 Timer -IC 566 Voltage controlled oscillator- IC 565 Phase-locked loops - IC LM317 voltage regulators.

Unit III	**COMBINATIONAL LOGIC CIRCUITS**	**9**	**0**	**0**	**9**

Representation of logic functions: SOP and POS forms - Simplification of switching functions: K-maps method and QuineMcCluskey (Tabulation) method.

Design:Adders -Subtractors– 2 bit Magnitude Comparator-Multiplexer- Demultiplexer- Encoder - Priority Encoder - Decoder – Code Converters. Implementation of combinational logic circuits using multiplexers and Decoder**.**

Unit IV	**SYNCHRONOUS SEQUENTIAL LOGIC CIRCUITS**	**9**	**0**	**0**	**9**

Flip-flops: SR, D, JK and T- Conversion of flip-flops; Classification of sequential circuits: Moore and Mealy models - Analysis and design of synchronous sequential circuits - Design of synchronous counters- Universal shift register.

Unit V	**ASYNCHRONOUS SEQUENTIAL LOGIC CIRCUITS**	**9**	**0**	**0**	**9**

Fundamental mode and pulse mode circuits , Analysis procedure of asynchronous circuits with /without using of SR latches-primitive state / flow table – Reduction of state and flow table - state assignment –Design Procedure of asynchronous circuits with /without using of SR latches-Problems in asynchronous sequential circuits: cycles -Races –Hazards.

Total (45L+0T) = 45 Periods

Text Books:

1. Ramakant A Gayakward, “Op-Amps and Linear Integrated Circuits”, Fourth Edition, Pearson Education, 2003.
2. Donald.E.Neaman, “Electronic Circuit, Analysis and Design”, Tata McGraw Hill Publishing Company Limited, Second Edition, 2002.
3. D.Roy Chowdhury and Shail B. Jain, “Linear Integrated Circuits”, Fourth Edition, New Age International (P) Ltd Publishers, 2014.
4. M. Morris Mano, “Digital Design” , Third Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2003 / Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2010 .
5. S. Salivahanan and S. Arivazhagan, “Digital Circuits and Design”, Third Edition, Vikas Publishing House Pvt. Ltd, New Delhi, 201

Reference Books:	
1.	Jacob Millman, Christos C.Halkias, “Integrated Electronics - Analog and Digital circuits system”, Tata McGraw Hill 2003.
2.	R.P.Jain, “Modern Digital Electronics”, Third Edition, Tata McGraw–Hill Publishing company limited, New Delhi, 2011.
3.	Thomas L. Floyd, “Digital Fundamentals”, Pearson Education, Inc, New Delhi, 2015
4.	Donald P.Leach and Albert Paul Malvino, “Digital Principles and Applications”, Fifth Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2012.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Understand the Op-amp characteristics	L2: Understanding
CO2	:	Understand the applications of Op-amp and other linear ICs.	L2: Understanding
CO3	:	Apply K-map and Tadulation methods to simplify the switching functions	L3: Applying
CO4	:	Design and implement of combinational logic circuits	L6: Creating
CO5	:	Analyse and design of synchronous & asynchronous sequential logic circuits	L4: Analyzing

COURSE ARTICULATION MATRIX

CO/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	1											2		
CO2	3	2	1	1									3		
CO3	3	2		2	2								3	3	
CO4	3	2	3	1	2							2	3	3	1
CO5	3	2	3	1	2							2	3	3	1
Avg.	**2.8**	**1.8**	**2.3**	**1.25**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**2.8**	**3**	**1**

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

22EEM02	**MICROPROCESSOR AND MICROCONTROLLER**		**SEMESTER**			
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**
C Programming		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1. To study the architecture of µP8085 and µC 8051.
2. To study the Interrupt structure of 8085 and 8051.
3. To do simple applications development with programming 8085 and 8051.

UNIT I	**8085 8 BIT MICROPROCESSOR**	**9**	**0**	**0**	**9**

Fundamentals of microprocessors – Architecture of 8085 – Groups of Instructions - Addressing modes – Basic timing diagram – Organization and addressing of Memory and I/O systems –Interrupt structure – Stack and sub-routines - Simple 8085 based system design and programming.

UNIT II	**8051 8 BIT MICROCONTROLLER**	**9**	**0**	**0**	**9**

Fundamentals of microcontrollers – Architecture of 8051 – Groups of Instructions - Addressing modes – Organization of Memory systems – I/O Ports – Timers/Counters – Serial Port - Interrupt structure – Simple programming concepts using Assemblers and Compliers.

UNIT III	**INTERFACING WITH 8051 MICROCONTROLLER**	**9**	**0**	**0**	**9**

Need and requirements of interfacing – Interfacing – LED, 7 segment and LCD Displays – Tactile switches, Matrix keyboard – Parallel ADC – DAC – Interfacing of Current, Voltage, RTD and Hall Sensors.

UNIT IV	**EXTERNAL COMMUNICATION INTERFACE**	**9**	**0**	**0**	**9**

Synchronous and Asynchronous Communication. RS232, RS 485, SPI, I2C. Introduction and interfacing to protocols like Blue-tooth and Zig-bee.

UNIT V	**APPLICATIONS OF MICROCONTROLLERS**	**9**	**0**	**0**	**9**

Simple programming exercises- key board and display interface –Control of servo motor stepper motor control- Application to automation systems.

Total (45L+0T)= 45 Periods

Text Books:

1. R.S. Gaonkar, ‘Microprocessor Architecture Programming and Application’, with 8085, Wiley Eastern Ltd., New Delhi, 2013.
2. K. J. Ayala, “8051 Microcontroller”, Delmar Cengage Learning, 2004.
3. Muhammad Ali Mazidi & Janice Gilli Mazidi, R.D.Kinely ‘The 8051 Micro Controller and Embedded Systems’, PHI Pearson Education, 5th Indian reprint, 2003.

Reference Books:

1. R. Kamal, “Embedded System”, McGraw Hill Education, 2009.
2. D. V. Hall, “Microprocessors & Interfacing”, McGraw Hill Higher Education, 1991.

E-References;

1. www.onlinecourses.nptel.ac.in/noc18_ee41
2. www.class-central.com
3. www.mooc-list.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand basics of microprocessor and microcontroller	L2: Understanding
CO2	:	Understand the architecture of Microprocessor and Microcontroller	L1: Remembering
CO3	:	Apply the digital concepts to measure and control simple electrical systems	L3: Applying
CO4	:	Design and interface communications between digital systems	L2: Understanding
CO5	:	Design a microcontroller based electrical control system.	L5: Evaluating

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2	1	1	1								1	1	1	
CO2	2	1	1	1								1	1	1	
CO3	2	3	2	3	2							1	1	1	2
CO4	2	3	3	3	2							2	2	2	2
CO5	2	3	3	3	2							2	2	2	2
Avg.	**2**	**2.2**	**2**	**2.2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**1.4**	**1.4**	**1.4**	**2**

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

22EEM03	**CONTROL SYSTEMS**		**SEMESTER**			
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**
Electrical Machines and Electric circuit analysis		**Hours/Week**	**L**	**T**	**P**	**TH**
			1	**1**	**0**	**3**

Course Objectives:

1. To understand the methods of representation of physical systems and getting their transfer function models.
2. To provide adequate knowledge in the time response of systems and steady state error analysis.
3. To give basic knowledge in obtaining the open loop and closed loop frequency response of systems.
4. To understand the concept of stability of control system and methods of stability analysis.
5. To study the designing compensators for a feedback control system.

UNIT I	**MODELLING OF LINEAR TIME INVARIANT SYSTEMS**	**6**	**9**	**0**	**9**

Basic elements in control systems – Open and closed loop systems – Feedback control system characteristics - Mathematical model and Electrical analogy of mechanical systems – Transfer function Representation– Synchro – AC and DC servo-motors – Block diagram reduction techniques – Signal flow graphs.

UNIT II	**TIME RESPONSE ANALYSIS**	**6**	**3**	**0**	**9**

Standard test signals – Time response of first order and second order systems –time domain specifications - Steady-state errors and error constants – Type and order of control systems – Effect of adding poles and zeros to transfer functions – Response with P, PI, PD and PID controllers.

UNIT III	**FREQUENCY RESPONSE ANALYSIS**	**6**	**3**	**0**	**9**

Correlation between time and frequency response: Second order systems – Frequency domain specifications - Polar plots – Bode plots – Computation of Gain Margin and Phase Margin — Constant M and N-circles – Nichols chart.

UNIT IV	**STABILITY OF CONTROL SYSTEM**	**6**	**3**	**0**	**9**

BIBO stability – Necessary conditions for stability – Routh-Hurwitz stability criterion – Root locus concepts – Rules for the construction of Root loci – Nyquist stability criterion – Assessment of relative stability using Nyquist criterion.

UNIT V	**COMPENSATOR AND CONTROLLER DESIGN**	**6**	**3**	**0**	**9**

Need for compensation – Types of compensators – Electric network realization and frequency characteristics of basic compensators: Lag, lead and lag-lead compensators – Design of compensators using root locus and Bode plot techniques-PID controller: Design using reaction curve and Ziegler - Nichols technique.

Total (30L+15T) = 45 Periods

Text Books:

1. A. Anand Kumar, "Control Systems", PHI Learning Pvt. Ltd., New Delhi, 2nd Edition, 2017.
2. I.J. Nagrath, and M. Gopal, "Control Systems Engineering", New Age International Publishers, Delhi, 7th Edition, 2021.

Reference Books:

1. K. Ogata, "Modern Control Engineering", Pearson Education, New Delhi, 5th Edition, 2021.
2. M. Gopal, "Control Systems: Principles and Design", TMH, New Delhi, 4th Edition, 2018.

