CURRICULUM

B.E – METALLURGICAL ENGINEERING (FULL TIME)

SEMESTER I

S. No.	Course Code	Course Title	Cat.	Hours / Week			Credit	Max. Marks		
				L	T	P		CA	FE	Total
1	22MC101	Induction Program	MC	-	-	-	0	-	-	-
THEORY										
2	22EN101	Communicative English (Theory cum Practical)	HS	2	0	2	3	50	50	100
3	22MA101	Matrices, Calculus and Ordinary Differential Equations	BS	3	1	0	4	40	60	100
4	22PH101	Engineering Physics	BS	3	1	0	4	40	60	100
5	22CS101	Problem Solving and C Programming	ES	3	0	0	3	40	60	100
6	22CE101	Engineering Mechanics	ES	3	0	0	3	40	60	100
7	22MC102	Heritage of Tamils /தமிழர்மரபு	HS MC	1	0	0	1	100	-	100
PRACTICAL										
8	22CS102	Computer Practice and C Programming Laboratory	ES	0	0	3	1.5	60	40	100
9	22ME102	Workshop Manufacturing Practices	ES	0	0	4	2.0	60	40	100
TOTAL							**21.5**			**800**

SEMESTER II

S. No.	Course Code	Course Title	Cat.	Hours / Week			Credit	Max. Marks		
				L	T	P		CA	FE	Total
THEORY										
1	22MA201	Partial Differential Equation, Vector Calculus and Complex Variables	BS	3	1	0	4	40	60	100
2	22CY101	Engineering Chemistry	BS	3	1	0	4	40	60	100
3	22EE203	Basic of Electrical Engineering for Metallurgy	ES	3	1	0	4	40	60	100
4	22ME101	Engineering Graphics & Design	ES	1	0	4	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	22EN102	Professional Skills Laboratory	HS	0	0	2	1	60	40	100
10	22PH103	Physics Laboratory	BS	0	0	3	1.5	60	40	100
11	22CY102	Chemistry Laboratory	BS	0	0	3	1.5	60	40	100
12	22EE204	Basic Electrical Engineering Laboratory for Metallurgy	ES	0	0	3	1.5	60	40	100
TOTAL							**25.5**			**1100**

*Only for NCC students, it is not considered for CGPA calculation.

SEMESTER III										
S. No.	**Course Code**	**Course Title**	**Cat.**	**Hours / Week**			**Credit**	**Max. Marks**		
				L	**T**	**P**		**CA**	**FE**	**Total**
THEORY										
1	22MA306	Linear Algebra and Transforms	BS	3	1	0	4	40	60	100
2	22MT301	Elements of Physical Metallurgy	PC	3	0	0	3	40	60	100
3	22MT302	Mineral Dressing, Fuels and Furnaces	PC	3	0	0	3	40	60	100
4	22MT303	Metallurgical Thermodynamics and Kinetics	PC	3	1	0	4	40	60	100
5	22PH102	Materials Science for Engineering	BS	2	1	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	22MT304	Metallography Laboratory	PC	0	0	3	1.5	60	40	100
9	22MT305	Chemical Metallurgy Laboratory	PC	0	0	3	1.5	60	40	100
TOTAL							**21**			**800**
SEMESTER IV										
S. No.	**Course Code**	**Course Title**	**Cat.**	**Hours / Week**			**Credits**	**Max. Marks**		
				L	**T**	**P**		**CA**	**FE**	**Total**
THEORY										
1	22MA403	Probability and Statistical Methods	BS	3	1	0	4	40	60	100
2	22CY401	Non Metallic Materials	BS	3	0	0	3	40	60	100
3	22MT401	Mechanical Behaviour and Testing of Materials	PC	3	0	0	3	40	60	100
4	22MT402	Advanced Physical Metallurgy	PC	3	0	0	3	40	60	100
5	22MT403	Heat Treatment Technology	PC	3	0	0	3	40	60	100
6	22MT404	Iron Making	PC	3	0	0	3	40	60	100
7	22MCIN03	Design Sprints	EE	0	0	2	1	100	-	100
8	22CYMC01	Environmental Science	MC	2	0	1	0	100	-	100
PRACTICAL										
9	22MT405	Material Testing Laboratory	PC	0	0	3	1.5	60	40	100
10	22EN401	Placement and Soft Skills Laboratory	HS	0	0	4	2	60	40	100
TOTAL							**23.5**			**1000**

SEMESTER V										
S. No.	**Course Code**	**Course Title**	**Cat.**	**Hours / Week**			**Credit**	**Max. Marks**		
				L	**T**	**P**		**CA**	**FE**	**Total**
THEORY										
1	22MT501	Non Ferrous Extractive Metallurgy	PC	3	0	0	3	40	60	100
2	22MT502	Forming Processes	PC	3	0	0	3	40	60	100
3	22MT503	Steel Making	PC	3	0	0	3	40	60	100
4	22MT504	Corrosion Engineering	PC	3	0	0	3	40	60	100
5	22MT505	Casting Engineering	PC	3	0	0	3	40	60	100
6	22MT506	Welding Engineering	PC	3	0	0	3	40	60	100
7	22MC301	Indian Constitution	MC	3	0	0	0	100	-	100
8	22MCIN04	Ideation Sprints	EE	0	0	2	1	100	-	100
PRACTICAL										
9	22MT507	Heat Treatment and Corrosion Laboratory	PC	0	0	4	2	60	40	100
10	22MT508	Machine Shop Practice	PC	0	0	3	1.5	60	40	100
TOTAL							**22.5**			**1000**

SEMESTER VI (Regular Stream)										
S. No.	**Course Code**	**Course Title**	**Cat.**	**Hours / Week**			**Credit**	**Max. Marks**		
				L	**T**	**P**		**CA**	**FE**	**Total**
THEORY										
1	22MTPExx	Professional Elective - I	PE	3	0	0	3	40	60	100
2	22MTPExx	Professional Elective - II	PE	3	0	0	3	40	60	100
3	22MTPExx	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	22MT601	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**			**Credit**	**Max. Marks**		
				L	**T**	**P**		**CA**	**FE**	**Total**
THEORY										
1	22PSPE01	Computational Hardware	PE	3	0	0	3	100	-	100
2	22PSPE02	Coding for Innovators	PE	3	0	0	3	100	-	100
3	22PSPE03	Industrial Automation	PE	3	0	0	3	100	-	100
4	22PSOE01	Applied Design Thinking	OE	3	0	0	3	100	-	100
5	22PSOE02	Startup Fundamentals	OE	3	0	0	3	100	-	100
6	22PSOE03	Prototype Development	OE	3	0	0	3	100	-	100
PRACTICAL										
7	22PSEE01	Robotics	EE	0	0	6	3	100	-	100
		TOTAL					**21**			**700**

SEMESTER VII										
S. No	**Course Code**	**Course Title**	**Cat.**	**Hours / Week**			**Credit**	**Max. Marks**		
				L	**T**	**P**		**CA**	**FE**	**Total**
THEORY										
1	22MT701	Characterization of Materials	PC	3	0	0	3	40	60	100
2	22MT702	Introduction to Industrial Management	HS	3	0	0	3	40	60	100
3	22MT703	Total Quality Management	HS	3	0	0	3	40	60	100
4	22MTPExx	Professional Elective - IV	PE	3	0	0	3	40	60	100
5	22MTPExx	Professional Elective – V	PE	3	0	0	3	40	60	100
6	22__OExx	Open Elective - IV	OE	3	0	0	3	40	60	100
PRACTICAL										
7	22MT704	Materials Characterization and Computer Application Laboratory	PC	0	0	3	1.5	60	40	100
8	22MT705	Manufacturing Processes Laboratory	PC	0	0	3	1.5	60	40	100
		TOTAL					**21**			**800**

SEMESTER VIII										
S. No	**Course Code**	**Course Title**	**Cat.**	**Hours / Week**			**Credits**	**Max. Marks**		
				L	**T**	**P**		**CA**	**FE**	**Total**
THEORY										
1	22MTPExx	Professional Elective – VI	PE	3	0	0	3	40	60	100
2	22MT801	Project Work	EE	0	0	20	10	120	80	200
		TOTAL					**13**			**300**

PROFESSIONAL ELECTIVE COURSES (PEC)

S. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PROFESSIONAL ELECTIVE –I (VI SEMESTER)								
1.	22MTPE11	Transport phenomena	PE	3	3	0	0	3
2.	22MTPE12	Fractography and failure Analysis	PE	3	3	0	0	3
3.	22MTPE13	Metallurgical kinetics	PE	3	3	0	0	3
4.	22MTPE14	Solidification Processing	PE	3	3	0	0	3
5	22MTPE15	Ferrous and Non Ferrous alloys	PE	3	3	0	0	3
PROFESSIONAL ELECTIVE –II (VI SEMESTER)								
6.	22MTPE21	Composite Materials	PE	3	3	0	0	3
7.	22MTPE22	Ceramic materials	PE	3	3	0	0	3
8.	22MTPE23	Metallurgy of tool Steels	PE	3	3	0	0	3
9.	22MTPE24	Bio and smart materials	PE	3	3	0	0	3
10.	22MTPE25	Welding Metallurgy	PE	3	3	0	0	3
PROFESSIONAL ELECTIVE –III (VI SEMESTER)								
11.	22MTPE31	Fracture Mechanics	PE	3	3	0	0	3
12.	22MTPE32	Continuous casting of steel	PE	3	3	0	0	3
13.	22MTPE33	Alternate routes of Iron making	PE	3	3	0	0	3
14.	22MTPE34	Foundry Metallurgy	PE	3	3	0	0	3
15	22MTPE35	X-Ray diffraction and electron Microscopy	PE	3	3	0	0	3
PROFESSIONAL ELECTIVE –IV (VII SEMESTER)								
16.	22MTPE41	Additive manufacturing	PE	3	3	0	0	3
17.	22MTPE42	Severe plastic deformation	PE	3	3	0	0	3
18.	22MTPE43	Metallurgical waste utilization And management	PE	3	3	0	0	3
19.	22MTPE44	Computational Materials Engineering	PE	3	3	0	0	3
20.	22MTPE45	Introduction to Instrumentation	PE	3	3	0	0	3
PROFESSIONAL ELECTIVE –V (VII SEMESTER)								
21.	22MTPE51	Non Destructive Evaluation And Failure Analysis	PE	3	3	0	0	3
22.	22MTPE52	Aerospace materials	PE	3	3	0	0	3
23.	22MTPE53	Nuclear materials	PE	3	3	0	0	3
24.	22MTPE54	Electrical, Electronics and Magnetic materials	PE	3	3	0	0	3

25.	22MTPE55	Nanomaterials	PE	3	3	0	0	3
PROFESSIONAL ELECTIVE –VI (VIII SEMESTER)								
26.	22MTPE61	Thin films, coatings and applications	PE	3	3	0	0	3
27.	22MTPE62	Modeling and simulation in material processes	PE	3	3	0	0	3
28.	22MTPE63	Powder Metallurgy	PE	3	3	0	0	3
29.	22MTPE64	Special casting Technology	PE	3	3	0	0	3
30.	22MTPE65	Secondary steel making	PE	3	3	0	0	3
31.	22MTPE66	Surface Engineering	PE	3	3	0	0	3

LIST OF OPEN ELECTIVE COURSES

S.No.	Course Code	Course	Cat	Hours/Week			Credits	Maximum Marks		
				L	T	P		CA	FE	Total
COURSES OFFERED BY THE DEPARTMENT OF MATHEMATICS										
1	22MAOE01	Sampling Theory amd Numarical Methods	OE	3	0	0	3	40	60	100
2	22MAOE02	Numerical Methods	OE	3	0	0	3	40	60	100
3	22MAOE03	Probability and Queuing Theory	OE	3	0	0	3	40	60	100
COURSES OFFERED BY THE DEPARTMENT OF CIVIL ENGINEERING										
4	22CEOE01	Environmental Management	OE	3	0	0	3	40	60	100
5	22CEOE02	Disaster Mitigation and Management	OE	3	0	0	3	40	60	100
6	22CEOE03	Repair and Rehabilitation of Building Elements	OE	3	0	0	3	40	60	100
7	22CEOE04	Mechanics of Deformable bodies	OE	3	0	0	3	40	60	100
COURSES OFFERED BY THE DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING										
8	22CSOE01	Object Oriented Programming 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 Machine Learning	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	OE	3	0	0	3	40	60	100

		Systems								
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 Artificial Intelligence	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	Advanced 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	Nanoscience and Technology	OE	3	0	0	3	40	60	100
41	22MTOE05	Materials for Automotive Components	OE	3	0	0	3	40	60	100

HONOURS DEGREE for Metallurgical Engineering Students

B.E – HONOURS for Metallurgical Engineering Students

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 1: WELDING	VERTICAL 2: MATERIALS AND PROCESSING
22MTH101 Welding Equipment and consumables	22MTH201 Electrical, Magnetic and Optical Materials
22MTH102 Welding codes and standards	22MTH202 Materials Technology
22MTH103 Automation and Robots in Welding	22MTH203 Polymers and Composites
22MTH104 Welding Applications Technology	22MTH204 Selection of Materials
22MTH105 Brazing, Soldering, Surfacing and Cutting	22MTH205 High Temperature Materials
22MTH106 Design of Weldments	22MTH206 Processing of Nonmetallic Materials
22MTH107 Failure Analysis in Weldments	22MTH207 Biomaterials
22MTH108 Finite Element Analysis in welding	22MTH208 Advances in Nuclear materials
	22MTH209 Automotive and Aerospace materials
	22MTH210 Processing of Nonferrous metal ores

VERTICAL 1: WELDING

S.NO	COURSE CODE	COURSETITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	22MTH101	Welding Equipment and consumables	PE	3	3	0	0	3
2	22MTH102	Welding codes and standards	PE	3	3	0	0	3
3.	22MTH103	Automation and Robots in Welding	PE	3	3	0	0	3
4.	22MTH104	Welding Applications Technology	PE	3	3	0	0	3
5.	22MTH105	Brazing, Soldering, Surfacing and Cutting	PE	3	3	0	0	3
6.	22MTH106	Design of Weldments	PE	3	3	0	0	3
7.	22MTH107	Failure Analysis in Weldments	PE	3	3	0	0	3
8.	22MTH108	Finite Element Analysis in welding	PE	3	3	0	0	3

HONOURS DEGREE for Metallurgical Engineering Students

VERTICAL 2: MATERIALS AND PROCESSING

S.NO	COURSE CODE	COURSETITLE	CATEGORY	CONTACTPERIODS	L	T	P	C
1.	22MTH201	Electrical, Magnetic and Optical Materials	PE	3	3	0	0	3
2	22MTH202	Materials Technology	PE	3	3	0	0	3
3.	22MTH203	Polymers and Composites	PE	3	3	0	0	3
4.	22MTH204	Selection of Materials	PE	3	3	0	0	3
5.	22MTH205	High Temperature Materials	PE	3	3	0	0	3
6.	22MTH206	Processing of Nonmetallic Materials	PE	3	3	0	0	3
7.	22MTH207	Biomaterials	PE	3	3	0	0	3
8.	22MTH208	Advances in Nuclear materials	PE	3	3	0	0	3
9.	22MTH209	Automotive and Aerospace materials	PE	3	3	0	0	3
10.	22MTH210	Processing of Nonferrous metal ores	PE	3	3	0	0	3

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 Secience 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 Microcontroller	22MEM02 Fluid Mechanics and Machinery	22MTM02 Thermodynamics and kinetics in Metallurgy
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 – Measurements and Instrumentation	22MEM04 Materials Engineering	22MTM04 Rate Processes 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 – Electrical Drives and Control	22MEM06 Hydraulics and Pneumatics	22MTM06 Materials Characterization
22CEM07 Green Building Technology	22CSM07 Advanced Database System Concepts	22ECM07 Communication Networks	22EEM07 – Electric Vehicles and Control	22MEM07 Design of Machine Elements	22MTM07 Automotive, Aerospace and Defence 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 Microcontroller	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	Electrical 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

SUMMARY

B.E., METALLURGICAL ENGINEERING											
S.NO	Course Work subject Area	Credits Per Semester								Total Credit	Credits Recommended by AICTE
		I	II	III	IV	V	VI	VII	VIII		
1	Basic Sciences	8	11	7	7	-	-	-	-	33	25
2	Humanities and Social Sciences	4	5	-	2	-	-	6	-	17	12
3	Engineering Sciences	9.5	8.5	-	-	-	-	-	-	18	24
4	Professional Core	-	-	13	13.5	21.5	-	6	-	54	48
5	Professional Elective	-	-	-	-	-	9	6	3	18	18
6	Open Elective	-	-	-	-	-	9	3	-	12	18
7	Employment Enhancement Course	-	-	-	-	-	3	-	10	13	15
8	Proto Sem	-	1	1	1	1	21	-	-	21/4	
TOTAL		**21.5**	**25.5**	**21**	**23.5**	**22.5**	**21/21**	**21**	**13**	**169**	**160***

SYLLABUS

PROFESSIONAL CORE COURSES

METALLURGICAL ENGINEERING - FULL TIME

REGULATION 2022 – SYLLABUS

SEMESTER-I

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

22EN101	COMMUNICATIVE ENGLISH			SEMESTER			I
PREREQUISTIES Basic language skills listening, speaking, reading and writing		CATEGORY		HS	Credit		3
		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, writingand 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	INTERPRETATATION	6	0	6	12

Listening – An interview with career advisor and recruitment agent, Feedbacks, Meeting extracts.
Speaking – Qualities required for employability, Improving employee productivity, presentation on problem-solving skills, teamwork, creativity and leadership quality.
Reading - Reading brochures, telephone messages, social media messages relevant to technical contexts.
Writing - Letter Writing – Formal Letters and Informal Letters - cover letter with resume, Mind maps, Charts - interpreting statistical data, charts, graphs and tables.
Grammar - One word substitution, Abbreviations and acronyms in technical contexts and technical vocabulary, Idioms.

Total (30L + 30P)= 60 Periods

REFERENCE BOOKS:	
1.	Meenakshi Raman and Sangeeta Sharma. Professional English. Oxford University Press, New Delhi, 2019.
2.	Krishna Mohan, Meera Bannerji. Developing Communication Skills. Macmillan India Ltd, Delhi, 1990.
3.	Sanjay Kumar, Pushp Lata. English Language and Communication Skills for Engineers. Oxford University Press, 2018.
E-RESOURCES:	
1.	https://learnenglish.britishcouncil.org/
2.	https://www.bbc.co.uk/learningenglish

COURSE OUTCOMES: Upon completion of this 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	PSO4
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)																

22MA101	**MATRICES, CALCULUS AND ORDINARY DIFFERENTIAL EQUATIONS** **B.E. (Common to all Branches Except EEE)**		**SEMESTER**		**I**
PRE-REQUISITE:		**Category**	**BS**	**Credit**	**4**
Basic 12th level Matrices, Differential Calculus, Integral Calculus and ODE.		**Hours/Week**	**L** / **3**	**T** / **1**, **P** / **0**	**TH** / **4**

Course Objectives:					
1.	To know the use of matrix algebra needed by engineers for practical applications.				
2.	To understand effectively both the limit definition and rules of differentiation.				
3.	To familiarize in solving maxima and minima problems in two variables.				
4.	To obtain the knowledge of multiple integrations and their related applications.				
5.	To obtain the knowledge to solve second order differential equations with constant and variable coefficients				
Unit I	**MATRICES**	**9**	**3**	**0**	**12**
System of linear equations – Characteristic equation of a Matrix – Eigen values and Eigen vectors – Properties – Cayley-Hamilton theorem (excluding proof) – Diagonalization of Matrices - Reduction of quadratic form to canonical form by orthogonal transformation.					
Unit II	**DIFFERENTIAL CALCULUS**	**9**	**3**	**0**	**12**
Representation of functions - Limit of a function - Continuity - Derivatives - Differentiation rules - Maxima and Minima of the function of a single variable.					
Unit III	**FUNCTIONS OF SEVERAL VARIABLES**	**9**	**3**	**0**	**12**
Partial derivatives – Euler's theorem for homogenous functions – Total Derivatives -Jacobians – Maxima, Minima and Saddle point- – Method of Lagrangian multipliers- Taylor's series.					
Unit IV	**MULTIPLE INTEGRALS**	**9**	**3**	**0**	**12**
Multiple integrals- Double integrals – Change of order of integration in double integrals – Change of variables (Cartesian to Polar) – Application to Areas – Evaluation of Triple integrals – Application to volumes.					
Unit V	**ORDINARY DIFFERENTIAL EQUATIONS**	**9**	**3**	**0**	**12**
Second-order linear differential equations with constant and variable coefficients –Cauchy-Euler equation and Cauchy- Legendre's linear equation - Method of variation of parameters –Simultaneous first order linear equations with constant coefficients.					
					Total (45L+15T) = 60 Hours

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

<u>COURSE ARTICULATION MATRIX</u>

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
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			
3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)																

<table>
<tr><td>22PH101</td><td colspan="3">ENGINEERING PHYSICS</td><td colspan="3">SEMESTER</td><td>I</td></tr>
<tr><td colspan="3">PREREQUISITES</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 Learning 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>Unit I</td><td colspan="3">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>Unit II</td><td colspan="3">LASER AND FIBER 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>Unit III</td><td colspan="3">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>Unit IV</td><td colspan="3">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 – Schrodinger’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>Unit V</td><td colspan="3">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, 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">Total (45+15) = 60 Hours</td></tr>
</table>

Text Books:	
1	Arumugam M, ‘Engineering Physics’, Anuradha publishers, 2019
2	Rajendran V. and Marikani A, ‘Engineering Physics’, PHI Learning Pvt., India, 2018.
3	Palanisamy P.K, ‘Engineering Physics’, SCITECH Publications, 2018.
4	Ragavan V, ‘Material science and engineering’, Prentice hall of India Pvt Ltd, New Delhi, 2004.
5	Introduction to crystal growth, Principles and Practice, H.L. Bhat, Taylor and Francis, 2015 edition
Reference Books:	
1	Gaur R.K. and Gupta S.L, ‘Engineering Physics’, Dhanpat Rai publishers, 2012.
2	Arthur Beiser, ‘Concepts of Modern Physics’, Tata McGraw Hill Publishing Co. Ltd, sixth Edition, 2019.
3	Gerd Keiser, ‘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 this course, the students will be able to:		**Bloom’s Taxonomy Level**
CO1	Understand the principle to produce ultrasonic waves and acoustics of buildings.	Understand
CO2	Understand the principle and applications of laser & optical fiber.	Understand
CO3	Analyze various modes involved in heat transmission.	Analyze
CO4	Gain knowledge in the basic concept of quantum physics.	Remember
CO5	Recognize Crystal structure, crystal defects and crystal growth techniques.	Evaluate

COURSE ARTICULATION MATRIX

COs/ POs	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PS O2	PS O 3	PS O 4
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								1	2			
CO4	3	2	1	1	2		1					1	1			
CO5	2.6	2.2	1	1	1.75	1	1					1.4	1.5	1	1	
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**																

<table>
<tr><td>22CS101</td><td colspan="4">PROBLEM SOLVING AND C PROGRAMMING</td><td colspan="2">SEMESTER</td><td>I</td></tr>
<tr><td colspan="4">PREREQUISITES</td><td>Category</td><td>ES</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 Learning Objectives</td></tr>
<tr><td>1</td><td colspan="8">To use general problem-solving techniques to device solutions to problems</td></tr>
<tr><td>2</td><td colspan="8">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="8">To provide complete knowledge about the programming concepts of C language.</td></tr>
<tr><td>Unit I</td><td colspan="4">SYSTEM SOFTWARE, PROBLEM SOLVING, AND C PROGRAMMING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">High level programming language – Machine level language – role of system software (Editor, Compiler, Assembler, Linker, Loader, and Operating System) in developing and executing a C program
C Programming: Character set – Case sensitivity – Identifiers – Keywords –Literals – Data types – Declaration statement- Variables and their associated information – Formed and unformed console input-output statements – Type conversion – Operators – Precedence and Associativity – Pre-processor directives (#include and #define) – the main ( ) function General problem-solving Techniques: Algorithm – Flow-chart – Pseudocode– Developing solution for problems involving only operators and writing their equivalent C programs.</td></tr>
<tr><td>Unit II</td><td colspan="4">CONTROL STATEMENTS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">General problem-solving Techniques: Representing Decision making: if-else statement – switch-case statement – Looping statement: for loop, while loop and do-while loop – Branching statements: break and continue with Algorithm, Flow-chart, and Pseudocode C programming: Decision Making: if-else statement – switch case statement - Looping statement: for loop, while loop and do-while loop – Branching statements: break and continue – Nesting
Developing solutions for problems involving control statements using General problem-solving techniques and their equivalent C programs</td></tr>
<tr><td>Unit III</td><td colspan="4">ARRAYS, POINTERS, AND STRINGS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">One-dimensional and two-dimensional Arrays: Declaration– Initialization – Processing – Pointers: Declaration– Initialization - Processing – relation between pointers and arrays – Strings – String operation – C Library support for string handling Developing solutions for problems involving arrays, pointers and strings using General problem-solving Techniques and their equivalent C programs.</td></tr>
<tr><td>Unit IV</td><td colspan="4">FUNCTIONS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">Function – Library functions and user-defined functions – Function prototypes and function definitions – Parameter passing mechanisms – Recursion – Storage classes – Working with multiple source files Developing solutions for problems involving functions using General problem-solving techniques and their equivalent C programs.</td></tr>
<tr><td>Unit V</td><td colspan="4">STRUCTURES, UNIONS AND FILE</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">Structure: declaration – definition - Structure within a structure – Passing structures to functions – Array of structures – Pointers to structures-Union - File operation: reading and writing/appending to binary and text files.</td></tr>
<tr><td colspan="9" align="right">Total = 45 Hours</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-References	
1	https://www.learn-c.org/
2	https://www.programiz.com/c-programming

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom’s Taxonomy Level**
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	PO 10	PO 11	PO 12	PSO 1	PS O2	PS O 3	PS O 4
CO1	2	1	3									3	1			
CO2	2	1	3		2							3	2			
CO3	2	1	3		2							3	3			
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**																

22CE101	**ENGINEERING MECHANICS**			**Semester**			**II**
PREREQUISITES		**Category**	**ES**	**Credit**			**3**
		Hours/Week	**L**	**T**	**P**		**TH**
			3	**0**	**0**		**3**

Course Learning Objectives

1	To explain the importance of mechanics in the context of engineering and conservation equations.
2	To apply resolution of forces
3	To explain the significance of centroid, center of gravity and moment of inertia
4	To apply the different principles to study the motion of a body, and concept of relative velocity and acceleration
5	To apply Impulse Momentum principle

Unit I	**BASICS & STATICS OF PARTICLES**	**9**	**0**	**0**	**9**
Introduction – Units and Dimensions – Laws of Mechanics – Lame's theorem, Parallelogram and triangular Law of forces – Vectors – Vectorial representation of forces and moments – Vector operations: additions, subtraction, dot product, cross product – Coplanar Forces – Resolution and Composition of forces – Equilibrium of a particle – Equilibrium of a particle in three dimensions – Equivalent systems of forces – Principle of transmissibility – Single equivalent force.					
Unit II	**EQUILIBRIUM OF RIGID BODIES**	**9**	**0**	**0**	**9**
Free body diagram – Types of supports and their reactions – requirements of stable equilibrium – Moments and Couples – Moment of a force about a point and about an axis – Vectorial representation of moments and couples – Scalar components of a moment – Varignon's theorem – Equilibrium of Rigid bodies in two dimensions – Equilibrium of Rigid bodies in three dimensions.					
Unit III	**PROPERTIES OF SURFACES AND FRICTION**	**9**	**0**	**0**	**9**
Determination of Areas and Volumes –Theorems of Pappus and Guldinus-First moment of area and the Centroid of sections –Second and product moments of plane area of various sections –Parallel axis theorem and perpendicular axis theorem-Polar moment of inertia –Principal moments of inertia of plane areas-Principal axes of inertia- Frictional force-Laws of Coulomb friction-simple contact friction-Rolling resistance –Belt friction.					
Unit IV	**KINEMATICS AND KINETICS OF PARTICLES**	**9**	**0**	**0**	**9**
Displacemnt, Velocity and acceleration, their relationship-Relative motion-Newton's low of motion-Work Energy Equation-Impulse and Momentum-Impact of elastic bodies					
Unit V	**KINEMATICS AND KINETICS OF RIGID BODIES**	**9**	**0**	**0**	**9**
Plane motion- Absolute motion- Relative motion- Translating ares and Rolling Axes- Work and Energy- Impulse and Momentum					
					Total= 45 Periods

Text Books:

1	Rajasekaran S and Sankara subramanian G., Fundamentals of Engineering Mechanics, Vikas Publishing House Pvt. Ltd., 3rd Edition,2017.
2	Bansal R.K., Engineering Mechanics, Laxmi Publications (P) Ltd., 8th Edition, 2015.
3	Palanichamy M.S. and Nagan S, Engineering Mechanics, Laxmi Publication(P) Ltd.,2022

Reference Books:

1	Kumar K.L., Engineering Mechanic, Tata McGraw–Hill Publishing Company Limited, New Delhi, 4th Edition, 2017.

2	Beer F.P and Johnson Jr. E.R. Vector Mechanics for Engineers, Vol. 1 Statics and Vol. 2 Dynamics, McGraw–Hill International Edition, 12th Edition, 2019
3	Hibbeller R.C., Engineering Mechanics, Vol. 1 Statics, Vol. 2 Dynamics, Pearson Education Asia Pvt. Ltd., 14th Edition, 2017.
4	Irving H. Shames, Engineering Mechanics – Statics and Dynamics, IV Edition – Pearson Education Asia Pvt. Ltd., 4th Edition, 2005.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Demonstrate the basics and statics of the particle by applying, knowledge of mathematics and engineering sciences	Apply
CO2	Explain the equilibrium of rigid bodies and draw the free body diagram and mention the supports and the reaction for the diagram.	Apply
CO3	Select and apply appropriate techniques to determine the areas of the surfaces using the various theorems and find the moment of inertia of different body shapes	Apply
CO4	Understand the complex engineering problems to solve the dynamics of particles	Apply
CO5	Understand the mechanisms of rigid bodies using Civil engineering solutions for sustainable development.	Apply

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**	**PSO1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	**2**	**3**	**1**	**1**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**-**
CO2	**2**	**3**	**2**	**1**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**-**
CO3	**2**	**3**	**2**	**1**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**-**
CO4	**2**	**3**	**2**	**1**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**-**
CO5	**2**	**3**	**2**	**1**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**-**
Avg	**2**	**3**	**1.8**	**1**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**-**
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**																

<table>
<tr><td>22MC102</td><td colspan="2">தமிழர் மரபு
B.E (Common to all Branches)</td><td colspan="4">Semester I</td></tr>
<tr><td colspan="2">முன் நிபந்தனைகள்:</td><td>Category</td><td>HSMC</td><td colspan="2">Credit</td><td>1</td></tr>
<tr><td colspan="2" rowspan="2">இலக்கணம் மற்றும் இலக்கியத்தின் அடிப்படைகள்</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>0</td><td>1</td></tr>
<tr><td colspan="7">பாடநெறிநோக்கங்கள்: மாணவர்களால்</td></tr>
<tr><td>1.</td><td colspan="6">தமிழ் மொழி மற்றும் இலக்கியம் பற்றியஅறிவைப் பெற முடியும்.</td></tr>
<tr><td>2.</td><td colspan="6">பாரம்பரியம், பாறை ஓவியங்கள் முதல் நவீன ஓவியங்கள் மற்றும் சிற்பக் கலைகள் பற்றி தெரிந்து கொள்ள முடியும்</td></tr>
<tr><td>3.</td><td colspan="6">நாட்டுப்புறக் கலைகள் மற்றும் வீரவிளையாட்டுகள் பற்றி அறிந்து கொள்ள முடியும்</td></tr>
<tr><td>4.</td><td colspan="6">தமிழர்களின் ஒழுக்க நெறிமுறைகளைப் பற்றி தெரிந்து கொண்டு அதன் படி நடந்து கொள்ள முடியும்.</td></tr>
<tr><td>5.</td><td colspan="6">பழங்கால இந்திய தேசிய இயக்கம் பற்றியும், இந்திய மக்களின் பண்பாட்டில் தமிழர்களின் பங்களிப்பு பற்றியும் நன்கு அறிந்து கொள்ள முடியும்.</td></tr>
<tr><td>அலகு I</td><td colspan="2">மொழி மற்றும் இலக்கியம்</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">இந்திய மொழிக்குடும்பங்கள் – திராவிட மொழிகள் – தமிழ் ஒரு செம்மொழி – தமிழ் செவ்விலக்கியங்கள்– சங்க இலக்கியத்தின் சமயச்சார் பற்றதன்மை – சங்க இலக்கியத்தில் பகிர்தல் அறம் – திருக்குறளில் மேலாண்மைக் கருத்துக்கள் – தமிழ்க் காப்பியங்கள், தமிழகத்தில் சமண பௌத்த சமயங்களின் தாக்கம்– பக்தி இலக்கியம், ஆழ்வார்கள் மற்றும் நாயன் மார்கள் – சிற்றிலக்கியங்கள் – தமிழில் நவீன இலக்கியத்தின் வளர்ச்சி – தமிழ் இலக்கிய வளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின் பங்களிப்பு.</td></tr>
<tr><td>அலகு II</td><td colspan="2">மரபு – பாறை ஓவியங்கள் முதல் நவீன ஓவியங்கள் வரை சிற்பக்கலை</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">நடுகல் முதல் நவீன சிற்பங்கள் வரை – ஐம்பொன் சிலைகள் – பழங்குடியினர் மற்றும் தயாரிக்கும் கைவினைப் பொருட்கள், பொம்மைகள் – தேர் செய்யும் கலை – சுடுமண் சிற்பங்கள் – நாட்டுப்புறத் தெய்வங்கள்- குமரி முனையில் திருவள்ளுவர் சிலை- இசைக்கருவிகள் – மிருதங்கம், பறை, வீணை, யாழ், நாதஸ்வரம் – தமிழர்களின் சமூக பொருளாதார வாழ்வில் கோவில்களின் பங்கு.</td></tr>
<tr><td>அலகு III</td><td colspan="2">நாட்டுப்புறக் கலைகள் மற்றும் வீர விளையாட்டுகள்</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">தெருக்கூத்து, கரகாட்டம், வில்லுப்பாட்டு, கணியான்கூத்து, ஒயிலாட்டம், தோல்பாவைக்கூத்து, சிலம்பாட்டம், வளரி, புலியாட்டம், தமிழர்களின்விளையாட்டுகள்.</td></tr>
<tr><td>அலகு IV</td><td colspan="2">தமிழர்களின் திணைக்கோட்பாடுகள்</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>அலகு V</td><td colspan="2">இந்திய தேசிய இயக்கம் மற்றும் இந்திய பண்பாட்டிற்குத் தமிழர்களின் பங்களிப்பு</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">இந்திய விடுதலைப் போரில் தமிழர்களின் பங்கு – இந்தியாவின் பிறப்பகுதிகளில் தமிழ்ப்பண்பாட்டின் தாக்கம் – சுயமரியாதை இயக்கம் – இந்திய மருத்துவத்தில், சித்த மருத்துவத்தின் பங்கு – கல்வெட்டுகள், கையெழுத்துப் படிகள் – தமிழ்ப் புத்தகங்களின் அச்சுவரலாறு.</td></tr>
<tr><td colspan="7">Total= 15 Periods</td></tr>
</table>

Text Books:	
1	தமிழகவரலாறு - மக்களும் பண்பாடும் - கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடுபாடநூல் மற்றும் கல்வியல் பணிகள் கழகம்)
2	கணினித் தமிழ் - முனைவர் இல.சுந்தரம் (விகடன் பிரசுரம்)
3	கீழடி - வைகைநதிக்கரையில் சங்ககாலநகரநாகரிகம் (தொல்லியல் துறைவெளியீடு)
4	பொருநை - ஆற்றங்கரைநாகரிகம். (தொல்லியல் துறைவெளியீடு)

பாடநெறிமுடிவுகள்: இந்தப் படிப்புமுடிந்ததும்,மாணவர்களால்		**Bloom's Taxonomy Mapped**
CO1	இந்தியமொழிகள், இந்தியமொழிக் குடும்பங்கள் பற்றியும் மற்றும் இலக்கியம், இலக்கியதின் வளர்ச்சி,தமிழ் இலக்கியவளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின் பங்களிப்புகளைபற்றியும் அறிந்துகொண்டனர்.	Understanding
CO2	சிற்பக் கலைகளில் அடங்கியுள்ளபாறைஓவியங்கள் முதல் நவினஓவியங்கள் வரைபற்றியும்,தமிழர்களின் சமூக,பொருளாதாரவாழ்வில் கோவில்களின் பங்கினைபற்றியும் தெரிந்துகொண்டனர்.	Understanding
CO3	தமிழர்களின் வாழ்வியல் முறைகளோடுஒன்றியநாட்டுபுறக் கலைகள் மற்றும் தமிழர்களின் வீரவிளையாட்டுகளைபற்றி அறிந்துகொண்டனர்.	Understanding
CO4	சங்ககாலத்தில் தமிழர்கள் பின்பற்றியதினைக் கோட்பாடுகள் பற்றிநடந்துகொண்டனர்.	Applying
CO5	இந்தியதேசிய இயக்கம் மற்றும் இந்தியபண்பாட்டிற்க்குத் தமிழர்களின் பங்கினைபற்றியும் அறிந்துகொண்டனர்.	Understanding

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
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 ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
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)

<table>
<tr><td>22CS102</td><td colspan="3">COMPUTER PRACTICE AND C PROGRAMMING LABORATORY</td><td colspan="3">SEMESTER</td><td>I</td></tr>
<tr><td colspan="3">PREREQUISITES</td><td>Category</td><td>ES</td><td colspan="2">Credit</td><td>1.5</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>3</td><td>3</td></tr>
<tr><td colspan="8">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="7">To provide basic knowledge to work with word processing applications</td></tr>
<tr><td>2</td><td colspan="7">To provide basic knowledge to work with spread sheet applications</td></tr>
<tr><td>3</td><td colspan="7">To promote the programming ability to develop C applications</td></tr>
<tr><td colspan="8">EXPERIMENTS</td></tr>
<tr><td colspan="8">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</td></tr>
<tr><td colspan="8">Total (45) = 45 Hours</td></tr>
</table>

<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>Understand and Apply</td></tr>
<tr><td>CO2</td><td>Demonstrate the usage of features supported by spread sheet applications.</td><td>Understand and Apply</td></tr>
<tr><td>CO3</td><td>Apply general programming techniques to develop digital solution to problems</td><td>Understand and Apply</td></tr>
<tr><td>CO4</td><td>Implement solutions develop with general programming techniques in C programming language</td><td>Understand and Apply</td></tr>
</table>

COURSE ARTICULATION MATRIX

COs/ POs	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O 1	PS O2	PS O 3	PS O 4
CO1										3			1			
CO2	2	3											1			
CO3	2	3	3									3	2			
CO4	1	1	1									3	3			
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**																

<table>
<tr><td>22ME102</td><td colspan="2">WORKSHOP MANUFACTURING PRACTICES</td><td colspan="3">SEMESTER</td><td>I</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>Category</td><td>ES</td><td colspan="2">Credit</td><td>2</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>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(P) = 60 Hours

Reference Books:

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

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

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PS O2	PS O 3	PS O 4
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)**																

<table>
<tr><td>22MA201</td><td colspan="4">PARTIAL DIFFERENTIAL EQUATIONS, VECTOR CALCULUS AND COMPLEX VARIABLES</td><td colspan="3">SEMESTER</td><td>II</td></tr>
<tr><td colspan="3">PREREQUISITES</td><td>Category</td><td>BS</td><td colspan="3">Credit</td><td>4</td></tr>
<tr><td colspan="3" rowspan="2">Basic 12th level knowledge of Partial Derivatives, Vector algebra and Complex Numbers.</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 Learning Objectives</td></tr>
<tr><td>1</td><td colspan="7">To familiarize with the formation and solutions of first-order partial differential equation.</td></tr>
<tr><td>2</td><td colspan="7">To familiarize with the solutions of higher-order partial differential equations.</td></tr>
<tr><td>3</td><td colspan="7">To acquire knowledge of vector differentiation and integration and its applications.</td></tr>
<tr><td>4</td><td colspan="7">To know about analytic functions with properties, construction of analytic functions and conformal transformations.</td></tr>
<tr><td>5</td><td colspan="7">To obtain the knowledge of Cauchy’s integral theorems, calculus of residues and complex integration around unit circle and semi-circle.</td></tr>
<tr><td>Unit I</td><td colspan="3">PARTIAL DIFFERENTIAL EQUATIONS – FIRST ORDER</td><td>9</td><td>3</td><td>0</td><td>12</td></tr>
<tr><td colspan="8">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.</td></tr>
<tr><td>Unit II</td><td colspan="3">PARTIAL DIFFERENTIAL EQUATIONS – HIGHER ORDER</td><td>9</td><td>3</td><td>0</td><td>12</td></tr>
<tr><td colspan="8">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.</td></tr>
<tr><td>Unit III</td><td colspan="3">VECTOR CALCULUS</td><td>9</td><td>3</td><td>0</td><td>12</td></tr>
<tr><td colspan="8">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.</td></tr>
<tr><td>Unit IV</td><td colspan="3">COMPLEX DIFFERENTIATION</td><td>9</td><td>3</td><td>0</td><td>12</td></tr>
<tr><td colspan="8">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.</td></tr>
<tr><td>Unit V</td><td colspan="3">COMPLEX INTEGRATION</td><td>9</td><td>3</td><td>0</td><td>12</td></tr>
<tr><td colspan="8">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.</td></tr>
<tr><td colspan="8" align="right">Total (45+15) = 60 Hours</td></tr>
</table>

Text Books:	
1	Grewal. B.S, "Higher Engineering Mathematics", 43rd Edition, Khanna Publications, Delhi, 2015.
2	Jain R.K. and Iyengar S.R.K., "Advanced Engineering Mathematics",3rd Edition, Narosa Publications, New Delhi, 2007.
Reference Books:	
1	James Stewart, "Essential Calculus", 2nd edition Cengage Learning, New Delhi, 2014.
2	P. Kandasamy, K. Thilagavathy and K. Gunavathy," Engineering Mathematics (For I year B.E., B. Tech)", 9thEdition, S. Chand & Co. Ltd. New Delhi, 2010.
3	Srimanta pal and Subath C. Bhumia, "Engineering Mathematics", Oxford university publications, New Delhi, 2015
4	Ewinkreyzig, "Advanced Engineering Mathematics", 9th Edition, John Wiley & Sons, 2007.
5	Siva RamakrishnaDas.P, Ruknmangadachari.E. "Engineering Mathematics", 2nd edition Pearson, Chennai & Delhi, 2013.