E-Reference

1. https://nptel.ac.in/courses/107106081
2. https://nptel.ac.in/courses/108106098

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Develop the transfer function models of any electrical and electro-mechanical systems.	L2: Understanding
CO2	:	Obtain the time responses of the systems and construct root locus plot.	L3: Applying
CO3	:	Analyze the frequency response of the system	L3: Applying
CO4	:	Analyze the absolute / relative stability of a control system.	L4: Analyzing
CO5	:	Design the compensators and PID controller of a feedback control system.	L3: Applying

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	3	2	2	2							1	3	2	1
CO2	3	3	3	2	2							1	3	2	1
CO3	3	3	3	2	2							1	3	2	1
CO4	3	3	3	2	2							1	3	2	1
CO5	3	3	3	2	2							1	3	2	1
Avg	**3**	**3**	**2.8**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**3**	**2**	**1**

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

22EEM04	**MEASUREMENTS AND INSTRUMENTATION**		**SEMESTER**			
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**
Electric Circuit Analysis		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1. To educate the fundamental concepts and characteristics of measurement System
2. To introduce the fundamentals of electrical and electronic instruments for measurement of Electrical and Non-electrical quantities
3. To familiarize Oscilloscope and the bridge circuits for electrical parameters measurement

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

Elements of a generalized measurement system - Static and dynamic characteristics - Errors in measurement. Measurement of voltage and current - permanent magnet moving coil and moving iron type meters

UNIT II	**MEASUREMENT OF POWER , ENERGY AND FREQUENCY**	**9**	**0**	**0**	**9**

Measurement of power - single and three phase- electrodynamometer type watt meters – Construction, operation – torque equation for deflection – errors. Measurement of energy-Single phase induction type energy meters, Instrument transformers – Current and Potential transformers, Power factor meters- Single phase electrodynamometer type power factor meter, frequency meter-Electrical resonance type frequency meter

UNIT III	**DC AND AC BRIDGES**	**9**	**0**	**0**	**9**

Balance equations - Wheatstone bridge – Kelvin double Bridge –Maxwell’s inductance capacitance bridge – Hay’s bridge – Anderson’s bridge – Schering bridge and De Sauty’s bridge

UNIT IV	**POTENTIOMETERS, OSCILLOSCOPES AND DIGITAL INSTRUMENTS**	**9**	**0**	**0**	**9**

DC Potentiometer- Crompton’s Potentiometer, AC potentiometer– Drysdale polar potentiometer- Gall Tinsley co-ordinate type potentiometer, Cathode Ray Oscilloscope and Digital storage Oscilloscope-Construction, operation and Applications, Digital multi-meters, Digital voltmeters.

UNIT V	**MEASUREMENT OF NON-ELECTRICAL QUANTITIES**	**9**	**0**	**0**	**9**

Classification of transducers –Position transducers, Piezo-electric transducers and Hall effect transducers. Measurement of pressure, temperature and displacement– Introduction to Smart Sensors

Total (45L+0T)= 45 Periods

Text Books:

1.	A.K. Sawhney, ‘A Course in Electrical & Electronics Measurement & Instrumentation’, Dhanpat Rai and Co, 2015
2.	E.O. Doebelin, ‘Measurements Systems- Application and Design’, Tata McGraw Hill publishing company, 2015.

Reference Books:

1.	D.V.S. Moorthy, ‘Transducers and Instrumentation’, Prentice Hall of India Pvt. Ltd, 2010.
2.	H.S. Kalsi, ‘Electronic Instrumentation’, Tata McGraw Hill, 2015.
3.	Martin Reissland, ‘ Electrical Measurements’, New Age International(P) Ltd., Delhi, 2011.

E-Reference:

1	https://archive.nptel.ac.in/courses/108/105/108105153/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recall the fundamentals of measurement system in electrical engineering.	L1: Remembering
CO2	:	Describe the working principle of different measuring instruments	L2: Understanding
CO3	:	Choose appropriate instrument for measuring the electrical parameters	L3: Applying
CO4	:	Employ the digital instruments in real time measurements.	L3: Applying
CO5	:	Select an appropriate transducer for measurement of non-electrical quantities	L4: Analysing

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2	2	2	3				1		2		2	2	1	1
CO2	1	3			3					2		1	2	1	
CO3	1	1		2	1	1	2		1				1	2	1
CO4	1	1		1	1		2	2	1		2	2	1	3	1
CO5	2	2	3	1	2	2	1			1	3		1	2	
Avg	**1.4**	**1.8**	**2.5**	**1.75**	**1.75**	**1.5**	**1.67**	**1.5**	**1**	**1.67**	**2.5**	**1.67**	**1.4**	**1.8**	**1**
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

22EEM05	ELECTRICAL MACHINES		SEMESTER			
PREREQUISTIES		CATEGORY	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1. To impart knowledge on construction, working and performance of DC generators and motors.
2. To deliberate the construction, working and performance of single phase and three phase transformers.
3. To impart knowledge on construction, working and performance of synchronous generators and motors.
4. To impart knowledge on construction, principle of operation and performance of single and three-phase induction motors.

UNIT I	**DC GENERATORS**	**9**	**0**	**0**	**9**

Principle of operation, constructional details, types - EMF equation, armature reaction, demagnetizing and cross magnetizing Ampere turns, compensating winding, commutation, methods of improving commutation, interpoles, Open circuit and load characteristics of different types of DC Generators. Parallel operation of DC Generators, applications of DC Generators.

UNIT II	**DC MOTORS**	**9**	**0**	**0**	**9**

Principle of operation, significance of back emf, torque equation and power developed by armature, load characteristics of shunt, series and compound type motors, starting methods, speed control methods - losses and efficiency calculation, condition for maximum efficiency. Testing of DC Machines: Brake test, Swinburne's test, Hopkinson's test, Retardation test, Separation of core losses - applications of DC motors**.**

UNIT III	**TRANSFORMER**	**9**	**0**	**0**	**9**

Single phase transformer: Construction and principle of operation, working of practical transformer - equivalent circuit, voltage regulation, losses and efficiency- testing : polarity test, open circuit and short circuit tests, back-to back test, all day efficiency, parallel operation, applications.

Autotransformer: Construction and working, saving of copper - applications, **Three phase transformer**: construction, types of connections and their comparative features.

UNIT IV	**SYNCHRONOUS GENERATOR AND MOTOR**	**9**	**0**	**0**	**9**

Synchronous Generator: Constructional and working details – Types of rotors – EMF equation – Phasor diagrams of non-salient pole synchronous generator connected to infinite bus - Synchronizing and parallel operation – Synchronizing torque - Voltage regulation – EMF, MMF and ZPF method – steady state power angle characteristics – Two reaction theory – slip test.

Synchronous Motor: Principle of operation – Torque equation – Operation on infinite bus bars - V and Inverted V curves – Power input and power developed equations – Starting methods – Current loci for constant power input, constant excitation and constant power Developed -Hunting – natural frequency of oscillations – damper windings- synchronous condenser.

UNIT V	**THREE PHASE AND SINGLE PHASE INDUCTION MOTOR**	**9**	**0**	**0**	**9**

Three phase induction motor: Constructional details – Types of rotors –- Principle of operation – Equivalent circuit – Torque-Slip characteristics - Condition for maximum torque – Losses and efficiency – load test - No load and blocked rotor tests - Circle diagram – Separation of losses – Starters: DOL, Autotransformer and Star delta starters – Speed control methods: Voltage control, Frequency control and pole changing – V/f control – Slip power recovery Scheme.

Single phase induction motor: Constructional details – Double field revolving theory and operation – Equivalent circuit – No load and blocked rotor test – Performance analysis – Starting methods of single-phase induction motors – split phase, Capacitor-start, capacitor start and capacitor run Induction motor.

Total (45L+0T)= 45 Periods

Text Books:

1. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 5th Edition, 2017.

2.	P. S. Bimbhra, “Electric Machinery”, Khanna Publishers, 2nd Edition, 2021.
3.	B.L.Theraja and A.K.Theraja,” A text book of Electrical Technology - Volume-II”, S.Chand & Company Ltd., New Delhi, 23rd Edition, 2009.
Reference Books:	
1.	B.R.Gupta, ’Fundamental of Electric Machines’ New age International Publishers,3rd Edition, Reprint 2015.
2.	Murugesh Kumar, ‘Electric Machines’, Vikas Publishing House Pvt. Ltd, First edition, 2010.
3.	A.E. Fitzgerald, Charles Kingsley, Stephen. D. Umans, ‘Electric Machinery’, Mc Graw Hill publishing Company Ltd, 6th Education, 2017.
4.	Stephen J. Chapman, ‘Electric Machinery Fundamentals’4th edition, McGraw Hill Education Pvt. Ltd, 4th Edition 2017.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Explain the construction and working principle of DC machines, and Interpret various characteristics of DC machines.	L2: Understanding
CO2	:	Compute various performance parameters of the machine, by conducting suitable tests.	L5: Evaluating
CO3	:	Describe the working principle of transformer, auto transformer, three phase transformer connection, and determine the efficiency and regulation.	L3: Applying
CO4	:	Understand the construction and working principle of Synchronous Machines.	L3: Applying
CO5	:	Understand the construction and working principle, speed control of three phase and single phase induction motor.	L5: Evaluating

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	3	1	1	1			1				1	3	2	1
CO2	3	3	1	1	1			1				1	3	2	1
CO3	3	3	1	1	1			1				1	3	2	1
CO4	3	3	1	1	1			1				1	3	2	1
CO5	3	3	1	1	1			1				1	3	2	1
Avg.	**3**	**3**	**1**	**1**	**1**	**-**	**-**	**1**	**-**	**-**	**-**	**1**	**3**	**2**	**1**

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

<table>
<tr><td>22EEM06</td><td colspan="2">ELECTRICAL DRIVES AND CONTROL</td><td colspan="3">SEMESTER</td><td></td></tr>
<tr><td colspan="2">PREREQUISTIES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">DC Machines and Transformers, Synchronous and Induction Machines, and Power Electronics</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
</table>

Course Objectives:

1.	To know about the operation analyse of chopper fed DC drive, both qualitatively and quantitatively.
2.	To understand the operation and performance of AC motor drives.

UNIT I	**DC MOTOR CHARACTERISTICS & CHOPPER FED DC DRIVES**	**9**	**0**	**0**	**9**

Review of torque-speed characteristics of separately excited dc motor, change in torque-speed curve with armature voltage, example load torque-speed characteristics, operating point, armature voltage control for varying motor speed. Review of dc chopper and duty ratio control, chopper fed dc motor for speed control, steady state operation of a chopper fed drive, armature current waveform and ripple, calculation of losses in dc motor and chopper.

UNIT II	**MULTI-QUADRANT & CLOSED-LOOP CONTROL OF DC DRIVE**	**9**	**0**	**0**	**9**

Review of Four quadrant operation of dc machine; single-quadrant, two-quadrant and four-quadrant choppers; Control structure of DC drive, inner current loop and outer speed loop, dynamic model of dc motor – dynamic equations and transfer functions, modeling of chopper as gain with switching delay, plant transfer function, current controller specification and design, speed controller specification and design.

UNIT III	**INDUCTION MOTOR CHARACTERISTICS**	**9**	**0**	**0**	**9**

Review of induction motor equivalent circuit and torque-speed characteristic, variation of torque-speed curve with (i) applied voltage, (ii) applied frequency and (iii) applied voltage and frequency. Review of three-phase voltage source inverter, generation of three-phase PWM signals, constant V/f control of induction motor

UNIT IV	**CONTROL OF SLIP RING INDUCTION MOTOR**	**9**	**0**	**0**	**9**

Impact of rotor resistance of the induction motor torque-speed curve, operation of slip-ring induction motor with external rotor resistance, starting torque, power electronic based rotor side control of slip ring motor, slip power recovery. .

UNIT V	**CONTROL OF SRM AND BLDC MOTOR DRIVES.**	**9**	**0**	**0**	**9**

SRM construction - Principle of operation - SRM drive design factors-Torque controlled SRM- Block diagram of Instantaneous Torque control using current controllers and flux controllers. Construction and Principle of operation of BLDC Machine - Sensing and logic switching scheme,-Sinusoidal and trapezoidal type of Brushless dc motors – Block diagram of current controlledd Brushless dc motor drive

Total (45L+0T)= 45 Periods

Text Books:

1.	G. K. Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall, 1989.
2.	R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control”, Prentice Hall,2010
3.	Bose B K, "Modern Power Electronics and AC Drives", Pearson Education New Delhi, 2010.

Reference Books:

1.	G. K. Dubey, “Fundamentals of Electrical Drives”, CRC Press, 2012.
2.	W. Leonhard, “Control of Electric Drives”, Springer Science & Business Media, 2001.

E-Reference

1	https://www.iith.ac.in/~ketan/drives.htmL

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the characteristics of dc motors and induction motors.	L2: Understanding
CO2	:	Summarize the operation of chopper fed DC drives.	L4: Analyzing
CO3	:	Understand the principles of speed-control of dc motors and induction motors.	L2: Understanding
CO4	:	Identify suitable power electronic converters used for dc motor and induction motor speed control.	L3: Applying
CO5	:	Analyze the SRM and BLDC motor drive control	L4: Analyzing

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	1	3			1	1					1	3	2	
CO2	3	3	1	3		1	1					1	3	2	
CO3	3	3	3	3	1	1	1					1	3	2	
CO4	1	3	3	2	1	1	1					1	3	2	
CO5	3	3	3	3	1	1	1					1	3	2	
Avg.	**2.6**	**2.6**	**2.6**	**2.75**	**1**	**1**	**1**	**-**	**-**	**-**	**-**	**1**	**3**	**2**	**-**

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

22EEM07	**ELECTRIC VEHICLES AND CONTROL**	**SEMESTER**			
PREREQUISTIES	**CATEGORY**	**PE**	**Credit**		**3**
Electrical drives and control	**Hours/Week**	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives:

1.	To provide knowledge on electric vehicle architecture and its configurations
2.	To impart knowledge on vehicle control, use of energy storage systems and energy management in Electric Vehicle

UNIT I	**ELECTRIC VEHICLES**	**9**	**0**	**0**	**9**

Configurations of Electric Vehicles (EV), Performance of Electric Vehicles, Tractive Effort in Normal Driving and Energy Consumption, Hybrid Electric Vehicles (HEV): Classification, Series Hybrid Electric Drive Trains, Parallel Hybrid Electric Drive Trains

UNIT II	**PLUG-IN HYBRID ELECTRICVEHICLES (PHEV) AND FUEL CELL ELECTRIC VEHICLES**	**9**	**0**	**0**	**9**

Functions and Benefits of PHEV, Components of PHEVs, Operating Principles of Plug-in Hybrid Vehicle, Control Strategy of PHEV, Fuel Cell: Operation and Types, Fuel Cell Electric Vehicle: Configuration and Control Strategy

UNIT III	**ELECTRIC PROPULSION SYSTEMS**	**9**	**0**	**0**	**9**

Typical electric propulsion system, Classification of electric motor drives for EV and HEV, Multiquadrant Control of Chopper-Fed DC Motor Drives, Vector Control of Induction Motor drives, Permanent Magnetic Brush-Less DC Motor Drives, Switched Reluctance Motor Drives for Electric Vehicles

UNIT IV	**ENERGY STORAGE SYSTEM**	**9**	**0**	**0**	**9**

Status of Battery Systems for Automotive Applications, Battery Technologies: Nickel–Metal Hydride (Ni–MH) Battery, Lithium–Polymer (Li–P) Battery, Lithium-Ion (Li-Ion) Battery, Ultracapacitors: Features, operation and performance, Ultrahigh-Speed Flywheels, Hybridization of Energy Storages

UNIT V	**ENERGY MANAGEMENT SYSTEM**	**9**	**0**	**0**	**9**

Energy Management System(EMS) in Electric Vehicle, Rule-based control strategy: Deterministic rule-based control, Fuzzy logic-based control, and Neural network-based control. Optimization based control strategy: Dynamic Programming, Metaheuristic optimization methods and Model predictive control, Semi-active type Hybrid Energy Storage System-based EMS, Fully-active type Hybrid Energy Storage System-based EMS

Total (45L+0T)= 45 Periods

Text Books:

1.	Iqbal Hussain, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, Taylor & Francis Group, Second Edition ,2011.
2.	Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, AliEmadi,, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles" CRC Press, 2016

Reference Books:

1.	Ali Emadi, Mehrdad Ehsani, John M.Miller ,"Vehicular Electric Power Systems", Ali Emadi, Mehrdad Ehsani, John M.Miller, Special Indian Edition, Marcel dekker, Inc 2010

E-Reference:

1	https://archive.nptel.ac.in/courses/108/106/108106170/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recall the fundamentals of electric vehicle and its mechanics	L1: Remembering
CO2	:	Explain the architecture of different forms of hybrid electric vehicles.	L2: Understanding

CO3	:	Illustrate the four-quadrant operation of DC drive, induction motor drive and SRM drive for Electric Vehicles.	L4: Analyzing
CO4	:	Select an appropriate energy storage system for Electric vehicle	L4: Analyzing
CO5	:	Use the suitable energy management control strategy for hybrid electric vehicle	L3: Applying

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	1		1	3	1		1					1	1	2	1
CO2	1	2	3	1			2					2	1	2	
CO3	1	1			2		3						1	1	1
CO4	3	1	2	1	2		1					2	1	2	1
CO5	1	2	1	2	1							1	1	2	1
Avg	**1.4**	**1.5**	**1.75**	**1.75**	**1.5**	**-**	**1.75**	**-**	**-**	**-**	**-**	**1.5**	**1**	**1.8**	**1**

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

<table>
<tr><td>22EEM08</td><td colspan="2">ELECTRICAL ENERGY CONSERVATION AND AUDITING</td><td colspan="3">SEMESTER</td><td></td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">Power Generation, Transmission and Distribution System</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
</table>

Course Objectives:

1.	To get knowledge about basics of energy and energy scenario of India.
2.	To familiarise the energy conservation methods.
3.	To acquire knowledge on energy auditing, energy efficiency and modern energy efficient devices.

UNIT I	**ENERGY SCENARIO**	**9**	**0**	**0**	**9**

Commercial and non-commercial energy -Primary energy resources - Commercial energy production - Final energy consumption - Energy needs of growing economy - Long term energy scenario - Energy pricing - Energy sector reforms - Energy and environment - Energy security - Energy conservation and its importance - Restructuring of the energy supply sector - Energy strategy for the future, air pollution, climate change. Energy Conservation Act-2001 and its features.

UNIT II	**BASICS OF ENERGY**	**9**	**0**	**0**	**9**

Electricity tariff - Load management and maximum demand control - Thermal Basics-fuels - Thermal energy contents of fuel, temperature and pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity & heat transfer, units and conversion.

UNIT III	**ENERGY MANAGEMENT AND AUDIT**	**9**	**0**	**0**	**9**

Definition - Energy audit – Need and types of energy audit. Energy management (audit) approach understanding energy costs - Bench marking - Energy performance - Matching energy use to requirement - Maximizing system efficiencies - Optimizing the input energy requirements, fuel and energy substitution - Energy audit instruments. Material and energy balance: Facility as an energy system - Methods for preparing process flow, material and energy balance diagrams.

UNIT IV	**ENERGY EFFICIENCY**	**9**	**0**	**0**	**9**

Electrical system: Electricity billing - Electrical load management and maximum demand control -Power factor improvement and its benefit - Selection and location of capacitors - Performance assessment of PF capacitors, distribution and transformer losses. Electric motors: Types - Losses in induction motors - Motor efficiency - Factors affecting motor performance - Rewinding and motor replacement issues - Energy saving opportunities with energy efficient motors.

UNIT V	**ENERGY EFFICIENT TECHNOLOGIES**	**9**	**0**	**0**	**9**

Maximum demand controllers - Automatic power factor controllers - Energy efficient motors –Soft starters with energy saver - Variable speed drives - Energy efficient transformers - Electronic ballast - Occupancy sensors - Energy efficient lighting controls - Energy saving potential of each technology.

Total (45 L+ 0 T) = 45 Periods

Text Books:

1.	Sonal Desai, “Handbook of Energy Audit”, McGraw Hill, 2015.
2,	Tripathy, S. C, “Utilization of Electrical Energy and Conservation”, McGraw Hill, 1991.
3.	Hossam A Gabbar, “Energy Conservation in Infrastructure Systems”, Wiley-IEEE Press, New Jersey, 2018

Reference Books:

1.	General Aspects of Energy Management and Energy Audit, Bureau of Energy Efficiency, New Delhi, 2015.
2,	Energy Efficiency in Electrical Utilities, Bureau of Energy Efficiency, New Delhi, 2015.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify the present energy scenario and future energy strategy.	L1: Understanding
CO2	Recognize the various forms of energy.	L1: Understanding
CO3	Interpret energy management methods and energy auditing.	L3: Applying
CO4	Familiar in energy efficiency of electrical systems.	L4: Analysing
CO5	Familiar with the advanced energy efficient technologies.	L4: Analysing

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	1	2	3	2	2		3					1	2	2	1
CO2	1	2	2	2	2		3					1	2	2	1
CO3	2	2	2	3	2		3					1	1	3	1
CO4	2	3	2	2	3		3					1	3	3	1
CO5	2	2	3	1	2		3					1	3	2	1
Avg	**1.6**	**2.2**	**2.4**	**2**	**2.2**	**-**	**3**	**-**	**-**	**-**	**-**	**1**	**2.2**	**2.4**	**1**

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

22EEM09	**SMPS AND UPS**	**SEMESTER**			
PREREQUISITES	**CATEGORY**	**PE**	**Credit**		**3**
Power Electronics	**Hours/Week**	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives:

1. To impart knowledge about modern power electronic converters and their applications in power utility.
2. To impart knowledge about Resonant converters and UPS.