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

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PS O2**	**PS O 3**	**PS O 4**
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			
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**																

22CY101	ENGINEERING CHEMISTRY			SEMESTER		II
PREREQUISITES		**Category**	**BS**	**Credit**		**4**
Basic Chemistry		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**1**	**0**	**4**

Course Learning Objectives

1	Basic Principles of Spectroscopy and their applications.
2	Knowledge of different methods for water analysis and purification & Nanomaterials and its application.
3	Various adsorption techniques 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 NANOTECHNOLOGY**	**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 radica 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), 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 (45+15) = 60 Hours

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	Prasanta Rath, ―Engineering Chemistry	Cengage Learning India PVT, LTD, Delhi, 2015.
3	Shikha Agarwal, ― 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 this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Recall the basic principles of spectroscopy and their applications	Remembrance
CO2	Paraphrase the different methods for water analysis & purification and Nanomaterial & its applications	Understand
CO3	Apply the various adsorption techniques 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	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O 1	PS O2	PS O 3	PS O 4
CO1	3	3		3									3	1	1	
CO2	3	2		1		2							3	1	1	
CO3	3	1		1									2	1	1	
CO4	2	1		1		2							2	3	2	
CO5	3	2		3		2							1	1	1	
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**																

22EE203	BASIS OF ELECTRICAL ENGINEERING FOR METALLURGY				SEMESTER			II
PREREQUISTIES			CATEGORY		ES	Credit		4
Engineering Physics			Hours/Week		L	T	P	TH
					3	1	0	4

Course Objectives:

1. To understand the concepts of DC circuits.
2. To analyze single phase and three phase AC circuits.
3. To understand the operation of transformers.
4. To understand the concepts and control of electrical machines.
5. To gain knowledge on switchgear equipments and earthing.

UNIT I	**DC CIRCUITS**	**9**	**3**	**0**	**12**

Electrical circuit elements (R, L and C) - Voltage and current sources – Ohms's law -- Kirchhoff's current and voltage laws - Analysis of simple circuits with dc excitation - Superposition, Thevenin's and Norton's Theorems.

UNIT II	**AC CIRCUITS**	**9**	**3**	**0**	**12**

Representation of sinusoidal waveforms - Peak and RMS values - Phasor representation - Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel) – Real power, reactive power, apparent power, power factor- Three phase circuits, voltage and current relations in star and delta connections.

UNIT III	**TRANSFORMERS**	**9**	**3**	**0**	**12**

Ideal and practical transformer – Equivalent circuit - Losses in transformers - Regulation and Efficiency – Introduction to Three phase transformers - Auto-transformer- Applications

UNIT IV	**EELCTRICAL MACHINES**	**9**	**3**	**0**	**12**

DC Motor: Construction, operation and types -- speed control of DC shunt motor –AC motor: Construction, operation and types of a three-phase induction motor –speed control of Three phase induction motor – Construction and Working of Single-phase induction motor -Applications

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–Batteries: Characteristics for Batteries - Types of Batteries - Applications

Total (45 L+15T) = 60 Hours

Text Books:

1.	D. P. Kothari and I. J. Nagrath, "Basic Electrical Engineering", Tata McGraw Hill, 2010.
2.	V. D. Toro, "Electrical Engineering Fundamentals", Prentice Hall India, 1989.
3.	D. C. Kulshreshtha, "Basic Electrical Engineering", McGraw Hill, 2009.

Reference Books:

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

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Associate the basic electric and magnetic circuits.	L2: Understanding
CO2	:	Analyze the electric and magnetic circuits	L4:Analysing
CO3	:	Understand the working principle and types of electrical machines. .	L2: Understanding
CO4	:	Analyze theparameter controlin the performance of electrical machines.	L4: Analyzing
CO5	:	Recall the components of low-voltage electrical installations.	L1:Remembering

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO1 0**	**PO1 1**	**PO1 2**	**PS O1**	**PS O2**	**PS O3**	**PS O4**
CO1	2	2	2	2	2	1	1	1	1	1	1	2	2	1	1	1
CO2	2	2	2	2	2	1	1	1	1	1	1	1	2	1	1	1
CO3	2	2	2	2	3	1	1	1	1	1	1	1	2	2	1	1
CO4	2	2	2	2	2	1	1	1	1	1	1	1	2	1	1	1
CO5	2	2	2	2	2	1	1	1	1	1	1	1	2	1	1	1
Avg.	2	2	2	2	2.2	1	1	1	1	1	1	1.2	2	1.2	1	1

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

22ME101	ENGINEERING GRAPHICS AND DESIGN		SEMESTER			II
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 Hours

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	Familiarize with the fundamentals and standards of engineering graphics.	Understand
CO2	Ability to understand the fundamental concepts of projection of points, lines and planes.	Analyze
CO3	Project the solids and section of solids.	Analyze
CO4	Familiarize and develop the lateral surfaces of solids	Analyze
CO5	Visualize and project the orthographic, isometric and perspective sections of simple solids.	Analyze

COURSE ARTICULATION MATRIX

CO/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
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)

22HS201	UNIVERSAL HUMAN VALUES		SEMESTER			II
PRE-REQUISITE:		**Category**	**HS**	**Credit**		**3**
1.Introduction of Universal Human Values		**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 Hours

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**
CO1			1			1		2		1		3	2	
CO2			1			3		1		1		3	1	
CO3			1			2		1		1		3	1	
CO4			2			1		1		1		3	1	
Avg			**1.25**			**1.75**		**1.25**		**1**		**3**	**1.25**	

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

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

Course Objectives:

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

UNIT I	STREET FIGHTING ENGINEERING	0	0	6	6

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

UNIT II	PROGRAMMING PARADIGM	0	0	6	6

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

UNIT III	BRAINS OF MACHINES	0	0	6	6

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

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

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

UNIT V	ENGINEERING THE REAL WORLD	0	0	6	6

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

Total = 30 Hours

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

<u>COURSE ARTICULATION MATRIX</u>

COs / POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
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**		**3**		**1**	**2**	**1**	**2**	**1**	**2**					**2**

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

<table>
<tr><td>22MC201</td><td colspan="2">தமிழரும் தொழில்நுட்பமும்
B.E (Common to all Branches)</td><td colspan="2">Semester</td><td>II</td></tr>
<tr><td colspan="2">முன்நிபந்தனைகள்:</td><td>Category</td><td>HS MC</td><td colspan="2">Credit</td><td>1</td></tr>
<tr><td colspan="2" rowspan="2">இலக்கணம் மற்றும் இலக்கியத்தின் அடிப்படைகள்</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>0</td><td>1</td></tr>
<tr><td colspan="7">பாடநெறிநோக்கங்கள்: மாணவர்களால்</td></tr>
<tr><td>1.</td><td colspan="6">நெசவுத் தொழிலின் நன்மைகள், அதன் பயன்கள், பானைத் தொழில் நுட்பத்தைப் பற்றி நன்கு அறிந்து கொள்ளமுடியும்.</td></tr>
<tr><td>2.</td><td colspan="6">கட்டிடம் கட்டுதல் மற்றும் கட்டிடத் தொழிலுள்ளநுட்பங்கள் பற்றி அறிந்து கொள்ள முடியும்.</td></tr>
<tr><td>3.</td><td colspan="6">உற்பத்தி தொழில் நுட்பம், இரும்பு, உலோகம், கனிமம், தொழிற்சாலைகள் பற்றி அறிந்து அவற்றின் பயன்பாடுகளை வெளிப்படுத்த முடியும்.</td></tr>
<tr><td>4.</td><td colspan="6">வேளாண்மை மற்றும் நீர் பாசன முறைகள், தொழில் நுட்பம், ஏர் உழுதல் போன்ற பண்டையகால நெறிமுறைகளைப் பற்றி தெரிந்து நடைமுறைப் படுத்த முடியும்.</td></tr>
<tr><td>5.</td><td colspan="6">இன்றைய காலகட்டத்தில் உள்ளவாறு அறிவியல் வளர்ச்சி, கணினித் தமிழ் பற்றி தெரிந்து கொண்டு அறிவை விரிவாக்க முடியும்.</td></tr>
<tr><td>அலகுI</td><td colspan="2">நெசவு மற்றும் பானை தொழில் நுட்பம்</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">சங்ககாலத்தில் நெசவுத் தொழில் - பானைதொழில் நுட்பம் - கருப்புசிவப்புபாண்டங்கள்- பாண்டங்களில் கீறல் குறியீடுகள்</td></tr>
<tr><td>அலகுII</td><td colspan="2">வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம்</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">சங்ககாலத்தில் வடிவமைப்புமற்றும் கட்டுமானங்கள் &சங்ககாலத்தில் வீட்டுப் பொருட்களில் வடிவமைப்பு- சங்ககாலத்தில் கட்டுமானபொருட்களும் நடுகல்லும்- சிலப்பதிகாரத்தில் மேடைஅமைப்புபற்றியவிவரங்கள் - மாமல்லபுரச் சிற்பங்களும்,கோவில்களும் - கோவில்களும் - சோழர் காலத்துப் பெருங்கோயில்கள் மற்றும் பிறவழிபாட்டுத் தலங்கள்- நாயக்கர் காலக் கோயில்கள் - மாதிரிகட்டகமைப்புகள் பற்றிஅறிதல்,மதுரைமீனாட்சிஅம்மன் ஆலயம் மற்றம் திருமலைநாயக்கர் மஹால் - செட்டிநாட்டுவீடுகள் - பிரிட்டிஷ் காலத்தில் சென்னையில் இந்தோசாரோசெனிக் கட்டிடக் கலை.</td></tr>
<tr><td>அலகுIII</td><td colspan="2">உற்பத்தித் தொழில் நுட்பம்</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">கப்பல் கட்டும் கலை-உலோகவியல் - இரும்புத் தொழிற்சாலை - இரும்பைஉருக்குதல்,எஃகு - வரலாற்றுச் சான்றுகளாகசெம்புமற்றும் தங்கநாணயங்கள் - நாணயங்கள் அச்சிடித்தல் - மணிஉருவாக்கம் தொழிற்சாலைகள் - கல்மணிகள்,கண்ணாடிமணிகள் - சுடுமண் மணிகள் - சங்குமணிகள் - எலும்புத்துண்டுகள் - தொல்லியல் சான்றுகள் - சிலப்பதிகாரத்தில் மணிகளின் வகைகள்.</td></tr>
<tr><td>அலகுIV</td><td colspan="2">வேளாண்மை மற்றும் நீர்ப்பாசனத் தொழில் நுட்பம்</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">அனை,ஏரி,குளங்கள்,மதகு, - சோழர்காலக் குமுழித் தூம்பின் முக்கியத்துவம் - கால்நடைபராமரிப்பு - கால்நடைகளுக்காகவடிவமைக்கப்பட்டகிணறுகள் - வேளாண்மைமற்றும் வேளாண்மைசார்ந்தசெயல்பாடுகள் - கடல்சார் அறிவு - மீன்வளம் - முத்துமற்றும் முத்துக்குளித்தல் - பெருங்கடல் குறித்தபண்டையஅறிவு - அறிவுசார் சமூகம்.</td></tr>
<tr><td>அலகுV</td><td colspan="2">அறிவியல் தமிழ் மற்றும் கணித்தமிழ்</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">அறிவியல் தமிழின் வளர்ச்சி - கணித்தமிழ் வளர்ச்சி - தமிழ் நூல்களைமின் பதிப்புசெய்தல் - தமிழ் மென் பொருட்கள் உருவாக்கம் - தமிழ் இணையக் கல்விக்கழகம் - தமிழ் மின் நூலகம் - இணையத்தில் தமிழ் அகராதிகள் - சொற்குவைத் திட்டம்.</td></tr>
<tr><td colspan="7" align="right">Total = 15 Periods</td></tr>
</table>

Text Books:	
1	தமிழகவரலாறு - மக்களும் பண்பாடும் - கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடுபாடநூல் மற்றும் கல்வியல் பணிகள் கழகம்)
2	கணினித் தமிழ் - முனைவர் இல.சுந்தரம் (விகடன் பிரசுரம்)
3	கீழடி - வைகைநதிக்கரையில் சங்ககாலநகரநாகரிகம் (தொல்லியல் துறைவெளியீடு)
4	பொருநை - ஆற்றங்கரைநாகரிகம். (தொல்லியல் துறைவெளியீடு)

பாடநெறிமுடிவுகள்: இந்தப் படிப்புமுடிந்ததும்,மாணவர்களால்		**Bloom's Taxonomy Mapped**
CO1	சங்காலத்தில் இருந்த நல்ல தொழில்களையும் கைவிணை கலைகளால் ஏற்படும் நன்மைகளையும் பற்றிஅறிந்துகொண்டனர்.	Understanding
CO2	கட்டிடங்கள் மற்றும் வீட்டுப்பொருட்களை வடிவமைப்பது, சங்காலத்தில் இருந்த கோவில்களை பற்றி அறிந்து கொண்டனர்	Understanding
CO3	உலோகவியல், இரும்புதொழிற்சாலைகள், 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 கல்விகழகம், இணையத்தில் தமிழ் அகராதிகள் பற்றி அறிந்து கொண்டனர்.	Understanding

COURSE ARTICULATION MATRIX

COURSE ARTICULATION MATRIX															
COs/ POs	**PO 1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PS O2**	**PS O 3**	**PS O4**
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)**																

<table>
<tr><td>22MC201</td><td colspan="5">TAMILS AND TECHNOLOGY
B.E (Common to all Branches)</td><td colspan="2">Semester</td><td>II</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td colspan="2">Category</td><td>HS MC</td><td colspan="3">Credit</td><td>1</td></tr>
<tr><td colspan="2" rowspan="2">Basics of Tamil Language and Literature</td><td colspan="2" rowspan="2">Hours/Week</td><td>L</td><td>T</td><td colspan="2">P</td><td>TH</td></tr>
<tr><td>1</td><td>0</td><td colspan="2">0</td><td>1</td></tr>
<tr><td colspan="9">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="8">To obtain the knowledge of weaving and ceramic technology</td></tr>
<tr><td>2.</td><td colspan="8">To familiarize about design and construction technology during sangam age and British period</td></tr>
<tr><td>3.</td><td colspan="8">To know about the manufacturing technologies</td></tr>
<tr><td>4</td><td colspan="8">To obtain the knowledge of agriculture and irrigation technology</td></tr>
<tr><td>5</td><td colspan="8">To know about the development of Scientific Tamil and Tamil computing</td></tr>
<tr><td>Unit I</td><td colspan="3">WEAVING AND CERAMIC TECHNOLOGY</td><td>3</td><td>0</td><td colspan="2">0</td><td>3</td></tr>
<tr><td colspan="9">Weaving Industry during Sangam Age – Ceramic technology – Black and Red Ware Potteries (BRW) – Graffiti on Potteries.</td></tr>
<tr><td>Unit II</td><td colspan="3">DESIGN AND CONSTRUCTION TECHNOLOGY</td><td>3</td><td>0</td><td colspan="2">0</td><td>3</td></tr>
<tr><td colspan="9">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.</td></tr>
<tr><td>Unit III</td><td colspan="3">MANUFACTURING TECHNOLOGY</td><td>3</td><td>0</td><td colspan="2">0</td><td>3</td></tr>
<tr><td colspan="9">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.</td></tr>
<tr><td>Unit IV</td><td colspan="3">AGRICULTURE AND IRRIGATION TECHNOLOGY</td><td>3</td><td>0</td><td colspan="2">0</td><td>3</td></tr>
<tr><td colspan="9">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.</td></tr>
<tr><td>Unit V</td><td colspan="3">SCIENTIFIC TAMIL & TAMIL COMPUTING</td><td>3</td><td>0</td><td colspan="2">0</td><td>3</td></tr>
<tr><td colspan="9">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.</td></tr>
<tr><td colspan="9" align="right">Total = 15 Periods</td></tr>
</table>

Text Books/Reference 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	Obtain the knowledge about weaving and ceramic technology	Understanding
CO2	Familiarize about design and construction technology during sangam age and British period	Understanding
CO3	Understanding about the manufacturing technologies	Applying
CO4	Acquring the skills in agricultural and irrigation technology	Applying
CO5	Acquire the knowledge about the development of Scientific Tamil and Tamil computing.	Understanding

COURSE ARTICULATION MATRIX

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**	**PSO 4**
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

		L	T	P	TH
Unit I	**NCC GENERAL & NATIONAL INTEGRATION AND AWARENESS**	**9**	**0**	**0**	**9**

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

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

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

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

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

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

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

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

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

Total = 45 Hours

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

22EN102	PROFESSIONAL SKILLS LABORATORY			SEMESTER			II
PRE-REQUISITE			**Category**	**HS**	**Credit**		**1**
Basic language skills listening, speaking, reading and writing			**Hours/Week**	**L**	**T**	**P**	**TH**
				0	**0**	**2**	**2**
Course Objectives:							
1.	To enable learners to improve their reading skills						
2.	To make learners show variations while reading						
3.	To assist learners to acquire speaking competency in English						
4.	To enable learners to strengthen their fluency in speaking						
UNIT I				**0**	**0**	**6**	**6**
Reading – Reading a short story – learning pronunciation, intonation, and splitting of sentences to form meaningful units. Speaking – Narrating a story without any help of handouts.							
UNIT II				**0**	**0**	**6**	**6**
Reading – Reading a poem – learning the skill of reciting, appreciate rhyme and music, change in tone as per the emotion of the poem. Speaking – Power-point presentation on a general topic.							
UNIT III				**0**	**0**	**6**	**6**
Reading – Reading newspaper article – learning vocabulary and language pattern of official communication. Speaking - Oral presentation on a topic from basic engineering pertained to their branch.							
UNIT IV				**0**	**0**	**6**	**6**
Reading – Reading dialogue scripts – learning expression, tone, stress and co-operative reading. Speaking –Proposing welcome address, vote of thanks and organizing events.							
UNIT V				**0**	**0**	**6**	**6**
Reading – Reading technical descriptions of gadgets – learning the different parts of devices. Speaking – Describing a process – everyday technical activities like taking printouts, purchasing equipment for a company, booking a hall for meetings etc.,							
							Total = 30 Hours

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

<u>COURSE ARTICULATION MATRIX</u>

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1				1					2	3		1			1	1
CO2				1					2	3		1			1	1
CO3				2					2	3		1			1	1
CO4				2					2	3		1			3	1
Avg				**1.2**					**2**	**3**		**1**			**1.2**	**1**

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

22PH103	PHYSICS LABORATORY			SEMESTER	II
PRE-REQUISITE		**Category**	**BS**	**Credit**	**1.5**
		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

(Any eight 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 Hours

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	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PS O1	PS O2	PS O3	PS O4
CO1	3	2		3	3				3	1		2	1	1	1	
CO2	3	2		2	1				2			1	1	1	1	
Avg	**3**	**2**		**2.5**	**2**				**2.5**	**1**		**1.5**	**1**	**1**	**1**	

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

22CY102	CHEMISTRY LABORATORY				SEMESTER		II
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 = 45 Hours

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	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**	**PSO 1**	**PSO 2**	**PSO 3**	**PS O4**
CO1	1	1		3									2			
CO2	1	2		3									2			
CO3	2	2		3									2			
Avg.	1.3	1.6		3									2			
3 / 2 / 1 – indicates strength of correlation (3 – High, 2 – Medium, 1 – Low)																

<table>
<tr><td>22EE204</td><td colspan="2">BASIC ELECTRICAL ENGINEERING LABORATOTY FOR METALLURGY</td><td colspan="3">SEMESTER</td><td>II</td></tr>
<tr><td colspan="2">PREREQUISTIES</td><td>CATEGORY</td><td>ES</td><td colspan="2">Credit</td><td>1.5</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>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="7">Course Objectives:</td></tr>
<tr><td colspan="7">1.To study basic safety equipment’s and measuring instruments.</td></tr>
<tr><td colspan="7">2.To analyze transient response of R-L-C circuits.</td></tr>
<tr><td colspan="7">3.To understand the cut-out sections of electrical machines.</td></tr>
<tr><td colspan="7">4.To understand power measurement in 3-phase circuits.</td></tr>
<tr><td colspan="7">5.To gain knowledge on working of Fluorescent lamp and Staircase light wiring schemes.</td></tr>
<tr><td colspan="7">LIST OF EXPERIMENTS</td></tr>
<tr><td colspan="7">1. Verification of Kirchhoff’s laws
2. Verification of Superposition theorem.
3. Loading of a transformer: measurement of primary and secondary voltages and currents, and power.
4. Measurement of three-phase power in three-phase circuits.
5. Demonstration of cut-out sections of machines: dc machine (commutator-brush arrangement), induction machine (squirrel cage rotor) and single-phase induction machine.
6. Demonstration of Fluorescent lamp wiring.
7. Staircase light wiring.
8. Load test on DC shunt motor
9. Speed control of DC shuntmotor
10. Study of basic safety precautions, measuring instruments – voltmeter, ammeter, multi-meter, Oscilloscope and Electrical components</td></tr>
<tr><td colspan="7" align="right">Total (45P) = 45 Hours</td></tr>
</table>

<table>
<tr><td colspan="3">Course Outcomes:
Upon completion of this course, the students will be able to:</td><td>Bloom’s Taxonomy Mapped</td></tr>
<tr><td>CO1</td><td>:</td><td>Associate the common electrical components and their ratings.</td><td>L2: Understanding</td></tr>
<tr><td>CO2</td><td>:</td><td>Make electrical connections by wires of appropriate ratings.</td><td>L4:Analysing</td></tr>
<tr><td>CO3</td><td>:</td><td>Understand the usage of common electrical measuring instruments.</td><td>L2: Understanding</td></tr>
<tr><td>CO4</td><td>:</td><td>Recall the basic characteristics of transformers and electrical machines.</td><td>L1: Remembering</td></tr>
<tr><td>CO5</td><td>:</td><td>Analyze the working of Fluorescent lamp and Staircase light wiring.</td><td>L4:Analysing</td></tr>
</table>

COURSE ARTICULATION MATRIX																
COs/ POs	**PO 1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO1 0**	**PO1 1**	**PO1 2**	**PSO 1**	**PSO 2**	**PSO 3**	**PS O 4**
CO1	2	2	2	1	2	1	1	1	2	1	1	1	2	1	1	1
CO2	2	2	2	1	2	1	1	1	2	1	1	1	2	1	1	1
CO3	2	2	2	1	2	1	1	1	2	1	1	1	2	1	1	1
CO4	2	2	2	1	2	1	1	1	2	1	1	1	2	1	1	1
CO5	2	2	2	1	2	1	1	1	2	1	1	1	2	1	1	1
Avg.	2	2	2	1	2	1	1	1	2	1	1	1	2	1	1	1
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MA306	LINEAR ALGEBRA AND TRANSFORMS B.E. (METT)		Semester			III
PREREQUISITES		**Category**	**BS**	**Credit**		**4**
Basic 12th level knowledge of Matrices, Vector, PDE, ODE and integration.		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**1**	**0**	**4**

	Course Learning Objectives
1	To understand the concepts of vector space and linear transformations.
2	To apply the concept of inner product spaces in orthogonalization.
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 Z-transform method

UNIT I	**VECTOR SPACES**	**9**	**3**	**0**	**12**
Vector spaces – Subspaces – Linear independence and linear dependence – Bases and dimensions. Linear transformation - Null spaces and ranges - Dimension theorem - Matrix representation of a linear transformations.					
UNIT II	**INNER PRODUCT SPACES**	**9**	**3**	**0**	**12**
Definition of Inner product, Inner product space- Examples- Gram Schmidt orthogonalization process - Adjoint of linear operations - Least square approximation.					
UNIT III	**LAPLACE TRANSFORM**	**9**	**3**	**0**	**12**
Laplace Transform- Conditions for existence – Transform of elementary functions – Basic Properties – Transform of derivatives and integrals – Initial and Final value theorems- Transform of periodic Functions – Inverse Laplace Transform- solutions of linear ODE of second order with constant coefficient's using Laplace transformation techniques- statement and application of convolution theorem.					
UNIT IV	**FOURIER TRANSFORM**	**9**	**3**	**0**	**12**
Statement of Fourier integral theorem – Fourier transform pair – Sine and Cosine transforms – Properties – Transforms of simple functions – Convolution theorem - Parseval's Identity.					
UNIT V	**Z -TRANSFORM AND DIFFERENCE EQUATIONS**	**9**	**3**	**0**	**12**
Z-transform of simple functions and properties – Inverse Z – transform –initial and final value theorems- Convolution theorem -Formation of difference equations – Solution of difference equations using Z – transform technique.					
	Total (45L+15T) = 60 Hours				

	Text Books:
1	Friedberg, A.H., Insel, A.J. and Spence, L., "Linear Algebra", Prentice Hall of India, New Delhi, 2004.
2	Grewal. B.S, "Higher Engineering Mathematics", 43rd Edition, Khanna Publications, Delhi, 2015.
3	Jain R.K. and Iyengar S.R.K., "Advanced Engineering Mathematics", Narosa Publications, New Delhi, 3rd Edition, 2007.

Reference Books:	
1	Kumaresan, S., “Linear Algebra – A Geometric Approach”, Prentice – Hall of India, New Delhi, Reprint, 2010.
2	Strang, G., “Linear Algebra and its applications”, Thomson (Brooks/Cole), New Delhi, 2005.
3	Erwin Kreyszig, “Advanced Engineering Mathematics”, 9th edition, John Wiley & Sons, 2006.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom’s Taxonomy Mapped**
CO1	Use the concepts of vector space and linear transformations.	Apply
CO2	Illustrate the concept of inner product spaces in orthogonalization	Understand
CO3	Apply the knowledge of Laplace transforms method to solve second order differential equations.	Apply
CO4	Apply the knowledge of Fourier transform in engineering problems..	Apply
CO5	Use the effective mathematical tools for the solutions of partial differential equations by using Z transform techniques for discrete time systems	Apply

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO 1	3	2	2	2									2			
CO 2	3	2	2	2									2			
CO 3	3	2	2	2									2			
CO 4	3	2	2	2									2			
CO 5	3	2	2	2									2			
Avg	3	2	2	2									2			
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MT301	ELEMENTS OF PHYSICAL METALLURGY			Semester		III
PREREQUISITES		**Category**	**PC**	**Credit**		**3**
Engineering Physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To develop an understanding of the basis of physical metallurgy and applications of principles to engineering applications.

UNIT I	**CRYSTAL STRUCTURES**	**9**	**0**	**0**	**9**

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, inter-planar 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.

UNIT II	**CRYSTALLINE IMPERFECTIONS**	**9**	**0**	**0**	**9**

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.

UNIT III	**ATOMIC DIFFUSION IN SOLIDS AND SOLIDIFICATION OF METAL**	**9**	**0**	**0**	**9**

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.

UNIT IV	**PHASE DIAGRAMS**	**9**	**0**	**0**	**9**

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.

UNIT V	**IRON-CARBON PHASE DIAGRAM**	**9**	**0**	**0**	**9**

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.

Total (45L) = 45 Hours

Text Books:	
1	Donald R. Askeland,"The Science and Engineering of Materials", Thomson Learning, India Edition,2007.
2	William D.Callister, "Materials Science and Engineering – An Introduction", 4th edition, John Wiley & Sons, New York, USA, 1997.
Reference Books:	
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, IndiaEdition, 2007.
3	Raghavan V., "Physical Metallurgy – Principles and Practice", Prentice Hall of India Ltd., New Delhi,1996.
4	William F.Smith, "Foundations of Materials Science and Engineering", Second Edition, McGraw-HillInc, New York, 1993.
E-Reference	
1	www.matter.org
2	www.doitpoms.ac.uk

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Illustrate the basic crystal structure, orientation and their influence on macroscopic properties.	L3: Applying
CO2	:	Describe the crystalline imperfection and correlate with the properties of materials.	L2: Understanding
CO3	:	Apply the diffusion mechanism in solidification of materials under different conditions.	L3: Applying
CO4	:	Apply the concept of phase diagrams in equilibrium transformation of materials phases.	L3: Applying
CO5	:	Explain the iron carbon phase diagram, properties and applications of steels and cast irons.	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			
CO2		1		1	1									1	1	
CO3	1												1			
CO4	1	1			1									1		
CO5				1									1			
Avg.	1	1	1	1	1	0	0	0	0	0	0	0	1	1	1	0

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

22MT302	MINERAL DRESSING, FUELS AND FURNACES				Semester		III
PREREQUISITES			**Category**	**PC**	**Credit**		**3**
Engineering Chemistry			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Learning Objectives

1	To gain knowledge on the theoretical aspects of common mineral processing techniques and the associated equipment used in extraction processes.
2	To understand the fundamentals and applications of fuels, furnaces and refractories.

UNIT I	**MINERAL DRESSING – I**	**9**	**0**	**0**	**9**

Introduction to mineral dressing – Minerals, Ores, Physical characteristics of ores relevant to mineral dressing, industrially important minerals; Sampling of ores ; Comminution – Crushing and Grinding - Jaw, gyratory, cone and roll crushers – ball, rod, vibratory and hammer mills - Closed and open circuit grinding – dry and wet grinding. Power requirement calculations for crushing and grinding, Rittingers law; Sizing, Industrial screening.

UNIT II	**MINERAL DRESSING – II**	**9**	**0**	**0**	**9**

Chemical processing of ores – leaching, ion - exchange and liquid - solvent extraction. Classification – Principles and laws of classification – theory of settling; Types of classifiers – mechanical, hydraulic and hydrocyclone. Gravity concentration – Principles, Jigs, types of jigs, spirals, tables; Heavy media separation– principles, different media used, static and dynamic separating vessels; Froth flotation – principle, operation and machines; Magnetic and electrostatic separation, Thickeners and filters.

UNIT III	**FUELS AND THEIR PROPERTIES**	**9**	**0**	**0**	**9**

Classification – solid, liquid and gaseous fuels; Coal – Classification, Manufacturing of metallurgical coke and its properties; Petroleum – classification, composition of crude petroleum; Gaseous Fuels - Natural gas, Coal gas, Producer gas, Water gas, Blast furnace gas – manufacture, properties and applications of above fuels; Testing of solid, liquid and gaseous fuels; Combustion calculations - Air requirements for combustion.

UNIT IV	**FURNACES**	**9**	**0**	**0**	**9**

Introduction, classification of furnaces; Measurement of Temperature and Pressure, Thermal efficiency, heat balance calculations – simple problems; Melting and Heat treatment furnaces – Constructional details and operation of Crucible furnaces, Reverberatory furnaces, Cupola, Rotary furnace, Induction furnaces (Core type and coreless type), Arc furnace (direct and indirect arc furnaces), Resistance furnaces, Batch and continuous type furnaces; Methods of heat recovery – recuperator and regenerators; Burners.

UNIT V	**REFRACTORIES**	**9**	**0**	**0**	**9**

Introduction, Classification – Acid, Basic, Neutral refractories; Properties and tests for refractories; Raw materials, manufacture, properties and applications of the following refractories – Silica, fire clay, alumina, magnesite, dolomite, chromite, chrome-magnesite, magnesite-chrome, carbon and graphite refractories, refractory cement, ramming mixes and castables.

Total (45L) = 45 Hours

Text Books:

1	Gilchrist.J.D., “Extraction Metallurgy”, 2nd Edition, Pergamon Press, London,1981.

2	Gupta.O.P., “Elements of Fuels, Furnaces and Refractories”, 4th Edition, Khanna Publishers, NewDelhi, 2000.
3	Gaudin A.M. , “Principles of Mineral Dressing”, TMH ,New Delhi,1986.
Reference Books:	
1	Wills.B.A., Napier-Munn, T.J., “Mineral Processing Technology”, 7th Edition, Pergamon Press, 2006.
2	Feurstenau, M.C. and Han, K.N., “Principles of Mineral Processing”, SME, USA, 2003.
3	Jain.S.K. “Ore Processing”, Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi, 1986.
E –References	
1.	https://nptel.ac.in/courses/113104008/
2.	https://nptel.ac.in/courses/113104060/10
3.	https://nptel.ac.in/courses/113104058/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Explain the basic mineral dressing principles, processes and equipment used in mineral dressing.	L2: Understanding
CO2	:	Understand the chemical processing of ores and gain knowledge on classification, froth floatation and other mineral beneficiation processes.	L1: Remembering
CO3	:	Explain the different types of fuels, testing of the fuels and quality valuation of the fuels.	L2: Understanding
CO4	:	Describe the basic operation of furnace, different types of furnaces and various methods of heat recovery.	L3: Applying
CO5	:	Discuss the various refractories, their properties, testings and applications.	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		
CO2	1		1										1	1		
CO3		1	1	1	1								1			
CO4	1	1											1	1		
CO5	1		1										1		1	1
Avg.	1	1	1	1	1	0	0	0	0	0	0	0	1	1	1	1
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MT303	METALLURGICAL THERMODYNAMICS AND KINETICS		Semester			III
PREREQUISITES		Category	PC	Credit		4
Engineering Chemistry & Engineering Mathematics		Hours/Week	L	T	P	TH
			3	1	0	4
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	**CONCEPTS AND FIRST LAW OF THERMODYNAMICS**		**9**	**3**	**0**	**12**
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 – Basic problems on Hess's and Kirchaff's law.						
UNIT II	**SECOND AND THIRD LAW OF THERMODYNAMICS**		**9**	**3**	**0**	**12**
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 - Basic problems on second and third law of thermodynamics.						
UNIT III	**THERMODYNAMIC POTENTIALS AND PHASE EQUILIBRIA:**		**9**	**3**	**0**	**12**
Thermodynamic potentials: Fugacity, Activity and Equilibrium constant. Clausius - Clapeyron equation, Trouton's rule. Le Chatelier's principle, Van't 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 – Basic problems related to thermodynamic potentials.						
UNIT IV	**THERMODYNAMICS OF SOLUTIONS**		**9**	**3**	**0**	**12**
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 – Basic problems on solution thermodynamics.						
UNIT V	**ELECTROCHEMICAL PROCESS AND KINETICS**		**9**	**3**	**0**	**12**
Electrochemical 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 (45L+15T) = 60 Hours

Text Books:	
1	Ahindra Ghosh, Textbook of Materials & MetallurgicalThermodynamics, Prentice Hall India, 2002
2	Upadhyaya G S andDube R K., "Problems in Metallurgical Thermodynamics & Kinetics", Pergamon,1977.
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.
E-References:	
1.	www.nptelvideos.in/2012/12/basicthermodynamics.html

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the basic concepts of thermodynamics and the first law of thermodynamics	L2: Understanding
CO2	:	Recall the concepts of second and third laws of thermodynamics.	L1: Remembering
CO3	:	Discuss the thermodynamic potential and apply the concepts of phase diagram.	L2: Understanding
CO4	:	Describe the thermodynamics of solutions and important correlations.	L2: Understanding
CO5	:	Discuss the concept of electrochemical processes and kinetics of thermodynamic reactions.	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			
CO3	1	1	1										1			
CO4		1		1	1								1			
CO5	1		1										1			
Avg.	1	1	1	1	1	1	1	0	0	0	0	0	1	0	0	0

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

<table>
<tr><td>22PH102</td><td colspan="4">MATERIALS SCIENCE FOR ENGINEERING</td><td colspan="2">Semester</td><td>III</td></tr>
<tr><td colspan="3">PREREQUISITES</td><td>Category</td><td>BS</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="3" 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>2</td><td>1</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 introduce the theory of conducting materials and Fermi distribution function.</td></tr>
<tr><td>2</td><td colspan="7">To give the basic ideas of semiconductors and its Fermi level.</td></tr>
<tr><td>3</td><td colspan="7">To give an overview of Dielectric polarization, dielectric losses and application of dielectrics.</td></tr>
<tr><td>4</td><td colspan="7">To insight into the magnetic nature of materials, superconductors and their applications.</td></tr>
<tr><td>5</td><td colspan="7">To introduce the synthesis and applications of metallic glasses, smart materials and nano phase materials.</td></tr>
<tr><td colspan="2">UNIT I</td><td colspan="2">CONDUCTING MATERIALS</td><td>6</td><td>3</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Conduction in metals - mobility and conductivity – Classical free electron theory of metals – Electrical and thermal conductivity – Wiedemann Franz law – Lorentz number – drawbacks of classical free electron theory – Quantum theory – Fermi distribution function - Effect of temperature on Fermi function – Density of states – Carrier concentration in metals – Band theory of solids - distinction between conductors, semiconductors and insulators.</td></tr>
<tr><td colspan="2">UNIT II</td><td colspan="2">SEMI CONDUCTING MATERIALS</td><td>6</td><td>3</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Properties of semiconductor - Bonds in semiconductors - Intrinsic semiconductors - Extrinsic semiconductors - N-type and P-type semiconductors – Carrier concentration in intrinsic semiconductors(derivation) –Electrical conductivity and band gap determination in intrinsic semiconductors - Carrier concentration in N-type semiconductor(derivation) –- variation of Fermi level with temperature and doping concentration – Compound semiconductors –Direct and indirect band gap semiconductors - Hall effect - Determination of Hall coefficient – Applications.</td></tr>
<tr><td colspan="2">UNIT III</td><td colspan="2">DIELECTRIC MATERIALS</td><td>6</td><td>3</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Electrical susceptibility – Dielectric constant – Dielectric polarization – Electronic , Ionic, Orientational and Space charge polarization – frequency and temperature dependence of polarization – Internal field – Classius – Mosotti relation (derivation) – dielectric loss – dielectric breakdown – Uses of dielectric materials (capacitor and transformer)- Polymeric dielectric materials.</td></tr>
<tr><td colspan="2">UNIT IV</td><td colspan="2">MAGNETIC AND SUPERCONDUCTING MATERIALS</td><td>6</td><td>3</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Magnetic materials: Origin of magnetic moment – Bohr magneton – Dia, Para and Ferro magnetism – Domain theory of ferromagnetism – Hysteresis – Hard and soft magnetic materials – Antiferro magnetism.
Super conductivity: Properties – Type I & Type II superconductors - BCS theory - Applications – magnetic levitation – SQUID.</td></tr>
<tr><td colspan="2">UNIT V</td><td colspan="2">MODERN ENGINEERING MATERIALS</td><td>6</td><td>3</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Metallic glasses - Preparation, properties, applications – Shape memory alloys (SMA) – Processing, characterization and applications.
Nanomaterials: Introduction – top down and bottom up approach – synthesis – Ball milling, Plasma arcing and Sol – Gel technique – properties – applications – Carbon nanotubes – Properties.</td></tr>
<tr><td colspan="8" align="right">Total (45L) = 45 Hours</td></tr>
</table>

Text Books:	
1	P.K.Palanisamy, ‘Materials Science’, Scitech Publications (India) pvt.ltd. Chennai, Second edition, 2009.
2	M. Arumugam, ‘Materials Science’, Anuradha Publications, Kumbakonam, 2018.
3	Rajendran V and Marikani A, ‘Materials Science’, Tata McGraw Publications, New Delhi, 2012
4	Jayakumar S, ‘Materials Science’, RK Publishers, Coimbatore, 2011.
Reference Books:	
1	Charles Kittel, ‘Introduction to Solid state Physics’, John Wiley and Sons, 7th Edition, Singapore, 2019.
2	Charles P. Poole and Frank J. Ownen, ‘Introduction to Nanotechnology’, Wiley India, 2007.
3	M.S. Vijaya and G. Rangarajan, ‘Materials Science’, Tata McGraw Hill, New Delhi, 2012.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	The theory involved in conducting materials, carrier concentration in metals.	L2: Understanding
CO2	:	The basics of semiconductor and variation of Fermi level with respect to different parameters	L4:Analysing
CO3	:	The mechanism involved in dielectric polarization and the applications of dielectric materials.	L2: Understanding
CO4	:	The concept of the magnetic, superconducting nature of materials and their applications.	L1: Remembering
CO5	:	The preparation techniques, their distinct properties and applications of Metallic glasses, SMAs, nano phase 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										2		
CO2	1	1		1										1	1	
CO3	2			1								1		1		
CO4	1	1		1										1		
CO5	1	1		1										1		1
Avg.	1.2	1		1								1		1.2	1	1

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		3				2	1		2						2
CO2		3		2					2						2
CO3			3	2					2						2
CO4	2		3	0				1	2						2
CO5									2	3					2
Avg	**2**	**3**	**2**	**2**		**2**	**1**	**1**	**2**	**3**					**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

22MT304	METALLOGRAPHY LABORATORY				Semester		III
PREREQUISITES			Category	PC	Credit		1.5
			Hours/Week	L	T	P	TH
				0	0	3	3

EXPERIMENTS

1	Sample preparation and Mounting and Study of Metallurgical Microscope
2	Microstructure of different types of cast iron in unetched condition
3	Microstructure of different types of cast iron in etched condition
4	Microstructure of pure iron, plain carbon steels
5	ASTM grain size determination
6	Microstructure of tool steels and stainless steels
7	Microstructure of cast and wrought aluminium alloys
8	Microstructure of copper alloys
9	Sulphur and Phosphor printing
10	Inclusion rating
	Total (45P) = 45 Hours

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Observe and Explain the metallurgical microscope	L2: Understanding
CO2	:	Interpret the process of sample preparation and mounting	L2: Understanding
CO3	:	View and analyze the microstructure of various samples	L3: Applying
CO4	:	Conduct the process of sulphur printing and phosphor printing	L2: Understanding
CO5	:	Observe the unconventional structure in steel and determine the ASTM grain size.	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		
CO2	1		1											1		
CO3	1	1											1			
CO4	1		1											1		
CO5	1												1			
Avg.	1	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0

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

22MT305	CHEMICAL METALLURGY LABORATORY			Semester		III
PREREQUISITES		**Category**	**PC**	**Credit**		**1.5**
Engineering Chemistry		**Hours/Week**	**L**	**T**	**P**	**TH**
			0	**0**	**3**	**3**

Course Learning Objectives	
1	To gain knowledge about the various properties of minerals and to become familiar with the equipment used in mineral processing, by means of experiments or demonstration of the laboratory scale equipment.

EXPERIMENTS	
1	Flash and Fire point of oils
2	Red wood viscometer
3	Size distribution using sieve analysis
4	Screening efficiency
5	Sampling of ores
6	Jaw crusher
7	Ball mill
8	Proximate analysis of Coal.
9	Settling velocity of $CaCO_3$ powder.
10	Froth Flotation
	Total (45P) = 45 Hours

E- References	
1.	https://www.youtube.com/watch?v=yLtuDv3GzWo
2.	https://www.youtube.com/watch?v=VzJ60uMdFe8
3.	https://www.youtube.com/watch?v=6kFONdchY0U

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Perform the mineral beneficiation operations.	L4: Analyzing
CO2	:	Perform the comminution related experiments and necessary calculations.	L4: Analyzing
CO3	:	Carry out the various sampling processes.	L3: Applying
CO4	:	Perform the analysis of fuels	L4: Analyzing

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	2	1		
CO2	1	1	1		1								1		1	
CO3	1	1				1						1		1		1
CO4	1	1		1		1	1					1			1	
Avg.	1	1	1	1	1	1	1	0	0	0	0	1	1.5	1	1	1

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

22MA403	PROBABILITY AND STATISTICAL METHODS B.E. (METT)			Semester			IV
PREREQUISITES		**Category**	**BS**	**Credit**			**4**
Basic 12th level knowledge of Probability and Statistics.		**Hours/Week**	**L**	**T**		**P**	**TH**
			3	**1**		**0**	**4**

Course Learning Objectives	
1	To familiar with basic concepts of probability and random variables.
2	To obtain the knowledge about discrete and continuous distributions.
3	To acquire knowledge of bivariate distributions and the problems related to coefficient of correlation.
4	To understand the statistical averages and fitting of curve.
5	To gain the knowledge of significance test for large and small samples.