UNIT I	**DC-DC CONVERTERS**	**9**	**0**	**0**	**9**

Introduction to SMPS – Non-isolated DC-DC converters: Cuk, SEPIC topologies, Z-source converter – Zeta converter - Analysis and state space modeling –- Concept of volt-second and charge balance – High gain input-parallel output-series DC-DC converter.

UNIT II	**SWITCHED MODE POWER CONVERTERS**	**9**	**0**	**0**	**9**

Isolated DC-DC converters: Analysis and state space modelling of fly back, Forward, Push pull, Luo, Half bridge and full bridge converters- control circuits and PWM techniques – Bidirectional DC-DC converters.

UNIT III	**RESONANT CONVERTERS**	**9**	**0**	**0**	**9**

Introduction- classification- basic concepts- Resonant switch- Load Resonant converters- ZVS , Clamped voltage topologies- DC link inverters with Zero Voltage Switching- Series and parallel Resonant inverters- Voltage control.

UNIT IV	**DC-AC CONVERTERS**	**9**	**0**	**0**	**9**

Introduction – Multilevel concept – Types of multilevel inverters – Diode-clamped MLI – Flying capacitors MLI – Cascaded MLI – Cascaded MLI – Applications – Switching device currents – DC link capacitor voltage balancing – Features of MLI – Comparisons of MLI.

UNIT V	**POWER CONDITIONERS, UPS, AND FILTERS**	**9**	**0**	**0**	**9**

Introduction- Power line disturbances- Power conditioners –UPS: offline UPS, Online UPS, Applications – Filters: Voltage filters, Series-parallel resonant filters, filter without series capacitors, filter for PWM VSI, current filter, DC filters – Design of inductor and transformer for power electronic applications – Selection of capacitors.

Total (45L+0T)= 45 Periods

Text Books:

1. Simon Ang, Alejandro Oliva,” Power-Switching Converters”, Third Edition, CRC Press, 2010.
2. M.H. Rashid – Power Electronics handbook, Elsevier Publication, 2001.

Reference Books:

1. Ned Mohan, Tore.M.Undeland, William.P.Robbins, “Power Electronics Converters, Applications and Design”, 3rd Edition, John Wiley and Sons, 2006.
2. M.H. Rashid, “Power Electronics circuits, devices and applications”, 3rd Edition, PHI, New Delhi, 2007.

E-References:

1. NPTEL Course: Power Electronics, IIT-B.
2. www.cdeep.iitb.ac.in. (Electrical Engineering)

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Analyze the state space model for DC – DC converters.	L4: Analyzing
CO2	:	Acquire knowledge on switched mode power converters.	L2: Understanding
CO3	:	Outline the PWM techniques for DC-AC converters.	L1: Remembering
CO4	:	Discuss about modern power electronic converters and its applications in electric power utility.	L2: Understanding
CO5	:	Identify the filters and UPS.	L2: Understanding

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2	1	2	2			1					2	2	2	1
CO2	1	1	3	2			1					2	3	3	2
CO3	2	2	2	3			1					1	2	2	1
CO4	2	1	1	2			1					2	2	3	2
CO5	1	1	2	1			1					1	2	2	1
Avg.	**1.6**	**1.2**	**2**	**2**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**1.6**	**2.2**	**2.4**	**1.4**

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

22EEM10	**UTILIZATION OF ELECTRICAL ENERGY**		**SEMESTER**			
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Electrical Machines, Power System, and Power Electronics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the economics of power generation, tariff and energy conservation methods.
2.	To impart knowledge on principle and design of illumination systems.
3.	To analyze the performance and different methods of electric heating and electric welding.
4.	To impart knowledge on electric traction systems and their performance.
5.	To understand electric drives for various industrial applications.

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

Economics of generation – definitions – load duration curve – number and size of generator units – Cost of electrical energy – tariff –– availability based Tariff- (ABT) – Battery Energy storage system (BESS)- Frequency based energy measurement - need for electrical energy conservation – methods.- Introduction to energy audit

UNIT II	**ILLUMINATION**	**9**	**0**	**0**	**9**

Introduction-nature of radiation – definition – laws of illumination – luminous efficacy-photometry – lighting calculations – design of illumination systems for residential, commercial, street lighting and sports ground– types of lamps –incandescent lamp- mercury vapour –fluorescent lamp-energy efficiency lamps – types of lighting schemes – requirements of good lighting

UNIT III	**HEATING AND WELDING**	**9**	**0**	**0**	**9**

Introduction- classification of methods of heating – requirements of a good heating material – design of heating element – temperature control of resistance furnace – electric arc furnace –induction heating – dielectric heating – electric welding – resistance welding – electric arc welding-electrical properties of arc-applications of electric arc welding.

UNIT IV	**ELECTRIC TRACTION**	**9**	**0**	**0**	**9**

Introduction – requirements of an ideal traction system – supply systems – train movement -mechanism of train movement – traction motors and control –speed control of three phase induction motor- multiple unit control – braking – recent trends in electric traction.

UNIT V	**DRIVES AND THEIR INDUSTRIAL APPLICATIONS**	**9**	**0**	**0**	**9**

Electric drive –advantages of electric drive-individual drive and group drive –factors affecting selection of motor – types of loads – steady state –transient characteristics –size of motor– load equalization – industrial applications – modern methods of speed control of D.C drives-dynamic braking using thyristors-regenerative braking using thyristors.

Total (45L+0T)= 45 Periods

Text Books:

1.	C.L. Wadhwa, "Generation, Distribution and Utilization of Electrical Energy", New Age International Pvt.Ltd, 2003.
2.	Eric Openshaw Taylor, "Utilisation of Electric Energy", English Universities Press Limited, 1937
3.	J.B. Gupta, "Utilization of Electric Power and Electric Traction", S.K.Kataria and Sons, 2002.

Reference Books:

1.	G.C.Garg, S.K.Gridhar&S.M.Dhir, "A Course in Utilization of Electrical Energy", Khanna Publishers, Delhi, 2003.
2.	H. Partab, "Art and Science of Utilization of Electrical Energy", Dhanpat Rai and Co, New Delhi, 2004.

E-References:

1.	www.onlinecourses.nptel.ac.in
2.	www.class-central.com
3.	www.mooc-list.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the economics of power generation, tariff and energy conservation methods.	L2: Understanding
CO2	:	Interpret the concept behind illumination and design a suitable illumination system for a specific application.	L3: Applying
CO3	:	Design and choose an appropriate heating method for specific application and gain knowledge about electric welding system.	L4: Analyzing
CO4	:	Explain the concepts and recent trends of traction system.	L4: Analyzing
CO5	:	Discuss the concepts of electric drives and their characteristics.	L2: Understanding

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	1	1	1	1	2	1	2	2	1	1	1	2	2	3
CO2	2	3	2	3	1	1	2	1	1			1	3	3	2
CO3	3	3	1	3	1	1	2	1					2	2	3
CO4	1	2	2	3	3	1	2	1					2	3	2
CO5	3	1	1	2	1	1	2	1		1		1	2	2	3
CO6	1	3	3	3	3	1	2	2				1	3	3	2
Avg	**2.17**	**2.17**	**1.67**	**2.5**	**1.67**	**1.17**	**1.83**	**1.33**	**1.5**	**1**	**1**	**1**	**2.33**	**2.5**	**2.5**

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

<table>
<tr><td>22MEM01</td><td colspan="5">ENGINEERING THERMODYNAMICS
<i>(Use of standard thermodynamic tables, Mollier diagram are permitted)</i></td><td colspan="4"></td></tr>
<tr><td colspan="5">PRE-REQUISITE:</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="5" rowspan="2"></td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="10">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="9">To impart the knowledge on concepts of zeroth and first law of thermodynamics.</td></tr>
<tr><td>2.</td><td colspan="9">To make the learners to understand the third law of thermodynamics and analyze the various work and heat interactions in closed and open systems.</td></tr>
<tr><td>3.</td><td colspan="9">To teach properties of pure substance.</td></tr>
<tr><td>4.</td><td colspan="9">To impart knowledge on the concepts of steam power cycle.</td></tr>
<tr><td>5.</td><td colspan="9">To derive thermodynamic relations for ideal and real gases.</td></tr>
<tr><td>UNIT I</td><td colspan="5">BASIC CONCEPT AND FIRST LAW</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>UNIT II</td><td colspan="5">SECOND LAW AND ENTROPY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>UNIT III</td><td colspan="5">PROPERTIES OF PURE SUBSTANCES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>UNIT IV</td><td colspan="5">STEAM POWER CYCLE</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">Basic Rankine cycle, T-s & h-s diagrams - Performance Improvement - Reheat cycle, regenerative cycle and their combination cycles.</td></tr>
<tr><td>UNIT V</td><td colspan="5">IDEAL AND REAL GASES AND THERMO DYNAMIC RELATIONS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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, Clausius Clapeyron equations and Joule Thomson Coefficient.</td></tr>
<tr><td colspan="10" align="right">Total (45L)= 45 Periods</td></tr>
</table>

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			1					1	3	1	1
CO2	3	3	2	2			1					1	3	1	1
CO3	3	3	3	2		1	1					1	3	1	1
CO4	2	3	2	2		1	1					1	3	1	1
CO5	3	3	2	2		1						1	3	1	1
Avg	**2.8**	**3**	**2.2**	**2**		**1**	**1**					**1**	**3**	**1**	**1**

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

22MEM02	**FLUID MECHANICS AND MACHINERY**					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
1.Engineering Physics 2.Engineering Chemistry 3.Engineering Mathematics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

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				2				1		2	2	1
CO2	3	3	1		2								2	2	1
CO3	2	3	2	2	1								2	2	1
CO4	3	3	3	2	1	2	1						2	2	1
CO5	3	3	3	2	1	2	1						2	2	1
Avg	**2.8**	**2.6**	**2**	**2**	**1.25**	**2**	**1.3**				**1**		**2**	**2**	**1**

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

<table>
<tr><td>22MEM03</td><td colspan="5">MANUFACTURING PROCESSES</td><td colspan="4"></td></tr>
<tr><td colspan="5">PRE-REQUISITE:</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="5" rowspan="2">1. Basic science, Engineering mathematics, Engineering Physics
2. Engineering Materials</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="10">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="9">To make the students familiarize with various manufacturing processes and fabrication techniques of metals and design of casting.</td></tr>
<tr><td>2.</td><td colspan="9">To develop design concepts of various manufacturing processes.</td></tr>
<tr><td>3.</td><td colspan="9">Gain knowledge to select appropriate manufacturing processes for various parts.</td></tr>
<tr><td>4.</td><td colspan="9">To develop an entrepreneur skill among the students.</td></tr>
<tr><td>5.</td><td colspan="9">To evaluate and select plastic deformation processes for various parts.</td></tr>
<tr><td>UNIT I</td><td colspan="5">CASTING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>UNIT II</td><td colspan="5">WELDING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>UNIT III</td><td colspan="5">METAL FORMING</td><td>10</td><td>0</td><td>0</td><td>10</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td>UNIT IV</td><td colspan="5">SHAPING OF PLASTICS</td><td>8</td><td>0</td><td>0</td><td>8</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>UNIT V</td><td colspan="5">SHEET METAL FORMING AND POWDER METALLURGY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td colspan="10" align="right">Total (45L) = 45 Periods</td></tr>
</table>

<table>
<tr><td colspan="2">Text Books:</td></tr>
<tr><td>1.</td><td>HajraChoudhury, "Elements of Workshop Technology", Vol. I and II, Media Promoters and Publishers Pvt., Ltd., Mumbai, 2005.</td></tr>
<tr><td>2.</td><td>NagendraParashar B.S. and Mittal R.K., "Elements of Manufacturing Processes", Prentice-Hall of India Private Limited, 2007.</td></tr>
<tr><td colspan="2">Reference Books:</td></tr>
<tr><td>1.</td><td>Serope Kalpajian, Steven R.Schmid, "Manufacturing Processes for Engineering Materials", 4/e, Pearson Education, Inc. 2007.</td></tr>
<tr><td>2.</td><td>Jain. R.K., and S.C. Gupta, "Production Technology", 16th Edition, Khanna Publishers, 2001.</td></tr>
<tr><td>3.</td><td>"H.M.T. "Production Technology – Handbook", Tata McGraw-Hill, 2000.</td></tr>
<tr><td>4.</td><td>Roy. A. Linberg, "Process and Materials of Manufacture", PHI, 2000.</td></tr>
</table>

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						1			1	2	1
CO2	2	1	2	1		1			1	1			1	2	1
CO3	1	1	1	1						1			1	1	1
CO4	1	1	1		1					1			1	1	1
CO5		1							1	1			1		1
Avg	**1.5**	**1**	**1.5**	**1**	**1**	**1**			**1**	**1**			**1**	**1.5**	**1**

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

22MEM04	**MATERIALS ENGINEERING**				
PRE-REQUISITE:	**CATEGORY**	**PE**	**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 (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						2	3	1
CO2	1		2	1	1	2	1						2	3	1
CO3		1	1	1	1		1						3	2	1
CO4		2	2	1	1	1	1						2	3	1
CO5		2	2	2	1		1						2	2	1
Avg	**1**	**1.5**	**1.8**	**1.4**	**1.0**	**1.3**	**1**						**2.2**	**2.6**	**1.0**
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

22MEM05	**KINEMATICS OF MACHINERY**					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
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									3	1	
CO2	3	2	2	1									3	1	
CO3	3	2	2	1									3	1	
CO4	3	2	2	1									3	1	
CO5	3	2	2	1									3	1	
Avg	**3**	**2**	**2**	**1**									**3**	**1**	

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

<table>
<tr><td>22MEM06</td><td colspan="4">HYDRAULICS AND PNEUMATICS</td><td colspan="4"></td></tr>
<tr><td colspan="4">PRE-REQUISITE:</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="4" rowspan="2"></td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="9">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="8">To enable the students understand the basics of hydraulics and pneumatics</td></tr>
<tr><td>2.</td><td colspan="8">Applying the working principles of hydraulic actuators and control components.</td></tr>
<tr><td>3.</td><td colspan="8">Designing and develop hydraulic circuits and systems.</td></tr>
<tr><td>4.</td><td colspan="8">Applying the working principles of pneumatic power system and its components.</td></tr>
<tr><td>5.</td><td colspan="8">Solving problems and troubles in fluid power systems.</td></tr>
<tr><td>UNIT I</td><td colspan="4">FLUID POWER PRINICIPLES AND HYDRAULIC PUMPS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td>UNIT II</td><td colspan="4">HYDRAULIC ACTUATORS AND CONTROL COMPONENTS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td>UNIT III</td><td colspan="4">HYDRAULIC CIRCUITS AND SYSTEMS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td>UNIT IV</td><td colspan="4">PNEUMATIC AND ELECTRO PNEUMATIC SYSTEMS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td>UNIT V</td><td colspan="4">DESIGN OF FLUID POWER CIRCUITS AND TROUBLESHOOTING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td colspan="9"></td></tr>
<tr><td colspan="9">Total (45L) = 45 Periods</td></tr>
</table>

<table>
<tr><td colspan="2">Text Books:</td></tr>
<tr><td>1.</td><td>Manjumdar S.R, “Oil Hydraulics”, Tata McGraw-Hill, December 2002.</td></tr>
<tr><td>2.</td><td>Anthony Esposito, “Fluid Power with Applications”, Pearson Education 2013.</td></tr>
<tr><td colspan="2">Reference Books:</td></tr>
<tr><td>1.</td><td>Andrew Parr, “Hydraulic and Pneumatics”, Jaico Publications House, 2005.</td></tr>
<tr><td>2.</td><td>Bolton W. “Pneumatic and hydraulic system”, Butterworth-Heinemann 1997</td></tr>
</table>

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										1	1	1
CO2		2	2	1									1	1	1
CO3	1	2	3			1							1	2	1
CO4	1	1	3	2	2								2	1	1
CO5	1	1	2										1	1	1
Avg	**1.25**	**1.4**	**2.2**	**1.5**	**2**	**1**							**1.2**	**1.2**	**1**

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

22MEM07	**DESIGN OF MACHINE ELEMENTS**				
PRE-REQUISITE:	**CATEGORY**	**PE**	**Credit**		**3**
1. Student should study engineering mechanics. 2. Student should study kinematic of machinery.	**Hours/Week**	**L**	**T**	**P**	**TH**
		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	Understand 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		1	1				1		3	2	1
CO2	2	2	1	2		1	1				1		3	2	1
CO3	2	2	1	2		1	1				1		3	2	1
CO4	2	2	1	2		1	1				1		3	2	1
CO5	2	2	1	2		1	1				1		3	2	1
Avg	**2.0**	**2.0**	**1.0**	**2.0**		**1.0**	**1.0**				**1.0**		**3.0**	**2.0**	**1.0**

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

22MEM08	**HEAT AND MASS TRANSFER**					
PREREQUISITES		**CATEGORY**	**PE**	**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 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 boiling and condensation. Heat Exchanger types - Overall Heat Transfer Co-efficient – 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(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		1						3	3	1
CO2	3	3	3	3	2		1						3	3	1
CO3	3	3	3	3	2		1						3	3	1
CO4	3	3	3	3	2		1						3	2	1
CO5	2	2	2	2	1		1						3	1	
Avg	**2.8**	**2.8**	**2.8**	**2.8**	**1.8**		**1**						**3**	**2.4**	**1**

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

<table>
<tr><td>22MEM09</td><td colspan="2">METROLOGY AND QUALITY CONTROL</td><td colspan="4"></td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2"></td><td rowspan="2">Horus/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">COURSE OBJECTIVES</td></tr>
<tr><td>1.</td><td colspan="6">Explaining the importance of measurements in engineering and the factors affecting measurements and to compute measurement uncertainty</td></tr>
<tr><td>2.</td><td colspan="6">Applying the applications of linear and angular measuring instruments</td></tr>
<tr><td>3.</td><td colspan="6">Interpretation of various tolerance symbols.</td></tr>
<tr><td>4.</td><td colspan="6">Applying the SQC methods in manufacturing.</td></tr>
<tr><td>5.</td><td colspan="6">Applying the advances in measurements for quality control.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT-I</td><td colspan="2">BASICS OF MEASUREMENT SYSTEM AND DEVICES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Definition of metrology, accuracy, precision and sensitivity, Abbe‘s principle. Three stages of generalized measurement system - mechanical loading – static characteristics of instruments – factors considered in selection of instruments - commonly used terms, error analysis and classification - sources of error. Measurement uncertainty.</td></tr>
<tr><td>UNIT-II</td><td colspan="2">CALIBRATION OF INSTRUMENTS AND QUALITY STANDARDS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>UNIT-III</td><td colspan="2">GEOMETRICAL MEASUREMENT AND MACHINE ELEMENTS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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&T. Inspection of straightness, flatness, roundness deviations.</td></tr>
<tr><td>UNIT-IV</td><td colspan="2">STATISTICAL QUALITY CONTROL</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Surface finish – terminology and measurements – Optical measuring instruments –Acceptance test for machines. Statistical Quality Control - Control charts - Sampling plans.</td></tr>
<tr><td>UNIT-V</td><td colspan="2">SIX SIGMA</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Six sigma: Define measure, analyse, improve and control phases. Analyze phase tools: CommonTools: Histogram, Box Plot, Control chart, Scatter chart, Cause and effect diagram, Pareto analysis, interrelations diagram. Special Tools: Regression Analysis, Hypothesis Testing, ANOVA Multi variate analysis.</td></tr>
<tr><td colspan="7" align="right">Total(45L) = 45 Periods</td></tr>
</table>

<table>
<tr><td colspan="2">TEXT BOOKS:</td></tr>
<tr><td>1</td><td>Gupta.I.C, ―A text book of Engineering Metrology, Dhanpat Rai publications, New Delhi, 2018</td></tr>
<tr><td>2</td><td>Beckwith.T.G, Roy D. Marangoni, John H. Lienhard, - Mechanical Measurements‖, Prentice Hall, 2006</td></tr>
<tr><td colspan="2">REFERENCE BOOKS:</td></tr>
<tr><td>1</td><td>Jain.R.K, ―Mechanical and Industrial Measurements, Khanna Publishers, Delhi, 1999.</td></tr>
<tr><td>2</td><td>Holmen.J.P, ―Experimental Methods for Engineers‖, Tata McGraw Hill Publications Co Limited, 2017.</td></tr>
<tr><td>3</td><td>Grant, E.L., Statistical Quality Control, Mc Graw-Hill, 2004. 3. Doeblin E.O., Measurement Systems, Mc Graw-Hill, 2004.</td></tr>
</table>