UNIT I	**PROBABILITY AND RANDOM VARIABLES**	**9**	**3**	**0**	**12**
Axioms of Probability, Conditional Probability, Total Probability, Bayes' theorem- Random variables: Discrete and Continuous random variables - Moments – Moment generating functions and their properties.					
UNIT II	**STANDARD DISTRIBUTION**	**9**	**3**	**0**	**12**
Binomial, Poisson, Exponential, Gamma and Normal Distributions and their properties - Chebyshev's inequality.					
UNIT III	**TWO DIMENSIONAL RANDOM VARIABLES**	**9**	**3**	**0**	**12**
Joint distributions – Marginal and Conditional distributions – Correlation, Regression and rank correlation.					
UNIT IV	**BASIC STATISTICS**	**9**	**3**	**0**	**12**
Measures of Central tendency: Moments, Skewness and Kurtosis, Curve fitting by the method of Least Squares – Fitting of straight lines, second degree parabolas and curves reducible to linear forms.					
UNIT V	**TEST OF HYPOTHESIS**	**9**	**3**	**0**	**12**
Test of significance: Large Sample tests for Single proportion, difference of proportion, single mean and difference of means- Small Sample test for single mean, difference of means and correlation coefficients, test for ratio of variances - Chi-square test for goodness of fit and independence of attributes.					
					Total (45L+15T) = 60 Hours

Text Books:	
1	Veerarajan. T, "Probability and Random Process (With Queuing theory)", 4th Edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2016.
2	Jay, L. Devore, "Probability and Statistics for Engineering and Sciences", Cengage Learning, New Delhi, 8th edition, 2012.
Reference Books:	
1	Veerarajan. T, "Probability and Random Process (With Queuing theory)", 4th Edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2016.
2	Jay, L. Devore, "Probability and Statistics for Engineering and Sciences", Cengage Learning, New Delhi, 8th edition, 2012.
3	Veerarajan. T, "Probability and Random Process (With Queuing theory)", 4th Edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2016.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Learn the fundamental knowledge of the Probability concepts	L2: Understanding
CO2	:	Apply the standard distributions	L4:Analysing
CO3	:	Analyze the two-dimensional random variables.	L2: Understanding
CO4	:	Learn about statistical averages and fitting the curves by Least Square Method.	L1: Remembering
CO5	:	Use the Large and small sample tests	L3:Applying

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
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)

<table>
<tr><td>22CY401</td><td colspan="2">NON METALLIC MATERIALS</td><td colspan="3">Semester</td><td>IV</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>Category</td><td>BS</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">Basic knowledge of polymer and their applications</td></tr>
<tr><td>2</td><td colspan="6">Understand the different methods processing of polymers</td></tr>
<tr><td>3</td><td colspan="6">Describe the various ceramics, glasses and explain their processing and properties.</td></tr>
<tr><td>4</td><td colspan="6">Describe the concept of composites and their types. Explain the uses of fiber composites in Commercial field.</td></tr>
<tr><td>5</td><td colspan="6">Explain the production, properties and uses of various Particulate and Laminar composites.</td></tr>
<tr><td>UNIT I</td><td colspan="2">INTRODUCTION TO POLYMERS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Definition – Nomenclature of Polymers – Classification of Polymers (Source, structure, methods of synthesis, growth of polymer chain, molecular force) – Polymerization types – mechanism-degree of polymerization – Molecular mass of a polymer – polydispersity index (PDI) – Glass transition and melting temperatures – Additives for polymers – process aids, antidegradants, fillers, curing agents and coupling agents – special additives</td></tr>
<tr><td>UNIT II</td><td colspan="2">POLYMER PROPERTIES AND PROCESSING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Properties: physical, mechanical, chemical, thermal, electrical, optical, magnetic, and biological properties Processing types: melt, rubbery stage, solution, emulsion, and suspension processing
Behavior of polymers: Viscoelasticity- Creep and stress relaxation in polymers- Yielding and fracture of polymers - Crazing of polymersApplication of polymers in various fields- agriculture, space, automobile, electronics, medicine , construction and transport</td></tr>
<tr><td>UNIT III</td><td colspan="2">CERAMICS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Introduction - important properties - Typical example of conventional and advanced ceramics. Comparison with metals and polymers. Preparation and properties: Boron Nitride, Silicon Carbide, Boron carbide, SlALON - Technical applications.Types of glasses - structure, properties and applications of various types of glasses manufacturing of glass – Blowing, pressing, drawing, rolling and casting, and Pilkington process for float glass.</td></tr>
<tr><td>UNIT IV</td><td colspan="2">FIBER COMPOSITES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Composites: Introduction Classification Examples. Fiber composites: Constituents and functions of fiber composites Rule of Mixtures - Types of fibers and matrices. Production techniques (in brief) for fiber composites: Use of fiber composites in automobile, aerospace, sports and leisure applications.</td></tr>
<tr><td>UNIT V</td><td colspan="2">PARTICULATE AND LAMINAR COMPOSITES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">True particulate and Dispersion strengthened composites Production techniques Applications Functions and examples of dispersoids - particle size and inter particle spacing - examples of particulate composites. Laminar composites – types layered and honeycomb structures- examples, manufacture and applications.</td></tr>
<tr><td colspan="7" align="right">Total (45L) = 45 Hours</td></tr>
</table>

Text Books:	
1	Introduction to Polymers B - Robert J. Young, Peter A. Lovell Third edition, CRC press, 2011

2	POLYMER CHEMISTRY - Pragati Prakashan , Global net publications.
3	Introduction to composite materials design - Ever J. Barbero, second edition
4	Composites Engineering handbook – P.K.Mallick, CRC press
Reference Books:	
1	Polymer Science – V.R.Gowarikar – New age international Pvt Ltd., 2015
2	Fundamentals of Polymers – Niranjan karak – PHI learning Private Ltd., 2009
3	Ceramic Materials-Science and Engineering - C. Barry Carter, M. Grant Norton, C. Barry Carter, M. Grant Norton – Springer Newyork- 2013
4	Composite Materials: Engineering and Sciencebooks - F. L. Matthews, Rees D. Rawlings · 1999

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the different types of polymers, polymerization mechanisms and polymer additives	L2: Understanding
CO2	:	Discuss the properties, processing and behaviour of polymers.	L2: Understanding
CO3	:	Describe the various ceramics, glasses and explain their processing and properties.	L3:Applying
CO4	:	Describe the concept of fiber reinforced composites and explain their applications in commercial field.	L3:Applying
CO5	:	Explain the production, properties and uses of various Particulate and Laminar composites.	L2: Understanding

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		1
CO2	1	1		1	1	1								1		
CO3	2			2											1	
CO4	1	2	1	1								1				1
CO5	2	1										1		1		
Avg.	1.6	1.25	1	1.3	1	1						1		1.3	1	1

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

22MT401	**MECHANICAL BEHAVIOUR AND TESTING OF MATERIALS**		**Semester**			**IV**
PREREQUISITES		**Category**	**PC**	**Credit**		**3**
Engineering Physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**
Course Learning Objectives						
1	To know the fundamental concepts of mechanical behavior of materials and to apply them to design the materials for various load-bearing structural engineering applications					
2.	To gain knowledge on fracture, fatigue and creep behaviour of materials.					
Unit I	**TENSILE BEHAVIOUR AND TESTS**		**9**	**0**	**0**	**9**
Introduction: Types of testing, Introduction to material properties (structure sensitive and insensitive), ASTM testing standards. Engineering stress and strain, True stress - strain curves, Relationship between the tensile properties, Hollomon-Ludwik equation, Ductility measurement in tension test. Effect of strain rate on flow properties. Plastic Instability (Necking), Hot tensile tests, Testing machines – types, Testing procedures, specimen dimensions, Notch tensile test, Anisotropy of tensile properties. Bend test, torsion test & shearing test.						
Unit II	**HARDNESS TESTS AND IMPACT TESTS**		**9**	**0**	**0**	**9**
Definition, Types of hardness tests- Vickers, Brinell, Rockwell and Rockwell superficial hardness tests, Precautions - Relative merits and demerits, Hardness conversion, Rebound hardness test, Microhardness tests - Vickers and Knoop hardness tests, Concept of nano indentation. Izod and Charpy Impact tests, Instrumented Charpy test, Drop-weight Test and other large scale tests.						
Unit III	**FRACTURE AND FRACTURE MECHANICS**		**9**	**0**	**0**	**9**
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, R Curve.						
Unit IV	**FATIGUE BEHAVIOUR AND TESTS**		**9**	**0**	**0**	**9**
Fatigue: Stress cycles, S-N curves, effect of mean stress, factors affecting fatigue, structural changes accompanying fatigue, cumulative damage, low cycle fatigue, application of fracture mechanics to fatigue crack propagation, fatigue testing machines.						
Unit V	**CREEP BEHAVIOUR AND TESTS**		**9**	**0**	**0**	**9**
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, Parameter methods of extrapolation. Introduction to remaining life assessment of high temperature structures and components, Creep-Fatigue interaction.						
						Total (45L) = 45 Hours

Text Books:	
1	George. E. Dieter, “Mechanical Metallurgy”, McGraw-Hill, New York, SI Edition, 2001.
2	Reed Hill, R.E., "Physical Metallurgy Principles", Affiliated East West Press, New Delhi, 1992.
Reference Books:	
1	Davis. H. E. Troxell G.E., Hauck.G.E.W. “The Testing of Engineering Materials”, McGraw- Hill, 1982
2	Thomas. H. Courtney, "Mechanical Behaviour of Materials", McGraw Hill Co., NY, 1990.
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	:	Demonstrate the material properties, Testing machines – types, Testing procedures.	L2: Understanding
CO2	:	Illustrate the types of hardness tests viz Vicker’s, Brinell & Izod and Charpy Impact tests.	L3: Applying
CO3	:	Explain the various fracture and mechanisms for different fractures, the Fracture toughness and the various theories describing them.	L3: Applying
CO4	:	Define and elaborate the Stress cycles, S-N curves, and application of fracture.	L1: Remembering
CO5	:	Discuss the Creep curve, creep mechanisms, metallurgical factors affecting creep.	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								2	2	1	
CO2	1	1	1		1								1	1	1	1
CO3	1	1	1	1	2							1	1	1		1
CO4	1	1	1	1	1								1	2	1	
CO5	1	1		1									1	1		
Avg.	1	1	1	1	1.25	0	0	0	0	0	0	1	1.2	1.4	1	1
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MT402	ADVANCED PHYSICAL METALLURGY			Semester		IV
PREREQUISITES		**Category**	**PC**	**Credit**		**3**
Elements of Physical Metallurgy		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1. Apply the basis of physical metallurgy and correlate transformations of structure of materials with their properties for engineering applications.

UNIT I	**SOLIDIFICATIONS**	**9**	**0**	**0**	**9**

Driving force for solidification, Alloy solidification – Single phase binary alloy solidification, Cellular and dendritic solidification, constitutional supercooling, eutectic solidification, Solidification during quenching from melt, Concept of Activation energy and Arrhenius equation, Simple problems in above topics.

UNIT II	**TRANSFORMATION KINETICS**	**9**	**0**	**0**	**9**

Nucleation - Types of nucleation; Homogeneous nucleation - critical nucleus size, critical free energy change and nucleation rate; Heterogeneous nucleation - critical nucleus size, critical free energy change and nucleation rate; Rate of Heterogeneous nucleation, Growth Kinetics, Interface-Controlled growth, Diffusion-Controlled growth, Overall Transformation Kinetics – Empirical equations.

UNIT III	**DIFFUSIONAL TRANSFORMATIONS**	**9**	**0**	**0**	**9**

Diffusional transformation in solid; Homogeneous and heterogeneous nucleation in solids; Transformation kinetics for interface controlled growth and diffusion controlled growth, Johnson-Mehl-Avrami equation, simple numerical problems, Pearlitic Transformation, Experimental characteristics, Mechanism and kinetics of growth, Eutectoid transformation – nucleation and growth of pearlite, Interlamellar spacing, Bainite transformation; Spinodal decomposition - uphill diffusion, examples from metallic systems; Order-Disorder transformations; Precipitation.

UNIT IV	**PARTICLE COARSENING AND RECOVERY RECRYSTALLIZATION AND GRAIN GROWTH**	**9**	**0**	**0**	**9**

Particle coarsening – Driving force for coarsening, Kinetics of coarsening (Greenwood’s model),
Recovery, Recrystallization and grain growth – Recovery, Recrystallization, Grain growth mechanisms.
Cold Working – Structure and Properties of cold worked metals, Effect of mechanical properties and microstructures, Factors controlling recrystallization, Annealing textures.

Hot Working – Concept of hot working, Comparisons with cold working, warm working, Simple problems in above topics.

UNIT V	**DIFFUSIONLESS TRANSFORMATIONS**	**9**	**0**	**0**	**9**

Massive transformations; Martensite transformation – Definition, Characteristic features of martensitic transformation in steels; Morphology of martensite - lath and plate martensite; Crystallography of martensitic transformation; Kinetic characteristics of martensitic transformation; Martensite in Non-Ferrous systems;Thermo elastic Martensite; Shape Memory effect - Examples and applications of shape memory alloys.

Total (45L) = 45 Hours

Text Books:

1	Raghavan, V."Solid State Phase Transformations", Prentice - Hall of India, New Delhi, 2004.
2	Porter, D.A. and Easterling , K.E., "Phase Transformations in Metals and Alloys", 2nd ed., Chapman and Hall, London 1992.

Reference Books:	
1	Romesh C. Sharma, “Phase transformation in Materials”, CBS Publishers & Distributors, New Delhi,2011.
2	Reed Hill, R.E., "Physical Metallurgy Principles", Affiliated East West Press, New Delhi, 1992.
3	R. E. Smallman A.H.W. Ngan, “Modern Physical Metallurgy”, Butterworth-Heinemann publication, 8th Edition, 2013.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Illustrate the mechanism of solidification and transformation	L3: Applying
CO2	:	Explain the concept of growth and nucleation of crystal structures and phases in different metals and alloys.	L2: Understanding
CO3	:	Interpret the phase transformation that is controlled by diffusion.	L3: Applying
CO4	:	Compare the particle coarsening, recovery recrystallization and grain growth, cold and hot working	L3: Applying
CO5	:	Describe the various phase transformations that occur due to diffusionless transformation.	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		
CO2	1	1											1		1	
CO3	1		1	1									1	1		
CO4		1		1	1								1			1
CO5	1	1	1		1								1		1	
Avg.	1	1	1	1	1	0	0	0	0	0	0	0	1	1	1	1

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

22MT403	HEAT TREATMENT TECHNOLOGY		Semester			IV
PREREQUISITES		Category	PC	Credit		3
Elements of Physical Metallurgy & Mineral Dressing, Fuels and Furnaces		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	To study transformations in steels, various heat treatment processes and their equipment.

Unit	Title	L	T	P	TH
Unit I	**TRANSFORMATIONS IN STEELS**	9	0	0	9
Iron - carbon equilibrium diagram**:** Transformations on heating and cooling, influence of alloying elements, general principles of heat treatment of steels, Isothermal and Continuous cooling transformations in steels. Continuous cooling curves TTT and CCT diagrams.					
Unit II	**HEAT TREATMENT PROCESSES**	9	0	0	9
Annealing - types, Normalizing, Hardening - Retained austenite -measurement and methods of its elimination, Hardenability studies- Jominy end quench test, Grossman's experiments Tempering- Hollomon & Jaffe tempering correlations, Temper embrittlement, Austempering and Martempering, Precipitation hardening, Thermo mechanical treatment Various heating media used for heat treatment, furnaces, temperature and atmosphere control, Quenching media and their characteristics, other heat treatment processes.					
Unit III	**CASE HARDENING**	9	0	0	9
Introduction, Carburising: Principle, carbon potential, application of Fick's law, depth of carburization and its control, methods of carburising, heat treatment after carburising, structure, properties and common problems in carburising. Nitriding: introduction, steels used, effect of microstructure, white layer, nitriding methods, ion nitriding and nitro- carburising. Induction and Flame hardening: principle, methods, operating variables. Measurement of case depth.					
Unit IV	**HEAT TREATMENT EQUIPMENT**	9	0	0	9
Various heating media used for heat treatment. Temperature and atmosphere control, carburising atmosphere and carbon potential measurement-simple problems, nitriding gas atmospheres. Quenching media and their characteristics. Various heat treatment furnaces, fluidized bed furnaces, cryo chamber, cryo treatment of steels, sealed-quench furnace					
Unit V	**HEAT TREATMENT OF SPECIFIC ALLOYS**	9	0	0	9
Heat treatment of carbon steels, stainless steels, tool steels. Heat treatment of gray cast irons, white cast irons, malleabilising and S.G.irons, austempering of S.G.Iron. Heat treatment of aluminium alloys and copper alloys. Defects in heat treated parts: causes and remedies.					
					Total (45L) = 45 Hours

Text Books:

1	Rajan and Sharma "Heat Treatment Principles and Techniques" – Prentice Hall of India (P) Ltd, New Delhi, 2009
2	Vijendra Singh,"Heat Treatment of Metals", Standard Publishers Distributors, Delhi, First edition 1998
	Romesh.C.Sharma, "Principles of Heat Treatment of Steels", New Age International Pvt. Ltd. Publishers, New Delhi, 2008**.**

Reference Books:

1	Prabhudev, K H., "Handbook of Heat Treatment of Steels", Tata - McGraw Hill Publishing Co., New Delhi, 2000
2	American Society for Metals, "Metals Handbook Vol.4", ASM Metals Parks, Ohio, USA, 2001

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Outline the different transformation processes that are taking place in steels with respect to parameter changes.	L1: Remembering
CO2	:	Describe the different processes of heat treatment that influences the materials properties and also the combination of heat and mechanical properties.	L3: Applying
CO3	:	Explain the process of carburizing, nitriding, nitrocarburizing etc.	L2: Understanding
CO4	:	Outline the various heat treatment equipment, heat treating medium, temperature for various heat treatment processes and also describe the heat treating furnaces	L3: Applying
CO5	:	Describe and discuss the heat treatment processes for specific alloys like tool steel, high speed steel and different varieties of 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		
CO2	1			1	1								1	1		
CO3	1	1				1	1									
CO4	1		1	1	1								1			
CO5		1			1								1	1		
Avg.	1	1	1	1	1	1	1	0	0	0	0	0	1	1	0	0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MT404	IRON MAKING				Semester		IV
PREREQUISITES			Category	PC	Credit		3
Metallurgical Thermodynamics & Mineral Dressing, Fuels and Furnaces			Hours/Week	L	T	P	TH
				3	0	0	3

Course Learning Objectives	
1	To know the significances of the iron making process and alternate routes for iron production facilities in industries.

		L	T	P	TH
UNIT I	**RAW MATERIALS AND BURDEN PREPARATION**	9	0	0	9
Iron ore classification, Indian iron ores, characteristics of coal for coke making, selection of coals, coke quality, problems associated with Indian raw materials, Burden preparation: Iron Ore beneficiation, Agglomeration - Theory and practice of Sintering and Pelletizing, testing of burden materials, burden distribution on blast furnace performance.					
UNIT II	**PHYSICO-CHEMICAL-THERMAL PRINCIPLES**	9	0	0	9
Reduction of iron ores and oxides of iron by solid and gaseous reductions, C-O and Fe-C-O equilibria, thermodynamics and kinetics study of direct and indirect reduction, Gruner’s theorem, physical chemistry of blast furnace reactions., Rist diagrams, Material and heat balance basics.					
UNIT III	**BLAST FURNACE DESIGN, PRACTICE AND INSTRUMENTATION CONTROL**	9	0	0	9
Blast furnace parts, construction and design aspects ancillary equipment for charging, preheating the blast,gas cleaning equipment, pig casting, blast furnace instrumentation and control of furnace.					
UNIT IV	**BLAST FURNACE OPERATION**	9	0	0	9
Blast furnace operation, irregularities and remedies, Compositional control of metal and slag in blast furnace, Desulphurisation of Hot metal , Reichard’s diagram, internal zones and gas flow in blast furnace, RAFT calculations, modern trends in blast furnace practice.					
UNIT V	**ALTERNATIVE ROUTES OF IRON MAKING**	9	0	0	9
Alternative routes of iron production – low shaft and charcoal furnace, electro-thermal processes, sponge iron production-coal based and gas based sponge iron production in India. Ferro alloy furnaces, production of Fe-Si, Fe-Mn and Fe –Cr, Introduction to mathematical modeling in Iron making processes					
					Total (45L) = 45 Hours

Text Books:	
1	Ahindra Ghosh and Amit Chatterjee, “Iron Making and Steel Making – Theory and Practice”, PrenticeHall of India Private Ltd., New Delhi 2008.
2	Tupkary R J, "Introduction to Modern Iron Making", Khanna Publishers, Third edition, New Delhi, 2004.
Reference Books:	
1	Biswas .A.K , “ Principles of blast furnace iron making- theory and practice” , SBA Pub, Kolkata 1994
2	David H Wekelin, "The Making, Shaping and Treating of Steel", AISE Steel Foundation, edition 11,1999.

E-References:	
1.	https://nptel.iitm.ac.in

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Classify the preparation of raw materials that must be processed before loading into the blast furnace.	L2: Understanding
CO2	:	Describe the various physical and chemical principles of blast furnace	L2: Understanding
CO3	:	Describe the various parts of blast furnace and the reactions taking place in it.	L2: Understanding
CO4	:	Demonstrate the operational features and the irregularities in blast furnace operation.	L3: Applying
CO5	:	Explain the iron making process using different methods like the production of sponge iron and the production of ferro alloys.	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			
CO2	1	1		1	1									1	1	
CO3		1	1	1									1	1		
CO4	1				1						1				1	
CO5	1	1		1	1									1		1
Avg.	1	1	1	1	1	0	0	0	0	0	1	0	1	1	1	1
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MCIN03	DESIGN SPRINTS					SEMESTER IV		
PRE-REQUISITE:			**Category**	**EE**	**Credit**		**1**
			Hours/Week	**L**	**T**	**P**	**TH**
				0	**0**	**2**	**2**
Course Objectives:							
1.	Develop key skill areas essential for a product designer from the perspective of design, its inherent complexity and supports them with tools and techniques to prototype rapidly.						
2.	To enable the participants to visualize the experience for a user.						
3.	To learn the roles and responsibilities of a designer in creating and shaping experiences for the user.						
4.	The participants shall learn through the lenses of system thinking of how existing products work.						
5.	Learn to select and apply various practice tools to aid them in rapid prototyping						
UNIT I	**DESIGN FUNDAMENTALS**			**0**	**0**	**6**	**6**
Introduction to Visual Design, History and Modernism, Design Thinking methodology, seven elements of design, principles of design, principles of good design, designing a product and a service							
UNIT II	**SYSTEM THINKING AND REVERSE ENGINEERING**			**0**	**0**	**6**	**6**
System Thinking for Engineering Problem Solving, Understanding Systems, Examples and understandings, Complex Systems, Reverse Engineering Methodology, Identify building blocks/Components - Re-Engineering a complex system							
UNIT III	**USER INTERFACE & USER EXPERIENCE**			**0**	**0**	**6**	**6**
Introduction to UI/UX, Human-Computer interface, user-centered Design Principles, User research techniques, UX Design workflow, Information Architecture, UI Components, need for UI prototyping, Wireframes							
UNIT IV	**MECHANICAL PROTOTYPING**			**0**	**0**	**6**	**6**
Need for prototyping - Domains in prototyping - Difference between actual manufacturing and prototyping - Rapid prototyping methods - Tools used in different domains - Introduction - Working with Fusion 360 - 3D Modeling - 3D Printing and classification - Laser Cutting and engraving - RD Works - Additive manufacturing							
UNIT V	**ELECTRONIC & SOFTWARE PROTOTYPING**			**0**	**0**	**6**	**6**
Introduction to Lumped Circuits - Electronic Prototyping - Tinker CAD - Designing in KI CAD - PCB design - Source code management and version control - GitHub - GitHub Actions - GitBash - Continuous Integration - Platform as service - Heroku - Build Packs							
							Total (30P) = 30 Periods

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

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

COURSE ARTICULATION MATRIX

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

<table>
<tr><td>22CYMC01</td><td colspan="2">ENVIRONMENTAL SCIENCE</td><td colspan="3">Semester</td><td>IV</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>Category</td><td>MC</td><td colspan="2">Credit</td><td>0</td></tr>
<tr><td colspan="2" rowspan="2"></td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>2</td><td>0</td><td>1</td><td>3</td></tr>
<tr><td colspan="7">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="6">To learn the concept of non conventional energy systems.</td></tr>
<tr><td>2</td><td colspan="6">To explore the environmental impact assessment and also to learn about the consequence of different types of pollutants</td></tr>
<tr><td>3</td><td colspan="6">They are part of the environment</td></tr>
<tr><td>4</td><td colspan="6">To have an ancient wisdom drawn from Vedas Activities based knowledge to preserve environment Conservation of water and its optimization</td></tr>
<tr><td colspan="7">Environmental Awareness</td></tr>
<tr><td colspan="7">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</td></tr>
<tr><td colspan="7">Environmental Activities</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7" align="right">Total (15) = 15 Hours</td></tr>
</table>

22MT405	MATERIALS TESTING LABORATORY			Semester		IV
PREREQUISITES		**Category**	**PC**	**Credit**		**1.5**
Mechanical behavior and testing of materials		**Hours/Week**	**L**	**T**	**P**	**TH**
			0	**0**	**3**	**3**

Course Learning Objectives	
1	To conduct the different material testing principles, procedures and eveluvate the material properties.
EXPERIMENTS	
1	Tensile testing of Metals and Alloys
2	Compression test
3	Impact testing of Metals (Charpy & Izod)
4	Bend Test of Metals
5	Hardness – Brinell & Rockwell
6	Hardness – Vickers
7	Microhardness test
8	Fatigue test
9	Wear test – Pin on disc
10	Creep test(using lead wire)
	Total (45P) = 45 Hours

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Select the relevant tools, machines and samples for testing.	L3: Applying
CO2	:	Identify the parameters involved in the testing methods and process.	L2: Understanding
CO3	:	Interpret the results obtained in the testing process.	L4: Analyzing

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	1	2	
CO2	2	1	1			1						1	2	1		1
CO3	1	2		1	1		1						1	1	1	
Avg.	1.33	1.33	1.00	1.00	1.00	1.00	1.00	0	0	0	1.00	1.00	1.33	1.00	1.50	1.00

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

22EN401	PLACEMENT AND SOFT SKILLS LABORATORY				Semester		IV
PREREQUISITES		Category		PC	Credit		2
		Hours/Week		L	T	P	TH
				0	0	4	4

Course Learning Objectives	
1	To develop the students' confidence and help them to attend interviews successfully
2	To express opinions, illustrate with examplesand 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	12	12

Letter seeking permission to go on industrial visit, Letter of invitation,Resume and cover letter, Job application, E-mail writing, Report writing, progress in project work.

Unit II	SPEAKING SKILLS	0	0	12	12

Welcome address and vote of thanks, Analysing and presenting business articles, Power point presentation, Presenting the visuals effectively, Group discussion, Participating in group discussions, Understanding group dynamics, Brain-storming the topics

Unit III	SOFT SKILLS	0	0	12	12

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	12	12

Error Spotting, Listening Comprehension, Reading comprehension, Rearranging Jumbled sentences, Vocabulary

Unit V	REASONING ABILITIES	0	0	12	12

Series completion, Analogy, Classification, Coding-Decoding, Blood relations, Seating Arrangements, Directional Sense, Venn Diagram,Logical reasoning, Statements and Conclusions

Total (60P) = 60 Hours

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-RESOURCES:

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

List of Exercises:

1) Cover Letter and Resume
2) Letter Writing
3) Email Writing
4) Report Writing
5) Powerpoint Presentation
6) Self-Introduction
7) Job Interview
8) Group Discussion
9) Welcome Address
10) Vote of Thanks
11) Presentation of BusinessArticle
12) Jumbled Sentences
13) Error Spotting
14) Reading Comprehension
15) Series completion
16) Analogy
17) Coding-decoding
18) Blood relations
19) Seating arrangements
20) Logical reasoning

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	To participate in group discussion and interview confidently
CO2	To develop adequate soft skills and career skills required for the workplace
CO3	To make effective presentations on given topics
CO4	To apply their verbal ability and reasoning ability in campus interviews

COURSE ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
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		1			1.	

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

22MT501	NON-FERROUS EXTRACTIVE METALLURGY			Semester		V
PREREQUISITES		**Category**	**PC**	**Credit**		**3**
Mineral dressing, Fuels and Furnaces & Metallurgical Thermodynamics.		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To study the various ores of nonferrous metals and their extraction through Pyro, Hydro and Electro metallurgy routes.
2	To apply the process principles used in the extraction of nonferrous metals.
3	To study the different refining techniques to purify the crude metals.

UNIT I	**PYROMETALLURGY**	**9**	**0**	**0**	**9**

Introduction: Sources of metals, unit operations and unit processes of metal extraction. Principles of Pyro metallurgy, advantages, Pyrometallurgical Processes – Drying, Calcination, Sintering, Roasting – Roasting Techniques – Predominance Area Diagrams. Principles of Smelting and Converting. Ellingham diagrams – Carbothermic, Hydrothermic and Metallothermic reductions.

UNIT II	**HYDROMETALLURGY**	**9**	**0**	**0**	**9**

Principles of Hydrometallurgy, advantages, Leaching – Properties of good solvent. Preparation of ore for Leaching – Leaching methods, Recovery of metals from Leach liquor - Solvent extraction, Ion exchange, Bio-leaching, Gaseous reduction of metals in aqueous solutions, Cementation, Recycling of leach liquor.

UNIT III	**ELECTROMETALLURGY AND PURIFICATION METHODS**	**9**	**0**	**0**	**9**

Principles of Electrometallurgy, advantages, Aqueous and Fused salt electrolysis, Electro-refining and Electro-winning of metals. Purification of Crude metals produced in bulk – Distillation, Liquation, Liquid-Liquid extraction. Fire refining, Electrolytic refining, Zone refining, VAR, EBM and ESR.

UNIT IV	**EXTRACTION AND REFINING OF METALS FROM SULPHIDE AND OXIDE ORES**	**9**	**0**	**0**	**9**

Extraction and Refining of metals from sulphide ores – Copper, Nickel, Lead and Zinc. Extraction and Refining of metals from oxide ores – Aluminium, Magnesium and Tin.

UNIT V	**EXTRACTION OF PRECIOUS AND RARE EARTH METALS AND BYPRODUCT METALS RECOVERY**	**9**	**0**	**0**	**9**

Extraction and Refining of precious metals – Gold, Silver and Platinum. Extraction of rare earth metals from halides – Titanium, Zirconium and Uranium. Recovery of by-product metals and treatment of Metallurgical wastes, Material and Energy balance.

Total (45L) = 45 Hours

Text Books:

1	Ray H.S, Sridhar R and Abraham K.P, Extraction of Non Ferrous Metals, Affiliated East-West Press Pvt Ltd, New Delhi, 2008.
2	Ray H.S and Gosh A, Principles of Extractive Metallurgy, Prentice Hall of India, New Delhi, 1994

Reference Books:	
1	Terkel Rosenqvist, Principles of Extractive Metallurgy, 2nd Edition, McGraw-Hill International book Company, 1983
2	Venkatachalam S, Hydrometallurgy, Narosa Publishing House, New Delhi, 1998
3	R.Raghavan Extractive Metallurgy of Non - Ferrous Metals ,Vijay Nicole Imprints Private Limited, Chennai 2016
4	Pehlke R.D, Unit Processes in Extractive Metallurgy, American Elsevier Publishing Company, New York, USA, 1977.
E-References:	
1.	https://nptel.ac.in/syllabus/113105021/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Identify the different sources of non ferrous metals and explain the process principles of pyrometallurgical extraction.	L2: Understanding
CO2	:	Illustrate the process principles of hydrometallurgical extraction.	L2: Understanding
CO3	:	Explain the process principles of electrometallurgical extraction and refining of metals.	L2: Understanding
CO4	:	Apply the extraction of metals from sulphide and oxide ores.	L3: Applying
CO5	:	Discuss the production of precious metals, rare earth metals and recovery of metals from metallurgical wastes.	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	2	1	1	1							1			2		
CO3		1	2	1	1									1		1
CO4	1		1		1							1	2		1	
CO5	2		1	1									1			
Avg.	1.5	1.0	1.2	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.3	1.5	1.0	1.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

<table>
<tr><td>22MT502</td><td colspan="3">FORMING PROCESSES</td><td colspan="3">Semester</td><td>V</td></tr>
<tr><td colspan="3">PREREQUISITES</td><td>Category</td><td>PC</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="3" rowspan="2">Mechanical behavior and Testing of materials,
Heat Treatment Technology &
Advanced Physical Metallurgy.</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">Know the concepts of Metal forming and associated technologies.</td></tr>
<tr><td>2</td><td colspan="7">Apply the forming concepts in conventional and advanced manufacturing.</td></tr>
<tr><td>3</td><td colspan="7">Know the applications of forming processes in various manufacturing sectors.</td></tr>
<tr><td>UNIT I</td><td colspan="3">FUNDAMENTALS OF METAL FORMING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Introduction to forming processes, Bulk forming Vs sheet metal forming, Classification of forming processes. Tensor Analysis, Yield criteria: Von Mises, Tresca yield criteria. Comparison of yield criteria, Octahedral shear stress and shear strain, Forming load calculations. Variables in metal forming, Flow stress determination, Temperature in metal forming, Hot, Cold and Warm working, Strain rate effects, Deformation zone geometry, Workability, Metallurgical structures, friction and lubrication, Residual stresses.</td></tr>
<tr><td>UNIT II</td><td colspan="3">FORGING AND ROLLING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Classification of Forging, Types of presses and hammers, Open die forging ,Closed die forging, Die properties and design, Calculation of forging loads, Effect of forging on microstructure Forging defects, causes and remedies, Forging applications. Classification of Rolling Processes, Rolling of Blooms, billets, slabs and sheet, types of rolling mills. Forces and geometrical relationship in rolling. Analysis of rolling load. Defects, causes and remedies.</td></tr>
<tr><td>UNIT III</td><td colspan="3">EXTRUSION AND DRAWING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Extrusion: Direct and Indirect extrusion, equipment, container less extrusion port hole extrusion die, hydrostatic extrusion, defects and remedies. Analysis of extrusion, tube extrusion and production of seamless pipe and tube. Hydrostatic extrusion. Equal Channel Angular Extrusion. Defects, causes and remedies. Drawing of rods, wires and tubes. Introduction to Super plasticity.</td></tr>
<tr><td>UNIT IV</td><td colspan="3">SHEET METAL WORKING AND HIGH VELOCITY FORMING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Sheet Metal Forming: Bending, spinning, stretch forming, deep drawing. Cutting methods - Shearing, blanking and Punching. Defects and applications. High velocity forming methods: Explosive forming, Electro hydraulic, Magnetic pulse forming and pneumatic method, Dynapak method. Formability tests: Effect of strain hardening coefficient (n value), strain rate sensitivity (m value), plastic strain ratio (r value) on formability. Introduction to formability limit diagram.</td></tr>
<tr><td>UNIT V</td><td colspan="3">POWDER METALLURGY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Steps in P/M, advantages and disadvantages. Powder production methods-physical, chemical and mechanical methods.Compaction-Pressure and pressure-less compaction techniques. Hot and Cold isostatic pressing, Sintering-solid state and liquid phase sintering. Microwave sintering, Typical applications.</td></tr>
<tr><td colspan="8" align="right">Total (45L) = 45 Hours</td></tr>
</table>

Text Books:	
1.	Dieter G.E ,Mechanical metallurgy , third edition ,McGraw hill company, SI edition 1995
2.	Sinha A.K ,Powder metallurgy, Dhanpat Rai & sons ,New Delhi,2001
Reference Books:	
1.	ASM Metal handbook Volume 14 Forming and forging ,Metal park Ohio USA,2001
2	ASM Metal handbook Volume 14A: Metalworking: Bulk Forming Metal park Ohio USA,2005
3.	ASM Metal handbook Volume 14B: Metalworking: Sheet Forming Metal park Ohio USA,2005
4.	Metal forming Handbook – Springer
5.	P.C Angelo, R. Subramanian Powder Metallurgy Science, Technology and Applications , PHI Learning Private

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the various fundamental aspects of metal forming processes.	L2: Understanding
CO2	:	Examine the Rolling and forging processes.	L3: Applying
CO3	:	Distinguish the Extrusion and Drawing processes, their defects and remedies.	L4: Analyzing
CO4	:	Discuss the fundamentals of various sheet metal forming processes.	L3: Applying
CO5	:	Outline the Powder metallurgy process and its applications.	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	2		1								1	2		1
CO2	2	1	1	1								1	2			
CO3	1	2		1			1							1	1	
CO4	1	1	2		1		1				1		2		1	
CO5	1		1	1										2		1
Avg.	1.2	1.3	1.5	1.0	1.0	0.0	1.0	0.0	0.0	0.0	1.0	1.0	1.7	1.7	1.0	1.0

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

22MT503	STEEL MAKING			Semester		V
PREREQUISITES		**Category**	**PC**	**Credit**		**3**
Iron making, Metallurgical Thermodynamics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To know the importance of the steel making and to apply them for the advancement of the production feasibilities in steel industries to compete with the modern day manufacturing routes.

UNIT I	**PHYSICAL CHEMISTRY OF STEEL MAKING**	**9**	**0**	**0**	**9**

History & Development of Steel making processes. Raw materials for Steel making & plant layout. Physico Chemical Principles and Kinetic aspects of Steelmaking - Carbon reaction, Phosphorus reaction, Silicon reaction, Manganese reaction & Sulphur reaction, Reaction at slag-metal interface, Oxygen transport mechanism, Deoxidation of steel – Thermodynamics, Kinetics and Mechanism, Slag – Functions, Composition, Properties and Theories.

UNIT II	**CONVENTIONAL STEEL MAKING PROCESSES**	**9**	**0**	**0**	**9**

Review of older Steel making process: Bessemer processes – Acid & Basic Bessemer Process, Open Hearth Process – Reasons for the decline, Electric Steel making process: Electric Arc Furnace and Induction furnace – Constructional features, Production practice for Plain Carbon Steels, Low Alloy Steels & Stainless Steels, Developments in Electric Arc Furnace technology – Furnace design, Operational features.
Modern approaches to Steelmaking – External treatments to remove Sulphur, Phosphorus & Silicon.

UNIT III	**OXYGEN STEEL MAKING PROCESS**	**9**	**0**	**0**	**9**

Top blown process, LD process – LD vessel design & Lance design, Charge material, Operational feature, Characteristics of LD process & Reactions in LD converter. LDAC, Kaldo process, Rotor process. Bottom blown basic Oxygen conventional process (Q-BOP/OBM/LWS),EOF. Principles & Mechanism of refining only.

UNIT IV	**SECONDARY STEEL MAKING PROCESS**	**9**	**0**	**0**	**9**

Introduction, Stirring techniques, Cleanliness improvement, Perrin Process, Decarburization techniques: Stainless Steel making technology - AOD process, VOD process, CLU process, Nitrogen problem in Stainless Steel making. Injection Metallurgy, Plunging techniques, Post solidification treatments – VAR & ESR process. Tundish Metallurgy. Ladle furnace. Vacuum treatment – Principle & Function of Degassing, Degassing processes - Ladle degassing, Stream degassing, Recirculation degassing.

UNIT V	**INGOT AND CONTINUOUS CASTING OF STEEL**	**9**	**0**	**0**	**9**

Casting Pit practice – Teeming Ladle, Ingot mould, Teeming methods. Solidification of Steel in Ingot moulds-Killed, Rimmed and Capped Steels. Ingot defects and their remedies. Gases in Steel. Continuous Casting of Steel – Introduction, Principles, Constructions features and Operation of a typical Continuous Casting Machine. Defects in Continuous Casting products. Current status of Continuous Casting Technology. Quality Control in Continues casting. Metallurgical Defects and their remedies. Indian Steel Industry and global trends in steel making technology, Introduction to mathematical modeling in steel making processes.

Total (45L) = 45 Hours

Text Books:

1	Ahindra Ghosh and Amit Chatterjee, Iron Making and Steel Making – Theory and Practice, Prentice Hall of India Private Ltd., New Delhi, 2008.
2	R.H.Tupkary and V.R. Tupkary, An Introduction to modern steel making, Khanna Publishers, 2000.

E-References:

1	https://nptel.ac.in/courses/113104013

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Identify the reactions taking place in the steel making process along with the thermodynamics, kinetics and the mechanism of reaction.	L3: Applying
CO2	:	Review the older steel making processes and modern electric steel making processes.	L4: Analyzing
CO3	:	Discuss and describe the conventional steel making processes viz. oxygen steel making processes.	L2: Understanding
CO4	:	Describe the secondary steel making processes, the process following the primary refining of raw pig iron.	L2: Understanding
CO5	:	Explain the melting process for steel, the ingot defects and their respective remedies.	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			1
CO2	2	1	1	1									2	1		
CO3	1	1			2		1							1	1	
CO4	2	1	1			1							2		1	
CO5	1	2			1									1	2	1
Avg.	1.4	1.2	1.0	1.0	1.3	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.7	1.0	1.3	1.0

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

22MT504	CORROSION ENGINEERING				Semester		V
PREREQUISITES		**Category**	**PC**	**Credit**			**3**
Engineering chemistry		**Hours/Week**	**L**	**T**		**P**	**TH**
			3	**0**		**0**	**3**

Course Learning Objectives	
1	To know the concept of different types of corrosion and the basic principles of corrosion engineering.