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							2	1	2				2	1	
CO2							3	1	2				1	2	
CO3							2	1					2	1	
CO4				3			2		1				1	2	
CO5				2				3	1				2	1	
Avg				**2.5**			**2.25**	**1.5**	**1.5**				**1.6**	**1.4**	
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

<table>
<tr><td>22MEM10</td><td colspan="2">DYNAMICS OF MACHINERY</td><td colspan="4"></td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">Engineering Mechanics, Kinematics of Machinery, Strength of Materials</td><td rowspan="2">Hours\Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
</table>

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 the 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					1		3	2	1	2
CO2	2	2	3	2	1					1		3	2	1	2
CO3	2	2	3	2						1		3	2	1	2
CO4	2	2	3	2	1					1		3	2	1	2
CO5	1	2	3	2						1		3	2	1	1
Avg	**1.8**	**2.0**	**3.0**	**2.2**	**1**					**1.0**		**3.0**	**2.0**	**1.0**	**1.8**

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

<table>
<tr><td>22MTM01</td><td colspan="2">ADVANCED PHYSICAL METALLURGY</td><td colspan="3">Semester</td><td></td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>Category</td><td>OE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">Engineering physics</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="6">To impart knowledge on the crystal structure, diffusion, phase diagrams for various engineering materials.</td></tr>
<tr><td>Unit I</td><td colspan="2">CRYSTAL STRUCTURES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Review of atomic bonds, Lattice, unit cell, crystal systems and Bravais lattices; Principal crystal structures – BCC, FCC, HCP and its characteristics; Miller indices for crystallographic planes and directions, interplanar spacing; Volume, planar and linear atomic density; Polymorphism and allotropy; CsCl, NaCl, Diamond structures; single crystal and polycrystalline and amorphous materials; isotropy and anisotropy; Simple problems in the above topics</td></tr>
<tr><td>Unit II</td><td colspan="2">CRYSTALLINE IMPERFECTIONS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Types of point defects, effect of temperature on vacancy concentration, interstitial sites-octahedral and tetrahedral sites; Line defects – dislocations – Edge, screw and mixed dislocations, Burger’s vector, slip and twinning; Planar defects – grain boundaries, tilt boundaries, small angle grain boundaries; ASTM grain size number, grain size determinations; Volume defects; Simple problems in the above topics.</td></tr>
<tr><td>Unit III</td><td colspan="2">ATOMIC DIFFUSION IN SOLIDS AND SOLIDIFICATION OF METAL</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Diffusion mechanisms, steady state diffusion and non-steady state diffusion-Fick’s first law and second law; Kirkendall effect and Darken’s equation; Factors affecting diffusion; Industrial applications of diffusion processes; Simple problems in the above topics; Basic principles of solidification of metals and alloys; Growth of crystals– Planar growth, dendritic growth, Solidification time, dendrite size; Cooling curves; Cast or Ingot structure, Solidification defects – Control of casting structure; Directional solidification – single crystal growth; Simple problems in the above topics.</td></tr>
<tr><td>Unit IV</td><td colspan="2">PHASE DIAGRAMS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Phases, solid solution types, compounds, Hume- Rothery rules; Gibb’s phase rule; Phase diagram determination; Binary isomorphous alloy systems – composition and amount of phases, development of microstructure – equilibrium and non-equilibrium cooling- Coring and its effects, homogenization; Binary eutectic system - composition and amount of phases, development of microstructure; Eutectoid, Peritectic and monotectic reaction, Phase diagrams with intermediate phases and compounds; Ternary phase diagrams. Simple problems in the above topics.</td></tr>
<tr><td>Unit V</td><td colspan="2">IRON-CARBON PHASE DIAGRAM</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Iron-carbon diagram, Phases in Fe-C system, Invariant reactions, Microstructure of slowly cooled steels, composition and amount of phases, Effect of Alloying elements on Fe-C system, Type, structure, properties and applications of Plain Carbon Steels and different types of Cast iron; IS Specification for Steels and Cast Irons, Simple problems in above topics.</td></tr>
<tr><td colspan="7">Total (45+0) = 45 Hours</td></tr>
</table>

<table>
<tr><td colspan="2">Text Books:</td></tr>
<tr><td>1</td><td>Donald R. Askeland,”The Science and Engineering of Materials”, Thomson Learning, India Edition, 2007.</td></tr>
<tr><td>2</td><td>William D.Callister, “Materials Science and Engineering – An Introduction”, 4th edition, JohnWiley & Sons, New York, USA, 1997.</td></tr>
<tr><td colspan="2">Reference Books:</td></tr>
</table>

1	Avner S H."An Introduction to Physical Metallurgy", McGraw Hill Book Co, New York, USA, 1997.
2	Donald R Askeland," Essentials of Material Science and Engineering ", Thomson Learning, India Edition, 2007
3	Raghavan V., "Physical Metallurgy – Principles and Practice", Prentice Hall of India Ltd., New Delhi, 199.
4	William F.Smith, "Foundations of Materials Science and Engineering", Second Edition, McGraw-Hill Inc, New York, 1993.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the basic crystal structure, orientation and their influence on macroscopic properties.	L2: Understanding
CO2	:	Discuss the role of imperfections in strengthening the materials.	L2: Understanding
CO3	:	Diagonise the diffusion mechanism in solidification of materials under different conditions.	L4:Analysing
CO4	:	Apply the concept of phase diagrams in equilibrium transformation of materials phases.	L3:Applying
CO5	:	Construct the Fe-Fe$_3$C phase diagram and discuss various properties of steel and cast iron.	L3:Applying

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	1		1	1								1		1	
CO2	1	1				1	1						1			1
CO3	1	1	1	1		1							1	1		
CO4	1	1		1	1								1			
CO5	1	1		1									1			1
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0

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

22MTM02	**THERMODYNAMICS AND KINETICS IN METALLURGY**	**Semester**			
PREREQUISITES	**Category**	**OE**	**Credit**		**3**
Engineering physics and Engineering chemistry	**Hours/Week**	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**
Course Learning Objectives					
1	To learn the basic principles and concepts of thermodynamics in the field of Metallurgy and materials; and to learn about equations and their applications.				
Unit I	**FUNDAMENTAL CONCEPT AND INTERNAL ENERGY**	**9**	**0**	**0**	**9**
Introduction: System and surrounding, Classification of systems, Path and state properties, Thermodynamic processes, Thermodynamic equilibrium, Reversible and Irreversible processes. First law of thermodynamics: Heat and work, Internal energy, Heat capacity of materials, Cp-Cv relations, Nernst Equation, Enthalpy, Thermochemistry Hess's law, Kirchoff's law, Maximum flame temperature.					
Unit II	**ENTROPY AND AUXILARY FUNCTIONS**	**9**	**0**	**0**	**9**
Second law of thermodynamics: Carnot cycle, Entropy - Statistical interpretation of entropy, Free energy, Combined statement of first and second laws, Thermodynamic functions - Maxwell's relations, Gibbs Helmholtz equation. Third and Zeroth laws of thermodynamics : Definition, concept and applications					
Unit III	**THERMODYNAMIC POTENTIALS AND PHASE EQUILIBRIA**	**9**	**0**	**0**	**9**
Thermodynamic potentials: Fugacity, Activity and Equilibrium constant. Clausius - Clayperon equation, Troutons rule. Le Chatelier's principle, Vant Hoff's equation. Equilibria in phase diagrams: Phase rule, Phase stability, Thermodynamics of surfaces, interfaces and defects, P-G-T diagrams, Application of free energy - composition diagrams to the study of alloy systems.					
Unit IV	**THERMODYNAMICS OF SOLUTIONS**	**9**	**0**	**0**	**9**
Gibbs - Duhem equation, Partial and integral molar quantities, chemical potential, Ideal solutions - Raoult's law, Real solutions, Activity coefficient, Henry's law, Alternative standard states, Sievert's law, Mixing functions and excess functions, Regular solutions, Applications of Gibbs - Duhem equation.					
Unit V	**THERMODYNAMICS OF REACTIONS AND KINETICS**	**9**	**0**	**0**	**9**
Electro chemical process: Cells, Interconversion of free energy and electrical work, Determination of thermodynamic quantities using reversible cells, Solid electrolytic cells. Kinetics: First, Second and third order reactions, Arrhenius equation - activation energy, Determination of order of the reaction.					
					Total (45+0) = 45 Hours

Text Books:	
1	Upadhyaya G S andDube R K., "Problems in Metallurgical Thermodynamics & Kinetics",Pergamon, 1977.
2	Ahindra Ghosh, Text book of Materials & MetallurgicalThermodynamics, Prentice Hall India, 2002
3	. David R Gaskell, "Introduction to the Thermodynamics of Materials", Fifth Edition, Taylor & Francis, 2008

Reference Books:	
1	David V Ragone, "Thermodynamics of Materials - Volume-1", John Wiley & Sons, Inc. 1995.
2	Dr S.K Dutta,Prof A.B.Lele – Metallurgical thermodynamics kinetics and numericals,S.Chand& co Ltd.,New Delhi 2011

3	Darken LS and Gurry R W,"Physical Chemistry of Metals", CBS publications and distributors, 2002.
4	Parker R H, "An introduction to chemical metallurgy", Pergamon press, New York, second edition, 1978.
5	Kapoor M.L., “Chemical and Metallurgical Thermodynamics Vol. I and II”, Nem Chand, 1st Ed., 1981

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Discuss the fundamental concepts of thermodynamics and internal energy	L2: Understanding
CO2	:	State the thermodynamics entropy and auxilary functions.	L2: Understanding
CO3	:	Identify the basic laws, chemical potential and phase equilibria.	L4:Analysing
CO4	:	Describe the thermodynamics of the solution and various important equations.	L2: Understanding
CO5	:	Apply to solve problems related to electrochemical processes and kinetics.	L3:Applying

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	1		1	1								1	1		
CO2	1	1	1										1		1	
CO3	1	1		1	1								1			
CO4	1			1	1								1		1	1
CO5	1	1				1	1						1		1	
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

<table>
<tr><td>22MTM03</td><td colspan="2">MECHANICAL BEHAVIOUR OF MATERIALS</td><td colspan="3">Semester</td><td></td></tr>
<tr><td colspan="2">PREREQUISITES</td><td></td><td>OE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">Engineering physics</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="6">To know the fundamental concepts of deformation behaviour for structural engineering applications.</td></tr>
<tr><td>Unit I</td><td colspan="2">DISLOCATIONS AND PLASTIC DEFORMATION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Strength of perfect crystal and need for dislocations; Characteristics of dislocations – Edge dislocation, Screw dislocation, Burger’s vector, mixed dislocation, dislocation loops; Movement of dislocation – Pierls stress, Cross slip, Climb; Dislocations in FCC, HCP and BCC lattice; Stress fields and energies of dislocations, forces on and between dislocations; Dislocation density; Intersections of dislocations – Jogs and kinks; Dislocation multiplication; Dislocation pile-ups; Deformation by slip and twinning; Critical resolved shear stress; Deformation bands and kink bands.</td></tr>
<tr><td>Unit II</td><td colspan="2">STRENGTHENING MECHANISMS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Strain hardening; Grain boundary strengthening; Solid solution strengthening - yield-point phenomenon, strain ageing; Precipitation hardening - Conditions for precipitation hardening, Ageing, Formation of precipitates, coarsening of precipitates, Mechanism of strengthening; Dispersion strengthening; Fiber strengthening; Martensite strengthening - examples for above strengthening mechanisms from ferrous and non-ferrous systems, Bauschinger effect; Preferred orientation; Sever plastic deformation.</td></tr>
<tr><td>Unit III</td><td colspan="2">FRACTURE AND FRACTURE MECHANICS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Types of fracture – ductile and brittle fracture, Ductile to Brittle Transition Temperature (DBTT), Metallurgical factors affecting DBTT, determination of DBTT, Hydrogen embrittlement and other embrittlement, Theoretical cohesive strength of metals, Griffith’s theory of brittle fracture, Orowan’s modification. Fracture mechanics - introduction, modes of fracture, stress intensity factor, strain energy release rate, fracture toughness and determination of KIC, introduction to COD, J integral.</td></tr>
<tr><td>Unit IV</td><td colspan="2">FATIGUE BEHAVIOUR AND TESTS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Fatigue: Stress cycles, S-N curves, effect of mean stress, factors affecting fatigue, structural changes accompanying fatigue, cumulative damage, HCF / LCF, thermo-mechanical fatigue, application of fracture mechanics to fatigue crack propagation, fatigue testing machines.</td></tr>
<tr><td>Unit V</td><td colspan="2">CREEP BEHAVIOUR AND TESTS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Creep curve, stages in creep curve and explanation, structural changes during creep, creep mechanisms, metallurgical factors affecting creep, high temperature alloys, stress rupture testing, creep testing machines, parametetric methods of extrapolation. Deformation Mechanism Maps</td></tr>
<tr><td colspan="7" align="right">Total (45+0) = 45 Hours</td></tr>
</table>

Text Books:	
1	George. E. Dieter, “Mechanical Metallurgy”, 3rd Edition, McGraw-Hill Publications, New York, SI Edition, 2004
2	Marc Andr’e Meyers, Krishan Kumar Chawla, “Mechanical Behavior of Materials”, Cambridge University Press, UK, 2009.

Reference Books:	
1	Reed Hill, R.E., "Physical Metallurgy Principles", Affiliated East West Press, New Delhi, 1992.
2	Davis.H.E. Troxell G.E., Hauck.G.E.W. “The Testing of Engineering Materials”, McGraw-Hill, 1982.
3	Wulff et al Vol. III “Mechanical Behavior of Materials”, John Wiley and Sons, New York, USA, 1983.
4	Honeycombe R.W.K., “Plastic Deformation of Materials”, Edward Arnold Publishers, 1984

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Discuss the mechanical behaviour of materials.	L2: Understanding
CO2	:	Discuss the strengthening mechanisms of materials.	L2: Understanding
CO3	:	List the various types of fractures and their mechanisms, fracture mechanics and various theories describing fracture mechanics.	L2: Understanding
CO4	:	Discuss the fatigue behaviour and the mechanism of fatigue, SN curve and fatigue testing machines.	L2: Understanding
CO5	:	Describe the creep behaviour and mechanism, factors affecting creep and creep testing machines.	L2: Understanding

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	1		1	1								1	1		
CO2	1	1		1	1								1	1		
CO3	1	1	1		1										1	1
CO4	1	1				1	1								1	1
CO5	1	1		1	1								1	1		
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0

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

22MTM04	**RATE PROCESSES IN METALLURGY**		**Semester**			
PREREQUISITES			**OE**	**Credit**		**3**
Engineering physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**
Course Learning Objectives						
1	To learn the basic principles and concepts of kinetics in the domain of metallurgy and materials; to learn about equations and their applications; And to appreciate that metallurgical kinetics as a Knowledge base with abundant applications.					
Unit I	**INTRODUCTION**		**9**	**0**	**0**	**9**
Introduction: Role of kinetics, heterogeneous and homogeneous kinetics, Role of heat and mass transfer in metallurgical kinetics, rate expression, Effect of Temperature and concentration on reaction kinetics: effect of temperature (Arrhenius Equation), Effect of concentration (order of a reaction), significance and determination of activation energy.						
Unit II	**KINETICS OF SOLID-FLUID REACTION**		**9**	**0**	**0**	**9**
Kinetics of solid-fluid reaction: kinetic steps, rate controlling step, definition of various resistances in series, shrinking core model, chemical reaction as rate controlling step, Product layer diffusion as rate controlling step, Mass transfer through external fluid film as rate controlling step, heat transfer as the rate controlling step, Concentration boundary layer, definition and significance of heat and mass transfer coefficient, Theoretical models for mass transfer coefficients, Correlations for heat and mass transfer coefficients						
Unit III	**LIQUID-SOLID PHASE TRANSFORMATION**		**9**	**0**	**0**	**9**
Principles of Solidification in metals and alloys: thermodynamics involved, eutectic and peritectic Solidification, Homogeneous and heterogeneous nucleation, Mechanisms of growth. Rapid Solidification Processing.						
Unit IV	**SOLID STATE PHASE TRANSFORMATIONS**		**9**	**0**	**0**	**9**
Nucleation and growth Kinetics, homogeneous and heterogeneous transformation, Precipitation: Coherency, age hardening, particle Coarsening. Ostwald ripening, Order-disorder transformation, spinodal decomposition, massive transformations						
Unit V	**SOLID STATE PHASE TRANSFORMATIONS IN STEEL**		**9**	**0**	**0**	**9**
Reconstructive and displacive transformations; Pearlitic transformation: mechanism and kinetics: Johnson-Mehl equation, morphology of pearlite; Bainitic transformation: mechanism and kinetics; morphology of upper bainite and lower bainite; Martensitic transformation: Mechanism- diffusionless displacive nature; morphology of high carbon and low carbon martensite.						
						Total (45+0) = 45 Hours

Text Books:	
1.	Ahindra Ghosh and Sudipto Ghosh, A Text book of Metallurgical Kinetics, PHI learning Pvt. Ltd., New Delhi, 2014
2.	H.S. Ray, Kinetics of Metallurgical Reactions, International Science publisher, 1993.
3.	F. Habashi, Kinetics of Metallurgical Processes, Metallurgy Extractive Québec, 1999.
4.	Upadhyaya G S and Dube R K., "Problems in Metallurgical Thermodynamics & Kinetics", Pergamon, 1977.

Reference Books:	
1.	Phase transformations in metals and alloys- D.A. Potter and K.E. Easterling, CRC Press, 1992. 2. Transformations in Metals, P.G. Shewmon, Mc-Graw Hill, 1969.
2.	Introduction to Physical Metallurgy – S. N. Avner, Tata McGraw Hill, 1997.
3.	Physical Metallurgy Principles, R. E. Reed-Hill and R. Abbaschian, 3rd ed, PWS-Kent Publishing, 1992.
4.	Modern Physical Metallurgy, R. E. Smallman, Butterworths, 1963

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Discuss the thermodynamic aspects of phase changes.	L2: Understanding
CO2	:	Discuss the fundamentals of solid –fluid reactions.	L2: Understanding
CO3	:	Explain the eutectic and peritectic solidifications and rapid solidification processes.	L2: Understanding
CO4	:	Describe the fundamentals of solidification.	L1: Remembering
CO5	:	Apply the solid state phase transformations in steel.	L3:Applying

<u>COURSE ARTICULATION MATRIX</u>

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	1		1	1								1			1
CO2	1	1			1	1									1	1
CO3	1	1		1	1								1	1		
CO4	1	1		1	1									1		1
CO5	1		1			1	1								1	1
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0

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

<table>
<tr><td>22MTM05</td><td colspan="2">CORROSION AND SURFACE ENGINEERING</td><td colspan="3">Semester</td><td></td></tr>
<tr><td colspan="2">PREREQUISITES</td><td></td><td>OE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">Engineering chemistry</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="6">To understand the corrosion and surface engineering, with its application in engineering field.</td></tr>
<tr><td>Unit I</td><td colspan="2">MECHANISMS AND TYPES OF CORROSION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Principles of direct and Electro chemical Corrosion, Hydrogen evolution and Oxygen absorption mechanisms – Galvanic corrosion, Galvanic series-specific types of corrosion such as uniform, Pitting, Intergranular, Cavitations, Crevice Fretting, Erosion and Stress Corrosion, corrosion fatigue, hydrogen damage –Factors influencing corrosion</td></tr>
<tr><td>Unit II</td><td colspan="2">TESTING AND PREVENTION OF CORROSION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Corrosion testing techniques and procedures- Corrosion Testing ASTM Standards, Pitting Corrosion Test, Hydrogen Induced Cracking Test, Sulphide Stress Corrosion Cracking Test- Prevention of Corrosion-Design against corrosion –Modifications of corrosive environment –Inhibitors – Cathodic Protection –Special surfacing processes.</td></tr>
<tr><td>Unit III</td><td colspan="2">CORROSION OF INDUSTRIAL COMPONENTS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Corrosion in fossil fuel power plants, Automotive industry, Chemical processing industries, corrosion in petroleum production operations and refining, Corrosion of pipelines- wear of industrial components.</td></tr>
<tr><td>Unit IV</td><td colspan="2">SURFACE ENGINEERING FOR WEAR AND CORROSION RESISTANCE</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Diffusion coatings –Electro and Electroless Plating –Hot dip coating –Hard facing-Metal spraying, Flame and Arc processes- Conversion coating –Selection of coating for wear and Corrosion resistance.</td></tr>
<tr><td>Unit V</td><td colspan="2">THIN LAYER ENGINEERING PROCESSES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Laser and Electron Beam hardening –Effect of process variables such as power and scan speed - Physical vapor deposition, Thermal evaporation, Arc vaporization, Sputtering, Ion plating - Chemical vapor deposition – Coating of tools, TiC, TiN, Al_2O_3 and Diamond coating-Properties and applications of thin coatings.</td></tr>
<tr><td colspan="7" align="right">Total (45+0) = 45 Hours</td></tr>
</table>