UNIT I	**CORROSION PRINCIPLES**	**9**	**0**	**0**	**9**
Electrochemical and thermodynamic principles, electrode potential of metals, EMF and galvanic series, Nernst equation, Pourbaix diagram and its importance, Exchange current density, polarization and its types, Tafel equation, passivity, electrochemical behaviour of active-passive metals, Mixed potential theory and its application.					
UNIT II	**FORMS OF CORROSION**	**9**	**0**	**0**	**9**
Atmospheric, galvanic, crevice, pitting, stress corrosion cracking, intergranular corrosion, corrosion fatigue, hydrogen damage, cavitation, fretting corrosion and high temperature oxidation-description, causes and remedial measures.					
UNIT III	**CORROSION TESTING**	**9**	**0**	**0**	**9**
Susceptibility tests of IGC, stress corrosion cracking and pitting, ASTM standards for corrosion testing; Corrosion testing for Passivating metals. Polarization methods to measure corrosion rate, Tafel extrapolation method, Linear Polarisation method.					
UNIT IV	**CORROSION PREVENTION**	**9**	**0**	**0**	**9**
Corrosion prevention by design improvements, anodic and cathodic protection, metallic, non-metallic and inorganic coatings, mechanical and chemical methods and various corrosion inhibitors					
UNIT V	**CORROSION IN INDUSTRIES**	**9**	**0**	**0**	**9**
Corrosion in boilers, pipe lines, automotive industry, chemical industries and petroleum refineries - Practical remedial treatments.					
					Total (45L) = 45 Hours

Text Books:	
1	Mars G. Fontana, Corrosion Engineering, Tata McGraw Hill Education, 2005.
2	Denny A. Jones, Principles and prevention of corrosion, 2nd Edition, Prentice Hall Inc.,1996.
Reference Books:1	
1	ASM hand book, Vol 13: Corrosion, ASM International, USA, 2001.
2	Rajnarayan, Metallic corrosion and prevention, Oxford Publications, 2001.
3	Trethewey, K.R., and Chamberlain, J., Corrosion – For science and engineering, 2nd Edition, Longman Inc., 1996.
4	Uhlig, H.H., and R. Winston Revie, Corrosion and corrosion control – An introduction to corrosion science and engineering, Third edition, John Wiley & Sons, 1985.
E-References:	
1.	www.nptel.ac.in/courses/113108051/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the electro chemical and thermodynamic principles and to sketch the pourbaix diagram.	L2: Understanding
CO2	:	Classify the different forms of corrosion and their causes and remedies.	L1: Remembering
CO3	:	Describe the processes of ASTM testing methods and polarization methods.	L2: Understanding
CO4	:	Report the corrosion preventive methods such as mechanical and chemical methods.	L4: Analyzing
CO5	:	Analyze the corrosion in petroleum industries and pipe lines.	L4: Analyzing

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	1		
CO2	2	1	1		2						1		2	1		1
CO3	1	1	1			1	1					1	1		1	
CO4	2	1		1			1					1		2		1
CO5	1	1			1									1		
Avg.	1.4	1.0	1.0	1.0	1.3	1.0	1.0	0.0	0.0	0.0	1.0	1.0	1.3	1.3	1.0	1.0

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

22MT505	CASTING ENGINEERING					Semester		V
PREREQUISITES				**Category**	**PC**	**Credit**		**3**
Mineral Dressing, Fuels and Furnaces & Advanced Physical Metallurgy				**Hours/Week**	**L**	**T**	**P**	**TH**
					3	**0**	**0**	**3**
Course Learning Objectives								
1	To know the basic concept of metal casting technology.							
2	To apply the concept of production of metals and alloys.							
UNIT I	**MOULDING MATERIALS AND PATTERNS**				**9**	**0**	**0**	**9**
Introduction to foundry operations, patterns - functions, types, allowances selection of pattern materials, colour codes, core boxes, moulding practice, ingredients of moulding sand and core sand, Testing of Moulding sands. Sand preparation.								
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, plaster mould casting, investment casting, squeeze casting, full mould process, Rheocasting, Thixo casting.								
UNIT III	**DESIGN OF CASTINGS**				**9**	**0**	**0**	**9**
Elements of gating system, types, design of gating system with examples, functions of risers, types of risers, Chvorinov‟s rule, design and positioning of riser with examples, directional solidification, use of chills, exothermic compounds etc., riser efficiency, yield calculations. Solidification and shrinkage, inoculation in cast irons, modification in Al-Si system.								
UNIT IV	**MELTING PRACTICE**				**9**	**0**	**0**	**9**
Types of furnaces used in foundry, Melting practice and special precautions for steels, alloy steels, cast irons, aluminium alloys, copper alloys and magnesium alloys, safety considerations, fluxing, degassing and inoculation.								
UNIT V	**QUALITY CONTROL, FETTLING, INSPECTION AND AUTOMATION**				**9**	**0**	**0**	**9**
Quality control: composition control in steels and cast irons. Simple problems on charge calculations. Cleaning and repair of castings. Casting defects and remedies. Heat treatment of castings. Inspection of casting. Principles of mechanization, automation and foundry layout. Sand reclamation and Pollution control in foundries.								
								Total (45L) = 45 Hours

Text Books:	
1	Heine R W., C.R., Loper, and P.C. Rosenthal, Principles of Metal Casting, Tata-McGraw Hill Publishing Co Ltd, New Delhi, 2018.
2	Jain, P.L , Principles of Foundry Technology, Tata McGraw Hill Publishing Co Ltd, New Delhi, 2013.
3	Srinivasan, N.K., Foundry Engineering, Khanna Tech Publications, New Delhi, 2017.
Reference Books:	
1	Ramana Rao, T.V., Metal Casting: Principles and Practice, New Age International Publishing Co., New Delhi, 2019.
2	ASM Metals hand Book, Vol 15, Casting ASM International, 10th edition, 2010.
3	Beeley, P.R., Foundry Technology, Butterworths, London, 2013.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the types of patterns and allowances.	L2: Understanding
CO2	:	Exemplify the various casting techniques.	L2: Understanding
CO3	:	Demonstrate the gating and riser systems.	L3: Applying
CO4	:	Explain the melting practice for various metals and alloys.	L1: Remembering
CO5	:	Discuss the fettling and inspections of castings.	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			
CO2	1	1		1		1							1			
CO3	1		1	1									1			
CO4	1	1	1		1		1							1		
CO5		1		1									1			
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MT506	WELDING ENGINEERING				Semester		V
PREREQUISITES		**Category**	**PC**	**Credit**			**3**
Engineering physics, Engineering chemistry and Basic electrical engineering		**Hours/Week**	**L**	**T**	**P**		**TH**
			3	**0**	**0**		**3**

Course Learning Objectives

1	To get familiarized with various materials joining processes.
2	To get familiarized with various surfacing and cutting processes

UNIT I	**CONVENTIONAL WELDING PROCESSES**	**9**	**0**	**0**	**9**

Introduction to welding and allied processes. Classification of welding processes. Heat sources and shielding methods. Overview of welding power sources, Open Circuit Voltage (OCV), Duty cycle and Heat input. Fusion welding processes – Principle, merits, demerits and applications of Oxy-acetylene welding (OAW), Shielded metal arc welding (SMAW), Submerged arc welding (SAW), Gas tungsten arc welding (GTAW), Gas metal arc welding (GMAW and FCAW). Arc welding defects, their causes and remedies.

UNIT II	**SOLID STATE WELDING PROCESSES**	**9**	**0**	**0**	**9**

Principle, merits, demerits and applications of Cold pressure welding, Hot pressure welding, Induction pressure welding, Friction welding, Friction stir welding, Ultrasonic welding, Explosive welding, Diffusion welding processes. Defects, their causes and remedies.

UNIT III	**SPECIAL WELDING PROCESSES**	**9**	**0**	**0**	**9**

Power density Vs heat input. Principle, merits, demerits and applications of Electron beam welding (EBW), Laser beam welding (LBW), Plasma arc welding (PAW), Electro slag welding (ESW), Electro gas welding (EGW), Thermit welding (TW) and Stud welding (SW) processes. Resistance welding processes (Spot and Seam welding).

UNIT IV	**BRAZING AND SOLDERING PROCESSES**	**9**	**0**	**0**	**9**

Fundamentals of Brazing and Soldering – Capillary action, wetting characteristics and joint design. Principle, merits, demerits and applications of Torch brazing, Furnace brazing, Dip brazing, Induction brazing, Resistance brazing processes. Brazing Vs Braze welding. Principle, merits, demerits and applications of Iron soldering, Torch soldering, Dip soldering, Infrared soldering, Laser soldering, Hot gas soldering, Wave soldering processes. Filler materials and fluxes for brazing and soldering.

UNIT V	**SURFACING AND CUTTING PROCESSES**	**9**	**0**	**0**	**9**

Types of Surfacing – Cladding, Hardfacing, Build-up and Buttering. Dilution concept. Surfacing by welding: OAW, SMAW, GTAW, GMAW, FCAW, SAW and PAW. Principle of operation, cutting equipment and applications of Oxy-fuel gas cutting, Air-carbon arc cutting, Metal powder cutting, Chemical flux cutting, Plasma arc cutting, Electron beam and Laser beam cutting processes.

Total (45L) = 45 Hours

Text Books:

1	Srinivasan N K ,"Welding Technology", Khanna Publishers, New Delhi, 2016.
2	Parmar, R.S., “Welding Processes and Technology”, 3rd edition. Khanna Publishers, New Delhi, 2003.

Reference Books:

1	Davies A C, "Welding",10th edition, Cambridge University Press, UK, 1996.
2	AWS Welding Handbooks, AWS, New York, 1995.
3	Howard B.Cary,"Modern Welding Technology", Prentice Hall, New Jersey, USA, 2004.

4	Nadkarni,S.V.,"Modern Arc Welding Technology", Oxford & IBH Publishing Co., 1988.
5	Schwartz,M.M.,"Metals Joining Manual", Mc Graw-Hill Inc., 1979.
6	ASM Metals Handbook,Vol.6,"Welding, Brazing & Soldering", ASM International, Metals park, Ohio, USA, 2001.
7	Jean Cornu, “Advanced Welding Systems”, Springer-Verlag Berlin Heidelberg GmbH, 1988.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Explain the fundamentals and merits of conventional welding processes.	L2: Understanding
CO2	:	Describe the fundamentals and merits of solid state welding processes.	L2: Applying
CO3	:	Compare the special welding processes with other welding processes.	L4: Analyzing
CO4	:	Demonstrate the types of brazing and soldering processes.	L3: Understanding
CO5	:	Illustrate different surfacing and cutting 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	2	2	1								2	2	1		
CO2	2				2											
CO3		2	1	1											1	
CO4		1		2									1	1		
CO5	2	2	2	1	2							2		1		1
Avg.	2	1.8	1.7	1.3	2	0	0	0	0	0	0	2	1.5	1	1	1
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MC301	INDIAN CONSTITUTION				SEMESTER V			
PREREQUISITE:			**Category**	**MC**	**Credit**		**0**	
			Hours/Week	**L**	**0**	**P**	**TH**	
				2	**0**	**0**	**2**	

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

UNIT I	**FUNDAMENTAL RIGHTS**	**9**	**0**	**0**	**9**
Union and its Territory – Citizenship–Fundamental Rights–Directive Principles of State Policy–Fundamental Duties					
UNIT II	**UNION AND TERRITORIES**	**9**	**0**	**0**	**9**
he Union–The States–The Union Territories–The Panchayats–The Municipalities					
UNIT III	**FINANCE, TRADE, AND COMMERCE**	**9**	**0**	**0**	**9**
The Co-operative Societies–The scheduled and Tribal Areas–Relations between the Union and the States–Finance, Property, Contracts and Suits–Trade and Commerce within the territory of India					
UNIT IV	**ELECTIONS**	**9**	**0**	**0**	**9**
Services under the Union, the States – Tribunals – Elections– Special Provisions –Relating to certain Classes					
UNIT V	**MISCELLANEOUS AMENDMENTS**	**9**	**0**	**0**	**9**
Languages–Emergency Provisions – Miscellaneous–Amendment of the Constitution					
					Total (30L) = 30 Periods

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

22MT507	HEAT TREATMENT AND CORROSION LABORATORY			Semester		V
PREREQUISITES		**Category**	**PC**	**Credit**		**2**
Heat treatment technology & Corrosion Engineering		**Hours/Week**	**L**	**T**	**P**	**TH**
			0	**0**	**4**	**4**

Course Learning Objectives	
1	To understand the various heat treatment processes.
2	To gain knowledge about corrosion testing.
	Heat treatment Experiments
1.	Annealing of carbon steels-Heat treatment practice and Analysis
2.	Normalising of carbon steels – Heat treatment practice and Analysis
3.	Effect of quenching media on hardening of steel – Heat treatment practice and Analysis
4.	Effect of tempering temperature on hardened steel – Heat treatment practice and Analysis
5.	Effect of tempering time on hardened steel- Heat treatment practice and Analysis
	Corrosion Experiments
6.	Corrosion rate determination by weight loss method.
7.	Electroplating of Copper and Nickel.
8.	Effect of inhibitors on the rate of corrosion.
9.	Oxalic acid etch test for IGC ASTM A262 – Practice A.
10.	Polarization studies using electrochemical workstation.
	Total (60P) = 60 Hours

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Perform the annealing and normalizing processes on Carbon steels.	L3: Applying
CO2	:	Determine the effect of Quenching and Tempering process of Hardened steel.	L4: Analyzing
CO3	:	Determine the corrosion rate by weight loss method.	L4: Analyzing
CO4	:	Analyze the effect of inhibitors on corrosion rate.	L4: Analyzing
CO5	:	Perform electroplating of copper and nickel.	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	1	2		1	1		1							1		
CO3	1	1	1		2								2			1
CO4	1	1	1	1										1		1
CO5	1				1								1		1	
Avg.	1.0	1.3	1.0	1.0	1.3	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.7	1.0	1.0	1.0

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

22MT508	MACHINE SHOP PRACTICE			Semester		V
PREREQUISITES		**Category**	**PC**	**Credit**		**1.5**
		Hours/Week	**L**	**T**	**P**	**TH**
			0	**0**	**3**	**3**
Course Learning Objectives						
1	To practice and know about various machining machine.					
EXPERIMENTS						
1	Lathe					
2	Drilling					
3	Shaping					
4	Gear hobbing					
5	Keyway milling					
6	Study on cylindrical grinding, boring, and CNC machines.					
	Total (45P) = 45 Hours					

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Apply the machining concepts and also do the machining operations like facing and turning for the given components.	L3: Applying
CO2	:	Practice the different methods of taper turning and do the taper turning operation using methods like tailstock set over and taper turning attachment.	L3: Applying
CO3	:	Recognize the performance and principle of basic drilling operation and also various successful machining of drilling, tapping, reaming and counter Sink by using radial drilling machine.	L4: Analyzing
CO4	:	Practice the concept of milling and do the keyway milling.	L3: Applying
CO5	:	Practice the various machining process like cylindrical grinding, boring and shaping.	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	1	
CO2		1			1							1		2		
CO3	1		1	1								1		2		
CO4		1	1								1			1		
CO5		1		1										1		
Avg.	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	2.0	1.4	1.0	0.0

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

22MT601	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 for various concepts of metallurgical processes, materials and its applications.
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. Requirement analysis and problem formation
b. Conceptual design and Methodology
c. Optimization of design, material selection and process (if applicable)
d. Model/Prototype development/Implementation
e. Testing and validation
f. Report submission

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 metallurgical applications.	L6:Creating
CO2	Create an environment to convert the ideas into design of prototype for useful industrial and societal applications.	L6:Creating
CO3	Familiarize the feasibility study and manage activities to complete task in specified duration.	L2:Understanding
CO4	Assign and undertake tasks in a team as per team discussion.	L5:Evaluating
CO5	Do presentation and write technical reports for effective communication within and outside the team.	L5:Evaluating

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	3	2	2	3	1	3		2		3	3	3	3
CO2	3	3	2	2	2	3	3		3		1		3	3	2	3
CO3	2	2	2	2	2	1	1	1	3	1	2	3	2	2		2
CO4	2	2	2	1	1	1	2	3	3	3		3	2	3		2
CO5					2	2		1	3	3		2	3		3	2
Avg	2.5	2.5	2.0	2.0	1.8	1.8	2.3	1.5	3.0	2.3	1.7	2.7	2.6	2.8	2.7	2.4
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)**															

<table>
<tr><td>22PSPE03</td><td colspan="6">INDUSTRIAL AUTOMATION</td><td colspan="2">Semester</td><td>VI</td></tr>
<tr><td colspan="6">PREREQUISITES</td><td>Category</td><td>PE</td><td>Credit</td><td>3</td></tr>
<tr><td colspan="6" 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="11">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="10">Acquire conceptual knowledge in Industrial Controllers by scaling of on-board devices and embedded board interfacing with various I/O peripherals.</td></tr>
<tr><td>2</td><td colspan="10">Learn PLC by working on internal features and also interfacing with Sensors and actuators along HMI concept using SCADA and standard communication protocols.</td></tr>
<tr><td>3</td><td colspan="10">To work with FPGA boards and RT controllers for reprogrammable embedded applications using LabVIEW</td></tr>
<tr><td>4</td><td colspan="10">Understand the concepts and design electronics circuits</td></tr>
<tr><td>Unit I</td><td colspan="6">INDUSTRIAL CONTROLLERS - I</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="11">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</td></tr>
<tr><td>Unit II</td><td colspan="6">INDUSTRIAL CONTROLLERS - II</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="11">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</td></tr>
<tr><td>Unit III</td><td colspan="6">INDUSTRIAL COMMUNICATION PROTOCOLS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="11">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.</td></tr>
<tr><td>Unit IV</td><td colspan="6">FPGA AND RT CONTROLLER PROGRAMMING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="11">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.</td></tr>
<tr><td>Unit V</td><td colspan="6">INDUSTRIAL CIRCUIT BOARD DESIGN</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="11">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</td></tr>
<tr><td colspan="11" align="right">Total = 45 Periods</td></tr>
</table>

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**	**PSO2**	**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
AVG	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)**															

<table>
<tr><td>22PSEE01</td><td colspan="3">ROBOTICS</td><td colspan="3">Semester</td><td>VI</td></tr>
<tr><td colspan="3">PREREQUISITES</td><td>Category</td><td>EE</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>0</td><td>0</td><td>6</td><td>6</td></tr>
<tr><td colspan="8">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="7">Learn the fundamentals of ROS</td></tr>
<tr><td>2</td><td colspan="7">Understand the requirements and choose the right sensors and actuators for the application development</td></tr>
<tr><td>3</td><td colspan="7">Create Bot in the virtual environment and simulate it to know the functionalities of the system developed</td></tr>
<tr><td>4</td><td colspan="7">Learn the basics of Robotics Vision System</td></tr>
<tr><td>5</td><td colspan="7">Integrate ROS and Computer Vision to build systems for various use cases</td></tr>
<tr><td>Unit I</td><td colspan="3">INTRODUCTION TO ROBOT KINEMATICS</td><td>0</td><td>0</td><td>12</td><td>12</td></tr>
<tr><td colspan="8">Introduction to Robotics - Transformations - Forward Kinematics - Kinematics equations - Link transformations - Inverse Kinematics - Kinematic analysis - Numerical Inverse Kinematic Solutions - Analytical Inverse Kinematic Solutions</td></tr>
<tr><td>Unit II</td><td colspan="3">SELECTION OF SENSORS AND ACTUATORS</td><td>0</td><td>0</td><td>12</td><td>12</td></tr>
<tr><td colspan="8">Introduction - Sensors & Actuators - Types - Selection criteria - Design considerations: Motor sizing - Selection of motors based on torque and speed characteristics - Hardware Interface & Assembly</td></tr>
<tr><td>Unit III</td><td colspan="3">INTRODUCTION TO ROBOT OPERATING SYSTEM</td><td>0</td><td>0</td><td>12</td><td>12</td></tr>
<tr><td colspan="8">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</td></tr>
<tr><td>Unit IV</td><td colspan="3">INTRODUCTION TO ROBOTICS VISION SYSTEM</td><td>0</td><td>0</td><td>12</td><td>12</td></tr>
<tr><td colspan="8">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</td></tr>
<tr><td>Unit V</td><td colspan="3">INTEGRATION OF ROS AND COMPUTER VISION</td><td>0</td><td>0</td><td>12</td><td>12</td></tr>
<tr><td colspan="8">Introduction - Installation - CV Bridge - Image publisher node - Image subscriber node - Nodes buildingand launching - Building real world applications</td></tr>
<tr><td colspan="8" align="right">Total = 60 Periods</td></tr>
</table>

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

<table>
<tr><td colspan="2">Reference Books:</td></tr>
<tr><td>1</td><td>https://www.intechopen.com/chapters/379</td></tr>
</table>

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)**

22MT701	CHARACTERIZATION OF MATERIALS			Semester		VII
PREREQUISITES		**Category**	**PC**	**Credit**		**3**
Engineering Physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To introduce the fundamental concepts and techniques of materials characterization.
2	To familiarize with various analytical instruments and methods used for characterization.
3	To enable the learners to interpret and analyze experimental data's.

UNIT I	**METALLOGRAPHIC TECHNIQUES**	**9**	**0**	**0**	**9**

Metallurgical microscope - principle, construction and working, metallographic specimen preparation, optical 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 TECHNIQUES**	**9**	**0**	**0**	**9**

Continuous & Characteristic X-ray spectrum, Bragg's Law, Diffraction methods - Laue method, rotating crystal method, powder method, X-ray diffractometer, filters and counters. Applications of X-ray diffraction in materials characterization – Determination of crystal structure, lattice parameter, measurement of stress, Introduction of GIXRD, SAX/WAX.

UNIT III	**ELECTRON OPTICAL TECHNIQUES**	**9**	**0**	**0**	**9**

Electron optical instruments, electron-specimen interactions, Transmission electron microscopy (TEM) – principle, construction and working, specimen preparation, various imaging modes, selected area diffraction, applications. Scanning electron microscopy (SEM) – principle, equipment, various operating modes and applications. Electron probe microanalyser (EPMA)- principle, instrumentation, qualitative and quantitative analysis, HRTEM.

UNIT IV	**SURFACE ANALYSIS TECHNIQUES**	**9**	**0**	**0**	**9**

Principle, instrumentation, working and applications of Auger Electron spectroscopy, X-ray photoelectron spectroscopy, Secondary ion mass spectroscopy / ion microprobe, Optical emission spectroscopy and X-ray Fluorescence spectroscopy.

UNIT V	**THERMAL ANALYSIS AND ADVANCED CHARACTERIZATION TECHNIQUES**	**9**	**0**	**0**	**9**

Advanced characterization techniques: Field ion microscopy including atom probe - principle, instrumentation and applications. Scanning probe microscopy - principle, instrumentation and applications. Atomic force microscopy - principle, instrumentation and applications. Thermal techniques: Principles of Differential thermal analysis, Differential scanning calorimetry and Thermogravimetric analysis – Instrumentation.

Total (45L) = 45 Hours

Text Books:

1	Angelo .P.C , " Materials Characterization ", Reed Elsevier India Pvt Ltd, Haryana, 2016.
2	Hebbar K R, " Basics of X-Ray Diffraction and its Applications", I.K. International Publishing House Pvt Ltd,New Delhi, 2011
3	Khangaonkar. P.R., "An Introduction to Materials Characterization", Penram International Publishing (India) Pvt. Ltd, Mumbai, 2010.

Reference Books:	
1	Phillips V A, “Modern Metallographic Techniques and their Applications”, Wiley Eastern, 1971.
2	Cherepin and Malik, “Experimental Techniques in Physical Metallurgy”, Asia Publishing Co., Mumbai, 1968.
3	Cullity B D., Stock S R "Elements of X-ray Diffraction", Prentice Hall, Inc 2001.
4	ASM Handbook, Volume 10, “Materials Characterization“, 9th edition, ASM international, USA, 1986.
5	Vander Voort, “Metallography: Principle and practice”, McGraw Hill Inc., 1984.
6	Kehl G L., "The Principles of Metallographic Laboratory Practice", McGraw Hill Book Company, 1949.
7	Small man R.E. Modern Physical Metallurgy“, 4th Edition, Butterworths, 1985.
8	Joseph I, Goldstein et.al. – Scanning electron microscopy and x-ray microanalysis, 4th edition, springer
Web resources:	
1	myscope.training

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Describe the principle of various illumination techniques in optical microscopy.	L2: Understanding
CO2	:	Determine the crystal structure and lattice parameter by XRD pattern.	L3: Applying
CO3	:	Demonstrate the principle and various working modes of electron microscope.	L3: Applying
CO4	:	Illustrate various techniques for surface analyses.	L3: Applying
CO5	:	Illustrate thermal technique to determine various thermal events in 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	2			2								1	1	2		1
CO2		1			2	1	1						2			
CO3	2	1	1	1											1	1
CO4			1	2								1				1
CO5	1	2			1								1	1		
Avg.	1.7	1.3	1.0	1.7	1.5	1.0	1.0	0.0	0.0	0.0	0.0	1.0	1.3	1.5	1.0	1.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MT702	INTRODUCTION TO INDUSTRIAL MANAGEMENT			Semester		VII
PREREQUISITES		**Category**	**HS**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	On studying this course the students can contribute to the success of companies by understanding the basics of management.
2	To provide an opportunity to learn basic management concepts essential for business.
3	Gain knowledge on various factors of production in increasing the efficiency of the company.
4	They can able to know better organizational behaviour and modern concepts of industrial management.

UNIT I	**BASICS OF MANAGEMENT**	**9**	**0**	**0**	**9**

Management – Definition – Functions – Evolution of Modern Management – Scientific Management Development of Management Thought. Approaches to the study of Management, Forms of Organization – Individual Ownership – Partnership – Joint Stock Companies – Co-operative Enterprises – Public Sector Undertakings, Corporate Frame Work – Share Holders – Board of Directors – Committees – Chief Executive – Trade Union.

UNIT II	**FUNCTIONS OF MANAGEMENT**	**9**	**0**	**0**	**9**

Planning – Nature and Purpose – Objectives – Strategies – Policies and Planning Premises – Decision Making – Organizing – Nature and Process – Premises – Departmentalization – Line and staff – Decentralization – Organizational culture, Staffing – selection and training – Placement – Performance appraisal – Career Strategy – Organizational Development. Leading – Managing human factor – Leadership – Communication, Controlling – Process of Controlling – Controlling techniques, productivity and operations management – Preventive control, Industrial Safety.

UNIT III	**ORGANIZATIONAL BEHAVIOUR**	**9**	**0**	**0**	**9**

Definition – Organization – Managerial Role and functions – Organizational approaches, Individual behaviour – causes – Environmental Effect – Behaviour and Performance, Perception – Organizational Implications. Personality –Contributing factors – Dimension – Need Theories – Process Theories – Job Satisfaction, Learning and Behaviour – Learning Curves, Work Design and approaches

UNIT IV	**GROUP DYNAMICS**	**9**	**0**	**0**	**9**

Group Behaviour – Groups – Contributing factors – Group Norms, Communication – Process – Barriers to communication – Effective communication, leadership – formal and informal characteristics – Managerial Grid – Leadership styles – Group Decision Making – Leadership Role in Group Decision, Group Conflicts – Types – Causes –Conflict Resolution – Inter group relations and conflict, Organization centralization and decentralization – Formal and informal – Organizational Structures – Organizational Change and Development – Change Process – Resistance to Change – Culture and Ethics.

UNIT V	**MODERN CONCEPTS**	**9**	**0**	**0**	**9**

Management by Objectives (MBO), Management by Exception (MBE), Strategic Management – Planning for Future direction – SWOT Analysis – Information technology in management – Decisions support system – Business Process Re-engineering (BPR) – Enterprises Resource Planning (ERP) – Supply Chain Management (SCM) – Activity Based Management (ABM).

Total (45L) = 45 Hours

Text Books:	
1	Ties, AF, Stoner and R.Edward Freeman, „Management‟ Prentice Hall of India Pvt. Ltd. New Delhi 110 011, 1992.
2	Joseph J, Massie, „Essentials of Management‟ Prentice Hall of India Pvt. Ltd. 1985.
3	P.C. Tripathi & P.N. Reddy, „Principles of Management‟, Tata McGraw Hill, 2006.
4	Ravi M. Kishore, "Project Management", Tata McGraw Hill, New Delhi, 2007.
E-References:	
1	https://nptel.ac.in/courses/112107142/
2	https://nptel.ac.in/courses/112107143/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the basics of the industrial management and the outline of industrial factors.	L2: Understanding
CO2	:	Apply the management functions for different situations.	L3: Applying
CO3	:	Apply their learning behaviour in an industrial set up.	L3: Applying
CO4	:	Improve Personality skills, Major determination in profession in group behaviour.	L1: Remembering
CO5	:	Discuss the modern concepts for better industrial management.	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	2	1				1
CO2							1	1			1	2				1
CO3										1	2	1				1
CO4											1	1				1
CO5											1	1				1
Avg.	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	0.0	1.0	1.4	1.2	0.0	0.0	0.0	1.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MT703	TOTAL QUALITY MANAGEMENT		Semester			VII
PREREQUISITES		**Category**	**HS**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To learn important concepts of quality management, to learn about quality philosophy and to learn about statistical tools used in quality.

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, Historical Review, Principles of TQM, Leadership-Concepts, Role of Senior Management, Quality Council, Quality Statements, Strategic Planning, Deming Philosophy, Barriers to TQM Implementation.					
UNIT II	**QUALITY MANAGEMENT SYSTEMS**	**9**	**0**	**0**	**9**
Leadership – Organizational Structure - Team Building - Information Systems and Documentation – Quality Auditing – Brief overview of ISO 9001:2015, ISO/TS 16949:2014, ISO 14001:2015 and ISO 45001:2018.					
UNIT III	**TQM TOOLS**	**9**	**0**	**0**	**9**
Business Excellence models (EFQM, Deming, Malcolm Balridge), TQM tools, Simple SQC tools to FMECA, New 7 tools, Business Process Reengineering, Cost/Time diagram, Quality Function Deployment - Business Excellence Awards and Case Studies - Six Sigma concepts, 5S, TPM.					
UNIT IV	**STATISTICAL QUALITY CONTROL**	**9**	**0**	**0**	**9**
Methods and Philosophy of statistical process control –Control Charts for Variables and Attributes – Cumulative sum and Exponential - weighted moving average control charts- other SPC techniques – Process Capability Analysis.					
UNIT V	**EMPLOYEE PARTICIPATION**	**9**	**0**	**0**	**9**
Historical foundation of employee involvement programs, classical and industrial engineering approaches, SQC, Behavioral management innovations, Quality circles, Self managed teams- Implementing Employee Involvement programs, Kaizen (Suggestion schemes).					
					Total (45L) = 45 Hours

Text Books:

1	Juran, J.M. and Gryna, 'Quality Control Hand Book', 2nd Ed., 1999.
2	Evans R. J and Lindsay M. W, 'The Management and control of quality', 2nd Ed, 2011, Jaico Publishing house.

Reference Books:

1	James R. Evans and William M. Lindsay, “The Management and Control of Quality”, 6th Edition, South- Western (Pg.Thomson Learning), 2005.
2	Janakiraman,B and Gopal, R.K, “Total Quality Management – Text and Cases”, Prentice Hall (Pg.India) Pvt. Ltd, 2006.
3	Pathak ,”Total Quality Management- Macmillan publishers India Ltd.
4	Suganthi,L and Anand Samuel, “Total Quality Management”, Prentice Hall (Pg.India) Pvt. Ltd.,2006.

E-References:

1	https://onlinecourses.nptel.ac.in/noc17_mg18/preview
2	https://onlinecourses.nptel.ac.in/noc18_mg04/preview

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Discuss the principles and concepts of Total Quality Management.	L2: Understanding
CO2	:	Apply the Quality Management System and ISO certification process and its need for the industries.	L3: Applying
CO3	:	Familiarize with various tools available for Total Quality Management.	L2: Understanding
CO4	:	Apply the statistical tools to ensure quality in industries.	L3: Applying
CO5	:	Explain the importance and methods of employee participation to maintain quality.	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
CO2						1		1		1	2	1				1
CO3							1			1	1	1				1
CO4											2	1				1
CO5											1	1				1
Avg.	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0	1.0	1.4	1.0	0.0	0.0	0.0	1.0

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

22MT704	MATERIALS CHARACTERIZATION AND COMPUTER APPLICATIONS LABORATORY				Semester		VII
PREREQUISITES			**Category**	**PC**	**Credit**		**1.5**
Materials characterization and Metallurgical Thermodynamics			**Hours/Week**	**L**	**T**	**P**	**TH**
				0	**0**	**3**	**3**

Course Learning Objectives

1.	To describe the various characterization methods and use of the tools.
2.	Compare the non-destructive testing with their principles with their principles and procedures for quality control.
3.	To become familiar with computational technique on thermodynamic and kinetics related mathematical background.

Materials Characterization Experiments

1.	(a) Determination of average grain size and volume fraction of phases using image analysis,, (b) nodularity and nodule count in cast iron using image analysis.
2.	(a) Determination of Structure Factor for BCC and FCC structure, (b) Indexing of XRD patterns.
3.	(a) Estimation of precise lattice parameter of cubic crystals, (b) Determination of crystallite size and r.m.s. strain for mechanically alloyed power.
4.	(a) Analysis of SEM & TEM images, (b) Interpretation of DSC curves.
5.	(a) Visual inspection, (b) Liquid penetrant inspection.
6.	(a) Magnetic particle inspection, (b) Eddy current inspection,
7.	Identification of welding & casting defects in radiographs.
8.	Ultrasonic testing, use of IIW blocks and Reference Blocks.

Computer Applications Experiments

Note : Compute the following experiments through programming and exhibit the results in graphicalmode

9.	(a) Factorial computation of a given number, (b) Determine Parametric approaches in creep data, Larson miller parameter.
10.	(a) Solve and give Numerical solution for non-linear equations, (b) Determination of unsteady state heat for low-cooling of a slab.
11.	(a) Calculation of adiabatic flame temperatures, at the tuyers of a coke fueled shaft furnace, (b) Calculation of heat loss through furnace wall in transfer ladle,
12.	(a) Calculation of Enthalpy change using thermo-chemical data, (b) Determination of Enthalpy and free energy change of a reaction.

Total (45P) = 45 Hours

E Reference

1.	https://materialsproject.org/
2	Myscope .training

3	www.doitpoms.ac.uk

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Illustrate indexing, calculate the residual stress and lattice parameter using XRD pattern.	L3: Applying
CO2	:	Analyze various micrographs by SEM, TEM and DSC curves.	L4: Analyzing
CO3	:	Demonstrate the testing procedures and identify the defects.	L3: Applying
CO4	:	Demonstrate the various metallurgical numerical problems using computer C program.	L3: Applying
CO5	:	Interpret the C program results in the graphical mode.	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	2			1	1			1				2		1	1
CO2	1		1	1	3		1		1			1	2			1
CO3	1	1		1							2					
CO4	1	2			1						1				1	
Avg.	1.0	1.7	1.0	1.0	1.7	1.0	1.0	0.0	1.0	0.0	1.5	1.0	2.0	0.0	1.0	1.0

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

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22MT705	MANUFACTURING PROCESSES LABORATORY			Semester		VII
PREREQUISITES		**Category**	**PC**	**Credit**		**1.5**
Casting Engineering, Forming processes, Welding Engineering		**Hours/Week**	**L**	**T**	**P**	**TH**
			0	**0**	**3**	**3**

Course Learning Objectives	
1	To know and apply the concept of casting technology for green sand testing.
2	To know and apply the concept of forming technology for various structural engineering applications.
3	To know about the concepts of welding technology and apply them for the fabrication of components.
Casting Experiments	
1.	Determine Average grain fineness number.
2.	Conduct clay content, moisture content and mouldability of green sand.
3.	Determination of green hardness, compression and shear strength.
4.	Determine permeability and shatter index test of green sand.
Forming Experiments	
1.	Determine Tension Test - n and k value of rod/sheet.
2.	Determine Erichsen index and Cold rolling reduction percent of aluminium/brass sheets.
3.	Effect of Recrystallisation annealing temperature & time on cold worked alloys.
4.	Determination of Flow rate, Apparent and Tap densities of Powders.
Welding Experiments	
1	Preparation of square butt joint and T-joint using Shielded Metal Arc Welding process.
2	Effect of welding parameters on weld bead characteristics (using Profile projector) and Microstructural observation of weldments.
3	Study and demonstration of GTA welding, GMA welding and Solid state welding processes.
4	Practice for preparation of WPS and PQR.
	Total (45P) = 45 Hours

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Estimate the properties of the green sand.	L4: Analyzing
CO2	:	Evaluate the formability behaviour of different sheet/rod/wire/powder materials.	L4: Analyzing

CO3	:	Prepare square butt and T joints with SMAW process, analyse the effect of welding parameters on the weld bead and demonstrate GTAW, GMAW and solid state welding processes.	L4: Analyzing
CO4	:	Interpret the microstructure and macrostructure analysis of weldment and preparation of WPS/PQR	L4: Analyzing

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	1							2	1		
CO2	1	2	1				1						1			1
CO3	1	1	1	1								1	3		1	
CO4	1	1											2			
Avg.	1.3	1.3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	2.0	1.0	1.0	1.0

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

22MT801	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 for various concepts of metallurgical processes, materials and its applications, 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 work should involve research, design/fabrication, generation/collection and analysis of data with solution 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 (120P) =120 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 various metallurgical applications.	L6: Creating
CO2	Create an environment to convert the ideas into design of prototype for useful industrial and societal applications.	L6: Creating
CO3	Create an environment to convert the design into manufacturing of prototype for useful industrial, agricultural and social applications.	L2: Understanding
CO4	Assign and undertake tasks in a team as per team discussion.	L5: Evaluating
CO5	Do presentation and write technical reports for effective communication within and outside the team.	L5: Evaluating

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	3	2	2	3	1	3		2		3	3	3	3
CO2	3	3	2	2	2	3	3		3		1		3	3	2	3
CO3	2	2	2	2	2	1	1	1	3	1	2	3	2	2		2
CO4	2	2	2	1	1	1	2	3	3	3		3	2	3		2
CO5					2	2		1	3	3		2	3		3	2
Avg	2.5	2.5	2.0	2.0	1.8	1.8	2.3	1.5	3.0	2.3	1.7	2.7	2.6	2.8	2.7	2.4
	3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

PROFESSIONAL ELECTIVE COURSES

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PROFESSIONAL ELECTIVE COURSES (PEC)

<table>
<tr><td>22MTPE11</td><td colspan="3">TRANSPORT PHENOMENA</td><td colspan="3">Semester</td><td>VI</td></tr>
<tr><td colspan="3" rowspan="3">Engineering Physics & Engineering Mathematics</td><td>Category</td><td>PE</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>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
</table>

(Use of HMT data book is permitted in University Examinations)

Course Objectives:

1. To understand basic concepts related to heat flow, fluid flow, mass transfer, in the context of metallurgical processes; to become familiar with the mathematical treatment and equations related to above transport phenomena; to comprehend the science behind process modeling.

UNIT I	**MOMENTUM TRANSFER – I**	**9**	**0**	**0**	**9**

Properties of fluid – Dimensions and Units, Newton's law of viscosity, Types of fluids, Types of flow, Classical Reynold's experiment, Concept of pressure and its measurement, Steady state - Hagen-Poiseuille equation, Laminar flow through circular pipe and flow over flat plate, Equation of Continuity, Concept of velocity boundary layer.

UNIT II	**MOMENTUM TRANSFER – II**	**9**	**0**	**0**	**9**

Creeping flow past a sphere – Stoke's law, Navier-Stokes equation, Bernoulli's equation and its applications of flow measurement by Venturimeter, Orifice meter and Pitot tube. Major and Minor head losses in fluid flow (Simple problems), Introduction - flow through packed bed of solids and fluidized beds, compressible flow and supersonic nozzles.

UNIT III	**HEAT TRANSFER – I**	**9**	**0**	**0**	**9**

Conduction: Fourier's law, Thermal conductivity of solids and fluids. General heat conduction equation, Steady state heat conduction in flat plates, cylinders, Composite walls – simple problems, Transient heat conduction system – lumped capacitance approach. Convection: Correlation for heat transfer with forced convection – flow through pipes, flow over plates (no derivations, simple problems only).

UNIT IV	**HEAT TRANSFER – II**	**9**	**0**	**0**	**9**

Correlation for heat transfer with natural convection – Heat transfer by natural convection from vertical plates, Natural convection over horizontal plates (no derivation, simple problems only), Concept of overall heat transfer coefficient and thermal boundary layer, Solidification heat transfer. Radiation: Fundamental laws, black body radiation, emissivity, absorptivity, reflectivity, transmissivity, Kirchhoff's law, view factors, radiation exchange between surfaces, radiation exchange between black bodies – simple problems.

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

Concept of mass diffusion, Factors affecting diffusivity in solids, liquids and gases. Fick's laws of diffusion and its applications, Darken's law. Steady state unidirectional diffusion: diffusion through a stagnant fluid. Introduction to Unsteady state diffusion. Mass transfer by forced and free convection in laminar flow, Mass transfer coefficients and concentration boundary layer. Dimensional Analysis- Rayleigh and Buckingham π method.

Total (45L) = 45 Hours

Text Books:

1. Gaskell, D.R., An Introduction to Transport Phenomena in Materials Engineering, 2nd Edition, Momentum Press,New Jersey, 2012.
2. Geiger, G.H., and D.R. Poirier, Transport Phenomena in Metallurgy, Addison-Wesley Publishing Company, Inc., Philippines, 1973

Reference Books:	
1.	Bansal R K, A textbook of fluid mechanics and hydraulic machines, Eleventh Edition, Laxmipublication (p) Ltd., New Delhi, 2019.
2.	Sachdeva, R.C., Fundamentals of Engineering Heat and Mass Transfer, New Age International Publishers, 2017.
3.	Bird, R.B., W.E. Stewart, E.N. Lightfoot, and D.J. Klingenberg, Introductory Transport Phenomena, John Wiley & Sons, Inc., 2015
4.	Themelis, N.J., Transport and Chemical Rate Phenomena, Gordon & Breach Publishing Group, 1995.
E References:	
1.	https://archive.nptel.ac.in/courses/103/105/103105128/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Analyze the mechanics of fluid and its basic properties and equation describing its motion and properties.	L4: Analyzing
CO2	:	Interpret the flow of fluids through plates and pipes.	L4: Analyzing
CO3	:	Explain the modes and mechanism of heat conduction of a material.	L2: Understanding
CO4	:	Identify the mode of natural heat transfer and different flow types.	L4: Analyzing
CO5	:	Explain the method of heat transfer and also the means of transfer of materials mass by different methods.	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	2	1	1							1	1			
CO2	1		1			1	1						2			
CO3	2	1	2	1	1								1			
CO4	1	1			1								2			
CO5	1			1									1			
Avg.	1.4	1.0	1.7	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	1.4	0.0	0.0	0.0

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

22MTPE12	FRACTOGRAPHY AND FAILURE ANALYSIS			Semester			VI
PRE-REQUISITES:		Category		PE	Credit		3
Mechanical Behaviour of Materials		Hours/Week		L	T	P	TH
				3	0	0	3

Course Objectives:

1	To learn about various types of failures and their mechanisms

UNIT I	**SOURCES OF FAILURES**	**9**	**0**	**0**	**9**
Deficiencies in Design, Material, Processing, Service and Maintenance. Stages of Failure Analysis, classification and identification of Various Types of Fracture-Overview of fracture mechanics concept. Ductile and Brittle Fracture, Fracture Origin, Initiators, characteristics of Ductile and Brittle Fracture.					
UNIT II	**FATIGUE AND CREEP FAILURE**	**9**	**0**	**0**	**9**
General Concepts, fracture Characteristics Revealed by Microscopy, Factors Affecting Fatigue Life Some Case Studies of Fatigue Failures. Creep, Stress Rupture, Elevated Temperature Fatigue, Metallurgical Instabilities, Environmental Induced Failure, Elevated Temperature Effects on Certain Gas Turbine Components and Petroleum Refinery Components.					
UNIT III	**WEAR AND CORROSION FAILURES**	**9**	**0**	**0**	**9**
Types of Wear, Role of Friction in Wear, Lubricated and Non-Lubricated Wear, Analyzing Wear Failure. Corrosion Failures-Factors Influencing Corrosion Failures, Analysis of Corrosion Failures, overview of Various types of Corrosion Stress Corrosion Cracking, Sources. Characteristics of Stress Corrosion Cracking. Procedure for Analyzing Stress Corrosion Cracking, various types of Hydrogen Damage Failures.					
UNIT IV	**FAILURE OF FORGING, CASTING AND WELDMENTS**	**9**	**0**	**0**	**9**
Causes of Failure in Forging like material characteristics, Deficiencies in design, Improper Processing, Fabrication or Deterioration resulting from service conditions, Failure of Iron and Steel Castings, effect of Surface Discontinuities, Internal Discontinuities, Microstructure, Improper Composition, Improper Heat Treatment, Stress Concentration and Service Conditions. Failure of Weldments-Reasons for Failure procedure for Weld Failure Analysis.					
UNIT V	**RELIABILITY**	**9**	**0**	**0**	**9**
Reliability Concept and Hazard Function, Life Prediction, Condition Monitoring, Application of Poisson. Exponential and Weibull Distribution for Reliability, Bath Rub Curve, Parallel and Series system, Mean Time Between Failures andLife Testing.					
					Total (45L) = 45 Hours

Text Books:

1.	Colangelo, V.J., and F.A. Heiser, Analysis of Metallurgical Failures, John Wiley and Sons Inc., NewYork, USA, 1974.
2.	Charlie R Brooks, Ashok Choudhury Metallurgical Failure Analysis, McGraw -Hill Publishing Co. USA,1993

Reference Books:

1.	ASM Handbook, Vol. 10: Failure Analysis and Prevention, ASM Metals Park, Ohio, 1995
2.	Das, A.K., Metallurgy of 'Failure Analysis, Tata McGraw-Hill Publishing Co., New Delhi, 1996.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Identify the different sources of failures and specify the deficiencies in design, material, processing, service and maintenance.	L3: Applying
CO2	:	Discuss the fatigue and creep failures that take place under cyclic loading and high temperature conditions.	L2: Understanding
CO3	:	Illustrate the failures occurring due to wear and corrosion damages.	L3: Applying
CO4	:	Contrast the failures occurring due to the process of forging, casting and weldments.	L4: Analyzing
CO5	:	Describe the process of reliability concept and hazard function and the different systems.	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		
CO2	2		1		1	1							1		1	
CO3	2	1	2	1			1					1		2		
CO4	1	2		1	1						1		1		1	
CO5	1	1											1			
Avg.	1.4	1.3	1.5	1.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0	1.0	1.5	1.0	0.0

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

22MTPE13	METALLURGICAL KINETICS		Semester			VI
Metallurgical Thermodynamics and Kinetics.		Category	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	To learn the basic principles and concepts of kinetics, in the domain of metallurgy and materials; and to learn about equations and their applications; and to appreciate that metallurgical kinetics is 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 model for mass transfer coefficients, Correlations for heat and mass transfer coefficients.

UNIT III	KINETICS OF LIQUID-SOLID TRANSFORMATION	9	0	0	9

Kinetics of liquid-liquid reaction, Kinetics of liquid-solid transformation - driving force, homogeneous and heterogeneous nucleation kinetics, kinetics of growth, kinetics of alloy solidification. Solid state phase changes - classification, nucleation and growth processes.
Diffusion - driving force, classification, Ficks laws and diffusion coefficients.

UNIT IV	KINETICS OF SOLID-STATE PHASE TRANSFORMATION	9	0	0	9

Kinetics of solid-state phase transformation - scope and classification, kinetics of homogeneous and heterogeneous nucleation, interface growth velocity, kinetics of special transformations (Widmanstatten, massive, polymorphic, coarsening, recrystallization, age hardening), kinetics of invariant and moving boundary transformation.

UNIT V	OVERALL TRANSFORMATION KINETICS	9	0	0	9

Kinetics of phase transition in polymers, glass, ceramics. Overall transformation kinetics - Johnson-Mehl and Avrami s model, kinetics of non-random nucleation, kinetics of diffusion controlled, isothermal and non-isothermal kinetics analysis.

Total (L)=45 Hours

Text Books:

1.	AhindraGhosh and Sudipta 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

Reference Books:

1.	F. Habashi, Kinetics of Metallurgical Processes, Métallurgie Extractive Québec, 1999
2.	Upadhyaya G S and Dube R K., "Problems in Metallurgical Thermodynamics & Kinetics", Pergamon, 1977.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Review the roles of kinematics, heat and mass transfer in metallurgy.	L2: Understanding
CO2	:	Report the kinematics of solid-fluid-gas reaction.	L3: Applying
CO3	:	Discuss the kinematics of solid-fluid transformation.	L3: Applying
CO4	:	Recall the knowledge on solid phase transformation.	L3: Applying
CO5	:	Discuss the overall transformation 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	2	1	1			1						1			
CO2	2	1	1		1	1							1			
CO3	2	1		1									1			
CO4	1	1		1	2								1			
CO5	1	1		1									1			
Avg.	1.4	1.2	1.0	1.0	1.5	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0

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

22MTPE14	SOLIDIFICATION PROCESSING			Semester			VI
Casting Engineering		Category		PE	Credit		3
		Hours/Week		L	T	P	TH
				3	0	0	3

Course Objectives:	
1.	To acquire basics knowledge on solidification, heat transfer, dendritic growth, runner, riser and fluid flow

UNIT I	**PRINCIPLES OF SOLIDIFICATION**	**9**	**0**	**0**	**9**
Thermodynamics of solidification: pure metal solidification i.e. G vs T curves for liquid and solid, alloy solidification.Scheil equation: Mathematical analysis of redistribution of solute during directional solidification Hierarchy of equilibrium, Local Interface equilibrium, Interface non-equilibrium.					
UNIT II	**THEORIES OF GRAIN GROWTH**	**9**	**0**	**0**	**9**
Microsegregation, Constitutional undercooling, Theories of nucleation and growth: Mullins-Sekerka instability, Ivantsov‘s theory of dendritic growth. Macro scale Phenomena- Mathematics of diffusive transport, Macro mass Transport-solute diffusion controlled segregation, analysis of solute redistribution- Macro modeling of solidification.					
UNIT III	**SOLIDIFICATION AND TYPES OF CASTING**	**9**	**0**	**0**	**9**
Multi phase solidification: regular and irregular eutectic solidification, Hunt-Jackson theory of eutectic growth, peritectic growth, Structure of casting and ingots, Types of casting, Heat transfer.					
UNIT IV	**MELTING FURNACES AND KINETICS**	**9**	**0**	**0**	**9**
Design of riser and gating, Solidification, heat transfer, fluid flow during fusion welding. Casting Defects. Melting furnaces. Role of kinetics,heterogeneous and homogeneous kinetics- Kinetics of solid-fluid reaction- Solid state diffusive transformation- Mechanism of transformation.					
UNIT V	**MELTING AND SOLIDIFICATION OF ALLOYS**	**9**	**0**	**0**	**9**
Melting and solidification of cast irons and aluminium. Solidification, heat transfer and fluid flow during fusion welding.					
					Total (45L) = 45 Hours

Text Books:	
1.	Kurz and Fisher: Solidification Processing, Trans Tech publications 1998.
2.	R. W. Heine, C. R. Loper, P. C. Rosenthal: Principles of metal casting, McGraw Higher Ed 1976.

Reference Books:	
1.	K. Easterling: Introduction to Physical metallurgy of welding, Butterworth-Hienemann 1992.
2.	P. K. Jain: Principles of foundry technology, McGraw-Hill 1987

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the principles of solidification in metals and alloys	L2: Understanding
CO2	:	Describe the different theories of grain growth.	L2: Understanding
CO3	:	Compare different casting techniques.	L3: Applying
CO4	:	Identify the melting furnaces and kinetics.	L3: Applying
CO5	:	Compare the melting and solidification of alloys.	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	1								1	1		
CO2	1	2	1											1		
CO3	2	2		1										1		
CO4	1	1	1		1		1						1	1		
CO5	1	1		1										1		
Avg.	1.4	1.4	1.0	1.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MTPE15	FERROUS AND NON-FERROUS ALLOYS				Semester	VI
Elements of physical Metallurgy and Advanced Physical metallurgy		Category	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1. To study the fundamentals, properties and applications of Ferrous and Non Ferrous systems.

UNIT I	ALLOY STEELS	9	0	0	9

Introduction: Modern melting processes for making special steels; the effect of alloying elements on Steel. Maraging steels, HSLA, micro alloyed steels, silicon steels, CRGO (Cold Rolled Grain Oriented Sheet) steels and high manganese steels: structure, property, heat treatment and applications. Steels for special applications**:** Armour steel, steels for high temperature applications–High carbon steels, Ultra high strength steels, creep resistant steels.

UNIT II	STAINLESS STEELS	9	0	0	9

Types of stainless steels: ferritic, martensitic, austenitic, precipitation hardening and duplex – structure, properties and applications; nickel free stainless steels, high nitrogen stainless steels – manufacture, structure, properties and applications. Sensitisation and the remedial measures for austenitic stainless steel.

UNIT III	COPPER ALLOYS	9	0	0	9

Properties and applications of copper, influence of alloying elements. Structure, properties and applications of Brasses, Bronzes and copper-nickel alloys. Strengthening of copper alloys by mechanical alloying, OFHC copper and its applications. Heat Treatment of Copper Alloys.

UNIT IV	LIGHT METALS AND ALLOYS	9	0	0	9

Properties and applications of Aluminium. Classification of Aluminium alloys. Wrought and Cast alloys, Heat treatable and Non-heat treatable, Age hardening. Al-Li alloys, superplastic forming of Al alloys. Properties and applications of Magnesium, influence of alloying elements. Classification – cast alloys and wrought alloys. Titanium -Unique characteristics. Alloying elements – Alpha stabilisers; beta stabilisers. α, α-β and β Titanium alloys – structure, properties and applications; thermo - mechanical processing; near-net shape processing; superplastic forming of titanium alloys. Titanium aluminides - properties and uses.

UNIT V	NICKEL AND OTHER ALLOYS	9	0	0	9

Properties of nickel and uses of nickel, Nickel base super alloys composition; solid solution alloys, precipitation hardenable alloys, ODS alloys - heat treatment, properties and applications; Nickel-iron base alloys - heat treatment, properties and applications; Ni base soft magnetic alloys, Ni base heating element alloys; Ni base controlled expansion alloys; nickel base DS alloys and single crystals. Nickel in special alloys and magnetic materials, Nickel aluminides. Zinc alloys, properties and uses, Die casting qualities. Use of zinc in corrosion protection of ferrous materials. Lead, Tin alloys. Major characteristics and applications, low melting nature solder alloys.

Total (45L) = 45 Hours

Text Books:	
1.	William F Smith, Structure and Properties of Engineering Alloys, McGraw Hill India, 1993.
2.	P.C. Angelo, B.Ravisankar, ―Non-Ferrous Alloys: Structure, Properties and Engineering applications, CengageLearning India Pvt. Ltd., New Delhi, 2017.
3.	Brick, Gordon and Pense, Structure and Properties of Engineering Materials, McGraw Hill Book Co., New York,1992.

Reference Books:	
1.	K.G.Budinski and M.K.Budinski, Engineering Materials- Properties and Selection, PHI Learning Pvt Ltd, NewDelhi, 2010.
2.	Clark and Varney, Physical Metallurgy for Engineers, Affiliated east West press, New York, 1987.
3.	Balram Gupta, Aerospace Materials, Vol.1,2 and 3, S.Chand & Co., New Delhi, 1996.
E-References:	
1.	www.nptel.ac.in/courses/113105021/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Distinguish different types of alloy steels.	L4: Analyzing
CO2	:	Discuss the types of stainless steels, properties and their applications.	L3: Applying
CO3	:	Discuss and describe the properties and applications of copper alloys.	L3: Applying
CO4	:	List the light weight division of aluminium alloys, Magnesium and Titanium alloys.	L2: Understanding
CO5	:	Explain the importance and applications of Nickel, Lead, zinc and tin alloys	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	1									2		
CO2	1	1	1				1						1	1		
CO3	1	2		1	1									1		
CO4	2	1		1		1							1	2		
CO5	1	1			1									1		
Avg.	1.4	1.2	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.4	0.0	0.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MTPE21	COMPOSITE MATERIALS				Semester			VI
Physical metallurgy and Engineering Chemistry			Category		PE	Credit		3
			Hours/Week		L	T	P	TH
					3	0	0	3

Course Objectives:

1.	To know manufacture of different type of Composite materials and develop for specific engineering applications

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

Fundamentals of composites - need for composites – enhancement of properties - classification of composites – Matrix-Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC) – Reinforcement – particle reinforced composites, Fibre reinforced composites. Applications of various types of composites. Fiber production techniques for glass, carbon and ceramic fibers.

UNIT II	**POLYMER MATRIX COMPOSITES**	**9**	**0**	**0**	**9**

Polymer resins – thermosetting resins, thermoplastic resins – reinforcement fibres – rovings– woven fabrics – non woven random mats – various types of fibres. PMC processes - 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 (GFRP). Laminates- different types.-applications of PMC in aerospace, automotive industries.

UNIT III	**METAL MATRIX COMPOSITES**	**9**	**0**	**0**	**9**

Characteristics of MMC, various types of metal matrix composites alloy vs. MMC, advantages of MMC, limitations of MMC, Reinforcements – particles – fibres. Effect of reinforcement – volume Fraction – rule of mixtures. Processing of MMC – powder metallurgy process - diffusion bonding– stir casting – squeeze casting, a spray process, Liquid infiltration In-situ reactions-Interface measurement of interface properties- applications of MMC in aerospace, automotive industries.

UNIT IV	**CERAMIC MATRIX COMPOSITES AND SPECIAL COMPOSITES**	**9**	**0**	**0**	**9**

Engineering ceramic materials – properties – advantages – limitations – monolithic ceramics -need for CMC – 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 and Hot Iso-static pressing (CIP and HIP). Applications of CMC in aerospace, automotive industries- Carbon /carbon composites – advantages of carbon matrix – limitations of carbon matrix carbon fibre – chemical vapour deposition of carbon on carbon fibre perform. Sol-gel technique Processing of Ceramic Matrix composites.

UNIT V	**MECHANICS OF COMPOSITES**	**9**	**0**	**0**	**9**

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

Total (45L) = 45 Hours

Text Books:

1.	Mathews F. L. and Rawlings R. D., Composite Materials: Engineering and Science, Chapman and Hall, London,England, 1st edition, 1994.
2.	Chawla K. K., Composite materials, Springer – Verlag, Second Edition, 2006.

Reference Books:

1.	Clyne, T. W. and Withers, P. J., Introduction to Metal Matrix Composites, Cambridge University Press,

	1993.
2.	Strong, A.B., Fundamentals of Composite Manufacturing, SME, 1989.
3.	Mallick P.K, Fibre-Reinforced Composites; materials, Manufacturing & Design, Third edition, CRC Press,2007.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the composites and know their properties.	L2: Understanding
CO2	:	Explain the processing of polymer matrix composites and their applications.	L3: Applying
CO3	:	List the various types of the metal matrix composites, and their applications.	L3: Applying
CO4	:	Illustrate the concept of ceramic matrix composite and other special composites.	L2: Understanding
CO5	:	Identify the mechanics of composites and determine the lamina stresses within laminates.	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	2		1	1								1	1		
CO2	2	1				1	1						1			
CO3	1	2	1	1	1									2		
CO4	1	2		1	1								1			
CO5	1	1											1	1		
Avg.	1.4	1.6	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.3	0.0	0.0

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

22MTPE22	CERAMIC MATERIALS		Semester			VI
Physical Metallurgy and Engineering Chemistry		Category	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	To study about preparation, properties and applications of ceramic materials

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

Review of bonding types in ceramics – calculation of percentage ionic character. Types of Ceramics, Ceramic crystal structures: Sodium chloride, cesium chloride, alumina, spinel and fluorite structures -examples. Co-ordination number and ionic radius ratio - Pauling's R

UNIT II	**PROPERTIES AND APPLICATIONS OF ENGINEERING CERAMICS**	**9**	**0**	**0**	**9**

Ceramics for mechanical functions: Abrasives - properties and applications SiC, Cubic Boron Nitride (CBN) - properties and applications. Ceramics for electrical and insulating functions - Barium Titanate and its modifications - insulating porcelains - properties and applications. Ceramics for magnetic functions - Normal and inverse spinel structure - Zinc, Nickel, Manganese and Iron ferrites - structure properties and applications Ceramics for thermal functions: Refractories - Desirable characteristics - applications - Ceramics for nuclear applications.

UNIT III	**PREPARATION AND FORMING OF CERAMICS**	**9**	**0**	**0**	**9**

Preparation of Alumina, Zirconia, Silicon carbide, Silicon Nitrides, Boron Nitride, Brief description of slip and slurry casting - applications. Powder processing equipment and process details of hot pressing, Hot Isostatic Pressing and Cold Isostatic Pressing. Liquid Phase sintering. shock wave compaction, reaction sintering, cermets.

UNIT IV	**GLASSES**	**9**	**0**	**0**	**9**

Types of glasses - structure, properties and applications of various types of glasses. Silicate Glass ceramics- heat flow and precipitation from glasses – growth controlled by diffusion of solutes – crystalline glasses - enamels – photosensitive and photo chromic glasses; Blowing, pressing, drawing, rolling and casting - Pilkington process for float glass.

UNIT V	**PROPERTY EVALUATION**	**9**	**0**	**0**	**9**

Rupture strength; fracture Toughness, Elastic Constants, Hardness, Creep, Thermal Property Coefficient of thermal expansion, Electronic Property, Measurement of electro-optic properties Weibull Statistics of Strength Data for Fine Ceramics.

Total (45L) = 45 Hours

Text Books:

1.	Michael Barsoum, Fundamentals of Ceramics, McGraw Hill Publishing Co. Inc, 1997.
2.	Kingery, W D, Introduction to Ceramics, John Wiley, USA, 1960

Reference Books:

1.	William F.Smith, Foundations of Materials Science and Engineering, Second Edition, McGraw- Hill Inc, New York, 1993.
2.	VanVlack K H, Physical Ceramics for Engineers, Addison Wesley, 1964.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Differentiate the structure and properties of different ceramic materials.	L4: Analyzing
CO2	:	Identify the properties and applications of ceramics.	L4: Analyzing
CO3	:	Discuss the production of ceramic materials.	L2: Understanding
CO4	:	Distinguish the structure, properties and applications of various glasses.	L4: Analyzing
CO5	:	Identify the mechanical, thermal and electro-optic properties of ceramic 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			
CO2	2	1			1	1	1							2		
CO3	2	2		1	1								1			
CO4	1	3		1		1	1							1		
CO5	1			1	1									1		
Avg.	1.4	2.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.3	0.0	0.0

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

22MTPE23	METALLURGY OF TOOL STEELS			Semester		VI
Advanced physical Metallurgy		Category	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	To gain understanding of heat treatment of tool components based on geometry and understand the metallurgy of different tool steel and in the materials.

UNIT I	FUNDAMENTALS OF HEAT TREATMENT AND TOOL STEELS	9	0	0	9

Classification of Tool steels-AISI system-composition of tool steels-Effect of alloying elements on Fe-C system, TTT diagrams, Formation of complex carbides, austenite formation, Hardenability and Tempering Effect of specific alloying elements. Heat Treatment of Tool steels: their characteristics and selection Distortion in tool steels during heat treatment, selection of tool steels for various application-Manufacturing methods of tool steels.

UNIT II	HEAT TREATMENT AND METALLURGY OF W, S, O, A & D TYPE TOOL STEELS	9	0	0	9

Water hardening tool steels, shock resistance tool steels, cold work tool steels-oil hardening, medium alloy and high carbon-high Cr (O,A&D types): Constitution, classification of principal types, heat treatment process, hardenability,distortion characteristics, properties and application.

UNIT III	HEAT TREATMENT AND METALLURGY OF H, T, M, SPECIAL PURPOSE TOOL STEELS	9	0	0	9

Hot work tool steels, high speed tool steels, maraging tool steels, special purpose tool steels: constitution, classification of principal types, heat treatment process, specific requirements and applications.

UNIT IV	ADVANCED TOOL MATERIALS	9	0	0	9

Sintered tungsten carbide tools-ISO classification-Uses of P, M and K grades-cermet-ceramics, mixed and reinforced grades-cubic boron nitride-polycrystalline diamond-Manufacturing techniques-properties.

UNIT V	SURFACE TREATMENTS AND COATINGS	9	0	0	9

Sulphidising of tool steels – Ti N coating by PVD - coating of carbide tools - mono and multi layer coatings of Ti C, Ti N, Alumina and DLC by PVD and CVD processes - selection of tool materials

Total (45L) = 45 Hours

Text Books:

1.	Robert Wilson, –Metallurgy and Heat Treatment of Tool Steels, McGraw-Hill, New York, 1975.
2.	Payson, —Metallurgy of Tool Steels, John Wiley and sons, New York, 1962.

Reference Books:

1.	Davis.J.R. —ASM Speciality Handbook-Tool Materials", American Society of Metals, Metals Park, Ohio, USA,1995.
2.	George Roberts, George Krauss and Richard Kennedy, –Tool Steels", ASM International, 1998, Metals Park, Ohio, USA, 1998
3.	Roberts, Haymaker and Johnson, –Tool Steels, 3 rd edition, ASM, 1962.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	List the tool materials according to AISI systems and discuss the heat treatment of tool steels.	L2: Understanding
CO2	:	Discuss the heat treatment methods adopted for tool steels.	L2: Understanding
CO3	:	Describe properties and the testing methods that are adopted for tool steels.	L2: Understanding
CO4	:	Interpret the production and properties of advanced tool steels.	L3: Applying
CO5	:	Name the coatings on tool steels.	L2: Understanding

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	1	1								1			
CO2	1	1		1	1	1							1			
CO3	2	2		1	1		1							1		
CO4	2	1		1	1									2		
CO5	1	1		1	1	1							1			
Avg.	1.6	1.2	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.5	0.0	0.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

<table>
<tr><td>22MTPE24</td><td colspan="2">BIO AND SMART MATERIALS</td><td colspan="2">Semester</td><td>VI</td></tr>
<tr><td colspan="2" rowspan="3">Elements of Physical Metallurgy</td><td>Category</td><td>PE</td><td>Credit</td><td>3</td></tr>
<tr><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P / TH</td></tr>
<tr><td>3</td><td>0</td><td>0 / 3</td></tr>
</table>

Course Objectives:

1. To study about Bio and shape memory material, dental materials

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

Smart materials–Functional materials–Poly functional materials–Structural materials, Electrical materials, bio- compatible materials–Intelligent biological materials–Biomimetics–Wolff‟s Law– Biocompatibility–Material response: swelling and leaching, corrosion and dissolution, deformation and failure, friction and wear–host response: the inflammatory process–coagulation and hemolysis–in vitro and in vivo evaluation of biomaterials.

UNIT II	**ELECTRO-RHEOLOGICAL AND PIEZOELECTRIC MATERIALS**	**9**	**0**	**0**	**9**

The principal ingredients of smart materials–microsensors-hybrid smart materials-an algorithm for synthesizing smart materials–active, passive reactive actuator based smart structures suspensions and electro-rheological fluids–fluidactuators-design parameter–application of Electro-rheological fluids–Basics, Principles and instrumentation and application of Magnetorheological fluids–Piezoelectric materials: polymers and ceramics, mechanism, properties and application. Introduction to electro-restrictive and magneto-restrictive materials

UNIT III	**SHAPE MEMORY MATERIALS**	**9**	**0**	**0**	**9**

Nickel –Titanium alloy (Nitinol)–Materials characteristics of Nitinol–martensitic transformations– austenitic transformations–thermo elastic martensitic transformations–classification of SMA alloys- mechanism of magnetic SMA–applications of SMA–continuum applications of SMA fasteners–SMA fibers–reaction vessels, nuclear reactors, chemical plant, etc.–SMA memorization process (Satellite Antenna Applications) SMA blood clot filter–Impediments to applications of SMA–Shape memory polymers–mechanism of shape memory-Primary moulding–secondary moulding–types and applications.

UNIT IV	**ORTHOPAEDIC AND DENTAL MATERIALS**	**9**	**0**	**0**	**9**

Bone and teeth composition, formation and properties–bioresorbable, bioinert, bioactive materials-temporary fixation devices–joint replacement–biomaterials used in bone and joint replacement metals and alloys-Fillings and restoration materials–Materials for oral and maxillofacial surgery–dental cements and dental amalgams–dental adhesives-bone tissue engineering.

UNIT V	**BIO MATERIALS FOR CARDIOVASCULAR OPHTHALMOLOGY AND SKIN REGENERATION**	**9**	**0**	**0**	**9**

Blood clotting–blood theology–approaches to thrombo resistance materials development–blood vessels–The heart–aorta and valves–geometry of blood circulation–cardiac pacemakers–blood substitutes–extracorporeal blood circulation devices. The lungs–vascular implants: vascular graft, cardiac valve prostheses, card–Biomaterials in ophthalmology-skin grafts-connective tissue grafts- tissue adhesives- drug delivery methods and materials.

Total (45L) = 45 Hours

Text Books:

1.	Sujata V., Bhat., Biomaterials, Narosa Publication House, New Delhi, 2002
2.	M. V. Gandhi and B. S. Thompson, Smart Materials and Structures, Chapman and Hall, London, FirstEdition, 1992

Reference Books:

1.	Duerig,T. W., Melton, K. N, Stockel, D. and Wayman, C.M., Engineering aspects of Shape memory Alloys,Butterworth – Heine
2.	Rogers, C. A., Smart Materials, Structures and Mathematical issues, Technomic Publishing Co., U.S.A, 1989.

3.	Mohsen Shahinpoor and Hans-Jo¨rg Schneider Intelligent Materials, RSC Publishing, 2008
4.	Mel Schwartz (Ed), Encyclopaedia of Smart Materials Volume –I and II, John Wiley & Sons, Inc.2002

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Classify the different types of bio and smart materials.	L3: Applying
CO2	:	Discuss the electro-rheological and piezoelectric materials.	L2: Understanding
CO3	:	Identify the shape memory alloys in engineering applications.	L3: Applying
CO4	:	Discuss about the orthopedic and dental materials applications.	L2: Understanding
CO5	:	Describe the biomaterials for cardiovascular Ophthalamology and Skin Regeneration.	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	2		
CO2	1	2		1	1									1		
CO3	2	1		1	1	1	1						1	2		
CO4	1	1	1											1		
CO5	2	2		1	1								1			
Avg.	1.4	1.6	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.5	0.0	0.0

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

22MTPE25	WELDING METALLURGY				Semester	VI
Welding Engineering, Physical Metallurgy, Ferrous and Non-ferrous alloys	Category	PE	Credit			3
	Hours/Week	L	T	P		TH
		3	0	0		3

Course Objectives:

1.	To familiarize with the weldability of metals and alloys.
2.	To interpret the physical metallurgy of metals and alloys with their welding metallurgy.

UNIT I	PHYSICAL METALLURGY OF WELDING	9	0	0	9

Overview of Binary Phase diagrams: Iron-Carbon diagram, TTT and CCT diagrams. Significance of weld CCT diagram. Precipitation hardening in non-ferrous alloy system. Weld metal solidification: Epitaxial growth, cellular and columnar structures, effect of welding parameters. Absorption of gases – gas/metal and slag/metal reactions. Significance of Acicular ferrite formation and its effect on weldmetal toughness. Classification of steels and cast irons.

UNIT II	WELDING METALLURGY PRINCIPLES	9	0	0	9

Heat flow in welding, Heat affected zone (HAZ), Weld thermal cycles: Basic heat transfer equations - Peak temperature equation and cooling rate equations. Temperature distribution and cooling curves, dependence of cooling rate on heat input, plate thickness, preheat and other factors. Comparison of welding processes based on these considerations, Simple problems. Concept of weld dilution. Dissimilar welding: Metallurgical difficulties encountered.

UNIT III	WELDABILITY OF CARBON STEELS, LOW ALLOY STEELS AND CAST IRONS	9	0	0	9

Weldability of C-Mn and low-alloy steels, formation of different microstructural zones in welded plain-carbon steels. Introduction to cracking phenomenon associated with welding - Hot cracking, Hydrogen induced cracking - role of hydrogen, carbon equivalent and residual stresses. Use of Graville diagram. Lamellar tearing and Reheat cracking. Weldability of cast irons – problems encountered and remedies.

UNIT IV	WELDABILITY OF STAINLESS STEELS	9	0	0	9

Types of Stainless steels, Ferrite and Austenite stabilizers. Weldability of stainless steels – Metallurgical difficulties associated with welding of ferritic, martensitic, duplex and precipitation hardenable stainless steels. Detailed study on austenitic stainless steel welding, Constitution diagrams – Schaeffler, Delong and WRC diagrams.

UNIT V	WELDING OF NON-FERROUS METALS & ALLOYS, WELDABILITY AND ITS ASSESSMENT	9	0	0	9

Weldability of non-ferrous materials: Welding of aluminium & its alloys, copper & its alloys, nickel & its alloys and titanium & its alloys – metallurgical difficulties encountered and solutions.

Concept of weldability - Definition, factors affecting weldability. Weldability tests: Self-restraint and externally loaded tests for cold cracking and hot cracking susceptibility.

Total (45L) = 45 Hours

Text Books:

1.	Parmar, R.S., ―Welding Engineering and Technology, Khanna Publishers, New Delhi, 2003.
2.	Lancaster J.F. ―Metallurgy of Welding, George Allen & Unwin. Boston. 1980.

Reference Books:

1.	Linnert. G.E. ―Welding Metallurgy, Vol. 1 and 2. 4th edition. AWS. USA, 1994.

2.	Sindo Kou, Welding Metallurgy, John Wiley & Sons, 1987.
3.	Granjon. H, ―Fundamentals of Welding Metallurgy, Jaico Publishing House, New Delhi, 1994.
4.	ASM Metals Handbook, Vol. 6,"Welding Brazing & Soldering", ASM International, Metals park, Ohio, USA, 2001.
5.	Nadkarni S.V., "Modern Arc Welding Technology", Oxford & IBH Publishing Co., 1988.
6.	Jean Cornu, “Advanced Welding Systems”, Springer-Verlag Berlin Heidelberg GmbH, 1988.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Recollect the fundamentals of physical metallurgy related to welding.	L1: Remembering
CO2	:	Explain the principles in welding metallurgy.	L2: Understanding
CO3	:	Apply the welding metallurgy principles in steels and cast irons.	L3: Applying
CO4	:	Apply the welding metallurgy principles in different types of stainless steels.	L3: Applying
CO5	:	Analyze the weldability of non-ferrous metals & alloys and weldability assessment.	L4: Analyzing

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		1		
CO2	2				2								2		1	
CO3		2	1											1		
CO4		1		2									1			1
CO5	2			1	2						2			1		
Avg.	2	1.5	1	1.3	2	0	0	0	0	0	2	2	1.5	1	1	1

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

22MTPE31	FRACTURE MECHANICS			Semester		VI
Mechanical behavior and testing of materials.	**Category**	**PE**	**Credit**			**3**
	Hours/Week	**L**	**T**	**P**		**TH**
		3	**0**	**0**		**3**

Course Objectives:

1.	To gain the knowledge of fracture mechanics and knowing the experimental measurements and applications of fracture mechanics

Unit I	**TYPES OF FRACTURE**	**9**	**0**	**0**	**9**
Ductile and brittle fracture, features of fracture surface for ductile, brittle and mixed modes, fractography Transition temperature approach: Notched bar impact tests. Ductile to brittle transition, influence of temperature, strain rate and multi-axial loading, limitations of charpy testing. Drop-weight test and other large scale tests – fracture analysis diagram.					
Unit II	**FRACTURE MECHANICS APPROACH**	**9**	**0**	**0**	**9**
Stress distributions around discontinuities, stress analysis in simple cracked bodies, plane strain and plane stress conditions, stress intensity factor and fracture toughness.					
Unit III	**YIELDING FRACTURE MECHANICS**	**9**	**0**	**0**	**9**
Concept of crack opening displacement, calculation of COD. The J contour integral- derivation of J from load – displacement diagram. The relationship between J integral and COD.					
Unit IV	**EXPERIMENTAL MEASUREMENT OF FRACTURE TOUGHNESS**	**9**	**0**	**0**	**9**
K_{IC} testing – test piece requirements and types, fatigue pre-cracking, determination of COD, estimation of critical CODfrom the test data. Measurement of J integral and R curve.					
Unit V	**APPLICATIONS OF FRACTURE MECHANICS**	**9**	**0**	**0**	**9**
Concepts of tolerable defects, use of fracture mechanics in design and material selection.					
					Total(L) = 45 Hours

Reference Books:

1.	David Broek, Elementary Engineering Fracture Mechanics, Suthoff Noordhoof, 1978.
2.	Hertzberg R.W. Deformation and Fracture Mechanics of Engineering Materials, 3rd edition, John Wiley 1989.
3.	Rolfe T., Bassom J., Fracture and Fatigue Control of Structures – Applications of Fracture Mechanics, Prentice Hall, 1977.
4.	Tetelmen A.S. and McEvily. A.J. Fracture of Structural Materials. John Wiley & Sons, 1967.
5.	Gurney T.R., Fatigue of Welded Structures, Cambridge University Press, 1979.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Illustrate the concept of DBTT and various mechanical tests of materials.	L2: Understanding
CO2	:	Label the crack, discontinuities and stress intensity factor.	L2: Understanding
CO3	:	Discuss the concept of COD, J integral and displacement diagram.	L3: Applying

CO4	:	Discuss about the experimental measurement of fracture toughness.	L2: Understanding
CO5	:	Apply the fracture mechanics in design and selection of various 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			
CO2	2	2		1	1								1			
CO3	1	1	1	1	1								1	1		
CO4	2	1		1		1	1						1			
CO5	1	1											1			
Avg.	1.4	1.2	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MTPE32	CONTINUOUS CASTING OF STEEL			Semester			VI
Iron making and casting Engineering		Category		PE	Credit		3
		Hours/Week		L	T	P	TH
				3	0	0	3

Course Objectives:

1.	To develop an understanding of the basic principles of continuous casting, impart modeling skills and to apply them for industrial problems to enable them to solve the problems encountered in the steel industries.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Advantages- design of casters, metallurgical comparison of continuous casting with ingot casting.					
UNIT II	**HEAT TRANSFER IN MOULD AND SECONDARY ZONE**	**9**	**0**	**0**	**9**
Heat transfer and solidification in continuous casting – heat transfer in mould- mould flux and heat transfer in secondary cooling zone.					
UNIT III	**TUNDISH DESIGN AND PRACTICE**	**9**	**0**	**0**	**9**
Modern Tundish practice for clean steel production. Tundish design and operation-mould and its operation electromagnetic stirring use of submerged entry nozzle (SEN) and water model study for funnel formation. Vortex vs the drum funnels through rotational flow. Their characteristics and use of vortex buster to allow beller slag free teeming.					
UNIT IV	**DEFECTS IN CONTINUOUS CASTING**	**9**	**0**	**0**	**9**
Metallurgical defects and their remedies. Centre line micro segregation and porosity –cracks other defects – Oscillation marks.					
UNIT V	**ROLE OF INCLUSIONS AND RECENT DEVELOPMENTS**	**9**	**0**	**0**	**9**
Inclusion distribution in cast products – inclusion modification. Application of Thermodynamics to deoxidation and inclusion formation. Deoxidation reaction. Modeling for inclusion prediction. Thin slab casting, Round casts and combination casts. High speed casting –breakouts and mould powder entrapments –Near net shape castings. Thin strip production of carbon steels and stainless steels and their characteristics. Recent studies on thin strip casting.					
					Total (45L) = 45 Hours

Text Books:

1.	Ahindra Ghosh Principles of Secondary Processing and Casting of liquid steel, , Oxford & IBA Publishers, 1990
2.	David H Wekelin,, The Making, Shaping and Treating of Steel, AISE Steel Foundation, 1999

Reference Books:

1.	Chatterjee A and Govindarajan S, Monograph on Continuous Casting at TATA Steel, Jamshedpur, 1991.
2.	Brimacombe J K and Samarasekara (Eds)., Continuous Casting Vol.2, The Iron and Steel Institute, USA,1984.
3.	Ahindra Ghosh and Amit Chatterjee, Iron Making and Steel Making – Theory and Practice, Prentice Hall of India Private Ltd., New Delhi 2008.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Compare continuous casting with ingot casting.	L3: Applying
CO2	:	Explain the transfer of heat in a continuous casting machine.	L3: Applying

CO3	:	Sketch proper metallurgical tundish for transferring heat from ladle to the continuous caster.	L2: Understanding
CO4	:	Discuss the remedies for the common defects that are formed during the continuous casting of steel	L3: Applying
CO5	:	Describe the role of inclusion in the steel, the modification of inclusion and its mechanical properties.	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			
CO2	2	1	1			1							2			
CO3	2	2			1								1			
CO4	1	1		1	1	1							1			
CO5	1						1						2			
Avg.	1.4	1.3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MTPE33	ALTERNATE ROUTES OF IRON MAKING				Semester	VI
PREREQUISITES: **Iron Making**		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To know the importance of the Iron making and to apply them for the advancement of alternative route for the Production feasibilities in steel Industries to compete with the modern day manufacturing routes.

UNIT I	**BLAST FURNACE AND ITS MODIFICATION**	**9**	**0**	**0**	**9**
Blast furnace iron making. Low Shaft Furnace – Construction, Process and Advantages, Mini Blast Furnaces (MBF) – Special Features, Modern Blast Furnace, Charcoal blast Furnace.					
UNIT II	**ELECTRO THERMAL PROCESSES**	**9**	**0**	**0**	**9**
Electro–Thermal Processes – Submerged Arc Furnace – Construction, Operation and Smelting practice. Modern trends & Special features. Irregularities in operation.					
UNIT III	**SPONGE IRON MAKING**	**9**	**0**	**0**	**9**
Sponge Iron production – Introduction, Properties, Uses & Process of making Sponge Iron. Coal Based Sponge Iron process: Rotary Kiln (SL/RN, Krupp-Renn), Rotary Hearth (FASTMET) process. Gas Based Sponge Iron process: Finmet process, HYL-I, MIDREX, HYL-IV M process.					
UNIT IV	**SMELTING, REDUCTION AND OTHER PROCESSES**	**9**	**0**	**0**	**9**
Smelting Reduction – Introduction, Raw materials & Fundamentals. Classification of Smelting Reduction process – Based on stages (Single stage, two stage operation), Based on Types of furnace –Vertical shaft furnace (COREX, FINEX), Electrical Furnace (INRED, ELRED), Converter type, Rotary Hearth furnace.					
UNIT V	**IRON MAKING IN INDIA**	**9**	**0**	**0**	**9**
Blast furnace design in India. Main problems in iron making in India. Sponge Iron making in India. India‘s role in Global steel trade. Future scope of Iron making processes in India.					
					Total (45L) = 45 Hours

Text Books:	
1.	Sarangi, A., and B. Sarangi, Alternative roots to Iron Making, 2nd Edition, Prentice Hall of India Pvt Ltd., New Delhi, 2016.
Reference Books:	
1.	R.H. Tupkary and V.R. Tupkary., An Introduction to Modern Iron Making, Khanna Publishers, Fourth Edition.New Delhi, 2010.
2.	Biswas .A.K , Principles of blast furnace iron making- theory and practice , SBA Pub, Kolkata 1994.
3.	David H Wekelin, The Making, Shaping and Treating of Steel, AISE Steel Foundation, 1999.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the special features of a blast furnace.	L2: Understanding
CO2	:	Explain the details of modern trends in the electro-thermal process.	L3: Applying
CO3	:	Discuss the sponge iron making.	L2: Understanding

CO4	:	Describe the smelting reduction and other processes.	L2: Understanding
CO5	:	Examine the problems and future scope of iron making in India.	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	1								1			
CO2	2	2		1									1			
CO3	1	2	1	1		1	1						1	1		
CO4	2	1		1			1						2			
CO5	1	1											1			
Avg.	1.6	1.4	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.2	1.0	0.0	0.0

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

2MTPE34	FOUNDRY METALLURGY				Semester	VI
PREREQUISITES: **Casting Engineering, Advanced Physical Metallurgy**	**Category**	**PE**		**Credit**		**3**
	Hours/Week	**L**	**T**	**P**		**TH**
		3	**0**	**0**		**3**

Course Objectives:

1.	To know the basic concept of metal casting technology
2.	To apply the concept to produce new materials

UNIT I	**SOLIDIFICATION OF METALS AND ALLOYS**	**9**	**0**	**0**	**9**

Solidification of Castings, Effect of Solidification Range on Freezing Pattern, effect of Moulding Materials and Cooling Rate on Freezing Pattern, Shrinkage of Casting and Directional Solidification of Castings, Fluidity, Definition, Factors Affecting and Measurement Fluidity.

UNIT II	**METALLURGY OF CAST IRONS**	**9**	**0**	**0**	**9**

Graphitization, types and Sizes of Graphite for Grey Cast Iron and S.G.Iron, effect of normal elements and Alloying Elements in Cast Irons, Compositional Aspects and Properties of Austenitic Cast Irons, High Silicon Cast Irons, High Chrome Cast Iron and Ni-Hard Cast Irons, Production of S.G Iron, Austempered SG Iron, CG Iron, Malleable Cast Iron and Alloy Cast Irons, brief introduction on Indian and ASTM Standards for Grey Cast Iron and SG Iron.

UNIT III	**METALLURGY OF STEELS**	**9**	**0**	**0**	**9**

Effect of Alloying Elements on Castability of Steels, Compositional Aspects and Properties of Alloy Steels, Specifications of Cast Steels, Low Alloy Steels and Stainless Steels. Stresses - Origin, Effects and Stress Relieving Operations, Precautions to be taken in Moulding and Melting of Steels, Gating and Riser Design for Steel Casting, Grain Refinement of Steels. Defects in Castings- appearance, their Causes and Remedies.

UNIT IV	**METALLURGY OF NON-FERROUS CAST ALLOYS**	**9**	**0**	**0**	**9**

Specifications, Composition, Properties and Phase Diagrams of Copper, Aluminium, Magnesium, Zinc Alloys and Nickel base Alloys, Modification and Grain Refinement -Defects in Castings- appearance, their Causes and Remedies.

UNIT V	**MELTING PROCEDURE AND COMPOSITION CONTROL**	**9**	**0**	**0**	**9**

Cast Irons Plain Carbon Steels, Stainless Steels, Al Alloys. Mg alloys, Nickel alloys. Zinc alloys and Copper alloys, Slag-Metal Reactions, Desulphurization, Dephosphorisation, inoculation and inoculating techniques- Gases in Metals and Degassing Technique.

Total (45L) = 45 Hours

Text Books:	
1.	Heine R W., Loper, C.R.Rosenthal, P.C., "Principles of Metal Casting" ,Tata-McGraw Hill Publishing Co Ltd, New Delhi, 2018.
2.	Beeley,P.R., Foundry Technology, Butterworths, London, 2016.
3.	Srinivasan N K.,"Foundry Engineering", Khanna Tech Publications, New Delhi, 2018.

Reference Books:	
1.	ASM Metals handBook, Vol 15, "Casting" ASM International, 10th edition, 2001.
2.	Flinn,R.A., Fundamentals of Metal Casting, Addison Wesley Inc., 1983.