Reference Books:	
1.	Fontana. G., Corrosion Engineering, McGraw Hill,1985.
2.	Kenneth G. Budinski, Surface Engineering for Wear Resistance, Prenticehall,1992.
3.	ASM Metals Hand Book –Vol. 5, Surface Engineering,1996.
4.	Denny A Jones, “Principles and prevention of corrosion”, 2^{nd}edition, Prentice Hall, New Jersey,1995.
5.	ASM International, Surface Engineering for Corrosion and Wear Resistance,2005.
6.	Schweitzer. P.A., Corrosion Engineering Hand Book, 3rd Edition, Marcel Decker, 1996.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Name the different types of corrosion and their mechanism.	L2: Understanding
CO2	:	Estimate corrosion resistance by different tests.	L4:Analysing
CO3	:	Explain the corrosion behavior of different metals in different industries.	L2: Understanding
CO4	:	Classify the different forms of processing techniques of surface engineering materials.	L1: Remembering
CO5	:	Select the type of deposition and spraying technique.	L3:Applying

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	1		1	1								1	1		
CO2	1	1		1		1							1	1		
CO3	1	1	1	1			1								1	1
CO4	1	1		1	1										1	1
CO5	1	1		1	1								1	1		
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0

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

22MTM06	**MATERIALS CHARACTERIZATION**		**Semester**			
PREREQUISITES			**OE**	**Credit**		**3**
Engineering physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**
Course Learning Objectives						
1	To acquire knowledge on various characterizations, chemical and thermal analysis of metallurgical components using its analysis tools.					
Unit I	**OPTICAL MICROSCOPY**		**9**	**0**	**0**	**9**
Metallographic specimen preparation. Macro-examination -applications. Metallurgical microscope - principle, construction and working, , Optic properties - magnification, numerical aperture, resolving power, depth of focus, depth of field, different light sources, lens aberrations and their remedial measures, Various illumination techniques-bright field , dark field, phase-contrast, polarized light illuminations, interference microscopy, high temperature microscopy; Quantitative metallography – Image analysis.						
Unit II	**X-RAY DIFFRACTION**		**9**	**0**	**0**	**9**
Characteristic X-ray spectrum, Bragg's Law, Diffraction methods - Laue method, rotating crystal method and powder method. Diffraction intensity – structure factor calculation. X-ray diffractometer -general features, filters and counters. Applications of X-ray diffraction in materials characterisation – Determination of crystallite size, crystal structure, precise lattice parameter, measurement of stress.						
Unit III	**ELECTRON MICROSCOPY**		**9**	**0**	**0**	**9**
Electron beam - specimen interactions. Construction and operation of Transmission Electron Microscopy – Diffraction effects and image formation, various imaging modes, selected area diffraction, applications, specimen preparation techniques. Scanning electron microscopy – principle, equipment, various operating modes and applications, Electron probe microanalyser (EPMA)- principle, instrumentation, qualitative and quantitative analysis. Introduction to HRTEM, FESEM, EBSD.						
Unit IV	**SPECTROSCOPIC TECHNIQUES**		**9**	**0**	**0**	**9**
X-ray spectroscopy – EDS and WDS. Principle, instrumentation, working and applications of Auger Electron spectroscopy, X-ray photoelectron spectroscopy and Secondary ion mass spectroscopy / ion microprobe. Optical emission spectroscopy, Atomic Absorption spectroscopy and X-ray fluorescence spectroscopy - principle, construction, working and applications. UV-Vis, FTIR and Raman spectroscopy.						
Unit V	**THERMAL ANALYSIS AND ADVANCED CHARACTERIZATION TECHNIQUES**		**9**	**0**	**0**	**9**
Thermal Analysis: Principles of differential thermal analysis, differential scanning calorimetry and thermo-graviometric analysis – Instrumentation and applications. Advanced characterization techniques: Scanning probe microscopy - STM and AFM - principle, instrumentation and applications. Field ion microscopy including atom probe - principles, instrumentation and applications.						
Total (45+0) = 45 Hours						

Text Books:	
1.	Cullity, B.D., Elements of X Ray Diffraction, Addison-Wesley Publishing Company Inc, Philippines, 1978
2.	Brandon, D. and W.D. Kaplan, Microstructural Characterization of Materials, John Wiley & Sons Ltd,

	England, 2013.
3.	Leng, Y., Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia) Pte Ltd, Singapore, 2008
Reference Books:	
1.	ASM Handbook, Volume 10, Materials Characterization, ASM international, USA, 1986.
2.	Vander Voort, G.F., Metallography: Principle and practice, ASM International, 1999.
3.	Phillips V A, Modern Metallographic Techniques and their Applications, Wiley Eastern, 1971.
4.	Angelo, P. C., Materials Characterization, Reed Elsevier India Pvt Ltd, Haryana, 2013.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Discuss the principles of metallurgical microscope, optical properties and various illumination techniques.	L2: Understanding
CO2	:	Analyze the various diffraction methods, X-ray diffractometer and determination of crystal parameter.	L4:Analysing
CO3	:	Discuss the principles of TEM, SEM, EPMA.	L2: Understanding
CO4	:	Explain various spectroscopic techniques,	L2: Understanding
CO5	:	Discuss the chemical and thermal analysis using advanced methods.	L2: Understanding

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	`1		1	1								1		1	
CO2	1	1	1	1		1							1			1
CO3	1		1			1	1					1	1			1
CO4	1	1		1	1							1	1			1
CO5	1	1		1	1								1		1	
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0					1.0	1.0		1.0	1.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MTM07	**AUTOMOTIVE, AEROSPACE AND DEFENCE MATERIAL**		**Semester**			
PREREQUISITES			**OE**	**Credit**		**3**
Engineering physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**
Course Learning Objectives						
1	To understand the properties and applications various materials suitable for automobile, aircraft and defnce industries and its components.					
Unit I	**MATERIALS FOR ENGINES AND TRANSMISSION SYSTEMS**		**9**	**0**	**0**	**9**
Materials selection for IC engines: Piston, piston rings, cylinder, Engine block, Connecting rod, Crank shaft, Fly wheels, Gear box, Gears, Splines, Clutches.						
Unit II	**MATERIALS FOR AUTOMOTIVE STRUCTURES**		**9**	**0**	**0**	**9**
Materials selection for bearings, leaf springs, chasis & frames, Bumper, shock absorbers, wind screens, panels, brake shoes, Disc, wheels, differentials , damping and antifriction fluids, Tyres and tubes. Materials for electronic devices meant for engine control, ABS, Steering, Suspension, Sensors, anti-collision, Anti-fog, Head lamps.						
Unit III	**AEROSPACE METALS AND ALLOYS**		**9**	**0**	**0**	**9**
Types of corrosion – Effect of corrosion on mechanical properties – Stress corrosion cracking – Corrosion resistance materials used for space vehicles. Heat treatment of carbon steels – aluminium alloys, magnesium alloys and titanium alloys – Effect of alloying treatment, heat resistance alloys – tool and die steels, magnetic alloys, powder metallurgy- application of materials in Thermal protection systems of Aerospace vehicles – super alloys						
Unit IV	**CERAMICS AND COMPOSITES**		**9**	**0**	**0**	**9**
Introduction – physical metallurgy – modern ceramic materials – cermet - cutting tools – glass ceramic – production of semi-fabricated forms - Plastics and rubber – Carbon/Carbon composites, Fabrication processes involved in metal matrix composites - shape memory alloys – applications in aerospace vehicle design.						
Unit V	**NUCLEAR WASTE AND RADIATION PROTECTION, IRRADIATION EFEFCTS**		**9**	**0**	**0**	**9**
Introduction-unit of nuclear radiation-Types of waste –disposal –ICRP recommendations-radiation hazards and prevention –radiation dose units - Irradiation Examination of Fuels, Irradiation behaviour of metallic uranium – irradiation growth, thermal cycling, swelling, adjusted uranium, blistering in uranium rods. Irradiation effects in ceramic oxide and mixed oxide fuels, definition and units of burn up, main causes of fuel element failure in power reactors and remedies to avoid failures.						
Total (45+0) = 45 Hours						

Reference Books:	
1.	ASM Handbook, “Selection of Materials Vol. 1 and 2”, ASM Metals Park, Ohio. USA, 1991.
2.	Materials Science and Engineering, Willium D. Callister, Jr. John Wiley & Sons publications Or Callister’s Materials Science and Engineering Adapted By R. Balasubramaniam, Wiley India, Edition -2010.

3.	Material Science and Engineering, V. Raghavan, Prentice Hall of India, 4th Edition.
4.	Engineering Metallurgy Applied Physical Metallurgy, R. A. Higgins, 6th Edition
5.	Gladius Lewis, “Selection of Engineering Materials”, Prentice Hall Inc. New Jersey USA, 1995.
6.	Charles J A and Crane. F A. A., “Selection and Use of Engineering Materials”, 3rd Edition, Butterworths, London UK, 1996
7.	ASM Handbook. “Materials Selection and Design”, Vol. 20- ASM Metals Park Ohio.USA, 1997
8.	Cantor,“ Automotive Engineering: Lightweight, Functional, and Novel Materials”, Taylor & Francis Group, London, 2006

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Describe the materials selection criteria for engine and transmission systems.	L2: Understanding
CO2	:	Analyze the different materials used for automotive structures and Different electronic materials for automotive applications.	L4:Analysing
CO3	:	Explain various topics such as elements of aerospace materials and mechanical behaviour of materials,	L2: Understanding
CO4	:	Compare the ceramics and composites of aerospace materials	L4:Analysing
CO5	:	Examine the fuels for nuclear materials.	L3:Applying

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	1		1	1								1	1		
CO2	1	1	1			1							1	1		
CO3	1			1	1								1		1	
CO4	1	1	1				1						1			1
CO5	1	1		1	1								1			1
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																