3.	Murphy,A.J., Ed., Non Ferrous Foundry Metallurgy, 1984
4.	The Foseco Foundryman's Hand book, Pergamon Press, 10th edition, 1995.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the solidification of casting, effect of solidification range, fluidity and factors affecting fluidity	L2: Understanding
CO2	:	Analyze the cast iron categories, their types and different heat treatment methods like graphitization, spheroidization etc. and denote the ASTM standards for all the varieties.	L4: Analyzing
CO3	:	Interpret the effect of the alloying element on steels and mention the precaution to be taken in moulding and melting of steels.	L4: Analyzing
CO4	:	Apply different casting methods employed for production of non-ferrous alloys.	L3: Applying
CO5	:	Select the melting procedure for various alloys.	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		
CO3	1	1	1		1		1						1	1		
CO4	1	1		1							1		1			
CO5	2		1		1								1	1		
Avg.	1.2	1.0	1.0	1.0	1.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0	1.0	0.0	0.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MTPE35	X-RAY DIFFRACTION AND ELECTRON MICROSCOPY			Semester		VI
Engineering Physics and Physical metallurgy		Category	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	To study about X-ray diffraction methods and its uses, TEM, SEM

UNIT I	**Fundamentals of X-ray Diffraction**	**9**	**0**	**0**	**9**
Properties of X-rays: Continuous spectrum, characteristic spectrum, absorption, filters. Production of x-rays, Detection of x-rays. X-ray diffraction- Bragg's Law, diffraction direction					
UNIT II	**X-ray Diffraction**	**9**	**0**	**0**	**9**
Diffraction methods – Laue, Rotating Crystal and Powder methods. Intensity of diffracted beams-Scattering by an electron, an atom and unit cell, Structure factor calculations. X-ray diffractometer – general features					
UNIT III	**Applications of X-ray Diffraction**	**9**	**0**	**0**	**9**
X-ray diffraction application in determination of crystallite size, crystal structure, precise lattice parameter and residual stress. Chemical analysis by x-ray diffraction and x-ray spectroscopy					
UNIT IV	**Transmission Electron Microscopy**	**9**	**0**	**0**	**9**
Transmission electron microscopy (TEM) instrumentation – electron sources, elements of electron optics, resolving power, image formation, contrast mechanism, bright field and dark field images, selected area diffraction, techniques of specimen preparation-mechanical thinning, electrochemical thinning and ion milling. Applications of TEM.					
UNIT V	**Scanning Electron Microscopy**	**9**	**0**	**0**	**9**
Components of scanning electron microscope (SEM), electron beam – specimen interaction, Detection of secondary electrons, detection of backscattered electrons, image formation, methods of specimen preparation, Operational variables, Introduction to electron backscatter diffraction (EBSD) and Focused-IonBeam microscopy					
					Total (45L) = 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

Reference Books:

1.	Goldstein, J., et al., Scanning Electron Microscopy and X-ray Microanalysis, Kluwer Academic/Plenum Publishers, New York, 2003.
2.	Goodhew, P.J., J. Humphreys, and R. Beanland, Electron Microscopy and Analysis, Taylor & Francis, London, 2000
3.	Hebbar, K.R., Basics of X-Ray Diffraction and Its Applications, I.K. International Publishing House Pvt. Limited, India, 2007.
4.	Williams, D.B. and C.B. Carter, Transmission Electron Microscopy: A Textbook for Materials Science, Springer Science Business Media, New York, 2009

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe Bragg's law of diffraction and the principle of XRD.	L2: Understanding
CO2	:	Analyze different XRD methods.	L4: Analyzing
CO3	:	Explain the applications of X-ray diffraction.	L3: Applying
CO4	:	Describe the principle and applications of Transmission electron microscopy.	L3: Applying
CO5	:	Interpret the principle and applications of Scanning electron microscopy.	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	2	2	1			1	1						1	1		1
CO3	2	2		1	1								2	1		
CO4	1	1		1									1		1	
CO5	1	1		1									1			
Avg.	1.4	1.4	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.4	1.0	1.0	1.0

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

22MTPE41	ADDITIVE MANUFACTURING				Semester	VII
PREREQUISITES: **Manufacturing Processes**		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives

1.	To Understand the fundamentals of various Additive Manufacturing Technologies and STL file formations for application to various industrial needs.
2.	To understand various methods of manufacturing of liquid based, powder based and solid based Additive Manufacturing techniques.

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

Prototyping fundamentals, Historical development, Advantages of AMT, Commonly used terms, process chain, 3D modeling, Data Conversion, and transmission, Checking and preparing, Building, Post processing, RP data formats, Classification of AMT process, Applications to various fields.

UNIT II	**LIQUID BASED SYSTEMS**	**9**	**0**	**0**	**9**

Stereo lithography apparatus (SLA): Models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages, case studies. Solid ground curing (SGC): Models and specifications, process, working, principle, applications, advantages and disadvantages, case studies.

UNIT III	**SOLID BASED SYSTEMS**	**9**	**0**	**0**	**9**

Laminated object manufacturing (LOM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies. Fused Deposition Modeling (FDM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies, practical demonstration.

UNIT IV	**POWDER BASED SYSTEMS**	**9**	**0**	**0**	**9**

Selective laser sintering (SLS): Models and specifications, process, working principle, applications, advantages and disadvantages, case studies. Three dimensional printing (3DP):Models and specification, process, working principle, applications, advantages and disadvantages, case studies

UNIT V	**APPLICATION OF ADDITIVE MANUFACTURING**	**9**	**0**	**0**	**9**

Artificial Heart, Prosthetic Cardiac Valves, Artificial lung (oxygenator), Artificial Kidney (Dialyser membrane), Dental Implants, Orthopedic Implants and Biomaterials in Ophthalmology - Aerospace, automobile, Agricultural, Oil and gas industries.

Total (45L) = 45 Hours

Text Books:

1.	Ian Gibson, Davin Rosen, Brent Stucker "Additive Manufacturing Technologies, Springer, 2nd Ed, 2014.
2.	Chua C.K., Leong K.F. and LIM C.S Rapid prototyping: Principles and Applications, World Scientific publications, 3rdEd., 2010

Reference Books:

1.	D.T. Pham and S.S. Dimov, "Rapid Manufacturing", Springer, 2001
2.	Paul F. Jacobs, " Rapid Prototyping and Manufacturing"–, ASME Press, 1996
3.	Terry Wohlers, " Wohlers Report 2000", Wohlers Associates, 2000.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the fundamentals of Additive Manufacturing.	L2: Understanding
CO2	:	Find the methodology to manufacture the products using SLA and SGC technologies.	L2: Understanding
CO3	:	Identify the methodology to manufacture the products using LOM and FDM technologies.	L2: Understanding
CO4	:	Discuss the methodology to manufacture the products using SLS and 3D Printing technologies.	L2: Understanding
CO5	:	Identify the Additive Manufacturing Technologies for various applications.	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						2			1
CO2	2	1			1	1							1	1		
CO3	1	1		1	1								1			
CO4	2	1		1	1								1	1		
CO5	1	1		1	1									1		
Avg.	1.4	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.3	1.0	0.0	1.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MTPE42	SEVERE PLASTIC DEFORMATION				Semester		VII
Mechanical Behaviour of materials		Category		PE	Credit		3
		Hours/Week		L	T	P	TH
				3	0	0	3

Course Objectives:

1.	To know the fundamental concepts of mechanical behaviour of materials and to apply them to design the materials for various load-bearing structural engineering applications.

UNIT I	**INTRODUCTION AND ECAE**	**9**	**0**	**0**	**9**
Severe plastic deformation processes (SPD), advantages over conventional metal forming processes. Concept of equal channel angular extrusion (ECAE), Plastic zone during ECAE. Material flow and stress distribution in ECAE.					
UNIT II	**ECAE – II**	**9**	**0**	**0**	**9**
Multi-pass processing in ECAE, Processing parameters, defects associated with ECAE. Continuous ECAE. Concept of Incremental equal channel angular pressing (I-ECAP). Tooling of ECAP – Configuration of channel, die design, punch design, tool materials for punch and dies.					
UNIT III	**HIGH PRESSURE TORSION**	**9**	**0**	**0**	**9**
Introduction to high pressure torsion (HPT) – advantages over other SPD techniques. Characteristic HPT microstructures. Principles of HPT-idealized, fully constrained, quasi-constrained HPT. Design criteria.					
UNIT IV	**CYCLIC EXTRUSION-COMPRESSION AND ARB**	**9**	**0**	**0**	**9**
Concept cyclic extrusion-compression, microstructural evolution during CEC, grain refinement in aluminium alloys. Introduction to accumulative roll bonding, principle of ARB, nanostructure formation during ARB.					
UNIT V	**TWIST EXTRUSION AND OTHER PROCESSES**	**9**	**0**	**0**	**9**
Introduction to twist extrusion, processing technique for TE, formation of nanostructure in TE. Applications and recent developments of TE. Friction stir processing: principle and operating parameters. Applications of FSP.					
					Total (45L) = 45 Hours

Text Books:

1.	Rosochowski, A., Severe Plastic Deformation Technology, Whittles Publishing, UK, 2017.

Reference Books:

1.	Proceedings of the Conference ― Nanomaterials by Severe Plastic Deformation – NANOPAD2, December 9-13, 2002, Vienna, Austria, Edited by Zehetbauer, M and Z. Valiev.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Discuss the material flow and stress distribution in ECAE	L2: Understanding
CO2	:	Explain the different processing parameters of ECAE and its tooling	L3: Applying
CO3	:	Identify the design criteria for high pressure torsion	L3: Applying
CO4	:	Describe the concepts of cyclic extrusion-compression and evolution of microstructure during CEC.	L2: Understanding
CO5	:	Describe the various processes and applications of Twist extrusion and Friction stir processing.	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			
CO2	2	2	1		1	1						1	1	2		
CO3	1	2		1	1		1						1		1	
CO4	1													1		
CO5	1	1					1						1			
Avg.	1.2	1.5	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	1.0	1.5	1.0	0.0

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

22MTPE43	METALLURGICAL WASTE UTILIZATION AND MANAGEMENT			Semester			VII
Iron making, Steel making, Non ferrous extractive metallurgy		Category		PE	Credit		3
		Hours/Week		L	T	P	C
				3	0	0	3

Course Objectives:

1.	Student should be capable of understand various wastes in environment conditions and choose suitable materials for various conditions and to learn about utilization of metallurgical waste.

UNIT I	**MINING AND METALLURGICAL WASTE**	**9**	**0**	**0**	**9**
Environmental and health impacts of Mining and Metallurgical waste. Various kinds of wastes: Mining and Beneficiation waste production. Ferrous metal waste production. Ferroalloys waste production. Hydrometallurgical waste production. Metal manufacturing and finishing waste production. Post-consumer waste production.					
UNIT II	**UTILIZATION OF MINING AND BENEFICIATION WASTE**	**9**	**0**	**0**	**9**
Utilization of mine overburden and waste rock. Potential utilization of mineral beneficiation tailings. Prevention and mitigation of acid mine drainage.					
UNIT III	**UTILIZATION OF FERROUS METAL WASTE**	**9**	**0**	**0**	**9**
Recycling and reuse of blast furnace iron making slags, steel making dusts and sludges. Utilization of steel making dusts – Plasma based processing, hydrometallurgical processing, solidification and stabilization. Recycling and reuse of steel making slags.					
UNIT IV	**UTILIZATION OF HYDROMETALLURGICAL AND METAL FINISHING WASTES**	**9**	**0**	**0**	**9**
Utilization of Jarosite, goethite produced during extraction of zinc, Utilization of red mud produced in Bayer process: metallurgical utilization through metal recovery, utilization in building and construction, Glass ceramics and Pigments. Recycling and utilization of surface oxide scale produced during metal forming operation. Metal recovery from pickling and plating sludges.					
UNIT V	**WASTE MANAGEMENT**	**9**	**0**	**0**	**9**
Waste management and utilization options: zero waste process approach, synergy between residue produces and residue end users. Process integration to mineral waste utilization. Process intensification.					
					Total (45L) = 45 Hours

Reference Books:

1.	Ndlovu, S., G.S. Simate and E. Matinde, Waste production and utilization in the Metal Extraction Industry, CRCPress, 2017
2.	R.C. Gupta, Energy and environmental management in metallurgical industries, Prentice-Hall India, 2012
3.	S. Ramachandra Rao, Resource recovery and recycling from metallurgical wastes, Elsevier, 2011.
4.	L. K. Wang, N. K. Shammas, Y.T Hung, Waste Treatment in the Metal Manufacturing, Forming, Coating, and Finishing Industries, CRC press, 2016
5.	Clyde S. Brooks, Metal Recovery from Industrial Waste, CRC press, 2018.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Analyse various mining and metallurgical waste and their health impacts.	L4: Analyzing
CO2	:	Explain the Utilization of wastes in mining and prevention of acid rain	L3: Applying

		drainage.	
CO3	:	Discuss the ways of recycling the iron and steel dust.	L2: Understanding
CO4	:	Apply various routes of utilization of hydrometallurgical and metal finishing wastes.	L3: Applying
CO5	:	Describe the approach of zero waste.	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									1			
CO2	1	3		1		1	2					1	1		1	
CO3	2	2	1	1	1	1							1			
CO4	1	1			1											1
CO5	1	1		1									1			
Avg.	1.4	1.6	1.0	1.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MTPE44	COMPUTATIONAL MATERIALS ENGINEERING				Semester		VII
PREREQUISITES: Engineering Mathematics		Category		PE	Credit		3
		Hours/Week		L	T	P	TH
				3	0	0	3

Course Objectives:

1.	To become familiar with computational techniques including related mathematical background

UNIT I	**Introduction To Computational Methods**	**9**	**0**	**0**	**9**
Solving sets of equations – Gauss elimination method, Cholesky method, Iterative methods, Relaxation method, System of non-linear equations- Newton Raphson method, Computer programs. Numerical Integration - Newton-Cotes integration formulae, Trapezoidal rule, Simpson's rule, Gaussian quadrature					
UNIT II	**Numerical solution of partial differential equations**	**9**	**0**	**0**	**9**
Laplace's equations - Representations as a difference equation, Iterative methods for Laplace's equations, Poisson equation - Derivative boundary conditions, Irregular and non-rectangular grids, Matrix patterns, Sparseness, ADI method, Applications to heat, mass and momentum transfer problems, Computer programs					
UNIT III	**Finite Element Method**	**9**	**0**	**0**	**9**
Weighted residual technique, variational approach, element types, plane triangular, quadrilateral curved isoparametric elements, three dimensional elements					
UNIT IV	**Analysis of production processes**	**9**	**0**	**0**	**9**
Finite element analysis of metal casting - Special considerations, latent heat incorporation, gap element, time stepping procedures – crank – Nicholson algorithm, Prediction of grain structure. Basic concepts of plasticity– solid and flow formulation – small incremental deformation formulation.					
UNIT V	**Curve fitting and approximation of functions**	**9**	**0**	**0**	**9**
Least square approximation, fitting of non-linear curves by least squares, Regression analysis Computer programs. Introduction to Artificial neural networks, various algorithms and CA studies Introduction to Genetic algorithms, GA for materials design and process optimization, case studies.					
					Total (45L) = 45 Hours

Text Books:	
1.	Zoe Barber, Introduction to Materials Modeling, Maney Publishing, Institute of Materials, London, 2005.
2.	Rao S S, –The Finite element Method in Engineering, Pergamon Press, New York, 1989.
Reference Books:	
1.	Lewis R W, Morgan K, Thomas H R and Seetharamu K N, –The Finite Element method in Heat Transfer Analysis, John Wiley, 1994
2.	Malanie Mitchell, —An introduction to genetic algorithms, MIT Press, 1998.
3.	Koenraad Janssens,Computational Materials Engineering, An introduction to microstructural evolution, Elsevier, 2007.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	State the basics of the computational methods used for numerical integration.	L2: Understanding
CO2	:	Solve the numerical solution of the partial differential equation.	L4: Analyzing
CO3	:	Describe the utilization of finite element methods.	L2: Understanding

CO4	:	Interpret the production processes.	L4: Analyzing
CO5	:	List the usage of Artificial neural networks and Genetic algorithms.	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	1				1	1					1				1
CO3	2	1	1	3	2											1
CO4	1			1	1											1
CO5	1	1														1
Avg.	1.4	1.3	1.0	2.0	1.3	1.0	1.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	1.0

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

22MTPE45	INTRODUCTION TO INSTRUMENTATION				Semeater		VII
Engineering Physics & Basic Electrical and Electronics Engineering		**Category**	**PE**	**Credit**			**3**
		Hours/Week	**L**	**T**	**P**		**TH**
			3	**0**	**0**		**3**

Course Objectives:	
1.	To acquire basic knowledge on measurements using different tools and skills to implement measurement techniques to control the system.

UNIT I	**GENERAL CHARACTERISTICS OF A MEASUREMENT SYSTEM**	**9**	**0**	**0**	**9**
Three stages generalized measurement system (sensing, modifying and terminative stages) Sensors and transducers -displacement and velocity transducers – potentiometer, strain gauge, LVDT - variable inductance transducers, capacitance transducers - Static and dynamic characteristics - Errors in measurement - Error analysis and classification - statistical treatment of data.					
UNIT II	**GEOMETRICAL MEASUREMENT**	**9**	**0**	**0**	**9**
Linear measurements- limit gauges (types and design) - mechanical Comparators, slip gauge, Instruments for angular measurement - vernier and optical protractors, Sine bar. Flatness, parallelism and roundness measurement, Measurement of surface finish: direct and indirect methods.					
UNIT III	**FORCE, TORQUE AND STRAIN MEASUREMENT**	**9**	**0**	**0**	**9**
Elastic elements for force measurement, torque measurements, electrical resistance. Strain gauges and measuring circuit, temperature compensation, strain gauge rosettes. Instrument calibration - calibration standards - test procedures.					
UNIT IV	**TEMPERATURE AND PRESSURE MEASUREMENT**	**9**	**0**	**0**	**9**
Temperature scales, thermometers, thermocouples, resistance thermometers, thermistors, pyrometers. Manometers, mechanical pressure sensors - electrical pressure measuring devices, pressure transmitters- low and vacuum pressure measurement systems.					
UNIT V	**MICROPROCESSOR AND CONTROLLERS**	**9**	**0**	**0**	**9**
Basics of open loop and closed loop system, classification of variables, ON/OFF, P, PI, PID controllers and their applications. Introduction to Microprocessor and its architecture. Instruction sets.					
					Total (45L) = 45 Hours

Text Books:	
1.	Radhakrishnan V.R., Instrumentation and control for the Chemical, Mineral and Metallurgical processes, Allied publishers pvt. limited, New Delhi 1997
2.	Beckwith T.G. and Buck N.L., Mechanical Measurements, Addison Wesley Publishing Company Limited, 1995.
Reference Books:	
1.	Rangan CS, Sarma GR and Mani VSV, ‘ Instrumentation devices and systems’, Tata McGraw Hill Publications Co. Ltd., New Delhi, 1985.
2.	Jain R.K., Mechanical and Industrial Measurements, Khanna Publishers, Delhi, 1984.
3.	Microprocessor Architecture, Programming, and Applications with the 8085, Ramesh S Gaonkar, Penram International Publications (Pvt) Ltd, 2013.
4.	Nakra B.C., Theory and Applications of Automatic Controls, New Age International (Pvt) limited Publishers, 2005.

E- references	
1.	https://nptel.ac.in/courses/112106138/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the general characteristics of a measurement system.	L1: Remembering
CO2	:	List the tools suitable for linear, angular and surface measurements.	L3: Applying
CO3	:	Interpret force, torque and strain measuring instruments.	L3: Applying
CO4	:	Describe the instruments used for different temperature and pressure measurements.	L2: Understanding
CO5	:	Develop knowledge on the basics of micro processors and micro controllers.	L2: Understanding

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	1	1		1						2	1		
CO2	1	2		1	1	1								1		1
CO3	2	2	1	1	1		1								2	1
CO4	1	1		1	1	1							1		1	
CO5	1	2		1	1								1			1
Avg.	1.4	1.6	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.3	1.0	1.5	1.0

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

22MTPE51	NON DESTRUCTIVE EVALUATION AND FAILURE ANALYSIS				Semester		VII
Testing of Materials		Category		PE	Credit		3
		Hours/Week		L	T	P	TH
				3	0	0	3

Course Objectives:

1.	To understand the basic principles of various NDT techniques, its applications, limitations, codes and standards.

UNIT I	BASIC CONCEPTS AND SURFACE NDT METHODS	9	0	0	9
Concepts of Non-Destructive testing - Relative merits and limitations - NDT Versus Mechanical testing - Various physical characteristics of materials and their applications in NDT. Visual inspection: Unaided and Aided. Liquid penetrant inspection: Principle, applications, advantages and limitations, Dyes, developers and cleaners, Fluorescent penetrant test. Magnetic particle inspection: Principle, applications, magnetisation methods, magnetic particles, Dry technique and Wet technique, demagnetization, Advantages and limitations.					
UNIT II	RADIOGRAPHY INSPECTION	9	0	0	9
X-rays and Gamma rays, Properties of X-rays relevant to NDE, Absorption of rays, scattering, types and use of filters and screens, geometric factors, Inverse square, law, characteristics of films - graininess, density, speed, contrast, characteristic curves, Penetrameters, Exposure charts, Radiographic equivalence. Fluoroscopy-Xero-Radiography.Safety with X-rays and Gamma rays, Industrial computed tomography (ICT).					
UNIT III	ULTRASONIC INSPECTION	9	0	0	9
Types of Ultrasonic waves, principles of wave propagation, characteristics of ultrasonic waves, Attenuation, couplants. Inspection methods - pulse echo, Transmission and resonance techniques, Thickness measurement. Types of scanning, Test block, IIW - reference blocks. Time of flight diffraction (TOFD), Phased array Ultrasonic Testing.					
UNIT IV	OTHER NDT METHODS AND CODES	9	0	0	9
Eddy current testing: Principle, application and Instrumentation of Eddy current testing. Other NDT techniques: Principle, application and Instrumentation of Infrared and Thermal inspection methods, Holography and Acoustic emission testing. Pressure and Leak testing. Codes: Introduction to ASNT standards and ASME codes related to NDT, certification of NDT Personnel level I, II & III.					
UNIT V	FAILURE ANALYSIS	9	0	0	9
Fundamental sources of failures- Deficiencies in design, material processing, service and maintenance. Stages of failure Analysis. Classification and identification of various types of fracture. Introduction to Fatigue, failure Elevated Temperature failure, Wear failure, and Corrosion failure.					
					Total (45L) = 45 Hours

Text Books:

1.	Barry Hull and Vernon John, Non Destructive Testing, ELBS / Macmillan, 2001.
2.	Baldev Raj, Jayakumar T. Thavasimuthu M, Practical Non-Destructive testing, Narosa Publishing House,NewDelhi, 1997.

Reference Books:

1.	ASM Handbook, Vol.17: Non destructive Evaluation and Quality Control, ASM International, Metals Park,Ohio, USA, 1992.
2.	Louis Cartz, Non-Destructive Testing, ASM International, Metals Park Ohio, US, 1995.
3.	McGonagall. W.J. Non-Destructive Testing, Gordon and Breach, 2nd Ed., 1971.
4.	ASM Handbook, Vol.11: Failure analysis and Prevention, ASM International, Metals Park, Ohio, USA, 1992.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the basic concepts of non-destructive testing, importance of Penetrant testing, and the procedures involved in the magnetic methods.	L2: Understanding
CO2	:	Explain the techniques involved in the Radiographic testing and the various advancements in Radiography.	L2: Understanding
CO3	:	Interpret the principles and calibrations in the Ultrasonic inspection.	L3: Applying
CO4	:	Interpret other NDT methods and certification related to NDT.	L3: Applying
CO5	:	Examine the needs for failure analysis of industrial components.	L4: Analyzing

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		1								1			
CO2	3	3	1	1	1							1	2			1
CO3	1	2			1		1							2	1	
CO4	1	1		1	1									2	1	
CO5	2	1			1	1										
Avg.	1.8	1.6	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	1.5	2.0	1.0	1.0

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

22MTPE52	AEROSPACE MATERIALS						VII
Ferrous and non ferrous alloys		Category	PE	Credit			3
		Hours/Week	L	T	P		TH
			3	0	0		3

Course Objectives:

1. To analyze the materials for aerospace.

UNIT I	**MECHANICAL BEHAVIOUR OF ENGINEERING MATERIALS**	**9**	**0**	**0**	**9**
Knowledge of various type of hardness testing machines and various types of hardness number linear and non – linear elastic properties – stress and strain curves – yielding and strain hardening toughness- modulus of resilience- bauschinger effect- effect of notches – testing and flaw detection of materials and components.					
UNIT II	**MATERIALS IN AIRCRAFT CONSTRUCTION-01**	**9**	**0**	**0**	**9**
Aluminium and its alloys: types and identification. Properties-casting-heat treatment processes-surface treatments Magnesium and its alloys: cast and wrought alloys-aircraft applications, future specification, fabrication problems, special treatments. Titanium and its alloys: application, forming, machining, welding and heat treatment.					
UNIT III	**MATERIALS IN AIRCRAFT CONSTRUCTION-02**	**9**	**0**	**0**	**9**
Steels: plain and low carbon steels, various low alloy steels. Aircraft steel specification, corrosion and heat resistant steels, structural applications. Maraging steels: Properties and applications Copper alloys: Monel, K-monel Superalloys: use –Ni base-Co base-Fe base- forging and casting of superalloys -welding, heat treatment.					
UNIT IV	**ADHESIVE AND SEALANTS FOR AIRCRAFTS**	**9**	**0**	**0**	**9**
Advantages of bonded structure in airframes, crack arresting-weight saving- technology of adhesive bonding structural adhesive materials- test for bonding structure Typical bonded joints & non destructive tests for bonded joint bonded sandwich structures- materials – methods of construction of honeycombs					
UNIT V	**NON METALS IN AIRCRAFT CONSTRUCTION**	**9**	**0**	**0**	**9**
Wood and fabric in aircraft construction and specifications- Glues use of glass, plastics and rubber in aircrafts, introduction to glass and carbon composites					
					Total (45L) = 45 Hours

Text Books:

1.	H. Buhl, Advanced Aerospace Materials, Springer Verlag, Berlin 1992.

Reference Books:

1.	Balram Gupta et.al Aerospace Materials Vol 1, 2, 3 ARDB, S. Chand & Co. 1996.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the properties of aerospace materials.	L2: Understanding
CO2	:	Describe the light alloys and special materials for aircraft construction.	L2: Understanding
CO3	:	Explain the metallic materials used in aircraft joining	L3: Applying
CO4	:	Discuss the adhesive and sealants used for aircrafts.	L2: Understanding
CO5	:	Explain the Nonmetallic materials used in the aircraft industries.	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	1	1	1	1									1			
CO3	2	2			1	1	1							1	1	
CO4	2	1		1	1									1		1
CO5	1	1		1		1							1			1
Avg.	1.4	1.4	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0

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

22MTPE53	NUCLEAR MATERIALS				Semester		VII
Engineering Physics		Category	PE		Credit		3
		Hours/Week	L	T	P		TH
			3	0	0		3

Course Objectives:

1.	To study materials required for nuclear applications.

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

Structure of a nuclear power plant, requirements of reactor materials, fuel materials, plutonium uranium and thorium and their alloys & compounds.

UNIT II	**CORE MATERIALS**	**9**	**0**	**0**	**9**

Core materials: beryllium, graphite, control and shielding materials, magnesium & its alloys, aluminium & its alloys, zirconium & its alloys, austenitic stainless steel; materials for reactor vessel and other components, pearlitic steels, ferritic, chromium stainless steels, copper alloys, titanium and its alloys, coolants used in reactors: radiation embrittlement, corrosion of reactor materials, mechanical properties of materials.

UNIT III	**REACTOR INSTRUMENTATION**	**9**	**0**	**0**	**9**

Reactor Instrumentation — general considerations — Reactor Nuclear Instrumentation systems — an overview — pressurized water nuclear instrumentation, boiling water reactor nuclear instrumentation, Encore detectors, self- powered detectors, detectors based on beta decay, detectors based on secondary electrons from gamma decay.

UNIT IV	**NUCLEAR TECHNIQUES FOR MATERIAL ANALYSIS**	**9**	**0**	**0**	**9**

Nuclear techniques for materials analysis — basic principles of materials analysis, basic requirements for the technique, nuclear techniques for elemental analysis, main nuclear processes useful for materials analysis, the quantitative estimate, Rutherford back scattering (RBS) and elastic recoil detection analysis(ERDA). Nuclear reaction analysis — principle of the technique and required instrumentation, nuclear reactions suitable for nuclear reaction analysis, neutron activation analysis. PIXE and XRF techniques.

UNIT V	**NUCLEAR WASTE MANAGEMENT**	**9**	**0**	**0**	**9**

Nuclear Waste Management: Introduces scientific and engineering aspects of the management of spent fuel, reprocessed high-level waste, low-level wastes, and decommissioning wastes. Characteristics and classification of nuclear wastes and waste forms. Fundamental processes and governing equations of radionuclide transport in the environment. Discussion of performance assessment for repositories. Design principles and evaluation methods for geologic waste disposal systems.

Total (45L) = 45 Hours

Text Book:

1.	V.Gerasimov& A. Monakhov, Nuclear Engineering Materials, Mir Publishers, Moskow, 1983.
2.	D.S.Clark & W.R Varney, Physical Metallurgy for engineers, East West Press, New Delhi, 1987

Reference Books:

1.	C.M. Srivatsava & C.Srinivasan, Science of engineering Materials, 1997, New Age International.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the structure of a nuclear power plant.	L2: Understanding
CO2	:	Identify the reactor core materials.	L3: Applying
CO3	:	Discuss various reactor vessel materials.	L2: Understanding
CO4	:	Identify nuclear techniques for material analysis.	L3: Applying
CO5	:	Discuss the waste management of 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	2	1		1	1								1			
CO2	2	1		1	1		1						1			
CO3	1	2	1		1	1							1			
CO4	1			1	1									1		
CO5	1	1		1	1								1			1
Avg.	1.4	1.3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0

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

22MTPE54	ELECTRICAL, ELECTRONICS AND MAGNETIC MATERIALS					Semester	VII
Engineering Physics		Category		PE	Credit		3
		Hours/Week		L	T	P	TH
				3	0	0	3

Course Objectives

1.	To study superconductors, magnetic materials, semiconductors, optoelectronic materials.

UNIT I	**DIELECTRIC AND PIEZO-ELECTRIC MATERIALS**	**9**	**0**	**0**	**9**
Free electron theory - Band theory - discussion on specific materials used as conductors - Dielectric phenomena - concept of polarization- frequency and temperature dependence - dielectric loss - dielectric breakdown - ferroelectricity - piezoelectricity and pyroelectricity – BaTiO3 – structure and properties.					
UNIT II	**SUPERCONDUCTORS**	**9**	**0**	**0**	**9**
Concept of superconductivity – BCS theory of superconductivity – Types of superconductors –YBCO- structure and properties – specific superconducting materials – Fabrication and engineering applications.					
UNIT III	**MAGNETIC MATERIALS**	**9**	**0**	**0**	**9**
Origin of Magnetism - Introduction to dia, para, ferri and ferro magnetism – Curie temperature – Magnetic anisotropy -hard and soft magnetic materials- iron based alloys - ferrites and garnets – rare earth alloys - fine particle magnets.					
UNIT IV	**OPTOELECTRONIC MATERIALS**	**9**	**0**	**0**	**9**
Principles of photoconductivity, luminescence- - photo detectors – Optical disc and optoelectronic materials –LCD, LED and diode laser materials - electro optic modulators - Kerr and Pockels effect – LiNbO3 .					
UNIT V	**SEMICONDUCTORS**	**9**	**0**	**0**	**9**
Semiconducting materials and types; simple, compound and oxide semiconductors – semiconducting materials in devices – Production of silicon starting materials – methods for crystal growth for bulk single crystals- zone melting – Czochralski method – Epitaxial films by VPE, MBE and MOCVD techniques – Lithography .					
					Total (45L) = 45 Hours

Text Books:

1.	Kittel C., _Introduction to Solid State Physics‘, 7th Edition, Wiley Eastern, New International Publishers, 2004
2.	Dekker A. J., _Electrical Engineering materials, Prentice Hall, 1995

Reference Books:

1.	Dekker. A.J, Solid state Physics, MacMillan India, 1995
2.	Van Vlack L.H, Elements of Materials Science and Engineering, 6th edition, Addison Wiley, 1989
3.	Kasap and Capper, Handbook of electronic and photonic materials, 2006, NY

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the dielectric phenomena and piezo-electricity.	L2: Understanding
CO2	:	Explain the BCS theory and types of superconductors.	L2: Understanding
CO3	:	Distinguish the dia, para and ferro magnetism.	L4: Analyzing
CO4	:	Describe the principles of photoconductivity.	L2: Understanding
CO5	:	Identify the semiconducting 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									2		1
CO2	1	2	1		1		1							1		
CO3	1	3		1	1									2		
CO4	2	2		1		1								1		
CO5	1	2			1									2		
Avg.	1.2	2.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	1.0

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

22MTPE55	NANOMATERIALS				Semester	VII
Engineering chemistry and surface engineering.		Category	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	Identify the various types and forms of Nanomaterials.
2.	Describe the various Nanomaterials synthesis methods.
3.	Know the application of nanomaterials in various fields

UNIT I	INTRODUCTION AND SYNTHESIS BY MECHANICAL METHODS	9	0	0	9

Introduction: Definition, classification of nanomaterials- Structure of nanomaterials - Effect of nanoscale dimensions on various properties – Structural, thermal, chemical, mechanical, magnetic, optical and electronic properties. Comparison nanomaterials with conventional materials. Synthesis: Basic approaches- top down and bottom up approaches- various methods for producing nanomaterials. Solid State (Mechanical methods): Mechanical Alloying (MA) and Mechanical Milling (MM)- Severe Plastic deformation – ECAP, HPT, ARB.

UNIT II	SYNTHESIS BY PHYSICAL & CHEMICAL METHODS	9	0	0	9

Top down approach, Nanolithography, Bottom up approach:Chemical methods:CVD – Steps and reactions involved for various types of CVD, Sol-gel method and co-precipitation techniques. Physical methods: PVD - Evaporation, Sputtering & Laser ablation .Consolidation of nanomaterials: Problems, Shockwave consolidations, Spark plasma sintering.

UNIT III	CHARACTERIZATION OF NANOMATERIALS	9	0	0	9

Application of X-ray diffraction in nanomaterial characterization. Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Atomic Force Microscope, Field Ion Microscope – Construction, working principle, different modes of operation and application in nanomaterial characterization. Nano indentation technique. Introduction to 3D Atom Probe Tomography.

UNIT IV	APPLICATIONS OF NANOMATERIALS - I	9	0	0	9

Nano-electronics, Micro and Nano Electromechanical systems, nanosensors, Electrical and optical applications. Quantum dots: Fabrication and applications. Nanofluids and their applications.

UNIT V	APPLICATIONS OF NANOMATERIALS - II	9	0	0	9

Energy applications: energy storage devices, fuel cells, solar cells, Biomedical applications. Structural applications. Carbon nanotubes: Types, structures, synthesis and applications. Health and environmental issues related to nanomaterials.

Total (45L) = 45 Hours

Text Books:

1.	B.S Murthy ,P.Shankar, Baldevraj, B.BRath, JamesMurday – Textbook nanoscience and nanotechnology, University press(India)Pvt Ltd, Hyderabad 2012
2.	Dieter vollath , Nanomaterials : An introduction to Synthesis, Properties and applications, Second edition, Wiley –VCH verlag Gmbh & co ,Germany 2013

Reference Books:

1.	Pradeep T, ― Nano : The essentials, Tata McGraw Hill Publishing Company Limited, New Delhi,2007
2.	Bharath Bhushan, Springer Handbook of Nanotechnology, Springer – Verlag, New York, 2004.
3.	Charles P. Poole and Frank J Owens, Introduction to Nanotechnology, John Wiley and Sons Inc, New York, 2003.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Discuss various synthesis of nanomaterials using mechanical methods.	L2: Understanding
CO2	:	Describe various synthesis of nanomaterials physical and chemical methods	L2: Understanding
CO3	:	Demonstrate the various nano material characterization techniques such as AFM, XRD, SEM and TEM.	L3: Applying
CO4	:	Illustrate the electronic and optical applications of nonmaterials in electronics.	L3: Applying
CO5	:	Demonstrate the applications of nano materials in energy storage devices and biomedical industries.	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	1		1							1		1
CO2	1	2		1		1								2		
CO3	2	3	1		1									2	1	
CO4	1	1		1	1								1	1		
CO5	1	2		1										1		
Avg.	1.4	1.8	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.4	1.0	1.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MTPE61	THIN FILMS, COATINGS AND APPLICATIONS		Semester			VIII
Physical Metallurgy		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1. To study thin films, coatings and application techniques.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Need for miniaturization, Basics of thin film, Brief review of kinetic theory of adsorption, desorption, film growth: nucleation and growth kinetics. Vacuum science and technology, Vacuum pumps, surface: role of substrate surface, substrate cleaning. Epitaxy, thin film growth control,					
UNIT II	**TECHNIQUES OF COATING**	**9**	**0**	**0**	**9**
Physical vapor deposition (PVD) processes, evaporation: thermal and e-beam. Principles of glow discharge and various sputtering processes. Fundamentals of Chemical Vapor Deposition (CVD) processes.					
UNIT III	**OTHER TECHNIQUES**	**9**	**0**	**0**	**9**
Pulsed laser deposition (PLD), other techniques: electro-deposition, spin Coating, sol-gel, Langmuir Blodgett (LB) techniques, SILAR technique, Doctor blade technique, printing.					
UNIT IV	**HARD COATINGS**	**9**	**0**	**0**	**9**
Hard coating: physical, mechanical and protective properties, basic thin film thickness measurement, microstructural characterization of films/coating.					
UNIT V	**APPLICATIONS**	**9**	**0**	**0**	**9**
Thin film devices: opto electronic devices, photo-detectors, solar cells. Applications: high hardness, corrosion resistance, biocompatibility and high temperature stability.					
					Total (45L) = 45 Hours

Text Books:

1.	Milton Ohring, Materials Science of Thin Films, 2nd Edition, Academic Press, 2001
2.	Hartmut Frey and Hamid R Khan, Handbook of Thin Film Technology, Springer,2016

Reference Books:

1.	K. L. Chopra & L. K. Malhotra, Thin film Technology and Application, Tata McGraw-Hill, 1985
2.	Peter M. Martin, Handbook of Deposition Technologies for Films and Coatings, Elsevier, 1994
3.	Sam Zhang, Nanostructured Thin Films and Coating, CRC Press, 2010

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the basics of adsorption, desorption and the need of vacuum.	L2: Understanding
CO2	:	Describe the principles, process and advantages of different techniques of coatings.	L2: Understanding
CO3	:	List out various hard coating techniques.	L2: Understanding
CO4	:	Discuss the hard coatings.	L2: Understanding
CO5	:	Identify thin film devices and applications of it.	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			
CO2	2	1				1	1						1			
CO3	1	2		1	1									2	1	
CO4	1														1	
CO5	1	1		1	1									1		
Avg.	1.2	1.5	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.5	1.0	0.0

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

22MTPE62	MODELING AND SIMULATION IN MATERIAL PROCESSES				Semester	VIII
Casting Engineering, Welding Engineering		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1. To study the softwares for modeling different processes.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Introduction to modeling, simulation models and Casting process: modeling of heat transfer, direct heat conductionmodeling, one-dimensional and multidimensional inverse modeling, fluid flow and heat transfer model.					
UNIT II	**CASTING MODELING**	**9**	**0**	**0**	**9**
Thermodynamics of solidification, metal/mold interfacial heat transfer, deformation and stresses in castings, thermo-mechanical modeling in casting, determination of heat transfer coefficient and air gap width in permanent mould castings, continuous casting and DC casting process.					
UNIT III	**WELDING AND HEAT TREATMENT SIMULATION**	**9**	**0**	**0**	**9**
Welding process: weld heat -source models, thermal analysis with-microstructure, transient fluid flow, residual stresses in welds, Heat treatment: metal quenchant, interfacial heat transfer, diffusion model, microstructure model, carburization model, quench crack simulation, creep simulation.					
UNIT IV	**MODELING**	**9**	**0**	**0**	**9**
Modeling of rolling, forming and extrusion processes, Artificial Neural Networks in materials processing, Phase-field modeling and Monte-Carlo simulations.					
UNIT V	**SOFTWARES**	**9**	**0**	**0**	**9**
Introduction to commercially available softwares - Solid Cast, Flow Cast, OptiCast, Deform HT, ProCast, Magma Soft, Design of experiments and factorial designs.					
					Total (45L) = 45 Hours

Text Books:

1. Modeling in Welding, Hot Powder Forming and Casting (Eds. L. Karlsson), ASM, MaterialsPark, OH, 1997.
2. Szekely,J., Evans, J.E .and Brimacombe, J.K., The Mathematical and Physical Modeling of Primary Metal processing Operations, Wiley, 1988.

Reference Books:

1. Numerical Recipes: The Art of Scientific Computing, Cambridge Univ. Press, N.Y., 1988.
2. D.R. Poirier and G.H. Geiger: Transport Phenomena in Materials Processing, TMS, warrendale 1994.
3. R.I. L. Guthrie: Engineering in Process Metallurgy, Oxford Science Publications (1989)

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the basics of modeling.	L2: Understanding
CO2	:	Describe the principles in casting modeling.	L2: Understanding
CO3	:	Compare the welding and heat treatment simulation.	L3: Applying
CO4	:	Interpret the principles in Modeling.	L3: Applying
CO5	:	Identify softwares for modeling	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	2		1	1								1		1	
CO2	2	1	1		1								1			1
CO3	1	2		1		1	1						1			1
CO4	2	1		1	1								1		1	
CO5	1	1			1										1	1
Avg.	1.6	1.4	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	1.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MTPE63	POWDER METALLURGY				Semester		VIII
Metal forming			Category	PE	Credit		3
			Hours/Week	L	T	P	TH
				3	0	0	3

Course Objectives:

1.	To introduce the importance of non-conventional processing routes for different materials and its importance foradvanced materials manufacturing.

UNIT I	CHARACTERISTICS AND TESTING OF METAL POWDERS	9	0	0	9

Sampling, chemical composition purity, surface contamination etc. Particle size and its measurement, Principle and procedure of sieve analysis, microscopic analysis: sedimentation, elutriation, permeability. Adsorption methods and resistivity methods: particle shape, classifications, microstructure. Specific surface area. Apparent and tap density. Green density, green strength, sintered compact density, porosity and shrinkage.

UNIT II	POWDER MANUFACTURE AND CONDITIONING	9	0	0	9

Mechanical methods - Machine milling, ball milling, atomization, shotting. Chemical methods - Condensation, thermal decomposition, carbonyl methods. Reduction by gas-hydride, dehydride process, electro deposition, precipitation from aqueous solution and fused salts, hydrometallurgical method. Powder Conditioning, Heat treatment, blending and mixing.

UNIT III	POWDER COMPACTION	9	0	0	9

Pressure less Compaction: slip casting and slurry casting. Pressure compaction- lubrication, single ended and doubleended compaction, Cold isostatic compaction, powder rolling, extrusion, and explosive compaction.

UNIT IV	SINTERING	9	0	0	9

Stages of sintering, property changes, mechanisms of sintering, liquid phase sintering and infiltration, activated sintering, Hot pressing and Hot Isostatic Pressing, vacuum sintering, sintering furnaces and sintering atmosphere, finishing operations – sizing, coining, repressing and heat treatment.

UNIT V	POWDER METALLURGY APPLICATIONS	9	0	0	9

Advantages and disadvantages of P/M, Major applications in aerospace. Nuclear and automobile industries. Bearing Materials-types, self lubrication and other types, methods of production, properties, applications. Sintered Friction Materials-clutches, brake linings, Tool Materials- cemented carbides, oxide ceramics, Cermets- Dispersion strengthened materials.

Total (45L) = 45 Hours

Text Books:

1.	Sinha..A.K., Powder Metallurgy, DhanpatRai& Sons. New Delhi, 2001.
2.	Sands. R L. and Shakespeare. C.R. Powder Metallurgy, George Newnes Ltd. London, 1966.

Reference Books:

1.	ASM Handbook. Vol. 7, Powder Metallurgy, Metals Park, Ohio, USA, 1990.
2.	Animesh Bose., Advances in Particulate Materials, Butterworth - Heinemann. New Delhi, 1995.
3.	Kempton. H Roll., Powder Metallurgy, Metallurgical Society of AMlE, 1988.
4.	Ramakrishnan.P., Powder Metallurgy Opportunities for Engineering Industries, Oxford and IBH Publishing Co., Pvt. Ltd, New Delhi, 1987.
5.	Erhard Klar, Powder Metallurgy Applications, Advantages and Limitations, American Society for Metals, 1983.

6.	P. C. Angelo, R.Subramanian, Powder metallurgy, Science, Tehcnology and applications.2009

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the basic characteristics and testing of powder.	L2: Understanding
CO2	:	Examine the various powders (materials) based on the engineering applications	L3: Applying
CO3	:	Interpret the processing routes for various powders (materials) and associated technology	L3: Applying
CO4	:	Discuss the modern day processing routes and different types of sintering.	L3: Applying
CO5	:	Find out the advantages, disadvantages and applications of powder metallurgy products.	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	1								1	1		
CO2	1	1	2		1		1						1	2		
CO3	1	2			1								1	1		
CO4	2	1	1	1									1	2		
CO5	3	1			1	1							1	1		
Avg.	1.8	1.2	1.5	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.4	0.0	0.0

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

22MTPE64	SPECIAL CASTING TECHNOLOGY			Semester			VIII
Casting Engineering		Category		PE	Credit		3
		Hours/Week		L	T	P	TH
				3	0	0	3

Course Objectives

1.	Knowledge on using economical design to give better quality castings to develop components of intricate shape and design by properly selecting the moulding and casting techniques

UNIT I	**SHELL MOULDING**	**9**	**0**	**0**	**9**
Various Special Casting Techniques-Shell Moulding Machines, Pattern Equipment, Sands, Resins and other Materials used for Shell Moulding, application of Shell Moulding, advantages of Shell Moulding over other Methods ofMoulding.					
UNIT II	**CENTRIFUGAL CASTING**	**9**	**0**	**0**	**9**
Types of Centrifugal Casting Processes-calculation of Mould Rotary Speeds, Techniques, equipment and Production Processes, advantages and limitations of Centrifugal Casting Methods.					
UNIT III	**INVESTMENT CASTING**	**9**	**0**	**0**	**9**
Introduction, Pattern and Mould Materials used, Techniques and Production of Investment Moulds, Shaw Process, Full Mould Process, applications of Investment Casting Process.					
UNIT IV	**DIE CASTING**	**9**	**0**	**0**	**9**
Die Casting Machines Gravity and Pressure Die Casting, Cold and Hot Chamber Operation and Details, Die Materials. Metals Cast by Die Casting Method, Casting of Aluminium, Magnesium and Zinc Alloys. Compo, Rheo and Thixo Processes, Advantages of Die Casting					
UNIT V	**ORGANIC AND OTHER PROCESSES**	**9**	**0**	**0**	**9**
Cold Box, Hot Box and No Bake Processes, Fluid Sand Process, V Process, Graphite Moulding Process, Magnetic Moulding, Impulse Moulding, High Pressure Moulding, Metal Injection Moulding.					
					Total (45L) = 45 Hours

Text Books:

1.	Beeley, P.R., Foundry Technology, Butterworths, London, 1982.
2.	Clegg A.J., Precision Casting Processes, Pergamon Press, London,1991.

Reference Books:

1.	Heine, Loper and Rosenthal, Principles of Metal Casting, Tata McGraw Hill Publishing Co., Ltd., New Delhi,1995.
2.	Dumond, T.C., Shell Moulding and Shell Moulded Castings, Reinhold Publishing Corporation Inc., 1984.
3.	Doehler, E.H., Die Casting, McGraw Hill Book Co, New York, 1991.

Course Outcomes: Upon completion of this course, the students will be able to:	**Bloom's Taxonomy Mapped**

CO1	:	Describe the shell moulding process over the conventional processes of casting.	L2: Understanding
CO2	:	Interpret the procedure for centrifugal casting of pipes and other hollow shafts.	L3: Applying
CO3	:	Discuss the investment casting method with different processes like Shaw, full mould process and mention their applications.	L2: Understanding
CO4	:	Name the modern die casting method, types and different operations performed in the chamber.	L3: Applying
CO5	:	Describe the organic processes that can be used to cast metals like metal injection moulding, magnetic moulding, impulse moulding.	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	2		1	1								1	1		
CO2	1	2		1			1						2			
CO3	2	1	1		1	1							2			
CO4	1	1		1	1								1			
CO5	1			1	1								1			
Avg.	1.4	1.5	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.4	1.0	0.0	0.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MTPE65	SECONDARY STEEL MAKING			Semester			VIII
Steel making, Metallurgical thermodynamics and kinetics, Transport Phenomena		Category		PE	Credit		3
		Hours/Week		L	T	P	TH
				3	0	0	3

Course Objectives:

1.	To become familiar with a wide array of making special steels by various process an learn about impurities present in it

UNIT I	**THERMODYNAMICS AND KINETICS OF DEOXIDATION**	**9**	**0**	**0**	**9**
Oxygen in molten steel, Types of Deoxidation, Complex Deoxidisers, Kinetics of removal of Deoxidation products, Deoxidation on Industrial Scale.					
UNIT II	**METALLURGICAL PRINCIPLES IN SECONDARY STEEL MAKING**	**9**	**0**	**0**	**9**
Thermodynamics of reactions during degassing, Fluid flow and mixing in ladle, Kinetics and mass transfer, Ladle injection metallurgy.					
UNIT III	**LADLE FURNACES AND SECONDARY STEEL MAKING**	**9**	**0**	**0**	**9**
Introduction, Process variables, Stirring, Synthetic slag, Purging, Vacuum treatments, Injection metallurgy, Ladle furnaces.					
UNIT IV	**INCLUSIONS IN STEEL**	**9**	**0**	**0**	**9**
Influence of inclusions on mechanical properties, Identification of inclusions, Origin of non-metallic inclusions, Inclusion control.					
UNIT V	**CONTINUOUS CASTING AND SEGREGATION**	**9**	**0**	**0**	**9**
Solidification rate in ingot, Heat transfer in continuous casting, Segregation of solutes in plane front solidification, Dendritic solidification, Morphology of killed steel ingots, Defects in continuous cast products, Developments in continuous casting.					
Total (45L) = 45 Hours					

Text Books:

1.	Ahindra Ghosh, Principles of Secondary Processing and Casting of liquid steel, Oxford & IBH Publishers, 1991.
2.	Ahindra Ghosh, Secondary steelmaking- Principles and applications, CRC Press, USA, 2001.

Reference Books:

1.	Chatterjee A and Govindarajan S, Monograph on Continuous casting at TATA Steel, Jamshedpur, 1991
2.	David H Wekelin, The Making, Shaping and Treating of Steel, AISE Steel Foundation, 1999
3.	Chow, C., et al., High speed continuous casting of steel billets Part 1 and Part 2, Iron making & Steelmaking,Vol.29, pp. 53-69, 2002

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Discuss the thermodynamics and kinetics of de-oxidation.	L2: Understanding
CO2	:	Explain the basic metallurgical principles that govern the process of secondary steel making.	L2: Understanding
CO3	:	Interpret the metallurgical processes in primary steel making.	L3: Applying

CO4	:	Distinguish the modification of steel properties using steel inclusions.	L3: Applying
CO5	:	Explain the process of continuous casting in steel and discuss the common defects and remedies in casting.	L2: Understanding

COURSE ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2		1	1									1		
CO2	1	2		1	1	1							2			
CO3	2	2	1	1			1							1		
CO4	1	2		1	1								1			
CO5	1	1		1									1			
Avg.	1.4	1.8	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.3	1.0	0.0	0.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MTPE66	SURFACE ENGINEERING				Semester		VIII
PREREQUISITES: **Engineering chemistry and Corrosion Engineering.**		Category	PE		Credit		3
		Hours/Week	L	T		P	TH
			3	0		0	3

Course Objectives:

1.	Analyze the various concepts of surface engineering and comprehend the design difficulties

UNIT I	**TRIBOLOGY AND PLATING PROCESSES**	**9**	**0**	**0**	**9**
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 electro deposition, plating of nickel, chromium, tin and copper, pulsed plating, hydrogen embrittlement, plating adhesion, electroless plating, electro chemical conversion coating, selective plating for repair, plating properties, hard anodizing.					
UNIT II	**HARD FACING PROCESSES**	**9**	**0**	**0**	**9**
SMAW,GTAW, GMAW, FCAW, SAW, PAW, Oxy-Acetylene Welding, Furnace fusing, Thermal- spray, flame spray processes-HVOF, Detonation gun and jet kote processes, hardfacing consumables.					
UNIT III	**SPECIAL DIFFUSION PROCESSES**	**9**	**0**	**0**	**9**
Principle of diffusion processes-Boriding, Aluminising, Siliconizing, Chromising Selection of diffusion Processes- Characteristics of diffused layer-micro structure and micro hardness evaluation-properties and applications.					
UNIT IV	**THIN FILM COATINGS**	**9**	**0**	**0**	**9**
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 andapplications.					
UNIT V	**HIGH ENERGY MODIFICATION AND SPECIAL PROCESSES**	**9**	**0**	**0**	**9**
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.					
					Total (45L) = 45 Hours

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

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Illustrate the influence of the tribological characteristics and explain the material properties by the plating processes.	L2: Understanding
CO2	:	Explain the various hard facing processes.	L3: Applying
CO3	:	Illustrate the surface properties with diffusion of foreign atoms into the outer surface of the material such as boriding, aluminizing, etc	L2: Understanding

CO4	:	Describe the various vapour deposition processes of different materials on the surface of native materials.	L2: Understanding
CO5	:	Describe the Modern processes and high energy processes like electron beam hardening, laser beam hardening.	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	3	1	1	2	1							1			1	1
CO3	2	2	1	1		1							1	2		
CO4	2	1			1								1		1	
CO5	1	2			1								1		1	
Avg.	1.8	1.4	1.0	1.3	1.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	1.0	1.5	1.0	1.0

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

OPEN ELECTIVE COURSES

22MAOE01	SAMPLING THEORY					
PREREQUISTIES		**CATEGORY**	**L**	**T**	**P**	**C**
Basic 12^{th} 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)", 4^{th} 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="4">DISASTER MITIGATION AND MANAGEMENT</td><td colspan="3">Semester</td><td>VI</td></tr>
<tr><td colspan="3">PREREQUISITES</td><td>Category</td><td>OE</td><td colspan="3">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="9">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="8">To provide students an exposure to disasters, their significance and types</td></tr>
<tr><td>2</td><td colspan="8">To ensure that students begin to understand the relationship between vulnerability disasters, disaster prevention and risk reduction</td></tr>
<tr><td>3</td><td colspan="8">To gain a preliminary understanding of approaches of Disaster Risk Reduction (DRR)</td></tr>
<tr><td>4</td><td colspan="8">To enhance the institutional processes in the country</td></tr>
<tr><td>5</td><td colspan="8">To evaluate the various case studies in disaster management</td></tr>
<tr><td colspan="2">Unit I</td><td colspan="2">INTRODUCTION TO DISASTERS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td colspan="2">Unit II</td><td colspan="2">APPROACHES TO DISASTER RISK REDUCTION (DRR)</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td colspan="2">Unit III</td><td colspan="2">INTER-RELATIONSHIP BETWEEN DISASTERS AND DEVELOPMENT</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td colspan="2">Unit IV</td><td colspan="2">DISASTER RISK MANAGEMENT IN INDIA</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td colspan="2">Unit V</td><td colspan="2">DISASTER MANAGEMENT: APPLICATIONS AND CASE STUDIES AND FIELD WORKS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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</td></tr>
<tr><td colspan="9" align="right">Total= 45 Periods</td></tr>
</table>

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)**															

<table>
<tr><td>22CEOE03</td><td colspan="2">REPAIR AND REHABILITATION OF BUILDING ELEMENTS</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">Construction materials and Technology & Concrete Technology</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 get the knowledge on causes of deterioration of structure</td></tr>
<tr><td>2</td><td colspan="6">To know about the assessment of distressed structures</td></tr>
<tr><td>3</td><td colspan="6">To get the knowledge on maintenance of building systems</td></tr>
<tr><td>4</td><td colspan="6">To know about the repairing of structures</td></tr>
<tr><td>5</td><td colspan="6">To gain knowledge about the techniques involved in the demolition procedure</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">MAINTENANCE OF ELECTRICITY AND DOMESTIC WATER PUMP SYSTEMS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</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">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</td></tr>
<tr><td>Unit IV</td><td colspan="2">REPAIRS,REHABILITATION AND RETROFITTING OF BUILDING SYSTEMS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</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">Engineered demolition techniques for dilapidated structures- case studies</td></tr>
<tr><td colspan="7" align="right">Total= 45 Periods</td></tr>
</table>

<table>
<tr><td colspan="2">Text Books:</td></tr>
<tr><td>1</td><td>Varghese P.C., Maintenance Repair Rehabilitation and Minor Works of Buildings, PHI Learning pvt.ltd.,NewDelhi,2014</td></tr>
<tr><td colspan="2">Reference Books:</td></tr>
<tr><td>1</td><td>Santhakumar A.R, Training Course notes on Damage Assessment and Repair in Low cost housing, “RHDC.NBO” Anna University, July 1992.</td></tr>
<tr><td>2</td><td>Shetty, M.S., Concrete Technology-Theory and Practice, S. Chand and company, NewDelhi,1992</td></tr>
<tr><td>3</td><td>RaikarR.N., Learning from failures- deficiencies in design, construction and services– R &D centre (SDCPL), raikar bhavan, Bombay,1987</td></tr>
</table>

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	Title	L	T	P	TH
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	Title	L	T	P	TH
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	Title	L	T	P	TH
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	Title	L	T	P	TH
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	Title	L	T	P	TH
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

<table>
<tr><td>22CSOE04</td><td colspan="2">PYTHON PROGRAMMING</td><td colspan="4"></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">To Learn the basic concepts of python programming.</td></tr>
<tr><td>2</td><td colspan="6">To write simple programs using python programming concepts.</td></tr>
<tr><td>3</td><td colspan="6">To build simple real world applications using python.</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">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.</td></tr>
<tr><td>UNIT II</td><td colspan="2">CONDITIONS,CONTROL STRUCTURES AND FILES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Conditionals and loops-if statement-else statement – elif-Conditional Expressions-while statement-for statement – break-continue –pass; Files and Input/ Output.</td></tr>
<tr><td>UNIT III</td><td colspan="2">PYTHON EXCEPTIONS, MODULES AND PACKAGES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Errors and Exceptions – Introduction-Detecting and handling Exceptions- Raising Exceptions – Assertions-Standard Exceptions – Modules: user defined modules, random and o s modules - Packages.</td></tr>
<tr><td>UNIT IV</td><td colspan="2">FUNCTIONS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Functions-Calling functions-Creating functions-Passing Functions-Formal Arguments-Variable length arguments- Variable scope – Recursion- Map, Filter, Reduce and List Comprehensions-Iterators -Generator Expressions.</td></tr>
<tr><td>UNIT V</td><td colspan="2">OBJECT ORIENTED PROGRAMMING AND REGULAR EXPRESSION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Introduction – Classes- Class Attributes – Instances-Instances attributes-Building and Method Invocation-Static methods and Class Methods – Inheritance-Operator overloading-Regular Expression.</td></tr>
<tr><td colspan="7">Total (45 L) =45 Periods</td></tr>
</table>

<table>
<tr><td colspan="2">Text Books:</td></tr>
<tr><td>1.</td><td>Wesley J.Chun-“Core Python Programming” –Prentice Hall, Third Edition, 2012.</td></tr>
<tr><td colspan="2">Reference Books:</td></tr>
<tr><td>1.</td><td>Swaroop C N, “ A Byte of Python “, ebshelf Inc., 1st Edition, 2013</td></tr>
<tr><td>2.</td><td>“A Practical Introduction to python programming”, Brian Heinold,MountSt.Mary’s University,2012</td></tr>
<tr><td>3.</td><td>Learning to Program with Python,” Richard L. Halterman”., Southern Adventist University</td></tr>
</table>

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

22CSOE06	COMPUTER ORGANIZATION		SEMESTER VI			
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
Digital Principles and System Design		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the basic structure and operations of digital computer and to learn the working of different arithmetic operations.
2.	To expose different types of processor control and the concept of pipelining and to familiarize hierarchical memory system including cache memory and virtual memory
3.	To expose the different ways of communicating 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/OInterfaces (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, 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

22CSOE07	DATA STRUCTURES USING C++			SEMESTER VI			
PREREQUISITES		**Category**	**OE**	**Credit**		**3**	
C Programming		**Hours/Week**	**L**	**T**	**P**	**TH**	
			3	**0**	**0**	**3**	

Course Learning Objectives	
1	To comprehend the fundamentals of object oriend programming, particularly in C++
2	To design linear and non linear data structure using object programming concepts
3	To apply various sorting and searching alogorithims.

UNIT I	**DATA ABSTRACTION & OVERLOADING**	**9**	**0**	**0**	**9**
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.					
UNIT II	**INHERITANCE AND POLYMORPHISM**	**9**	**0**	**0**	**9**
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.					
UNIT III	**LINEAR DATA STRUCTURES**	**9**	**0**	**0**	**9**
Abstract Data Types (ADTs) – List ADT – array-based implementation – linked list implementation –Singly Linked lists –Polynomial Manipulation – Stack ADT – Queue ADT – Evaluating arithmetic expressions.					
UNIT IV	**NON-LINEAR DATA STRUCTURES**	**9**	**0**	**0**	**9**
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.					
UNIT V	**SORTING AND SEARCHING**	**9**	**0**	**0**	**9**
Sorting algorithms: Insertion sort – Quick sort – Merge sort – Searching: Linear search –Binary Search					
					Total (45 L) =45 Periods

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. Geoffrey C 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.

		L	T	P	TH
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 Diode.

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)															

<table>
<tr><td>22ECOE02</td><td colspan="6">PRINCIPLES OF MODERN COMMUNICATION SYSTEMS</td><td colspan="3">OPEN ELECTIVE</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>
</table>

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

<table>
<tr><td>Unit I</td><td>FUNDAMENTALS OF ANALOG COMMUNICATION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="6">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).</td></tr>
<tr><td>Unit II</td><td>BASICS OF DIGITAL COMMUNICATION AND PULSE MODULATION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="6">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).</td></tr>
<tr><td>Unit III</td><td>DIGITAL MODULATION TECHNIQUES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="6">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).</td></tr>
<tr><td>Unit IV</td><td>SATELLITE COMMUNICATION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="6">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.</td></tr>
<tr><td>Unit V</td><td>CELLULAR MOBILE COMMUNICATION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="6">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.</td></tr>
<tr><td colspan="6" align="right">Total (45L)= 45 Periods</td></tr>
</table>

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)

<table>
<tr><td>22ECOE03</td><td colspan="5">MICROCONTROLLERS AND ITS APPLICATIONS</td><td colspan="4">OPEN ELECTIVE</td></tr>
<tr><td colspan="5">PREREQUISITES</td><td>CATEGORY</td><td>OE</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 learn microcontroller basics and get exposure to 8051 architectures</td></tr>
<tr><td>2.</td><td colspan="9">To embed and program with 8051 microcontrollers</td></tr>
<tr><td>3.</td><td colspan="9">To introduce the advanced features in microcontrollers and its applications</td></tr>
<tr><td>Unit I</td><td colspan="5">INTRODUCTION TO 8051 MICROCONTROLLER</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>Unit II</td><td colspan="5">ASSEMBLY LANGUAGE PROGRAMMING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>Unit III</td><td colspan="5">I/O PORT AND INTERRUPTS PROGRAMMING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>Unit IV</td><td colspan="5">PIC MICROCONTROLLERS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">Main characteristics of PIC microcontrollers – PIC microcontroller families-12-bit instruction word-14-bit instruction word-16-bit instruction word-Inside a PIC microcontroller.</td></tr>
<tr><td>Unit V</td><td colspan="5">APPLICATIONS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">Multiplexed seven-segment display, LCD module, ADC 0804, wave form generation using DAC 0808, DC motor-PWM for speed control, Stepper motor, appropriate program.</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>A.Mazidi , J.C. Mazidi&R.D.McKinlay,” The 8051 Microcontroller & Embedded systems using assembly and C” (2ndEdition)</td></tr>
<tr><td>2.</td><td>Lucio Di Jasio et.al., “PIC Microcontrollers: Know It All”, Elsevier Science,2007</td></tr>
<tr><td colspan="2">Reference Books:</td></tr>
<tr><td>1.</td><td>Microcontrollers & applications, Ramani Kalpathi, & Ganesh Raja</td></tr>
<tr><td>2.</td><td>Embedded C - Michael .J.Pont - Pearson Education -2002</td></tr>
<tr><td>3.</td><td>I. Scott MacKenzie, Raphael C.-W. Phan “The 8051 Microcontroller” , Pearson/Prentice Hall Publishers, 2008.</td></tr>
<tr><td>4.</td><td>M. Mahalakshmi, “8051 Microcontroller Architecture, Programming and Application”, Laxmi Publications , 2008.</td></tr>
</table>

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	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	2	-	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)

22ECOE04	COMPUTER NETWORKS					OPEN ELECTIVE
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To introduce the basic concept in modern data communication and computer networking.
2.	To introduce the students the functions of different layers and in - depth knowledge of data link layer.
3.	To make students to get familiarized with different protocols and network layer components.
4.	To introduce the basic functions of transport layer and congestion in networks.
5.	To understand the concepts of various network Applications and Data security.

Unit I	NETWORK FUNDAMENTALS AND PHYSICAL LAYER	9	0	0	9

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

Unit II	DATA LINK LAYER	9	0	0	9

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.

Unit III	NETWORK LAYER	9	0	0	9

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.

Unit IV	TRANSPORT LAYER	9	0	0	9

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

Unit V	APPLICATION LAYER	9	0	0	9

Domain Name Space (DNS) – Electronic mail (SMTP, MIME, POP3, IMAP4) - Application protocols: WWW, HTTP, FTP and TELNET, Network management protocol: SNMP.

Total (45L)= 45 Periods

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	PS O 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**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO1 0**	**PO1 1**	**PO1 2**	**PS O1**	**PS O2**	**PSO 3**
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.

		L	T	P	Total
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**	**PSO3**
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**	**PSO3**
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", 8^{th}Edition, 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)

22MEOE03	INDUSTRIAL ROBOTICS			SEMESTER VI/VII			
		CATEGORY		OE	Credit		3
		Hours/Week		L	T	P	TH
				3	0	0	3

COURSE OBJECTIVES

1	To explore concepts of robot technologies that is playing vital role in manufacture.
2	Describe various robot technology applications.
3	Develop an understanding of robot Kinematics and dynamics.
4	Explain and summarize robot end effectors and Sensors.
5	Explore conceptual understanding of Robot programming.

UNITI	**INTRODUCTION**	**9**	**0**	**0**	**9**
Robot - definition - robot anatomy - co-ordinate systems - work envelope - types and classification - specifications – joint notations – types of joints - speed of motion - pay load - robot parts and their functions - need for robots in Indian scenario.					
UNIT II	**ROBOT DRIVE SYSTEMS AND END EFFECTORS**	**9**	**0**	**0**	**9**
Drives - hydraulic, pneumatic, mechanical and electrical - servo motors - stepper motors - salient features, application – end effectors – types: tools - grippers - mechanical grippers - pneumatic and hydraulic grippers, magnetic grippers, vacuum grippers, multiple grippers.					
UNIT III	**SENSORS AND MACHINE VISION**	**9**	**0**	**0**	**9**
Requirements of sensors – principles, types and applications of following types of sensors proximity (inductive, Hall effect, capacitive, ultrasonic and optical) – range (Triangulation, structured light approach, laser range) – speed, position (resolvers, optical encoders, pneumatic) – force – torque – touch sensors (binary, analog sensor) - Introduction to machine vision -functions - image processing and analysis.					
UNIT IV	**ROBOT KINEMATICS AND ROBOT PROGRAMMING**	**9**	**0**	**0**	**9**
Forward kinematics and reverse kinematics of manipulators - two, three degrees of freedom (in 2 dimensional) – homogeneous transformation matrix - simple problems - lead through programming, robot programming languages - VAL programming –motion commands - sensor commands - end effecter commands - simple programs for loading, unloading and palletizing operations.					
UNIT V	**APPLICATIONS, IMPLEMENTATION AND ROBOT ECONOMICS**	**9**	**0**	**0**	**9**
Robot cell design – types - Application of robots in processing - assembly - inspection - material handling - loading - unloading - automobile - implementation of robots in industries - safety considerations for robot operations – economic analysis of robots - pay back method and rate of return method.					
					Total (45L) = 45Periods

REFERENCE BOOKS:

1	Mikell. P. Groover, 'Industrial Robotics Technology', Programming and Applications, McGraw Hill Co, 1995.
2	Fu.K.S. Gonzalz.R.C., and Lee C.S.G., "Robotics Control, Sensing, Vision and Intelligence", McGraw Hill Book Co., 1987.
3	Richard D.Klafter, Thomas A.Chmielewski and MichealNegin, "Robotic engineering –An Integrated Approach", Prentice Hall Inc, Englewoods Cliffs, NJ, USA, 2005.
4	Janakiraman.P.A. "Robotics and Image Processing", Tata McGraw-Hill, 1995.
5	YoramKoren, "Robotics for Engineers", McGraw-Hill Book Co., 1992.
6	A.K.Gupta and S.K.Arora, "Industrial Automation and Robotics", Laxmi Publications Pvt ltd, 2007.
7	Fu. K. S., Gonzalez. R. C. & Lee C.S.G., 'Robotics control, sensing, vision and intelligence', McGraw Hill Book co, 1987.

8	Craig. J. J. 'Introduction to Robotics mechanics and control',Addison- Wesley, 1999
9	Ray Asfahl. C., 'Robots and Manufacturing Automation', John Wiley & Sons Inc., 1985.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the basic concepts, parts of robots and types of robots.	Understand
CO2	Understand the potential applications of robots in industries as part of automation tool.	Understand
CO3	Familiar with the various drive systems for robot, sensors and their applications in robots, programming of robots.	Remember
CO4	Discuss about the various applications of robots, justification, implementation and safety of robot	Analyze
CO5	Select an appropriate robot for a particular application.	Apply

COURSE ARTICULATION MATRIX														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1			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**	**PO 5**	**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)															

22MEOE07	RENEWABLE SOURCES OF ENERGY				SEMESTER VI/VIII
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	**CATEGORY**	**OE**	**Credit**		**3**
	Horus/Week	**L**	**T**	**P**	**TH**
		3	**0**	**1**	**4**

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 RADIATION AND ITS MEASUREMENTS**	**9**	**0**	**0**	**9**

Alternative energy sources, Global and Indian energy scenario. Solar Energy: Introduction – Solar Radiation Measurement and Instruments – Data and estimation.

UNIT II	**SOLAR ENERGY COLLECTORS, SOLAR ENERGY STORAGE AND APPLICATIONS OF SOLAR ENERGY**	**9**	**0**	**0**	**9**

Flat Plate and Concentrating Collectors –Solar direct Thermal Applications – Solar thermal Power Generation – Fundamentals of Solar Photo Voltaic Conversion – Solar Cells – Solar PV Power Generation –Solar Energy Storage: Thermal energy, Chemical Energy and Electromagnetic energy storage; Solar PV Applications: Solar water heating, Space heating and cooling, Solar distillation, Solar pumping, Solar furnace, Solar cooking.

UNIT III	**BIOMASS AND ITS CONVERSION TECHNOLOGIES**	**9**	**0**	**0**	**9**

Bio-mass conversion Techniques: Direct combustion (incineration); Thermo-chemical conversion-Gasification and its types; Wet Process- Classification of biogas plant- types of Anaerobic digestion (Khadi and Village Industries type, Pragati design, Gasnesh biogas plant and Ferro-cement digester biogas plant) – Fermentation process;

UNIT IV	**WIND, GEOTHERMAL AND TIDAL ENERGY**	**9**	**0**	**0**	**9**

Basic principle of wind energy conversion, types of wind energy conversion; Geothermal sources – hydrothermal geothermal resources, geopressurised resources, hot dry rock resources of petrothermal systems, Magma resources – Comparison of flashed steam and total flow concept. Basic principle of tidal power, components of tidal power plants, operation methods of utilization of tidal power.

UNIT V	**CHEMICAL ENERGY, HYDROGEN ENERGY AND MAGNETO HYDRO DYNAMIC**	**9**	**0**	**0**	**9**

Design and principle operation of a Fuel cells, classification of fuel cells, types of fuel cells, Advantages, disadvantages and applications of fuel cells. Basic principle of Magneto Hydro Dynamic – Open cycle and closed cycle system.

Total (45L) = 45Periods

REFERENCE BOOKS:

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

E-REFERENCES:

1.	https://en.wikipedia.org/wiki/Renewable_energy
2.	Ellabban, Omar; Abu-Rub, Haitham; Blaabjerg, Frede (2014). "Renewable energy resources: Current status, future prospects and their enabling technology". Renewable and Sustainable Energy Reviews. 39: 748–764 [749]

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the principles 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				Semester VI/VII	
PRE-REQUISITES: 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 the production of new materials.
2.	To know the concepts of different materials joining technology and emphasis on the underlying science and engineering principle of every process.

UNIT I	**MOULDING MATERIALS AND PATTERNS**	**9**	**0**	**0**	**9**
Introduction to foundry operations, patterns - functions, types, allowances, selection of pattern materials, colour codes, 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 alloys and 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 and laser beam welding processes. Friction, friction stir welding, ultrasonic, explosive and diffusion welding processes.					
					Total (45L) = 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", 3rd edition. Khanna Publishers, New Delhi, 2003.
4.	Srinivasan N K ,"Welding Technology", Khanna Publishers, Delhi, 2016

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	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	1.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MTOE02	ADVANCED SURFACE ENGINEERING				Semester VI/VII	
PRE-REQUISITES: Manufacturing Technology		**Category**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	Analyze the various concepts of surface engineering and comprehend the design difficulties

UNIT I	**TRIBOLOGY AND PLATING PROCESSES**	**9**	**0**	**0**	**9**
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.					
UNIT II	**HARD FACING PROCESSES**	**9**	**0**	**0**	**9**
SMAW, GTAW, GMAW, FCAW, SAW, PAW, Oxy-Acetylene Welding, Furnace fusing, Thermal-spray, Flame spray processes - HVOF, Detonation gun and Jet kote processes, Hard facing consumables.					
UNIT III	**SPECIAL DIFFUSION PROCESSES**	**9**	**0**	**0**	**9**
Principle of diffusion processes - Boriding, Aluminising, Siliconizing, Chromising - Selection of diffusion processes - Characteristics of diffused layer - microstructure and microhardness evaluation - properties and applications.					
UNIT IV	**THIN FILM COATINGS**	**9**	**0**	**0**	**9**
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.					
UNIT V	**HIGH ENERGY MODIFICATION AND SPECIAL PROCESSES**	**9**	**0**	**0**	**9**
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.					
Total (45L) = 45 Hours					

Text Books:

1.	Chattopadhyay R., Surface Wear: Analysis, Treatment, Prevention, ASM International, USA, 2001
2.	Kenneth G. Budinski, Surface Engineering for Wear Resistance, Prentice Hall, Englewood Cliff, 1990.

Reference Books:

1.	ASM Metals Handbook, Vol 5: Surface Engineering, ASM International, Ohio, 1994.
2.	Ernest Rabinowicz, Friction and Wear of Materials, 2nd ed., John Wiley & Sons, NY, 1995.
3.	Davis J.R., Surface Engineering for Corrosion and Wear resistance, ASM International, 2001.

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	L2: Understanding

		outer surface of the material such as boriding, aluminizing, etc.	
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	0.0	0.0	0.0	0.0	1.0	1.3	1.5	0.0	1.0

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

22MTOE03	DESIGN AND SELECTION OF MATERIALS				Semester VI/VII		
PRE-REQUISITES: 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 for Different 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 (45L) = 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 the 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

<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	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	0.0	0.0	0.0	0.0	0.0	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					Semester VI/VII	
PRE-REQUISITES: **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 Plastic Deformation, 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) or graphene.					
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, biomedical fields, solar cells, LED, LCD, electrically conducting polymers, batteries, fuel cells, SMART Materials. Environmental and health issues related to nanomaterials.					
					Total (45L) = 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 engineering applications.	L2: Understanding
CO2	:	Explain the various applications of nanomaterials.	L3: Applying
CO3	:	Discuss the fabrications of composites and nanocomposites.	L2: Understanding
CO4	:	Describe the characterization 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	0.0	0.0	0.0	0.0	0.0	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				Semester VI/VII
PRE-REQUISITES: 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 automotive structures
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 for climate control, anti-collision, Anti-fog, Head lamps.					
					Total (45L) = 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, WoodHead 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 andFunctional requirements on selection strategies.	L4: Analyzing
CO3	:	Recognize the temperature regime, nature of load and property requirements of materials for engines and transmission systems.	L4: Analyzing
CO4	:	Analyse the various stresses acting on the structural members of automobile underDynamic loading and select suitable material.	L4: Analyzing
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	0.0	0.0	0.0	0.0	0.0	1.5	1.7	1.0	1.0

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

ELECTIVES FOR HONOURS

HONOURS DEGREE for Metallurgical Engineering Students

VERTICAL 1 : WELDING

22MTH101	**WELDING EQUIPMENT AND CONSUMABLES**		**Semester**			
PREREQUISITES			**PE**	**Credit**		**3**
Engineering physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**
Course Learning Objectives						
1.	To know the basic knowledge of equipment and accessories of various welding processes.					
2.	To gain knowledge on selection of consumables for different welding processes.					
Unit I	**EQUIPMENT AND ACCESSORIES FOR VARIOUS WELDING PROCESS**		**9**	**0**	**0**	**9**
Gas welding process – Compressed gas cylinders, Cylinder valves, Pressure valves, Gas hoses, Welding torches, Torch tips, Tip cleaner and spark lighter. Arc welding process – Shielded metal arc welding (SMAW): Equipment and operating accessories.Gas tungsten arc welding (GTAW): Power source, GTAW torch, wire feed mechanism, materials.Gas metal arc welding (GMAW): power source, wire feed units, GMAW gun and wire feed conduit assembly, shielding gas and cooling water systems, materials used.Submerged Arc Welding (SAW): Equipment and materials.						
Unit II	**EQUIPMENT AND ACCESSORIES FOR SPECIAL WELDING PROCESS**		**9**	**0**	**0**	**9**
Electron Beam Welding – Cathode, Electron accelerating system, Beam focusing system, Weld viewing system, Vacuum chamber, Work traversing system, Seam tracking methods. Laser welding – Principle and mechanism of laser operation, ruby laser equipment and setup. Thermit Welding – Equipment setup and operation. Solid-State Welding Processes – Friction welding machines and equipment. Resistance Welding – Rocker-Arm Type Machines, Press Type Machines, Portable Welder						
Unit III	**ARC WELDING POWER SOURCES**		**9**	**0**	**0**	**9**
A.C. Welding Power Sources – Operating Principles of a Welding Transformer, Requirements of a Welding Transformer, Basic Types of Welding Transformers. D.C. Welding Power Sources – Opposition Series Generator (Separately Excited), Opposition Series Generator (Self Excited), Split-Pole D.C. Welding Generator, Output Volt-Ampere Characteristics of Welding Generators, Multi-Operator D.C. Welding Power Sources. Rectified D.C. Welding Power Sources – General Theory of Rectifier Design, Solid-State Welding Rectifiers, SCR Welding Power Source, Pulsed Arc Welding Power Sources, Transistor Welding Power Sources.						
Unit IV	**AUTOMATION IN WELDING**		**9**	**0**	**0**	**9**
Introduction to automation in welding, Welding sequence and classification of processes, Manual welding, Semi-Automatic welding, Automatic welding, Automated welding, Adaptive controls, Automatic welding versus Automated welding, remote welding, Robotic welding and Selecting a welding system.						
Unit V	**WELDING CONSUMABLES**		**9**	**0**	**0**	**9**
Coated Electrodes- Electrode Coating, classification and coding of covered (heavy coated), Classification and coding of electrodes for SMAW/MMAW of low and medium alloy steels. Welding Rods and Wires – Specifications for solid Wires and Rods and Tubular Electrodes or Flux-Cored Wires. Welding Fluxes – Composition and chemical classification of SAW Fluxes, Roles of flux ingredients, Physical classification of SAW fluxes and Shielding gases – inlet and activated shielding gases.						
						Total (45L) = 45 Hours

Text Books:

1.	Welding Engineering and Technology by Dr. R.S. Parmar, Khanna Publishers, 2013.
2.	Welding Technology by Dr. N.K.Srinivasan, Khanna Publishers, 2001.
Reference Books:	
1.	Text Book Of Welding Technology by Bruce Stirling, DhanpatRai Publications, 2011.
2.	AWS Welding Handbook. 9th edition Volume1, “Welding Science and Technology”, 2013
3.	AWS Welding handbook, 3^{rd} edition, Welding Consumables Gases and Gas Mixtures for Fusion Welding and Allied Processes, 2021

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Discuss the basic knowledge on handling welding equipment and accessories.	L2: Understanding
CO2	:	Discuss the equipment and accessories for special welding processes like EBW, LBW, FSW and resistance welding.	L2: Understanding
CO3	:	Describe the appropriate power sources for arc welding operations.	L2: Understanding
CO4	:	Diagnose the advancements of automations in the welding process.	L3: Applying
CO5	:	Demonstrate and select suitable consumables for different 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	1	1		1			1						1	1		
CO2	2	1		1		1							2			
CO3	2	1	1		1	1		1					1	1		1
CO4	1	2		1		1							1			
CO5	1	1		1									1			1
Avg.	1.4	1.2	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	1.2	1.0	0.0	1.0

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

22MTH102	WELDING CODES AND STANDARDS			Semester			
PREREQUISITES				**PE**	**Credit**		**3**
Engineering physics			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**
Course Learning Objectives							
1.	Overview and Introductory treatment of codes and standards in the reference–No numerical problems, written document procedures and qualification						
2.	To acquire knowledge on various welding codes and standards related to various engineering applications.						
Unit I	**STRUCTURAL WELDING CODES**			**9**	**0**	**0**	**9**
Design requirements, allowable stress values, workmanship and inspection, introduction to welding codes and standards							
Unit II	**PETROLEUM PIPING FABRICATION**			**9**	**0**	**0**	**9**
Process and product standards for manufacturing of pipe – welding procedure and welder qualifications, field welding and inspection, API 1104 and API 5L							
Unit III	**PRESSURE VESSEL FABRICATION**			**9**	**0**	**0**	**9**
Design requirements fabrication methods, joint categories, welding and inspection, post weld heat treatment and hydro testing.							
Unit IV	**WELDING PROCEDURE AND WELDER QUALIFICATION**			**9**	**0**	**0**	**9**
Type of variables involved in Welding procedure specification, procedure qualification records, performance qualification.							
Unit V	**MATERIALS AND CONSUMABLES**			**9**	**0**	**0**	**9**
Introduction to materials standards and testing of materials, consumables testing and qualification as per ASME/AWS requirements							
							Total (45L) = 45 Hours

Reference Books:	
1.	AWS D1.1 Structural Welding Code
2.	API 1104
3.	ASME Section VIII – Division 1
4.	ASME Section IX
5.	ASME Section II Part A, B and C
6.	API 6A

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Identify various design requirements as per AWS D1.1.	L4: Analyzing
CO2	:	Apply variables for procedure and performance qualifications as per API 1104 and AP15L.	L3: Applying
CO3	:	Apply variables, requirements for inspection and testing as per ASME VIII.	L3: Applying
CO4	:	Discuss WPS, PQR and processes as per section IX.	L2: Understanding
CO5	:	Explain different materials standard, and testing as per ASME section II part A, B and C.	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	2	1	1			1					1	1	1		
CO3	2	2		1	1	1						1	1	2		1
CO4	1	1	1	1	1								1			1
CO5	1	1											1			1
Avg.	1.4	1.4	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0	1.5	1.0	1.0

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

22MTH103	AUTOMATION AND ROBOTS IN WELDING			Semester			
PREREQUISITES			PE	Credit		3	
Engineering physics, Welding Engineering		**Hours/Week**	L	T	P	TH	
			3	0	0	3	

Course Learning Objectives	
1.	To compile and work with the automated equipment and its processing are Automation of arc welding processes and other related welding processes.
2.	To emulate the automated welding equipment, arc and work motion and standardized arc welding machines and gain knowledge on operations using the robots.

		L	T	P	TH
Unit I	**AUTOMATION OF ARC WELDING PROCESSES**	9	0	0	9
Need for automation in welding, methods of application of welding, introduction to manual, semi-automatic, mechanized, automatic, automated, remote, adaptive control and robotic welding. Advantages and disadvantages of welding automation. Degree of automation possible in different welding processes like GMAW, FCAW, SAW, GTAW, PAW and Stud welding.					
Unit II	**AUTOMATION OF OTHER RELATED PROCESSES**	9	0	0	9
Automation in Resistance welding, Electron Beam Welding, Laser Beam Welding and Solid State welding processes. Automation in Oxygen cutting, Plasma arc cutting, Laser Beam cutting and Thermal spraying.					
Unit III	**AUTOMATED WELDING EQUIPMENT, ARC AND WORK MOTION DEVICES**	9	0	0	9
Welding power sources, type of electrode wire feeders and electrode wire dispensing systems. Arc motion devices – Welding tractors, carriages, side beam carriages, manipulators and Gantry carriages. Work motion devices – Universal positioners, turning rolls, head and tail stock positioners.					
Unit IV	**STANDARDIZED ARC WELDING MACHINES**	9	0	0	9
Standardized automatic welding machines, types of standardized welding machines – seamers, welding lathe, weld–around machine, nozzle welder, bore welder, beam welder, strip welder, Laser welding cell and Plasma Transferred Arc Overlay system. Automatic welding of pipes and tubes.					
Unit V	**ROBOTIC ARC WELDING**	9	0	0	9
Flexible automation of arc welding. Robotic arc welding system, types of welding Robots – Revolute, Cartesian, Spherical, Cylindrical and Scara – Hybrid robots for welding, features of a welding robot, robotic part – holding positioners, Teaching the robot, Specifying the Welding robot.					
					Total (45L) = 45 Hours

Reference Books:	
1.	Howard B. Cary "Arc welding Automation"- Marcel Dekker, New York1995.
2.	AWS Welding Handbook, Vol. 3, 9th edition, A W S.,2015.
3.	AWS Welding Handbook, vol.5, "Engineering Costs, Quality and Safety", 9th edition,AWS,2015.
4.	Parmar, R.S., "Welding Processes and Technology", 3rd edition. Khanna Publishers, New Delhi, 2003.
5.	The Procedure Handbook of Arc Welding, 13th Edition, Lincoln Electric, USA,1994.

6.	Proceedings of the International Conference on Assembly Automation, British Welding Institute,1985. Kozyrev, Industrial Robots Handbook, Mir Publishers, Moscow.
7.	Kozyrev, Industrial Robots Handbook, Mir Publishers, Moscow,1975.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Demonstrate the automation of arc welding processes.	L2: Understanding
CO2	:	Demonstrate the automation of other welding and related processes.	L2: Understanding
CO3	:	Apply the automated welding equipment, arc and work motion devices for various welding processes.	L3: Applying
CO4	:	Explain the standardized arc welding machines	L2: Understanding
CO5	:	Explain the Robot Arc welding	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
CO2	2	2	1	1								1	2			
CO3	2	2			1	1	1					1	2			
CO4	1	2		1	1								1		1	
CO5	1	1						1					1			1
Avg.	1.4	1.6	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	1.4	0.0	1.0	1.0

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

22MTH104	WELDING APPLICATIONS TECHNOLOGY			Semester		
PREREQUISITES			**PE**	**Credit**		**3**
Engineering physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1. To understand the materials, process, fabrication techniques used in welding of pressure vessels, piping and pipelines.
2. to understand materials, processes, fabrication, and inspection of automobile and nuclear industrial components.

Unit	Title	L	T	P	TH
Unit I	**WELDING OF PRESSURE VESSELS**	**9**	**0**	**0**	**9**
Materials, processes, fabrication techniques and field welding for pressure vessel applications					
Unit II	**WELDING OF HEAT EXCHANGER AND PIPEINGS**	**9**	**0**	**0**	**9**
Heat exchanges, power cycle piping, super heaters, reheaters, economiser, auxiliary pipes, materials, processes and testing/inspection.					
Unit III	**WELDING IN OIL AND GAS INDUSTRIES**	**9**	**0**	**0**	**9**
Oil and gas industry, materials, processes, fabrication, inspection and testing, case studies, recent trends and developments.					
Unit IV	**WELDING IN AUTOMOBILE INDUSTRIES**	**9**	**0**	**0**	**9**
Materials, processes, fabrication and construction, use of automatic welding and systems in automobile industry, automation.					
Unit V	**WELDING IN NUCLEAR INDUSTRIES**	**9**	**0**	**0**	**9**
Materials, processes, fabrication, inspection and testing, reasons for stringent quality control measures in the nuclear industry.					
					Total (45L) = 45 Hours

Reference Books:

1. S.V.Nadkarni, “Modern Arc Welding Technology”, Oxford-IBH Publishers, New Delhi, 7th edition1996.
2. R.S.Parmar, “Welding Engineering and Technology”, Khanna Publishers, New Delhi, 1stedition1997
3. AWS Welding Handbook, Sec.5 – Applications of Welding, 5thEdition,1967.
4. AWS Welding Handbook, Vol.4, 7th Edition,1991.
5. ASM Metals Handbook, Vol.6, Welding, Brazing and Soldering, ASM, New York, 1998.
6. Howard B. Cary, "Modern Welding Technology", Prentice Hall, New Jersey, USA, 1989

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the conventional pressure vessels and solve the difficulties in welding of pressure vessel steels.	L4: Analyzing
CO2	:	Choose the fittings for the fabrication of heat exchanger and piping.	L4: Analyzing
CO3	:	Solve the problems involved in welding of oil refinery components,	L4: Analyzing
CO4	:	Apply the materials used in Automobile components and their weldments.	L3: Applying
CO5	:	Explain the welding of nuclear industrial components.	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							2			
CO2	2	2		1											1	
CO3	2	1	1	1			1						1		1	1
CO4	1	2	1		1		1	1					1	1		
CO5	1	1		1	1								1			
Avg.	1.4	1.4	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	1.3	1.0	1.0	1.0

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

22MTH105	BRAZING, SOLDERING, SURFACING AND CUTTING		Semester			
PREREQUISITES			**PE**	**Credit**		**3**
Engineering physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**
Course Learning Objectives						
1.	To understand the fundamental concepts, applications, advantages and limitations of brazing, soldering, surfacing and cutting					
Unit I	**FUNDAMENTALS OF BRAZING AND SOLDERING**		**9**	**0**	**0**	**9**
Wetting and spreading characteristics, surface tension and contact angle concepts. Filling of horizontal and vertical capillary joints. Capillary dams.						
Unit II	**FLUXES AND ATMOSPHERES FOR BRAZING AND SOLDERING**		**9**	**0**	**0**	**9**
Role of flux and characteristics constituents of flux, grouping and applications Fluxes used for specific braze metal flux removal and related corrosion problems. Atmosphere for brazing and atmosphere for brazing specific base metal metallurgy of filler metal for brazing and soldering - joint design and fixturing for brazing.						
Unit III	**SOLDERING AND BRAZING PROCESSES**		**9**	**0**	**0**	**9**
Hand soldering, flame soldering furnace soldering, hot gas blanket soldering, wave soldering, etc., torch brazing furnace brazing, induction brazing, dip brazing resistance brazing, vacuum brazing, etc., applications of brazing soldering-brazing and soldering defects.						
Unit IV	**SURFACING**		**9**	**0**	**0**	**9**
Thermal spraying, plasma spraying, laser surface alloying and modification. Surfacing spraying to improve wear resistance and corrosion resistance. CVD, PVD and ion implantation. Cladding and its applications.						
Unit V	**THERMAL CUTTING PROCESSES**		**9**	**0**	**0**	**9**
Oxygen cutting-oxy fuel gas, metal powder, chemical flux and oxygen arc cutting. Arc cutting processes- carbon arc, air carbon arc cutting. Metal and plasma arc cutting, High energy beam cutting, laser beam cutting, water jet cutting and underwater cutting.						
						Total (45L) = 45 Hours

Reference Books:	
1.	Schwartz. M., “Brazing – for the Engineering Technologies”, Chapman and Hall, 1995.
2.	Manko. H.H., “Solders and Soldering”.2nd Edition, McGraw Hill1979..
3.	Udin, Funk, and Wulf ., “Welding for ENGINEERS”.
4.	ASM Metals Hand Book Vol. 6 “Welding and Brazing”,1988.
5.	Lancaster .J .F . “Metallurgy of Welding, Brazing and Soldering” 3rdedition. George Allen & Unwin.1980.
6.	Brooke, “Industrial Brazing”, Bcton.1975.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Discuss the concepts of brazing and soldering.	L2: Understanding
CO2	:	Explain the fluxes and atmosphere for brazing and soldering.	L3: Applying
CO3	:	Compare the brazing and soldering processes.	L3: Applying
CO4	:	Describe surfacing techniques.	L2: Understanding
CO5	:	Locate the areas of thermal cutting 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	1	1		1	1								1			
CO2	2	1	1			1							2		**1**	
CO3	2	2	1	1	1		1						2		**1**	
CO4	1	1				1							1			
CO5	1	1	1					1					1			
Avg.	1.4	1.2	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	1.4	0.0	1.0	0.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MTH106	DESIGN OF WELDMENTS		Semester			
PREREQUISITES			PE	Credit		3
Engineering physics		Hours/Week	L	T	P	TH
			3	0	0	3
Course Learning Objectives						
1.	To design a system, a component, or a process to meet desired needs within realistic constraints such as design basics, weld design for static loading, weld design for dynamic loading, distortion and residual stresses and failure analysis of the manufacturing.					
Unit I	**DESIGN BASICS**		**9**	**0**	**0**	**9**
Types of joints, Types of welds, variants of joints, selection of weld type, weld joints for structural tubular connections, welding symbols, weld dimensions, NDT symbols. Principles of weld joint design – General and specific design principles.						
Unit II	**WELD DESIGN FOR STATIC LOADING**		**9**	**0**	**0**	**9**
Material or section properties, Weld design stress calculation for welds, design under different types of loading like tension, compression, bending, shear, torsion and shock						
Unit III	**WELD DESIGN FOR DYNAMIC LOADING**		**9**	**0**	**0**	**9**
Basic details of fatigue and fatigue failure, S-N curve, Goodman diagram, factors affecting fatigue life of welded joints, methods of improving fatigue life of welded structures, design for fatigue loading, weld design using fracture toughness value (KIC).						
Unit IV	**RESIDUAL STRESSES**		**9**	**0**	**0**	**9**
Welding residual stresses–causes, occurrence, effects–thermal and mechanical stress relieving.						
Unit V	**DISTORTION**		**9**	**0**	**0**	**9**
Types of distortion - factors affecting distortion - distortion control methods - prediction - correction, jigs, fixtures and positioners.						
						Total (45L) = 45 Hours

Reference Books:

1.	Blodgett. O. W., Design of Weldments, James F. Lincoln Arc Welding Foundation, 1991.
2.	R.S.Parmar, Welding Engineering and Technology 2^{nd} edition, 2010.
3.	Gurney T.R. Fatigue of Welded Structures. Cambridge University Press,1980.
4.	Rolfe. T., Barsom. J., Fracture and Fatigue Control of Structures – Applications of Fracture Mechanics, Prentice Hall, 1987.
5.	ASM Metals Hand Book. Failure Analysis and Prevention. Vol. 11. ASM2002.
6.	Das, A.K., Metallurgy of Failure Analysis, Tata McGraw Hill, New Delhi,1997.
7.	Donald J. Wulpi, Understanding how components fail, ASM International, 3^{rd} Edition, 2013.

8.	Colangelo.V.J. and Heiser.F. A., “Analysis of Metallurgical Failures”, John Wiley and Sons Inc. New York, USA, 1987.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Figure out the design basics of the welding operations.	L2: Understanding
CO2	:	Analyze the weld design for static loading processes.	L4: Analyzing
CO3	:	Analyze the weld design for dynamic loading processes.	L4: Analyzing
CO4	:	List the factors influencing residual stresses	L3: Applying
CO5	:	List the factors influencing distortion.	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									2			
CO2	2	2		1		1	1						1			1
CO3	2	2	1		1			1					2			1
CO4	1	1		1									1		1	
CO5	1	2		1									1			1
Avg.	1.4	1.6	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	1.4	0.0	1.0	1.0

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

<table>
<tr><td>22MTH107</td><td colspan="4">FAILURE ANALYSIS IN WELDMENTS</td><td colspan="3">Semester</td><td></td></tr>
<tr><td colspan="3">PREREQUISITES</td><td colspan="2"></td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="3" rowspan="2">Engineering physics</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 Learning Objectives</td></tr>
<tr><td>1.</td><td colspan="8">To understand the concepts on failure and fracture analysis of weldments and to design new materials that can withstand catastrophic failures of weldments in different environments.</td></tr>
<tr><td>Unit I</td><td colspan="4">INTRODUCTION TO FAILURE ANALYSIS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">Stages of failure analysis, classification and identification of various types of fracture. Overview of fracture mechanics, characteristics of ductile and brittle fracture.</td></tr>
<tr><td>Unit II</td><td colspan="4">WELDMENT SURFACE FAILURES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">Types of wear, analyzing wear failure. Corrosion failures- factors influencing corrosion failures, overview of various types of corrosion stress corrosion cracking, sources, characteristics of stress corrosion cracking. Procedure for analyzing stress corrosion cracking, various types of hydrogen damage failures.</td></tr>
<tr><td>Unit III</td><td colspan="4">WELDMENT FATIGUE FAILURES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">General concepts, fracture characteristics revealed by microscopy, factors affecting fatigue life, elevated temperature fatigue, metallurgical instabilities, environmental induced failure. Some case studies on weldment failures.</td></tr>
<tr><td>Unit IV</td><td colspan="4">WELDMENT CREEP FAILURES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">General concepts Creep, stress rupture - fracture characteristics revealed by microscopy, - creep mechanisms, creep curve, variables affecting creep, accelerated creep testing, development of creep resistant alloys, Larsen Miller parameter – Manson Haferd parameter. Some case studies on weldment failures.</td></tr>
<tr><td>Unit V</td><td colspan="4">FAILURE OF WELDED PRODUCTS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">Causes of failure in forge weldments, failure of welded iron and steel castings, improper heat treatment of weldments, stress concentration by weldments, in-service weldment failures. Procedure for weld failure analysis and data extraction.</td></tr>
<tr><td colspan="9">Total (45L) = 45 Hours</td></tr>
</table>

Reference Books:	
1.	Colangelo.V.J. and Heiser.F.A., “Analysis of Metallurgical Failures”, John Wiley and Sons Inc. New York, USA,1987.
2.	Das, A.K., “Metallurgy of Failure Analysis”, Tata McGraw Hill, New Delhi,1992.
3.	DonaldJ.Wulpi,“Understanding how components fail”, ASM International, 3rd Edition, 2013.
4.	ASM Metals Handbook “Failure Analysis and Prevention”, ASM Metals Park. Ohio, Vol.10, 10thEdition,1995.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the concepts and types of failure analysis in weldments.	L2: Understanding
CO2	:	Analyze the various wear and corrosion failures in weldments.	L4: Analyzing
CO3	:	Discuss the weldment fatigue failures.	L2: Understanding
CO4	:	Discuss the weldment creep failures.	L2: Understanding
CO5	:	Review the failures in welded products.	L4: Analyzing

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							2		1	
CO2	2	2	1	1			1	1					1			1
CO3	2	1			1	1							2			
CO4	1	1		1	1								1			
CO5	1	1	1				1	1							1	1
Avg.	1.4	1.4	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	1.5	0.0	1.0	1.0

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

<table>
<tr><td>22MTH108</td><td colspan="2">FINITE ELEMENT ANALYSIS IN WELDING</td><td colspan="3">Semester</td><td></td></tr>
<tr><td colspan="2">PREREQUISITES</td><td></td><td>PE</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 provide the basic FEM modeling and to analyze and solve metallurgical problems using those methods.</td></tr>
<tr><td>Unit I</td><td colspan="2">TWO DIMENSIONAL PROBLEMS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Poisson equation – Laplace equation – Weak form – Element matrices for triangular and rectangular elements – Evaluation of integrals – Assembly – Axi-symmetric problems – Applications – Conduction and convection heat transfer – Torsional cylindrical member – Transient analysis - Theory of elasticity – Plane strain – Plane stress – Axi-symmetric problems– Principle of virtual displacement</td></tr>
<tr><td>Unit II</td><td colspan="2">ISOPARAMETRIC ELEMENTS AND ITS APPLICATIONS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Introduction – Bilinear quadrilateral elements – Quadratic quadrilaterals – Hexahedral elements - Numerical integration – Gauss quadrature – Static condensation – Load considerations – Stress calculations – Examples of 2D and 3D applications</td></tr>
<tr><td>Unit III</td><td colspan="2">NON-LINEAR PROBLEMS AND ERROR ESTIMATES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Introduction-Iterative Techniques-Material non-Linearity-Elasto Plasticity-Plasticity-Visco plasticity-Geometric Nonlinearity-large displacement Formulation-Application in Metal Forming Process and contact problems- Error norms and Convergence rates- high refinement with adaptivity-Adaptive refinement</td></tr>
<tr><td>Unit IV</td><td colspan="2">DYNAMIC PROBLEM</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Direct Formulation-Free-Transient and Forced Response-Solution Procedures-Subspace Iterative Technique - Houbolt- Wilson- Newmark - Methods –Examples</td></tr>
<tr><td>Unit V</td><td colspan="2">FLUID MECHANICS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Governing Equations of Fluid Mechanics-Inviscid and Incompressible Flow-Potential Formulations-Slow Non-Newtonian Flow-Navier Stokes Equation-Steady and Transient Solutions.</td></tr>
<tr><td colspan="7" align="right">Total (45L) = 45 Hours</td></tr>
</table>

Reference Books:	
1.	Cook, Robert Davis et al "Concepts and Applications of Finite Element Analysis", Wiley, John & Sons, 1981.
2.	Desai C.S. and Abel J.F., "Introduction to Finite Element Method", Affiliated East- West Press, 1972.
3.	Chandrupatla, Belagundu, "Finite Elements in Engineering", Prentice Hall of India Private Ltd., 2002.
4.	O.C. Zienkiewicz and R.L. Taylor, Finite element methods Vol I & Vol II, McGraw Hill,1989,1992

5.	K.J. Bathe, Finite element procedures, PHI Ltd.,1996

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Demonstrate the FE formulation for axi- symmetric problems in heat transfer and elasticity.	L2: Understanding
CO2	:	Identify the primary and secondary variables of the problem and choose correct nodal degrees of freedom and develop suitable shape functions for an iso parametric element.	L3: Applying
CO3	:	Solve the contact problems by using the techniques of nonlinear equations of equilibrium.	L4: Analyzing
CO4	:	Analyze the dynamic flow problems by iterative methods.	L4: Analyzing
CO5	:	Examine non Newtonian Flow-Navier Stokes Equation by FE equations.	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			
CO2	2	2		1	1								2			
CO3	1	2	1			1	1						2			1
CO4	2	1	1			1	1						1	1		
CO5	1	2		1	1								1			
Avg.	1.4	1.6	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.4	1.0	0.0	1.0

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

HONOURS DEGREE

VERTICAL 2: MATERIALS AND PROCESSING

<table>
<tr><td>22MTH201</td><td colspan="2">ELECTRICAL, MAGNETIC AND OPTICAL MATERIALS</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">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 understand the electrical, magnetic and optical properties of materials.</td></tr>
<tr><td>Unit I</td><td colspan="2">ELECTRICAL AND DIELECTRIC MATERIALS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Review of electrical conduction - resistivity and dielectric phenomena - concept of polarization - effects of composition, frequency and temperature on these properties - discussion on specific materials used as conductors (OFHC Copper, Al alloys, Fe-Si alloys, amorphous metals) - discussion on specific materials used as dielectrics (ceramics and polymers) - dielectric loss, dielectric breakdown – Ferro electricity, piezo and pyroelectricity.</td></tr>
<tr><td>Unit II</td><td colspan="2">MAGNETIC MATERIALS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Introduction to dia, para, ferri and ferro magnetism - hard and soft magnetic materials - iron- silicon alloys – iron, nickel alloys - ferrites and garnets - (Ag - Mn - Al) alloys - (Cu - Ni- Co) alloy - fine particle magnets - applications of hard and soft magnetic materials - Giant magneto resistance- Nano materials</td></tr>
<tr><td>Unit III</td><td colspan="2">SEMICONDUCTING AND SUPERCONDUCTING MATERIALS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Review of semiconducting materials - concept of doping - simple and compound semiconductors - amorphous silicon, oxide semiconductors; amorphous semiconductors - FER, MOSFET and CMOS - Concept of superconductivity</td></tr>
<tr><td>Unit IV</td><td colspan="2">PRODUCTION OF ELECTRONIC MATERIALS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Review of electronic materials - methods of crystal growth for bulk single crystals - zone melting-refining, leveling - synthesis of epitaxial films by VPE, PVD, MBE and MOCVD techniques - lithography; production of silicon - starting applications.</td></tr>
<tr><td>Unit V</td><td colspan="2">OPTICAL PROPERTIES OF MATERIALS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Introduction to electromagnetic radiation, atomic and electronic interactions with electromagnetic radiation, optical properties of metals, optical properties of nonmetals, opacity and translucency in insulators, color of materials, applications of optical phenomena-luminescence, photoconductivity, lasers, optical fibers in communications</td></tr>
<tr><td colspan="7" align="right">Total (45L) = 45 Hours</td></tr>
</table>

Reference Books:	
1	Raghavan V, Materials Science and Engineering, 4th Edition, Prentice Hall of India, 1998.
2	Pradeep fuley, Electrical, magnetic, and Optical Materials, 1st edition, CRC press, 2010
3	Kittel C, Introduction to Solid State Physics, 6th Edition, Wiley Eastern, New International Publishers, 1997.
4	Dekker A.J, Solid State Physics, MacMillan India, 1995

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Classify the conducting, semiconducting, superconducting, dielectric, ferro-electric and piezoelectric behavior of materials.	L4: Analyzing
CO2	:	Differentiate between diamagnetic, paramagnetic, ferrimagnetic, and ferromagnetic behavior of materials.	L4: Analyzing
CO3	:	Describe the synthesis and processing of semi and superconducting materials for engineering applications.	L2: Understanding
CO4	:	Discuss the production of electronic materials.	L2: Understanding
CO5	:	Describe the interaction of light with 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	2	2			1		1							2		1
CO2	2	1	1	1		1								2		1
CO3	1	2		1	1								1		1	
CO4	1	1	1											1		
CO5	1	2		1										2		
Avg.	1.4	1.6	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.8	1.0	1.0

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

22MTH202	MATERIALS TECHNOLOGY			Semester			
PREREQUISITES		**Category**	**PE**	**Credit**			**3**
Engineering physics		**Hours/Week**	**L**	**T**	**P**		**TH**
			3	**0**	**0**		**3**

Course Learning Objectives

1	To understand the basic principles of physical metallurgy, heat treatment, and applications of various ferrous and non-ferrous materials.

Unit I	**CONSTITUTION OF ALLOYS AND PHASE DIAGRAMS**	**9**	**0**	**0**	**9**

Phases, solid solutions, compounds - Concept of phase diagram – phases and micro constituents in steels and cast irons – equilibrium and non-equilibrium cooling of various Fe-C alloys – Fe-C Equilibrium diagram - effects of alloying elements and cooling rate on structure and properties of steels and cast irons.

Unit II	**HEAT TREATMENT**	**9**	**0**	**0**	**9**

Introduction to heat treatment; TTT diagram and CCT diagram – hardenability measurement, annealing – normalizing – hardening and tempering – heat treatment atmospheres – quenching media – case hardening techniques.

Unit III	**STEELS**	**9**	**0**	**0**	**9**

Introduction to specifications – plain carbon steels – low alloy and Q and T steels dual phase steels – Ultra high strength steels – maraging steels – HSLA steels – steels for magnetic and electrical applications, processing, properties & applications.

Unit IV	**STAINLESS STEELS AND CAST IRONS**	**9**	**0**	**0**	**9**

Stainless steels – phase diagrams – effects of chromium and nickel – Ferritic and Austenitic, martensitic, duplex and precipitation hardened stainless steels. Types of Cast Irons- Gray Cast iron, white iron, malleable iron, S.G. Iron and alloy cast irons – physical metallurgy, composition of cast irons, properties and applications. Heat treatment of cast irons.

Unit V	**NON-FERROUS ALLOYS**	**9**	**0**	**0**	**9**

Brasses, bronzes, Cu-Ni alloys – High Strength Al Alloys, Ti alloys, Ni alloys and Mg alloys - Physical metallurgy, composition, properties and applications.

Total (45L) = 45 Hours

Text Books:

1	Raghavan V. “Physical Metallurgy – Principles and Practice”, Prentice Hall of India, 1993.
2	Brick Garden Phillips. “Structure and Properties of Alloys", McGraw Hill, 1976.
3	Flinn. R.A. and Trojan. P.K. “Engineering Materials and their Applications”, 4th Edition, Jaico, 1999

Reference Books:

1	Leslie. W.C., “The Physical Metallurgy of Steels”. McGraw Hill. 1983.
2	Metals Hand book. 10th edition. Volume 2. ASM. 1995.

3	Askeland. D.R. "The Science and Engineering of Materials". PWT Kent Publishing Company, Boston, 1989
4	Pickering F.B. "Physical Metallurgy and Design of Steels". Applied Science Publishers Limited. Lon

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Discuss the solid solutions and phase diagrams.	L2: Understanding
CO2	:	Classify the various heat treatment processes.	L4: Analyzing
CO3	:	Describe the various types of steels.	L2: Understanding
CO4	:	Discuss the types of stainless steels and cast irons.	L2: Understanding
CO5	:	Analyze the composition and applications of various non ferrous alloys.	L4: Analyzing

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	2	1				1	1							1	1	
CO3	2	2	1	1	1								1	2		1
CO4	1	1	1		1									1		1
CO5	1	1			1	1							1			1
Avg.	1.4	1.2	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.3	1.0	1.0

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

22MTH203	POLYMERS AND COMPOSITES			Semester			
PREREQUISITES			**PE**	**Credit**		**3**	
Engineering physics		**Hours/Week**	**L**	**T**	**P**	**TH**	
			3	**0**	**0**	**3**	

Course Learning Objectives

1	To make the student acquire knowledge in fundamentals of polymers, bio and inorganic polymers.
2	To enable students know about various additives and to make the student to acquire knowledge about polymers meant for various engineering applications and special applications.
3	To understand the fundamentals of composite material strength and its mechanical behavior

Unit I	**BIO AND INORGANIC POLYMERS**	**9**	**0**	**0**	**9**

Naturally occurring polymers – starch, proteins, cellulose – Derivatives of cellulose polymers – rayon, cellophane, cellulose acetate, butyrate and nitrate – ethyl cellulose – carboxymethyl cellulose- preparation, properties-application organometallic polymers - coordination polymers - polyamides- Inorganic polymers - phosphorus and nitrogen containing polymers, – silicones - hybrid polymers.

Unit II	**INTRODUCTION TO ADDITIVES**	**9**	**0**	**0**	**9**

Introduction-Technological Requirements-Classification-Chemistry and Mechanism- Selection Criteria-General effect on Properties-Evaluation and functions of additives – Antioxidants - Stabilizers (Heat & UV)-carbon black-its types, manufacture and characteristics- mechanism of reinforcement of a rubber, non black fillers in rubbers

Unit III	**POLYMERS IN ENGINEERING & SPECIALITY POLYMERS**	**9**	**0**	**0**	**9**

Polymers for electrical and electronics applications - polymers for high temperature applications - polymer blends, alloys and liquid crystals - polymers in lithography and water treatment - polymers for biomedical applications. Liquid crystalline polymers (LCP) - conducting polymers - heat resistant polymers - photosensitive polymers and polymers as coating additives - polymers in miscellaneous specialty applications.

Unit IV	**COMPOSITES – INTRODUCTION & LAMINA CONSTITUTIVE EQUATIONS**	**9**	**0**	**0**	**9**

Definition–Need–General Characteristics, Applications. Fibers – Glass, Carbon, Ceramic and Aramid fibers. Matrices – Polymer, Graphite, Ceramic and Metal Matrices – Characteristics of fibers and matrices. Lamina Constitutive Equations: Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke’s Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Qij), Typical Commercial material properties, Rule of Mixtures. Generally Orthotropic Lamina –Transformation Matrix, Transformed Stiffness.

Unit V	**LAMINATES & TESTING OF COMPOSITES**	**9**	**0**	**0**	**9**

Mechanics of composites - Fracture and damage mechanics - laminates –delamination - Measurement of physical and mechanical properties: density- fibre volume fraction-void content, test for tensile-compression- flexural in fiber direction –Non- Destructive Evaluation Methods for Composites – Visual Inspection, Ultrasonic Methods, X-Ray Imaging.

Total (45L) = 45 Hours

Text Books:

1	Bhargava., Engineering Materials- Polymers, Ceramics and Composites, Prentice Hall of India Ltd’ New Delhi.

2	Van Vlack L K Physical Ceramics for Engineers, Addison Wesley, Massachusetts, 1964.
3	Mathews & Rawlings, Composites: Science and Engineering, ELBS, London, 1994.
Reference Books:	
1	Gabor Koves, Materials for structural and Mechanical Functions, Taraporevala & Sons,Bombay, 1980.
2	Broutman L J and Krock R J, Modern Composite Materials, Addison Wesley Pub. Co., Massachusetts, 1986.
3	Jacobs, J A and Kilduff T F, Engineering Materials Technology, Prentice Hall Inc., N.J., 1988.
4	Mallick P K, Fiber Reinforced Composites: materials, manufacturing and design, CRC Press, Taylor & Francis group, London, 2010.
5	Krishnan K Chawla, Composite materials: Science and Engineering, Springer, 1998.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the utility of bio and inorganic polymer	L2: Understanding
CO2	:	Discuss various additives for rubbers and plastics – their needs, their functions and the mechanisms by which they act.	L3: Applying
CO3	:	Describe the uses of polymers in various fields of engineering and methodically discuss the applications of specialty polymers.	L2: Understanding
CO4	:	Familiarize about the fibers, matrices and lamina constitutive equations in composites	L1: Remembering
CO5	:	Develop the knowledge about laminates and testing of composites	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	2	2	1	1									1	1	1	1
CO3	2	2			1	1	1						1		1	
CO4	1	1		1	1								1	1	1	
CO5	1	2		1	1									1		1
Avg.	1.4	1.6	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0

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

22MTH204	SELECTION OF MATERIALS			Semester			
PREREQUISITES		**Category**	**PE**	**Credit**		**3**	
Engineering physics		**Hours/Week**	**L**	**T**	**P**	**TH**	
			3	**0**	**0**	**3**	

Course Learning Objectives

1	To know different types of materials and properties to select mental materials for different applications.

Unit I	**MATERIAL PROPERTIES**	**9**	**0**	**0**	**9**

Technologically important properties of materials - Physical, chemical, mechanical, thermal, optical, environmental and electrical properties of materials. Material property charts - Modulus – density, strength-density, fracture toughness-strength.

Unit II	**DESIGN AND DATA**	**9**	**0**	**0**	**9**

Types of design, Design tools and materials data – Materials and shape – microscopic and micro structural shape factors – limit to shape efficiency Comparison of structural sections and material indices – case studies.

Unit III	**SERVICE AND FABRICATION**	**9**	**0**	**0**	**9**

Service, Fabrication and economic requirements for the components – Methodology for selection of materials – Collection of data on availability, requirements and non-functional things- its importance to the situations – case studies.

Unit IV	**PROCESS CLASSIFICATION**	**9**	**0**	**0**	**9**

Classifying process - systematic selection of process – Selection charts - Ranking of processes – case studies - Influence of manufacturing aspects and processing route on properties of materials and its influence on selection of materials.

Unit V	**MATERIALS FOR ENGINEERING APPLICATIONS**	**9**	**0**	**0**	**9**

Selection of materials for automobile, nuclear, power generation, aerospace, petrochemical, electronic and mining industries.

Total (45L) = 45 Hours

Reference Books:

1	M.F. Ashby, “Materials Selection in Mechanical Design’ – Third edition, Elsevier publishers, Oxford, 2005.
2	Gladius Lewis, “Selection of Engineering Materials", Prentice Hall Inc, New Jersey, USA, 1995.
3	Charles.J.A. and Crane,F.A.A., "Selection and Use of Engineering Materials", Butter worths, London, UK, 1989.
4	Angelo P C and Ravisankar B, “Introduction to Steel- Processing, Properties and Applications”, CRC Press, Taylor & Francis Group, Florida, U.S.A., 2019.
5	ASM Handbook. “Materials Selection and Design”, Vol.20- ASM Metals,Park Ohio. USA, 1997

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Discuss the types of materials and properties.	L2: Understanding
CO2	:	Analyze the design tool and data.	L4: Analyzing
CO3	:	Discuss the service and fabrication and economic requirements of the components.	L2: Understanding
CO4	:	Describe the process classification.	L2: Understanding
CO5	:	Apply the materials for Specific engineering applications and 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	1	2		1	1								1	2	1	
CO2	2	2	1	1										2		
CO3	2	2			1	1	1							2		1
CO4	1	1		1	1									1		
CO5	1	2		1	1									1		1
Avg.	1.4	1.8	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.6	1.0	1.0

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

22MTH205	HIGH TEMPERATURE MATERIALS			Semester			
PREREQUISITES		Category	PE	Credit			3
Engineering physics		Hours/Week	L	T		P	TH
			3	0		0	3

Course Learning Objectives	
1	To impart knowledge on requirements for materials for high temperature use and the behavior of materials at high temperatures.

Unit I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Need for high temperature materials, historical development of high temperature materials, and equipment for material testing at high temperatures, requirements of high temperature materials (mechanical properties and preferred microstructure, environmental resistance, erosion and wear).					
Unit II	**STRENGTHENING MECHANISMS**	**9**	**0**	**0**	**9**
Metallic materials (solid solution strengthening, precipitation strengthening, dispersion strengthening grain size and grain boundary effects) Ceramic materials (phase control, defect tolerance, thermal shock resistance) composite materials.					
Unit III	**CREEP AND STRESS RUPTURE TEST**	**9**	**0**	**0**	**9**
Creep test, stress rupture test, structural changes during creep, mechanism of creep deformation, fracture at elevated temperatures - fatigue interaction: Modes of high temperature fracture and fatigue fracture, creep-fatigue interaction (creep accelerated by fatigue), fatigue-creep interaction (fatigue accelerated by creep), micro-mechanism of damage, fracture criterion for creep fatigue, creep-fatigue failure mapping, creep-fatigue testing, influence of environment.					
Unit IV	**MATERIALS FOR HIGH TEMPERATURE**	**9**	**0**	**0**	**9**
Metals / alloys, super alloys, steels, titanium and its alloys, ceramics (Alumina, Zirconia, Silicon carbide, Silicon nitride, Glass ceramics) composites (Metal matrix composites, ceramic matrix composites) carbon – carbon composites.					
Unit V	**THERMAL BARRIER COATINGS AND ITS INDUSTRIAL APPLICATIONS**	**9**	**0**	**0**	**9**
Corrosion / oxidation resistant coatings (metallic, ceramic, rare and reactive metal reinforced coatings), high temperature erosion and wear, thermal barrier coats - Applications in industry, aerospace, defense and nuclear industry.					
					Total (45L) = 45 Hours

Reference Books:	
1	Meetham, G. W., Van de Voorde, M. H., "Materials for High Temperature Engineering Applications (Engineering Materials)", 1st 2000 Ed., Springer., 2013.
2	Chan R. W., "High temperature structural materials", Chapman & Hall, 1996.
3	Reed R. C., "The Super-alloys: Fundamentals and Applications", Cambridge University Press, 2008.

4	Birks, N., Meier, G. H., and Pettit, F. S., "Introduction to the High Temperature Oxidation of Metals", Cambridge University Press, 2009.
5	Bose, S., "High Temperature Coatings" , Butterworth-Heinemann, 2007.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the materials behavior at high temperature.	L2: Understanding
CO2	:	Discuss the oxidation mechanisms of metallic and ceramic materials.	L4: Analyzing
CO3	:	Explain mechanisms of creep, and stress rupture of materials.	L2: Understanding
CO4	:	Classify materials for high temperature applications.	L3: Applying
CO5	:	Identify the materials and coatings for high temperature applications.	L4: Analyzing

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	2	1	
CO2	2	1	1				1							2	1	1
CO3	2	1		1	1								1	1	1	
CO4	1	2		1	1								1	2	1	
CO5	1	1	1			1								2	1	1
Avg.	1.4	1.4	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.8	1.0	1.0

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

22MTH206	PROCESSING OF NON METALLIC MATERIALS		Semester			
PREREQUISITES			PE	Credit		3
Engineering physics		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1.	To introduce the student to the range of non-metallic materials available for engineering.
2.	To get an exposure to the techniques associated with the synthesis and processing of these materials

Unit I	INTRODUCTION TO NON METALLIC MATERIALS	9	0	0	9

Definition and classification of nonmetallic materials, comparison of properties of metals and nonmetallic materials. Introduction to Polymers: Concept of polymers, types of polymers reactions, Mechanism of polymerization, Ceramics: Introduction, classification, structure, and applications of ceramics. Glasses: Introduction, classification, structural features and applications of glasses. Composites: Introduction, classification, and applications of composite materials.

Unit II	PROCESSING OF POLYMERS	9	0	0	9

Extrusion - single screw and twin screw extrusion, Film blowing, Pipe extrusion, extrusion of sheet, Calendaring, Thermoforming. Molding - Injection molding, Blow molding, Compression molding, Injection stretch blow molding, Resin transfer molding, Gas and water assisted injection molding, Reaction Injection Molding, Pultrusion, Pull winding.

Unit III	PROCESSING OF CERAMICS	9	0	0	9

Powder Preparation Techniques: Sol-gel technology – Precipitation, Coprecipitation and Hydrothermal precipitation techniques. Preparation of Al_2O_3, ZrO_2, SiC, Si_3N_4 BN & B_4C.

Ceramic Processing Techniques: Hot Pressing, Hot Isostatic Pressing, (HIP). Spark Plasma Sintering. Sintering, Sinter / HIP, Injection moulding, Slip casting, Tape casting, Gel casting, Extrusion.

Unit IV	PROCESSING OF GLASSES	9	0	0	9

Glass Melting Process: Process leading to glass formation – Volatilization – Effect of pre-sintering-refining - Physico - chemical reactions taking in glass batch- Homogenization and devitrification - Tempering – Annealing. Glass Forming Process: Hand operation – Laboratory ware and Bulb making, Tube making – Danner process – Up draw process, down draw process, pressing – Hand press, Flat glass - Pittsberg process, Foucault process, Float process.

Unit V	PROCESSING OF COMPOSITES	9	0	0	9

Processing of PMC: Processing of Thermoset Matrix Composites - Hand Lay-Up and Spray Techniques, Filament winding, Pultrusion, Resin Transfer Molding (RTM), Bag molding processes. Processing of Thermoplastic Matrix Composites - Film Stacking Technique, Diaphragm Forming, Commingled fibers, Injection molding, Sheet Molding Compound (SMC). **Processing of CMC** Cold Pressing & Sintering, Hot Pressing, Reaction Bonding Processes, Infiltration, Directed Oxidation, In Situ Chemical Reaction Technique, Sol-Gel, Polymer Infiltration & Pyrolysis.

Total (45L) = 45 Hours

Text Books:	
1.	Textbook of Polymer Science; Fred W. Billmeyer, Wiley 2007
2.	Introduction to Ceramics; Kingery, Bowen, Uhlman. Wiley India Pvt Limited, 2012
3.	Composite Materials: Science and Engineering; Krishan K. Chawla, Springer, 2012
Reference Books:	
4.	W.S. Smith: Principles of Materials Science and Engineering, McGraw-Hill.
5.	Manufacturing Processes for Engineering Materials : S. Kalpakjian, 3rd edition Addison - Wesley, 1997
6.	Plastic Materials and Processing : A. Brent Strong, Prentice Hall, ISBN 0-13-021626-7
7.	Handbook of Glass Manufacture - F.V. Tooley
8.	Composite Materials: Engineering and Science: F.L. Mathews and R.D. Rawlings, CRC press, 084930251X

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	List the prominent non-metallic materials available for engineering applications.	L2: Understanding
CO2	:	Discuss the various processing techniques of polymers.	L2: Understanding
CO3	:	Identify the various manufacturing techniques of ceramic materials.	L4: Analyzing
CO4	:	Indicate the various glass melting and forming techniques.	L3: Applying
CO5	:	Name the various manufacturing techniques of PMCs and CMCs.	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	2		1	1		1						1	2		
CO2	1	1		1	1								1		1	
CO3	2	2	1	1		1						1	1	2		1
CO4	1	2		1	1								1	2		
CO5	1	2		1	1	1						1	1			1
Avg.	1.4	1.8	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	1.0	2.0	1.0	1.0

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

22MTH207	BIOMATERIALS				Semester		
PREREQUISITES		Category	PE	Credit			3
Engineering physics		Hours/Week	L	T	P		TH
			3	0	0		3

Course Learning Objectives

1	Learn characteristics and classification of Biomaterials
2	To understand the importance of Biomaterials in medical applications

Unit	Title	L	T	P	TH
Unit I	**INTRODUCTION TO BIOMATERIALS**	9	0	0	9
Definitions, Types of materials – Ceramics, metals, polymers and composites. Basic properties of materials - Tensile testing, Compressive testing, Shear testing, Bend or flexural tests, Ductile and brittle fracture, Stress concentration, Fracture toughness and Fatigue.					
Unit II	**METALLIC AND CERAMIC MATERIALS**	9	0	0	9
Metallic implants – Stainless steels, co-based alloys, Ti-based alloys, shape memory alloy, nanostructured metallic implants, degradation and corrosion, ceramic implant – bio inert, biodegradable or bioresorbable, bioactive ceramics, nanostructured bio ceramics.					
Unit III	**POLYMERIC IMPLANT MATERIALS**	9	0	0	9
Polymerization, factors influencing the properties of polymers, polymers as biomaterials, biodegradable polymers, Bio polymers: Collagen, Elastin and chitin. Medical Textiles, Materials for ophthalmology: contact lens, intraocular lens. Membranes for plasma separation and Blood oxygenation, electro spinning: a new approach.					
Unit IV	**TESTING OF BIOMATERIALS**	9	0	0	9
Biocompatibility, blood compatibility and tissue compatibility tests, Toxicity tests, sensitization, carcinogenicity, mutagenicity and special tests, Invitro and Invivo testing; Sterilisation of implants and devices: ETO, gamma radiation, autoclaving. Effects of sterilization.					
Unit V	**APPLICATION OF BIOMATERIALS**	9	0	0	9
Artificial Heart, Prosthetic Cardiac Valves, Artificial lung (oxygenator), Artificial Kidney (Dialyser membrane) , Dental Implants, Orthopedic Implants and Biomaterials in Ophthalmology.					
					Total (45L) = 45 Hours

Text Books:

1	C. Mauli Agrawal, Joo L. Ong, Mark R. Appleford and Gopinath Mani, Introduction to Biomaterials Bas Theory with Engineering Applications, Cambridge University Press 2014
2	Sujata V. Bhatt, “Biomaterials”, Second Edition, Narosa Publishing House, 2005

Reference Books:

1	Donglu Shi, Introduction to Biomaterials, Tsinghua University Press 2006
2	Sreeram Ramakrishna, MuruganRamalingam, T. S. Sampath Kumar, and Winston O. Soboyejo, “Biomaterials: A Nano Approach”, CRC Press, 2010.
3	Myer Kutz, “Standard Handbook of Biomedical Engineering & Design”, McGraw Hill, 2003.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Predict the testing standards applied for biomaterials.	L3: Applying
CO2	:	Identify significant gap required to overcome challenges and further development in metallic and ceramic materials	L4: Analyzing
CO3	:	Identify significant gap required to overcome challenges and further development in polymeric materials	L4: Analyzing
CO4	:	Demonstrate purpose of Biomaterials in various applications.	L2: Understanding
CO5	:	Predict the testing standards applied for biomaterials.	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	2		1	1								1	2		
CO2	2	2	1	1		1						1		2		1
CO3	1	2	1		1		1							1		1
CO4	1	1		1	1									2	1	
Avg.	1.5	1.8	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	1.0	1.8	1.0	1.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

22MTH208	ADVANCES IN NUCLEAR MATERIALS				Semester			
PREREQUISITES		**Category**	**PE**	**Credit**		**3**		
Engineering physics		**Hours/Week**	**L**	**T**	**P**	**TH**		
			3	**0**	**0**	**3**		

Course Learning Objectives					
1	To understand concepts of nuclear reaction and materials for requirements				
Unit I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Introduction to nuclear energy / reactors – comparison of different modes of energy generation – ecological and environmental aspects					
Unit II	**NUCLEAR REACTIONS**	**9**	**0**	**0**	**9**
Nuclear reactions – concept of half-life, nuclear minerals – related exploration and processing.					
Unit III	**NUCLEAR MATERIALS**	**9**	**0**	**0**	**9**
Material requirements – structural materials, rare earth materials coolants, shielding materials and fuel rods – fabrication requirements					
Unit IV	**SAFETY IN NUCLEAR INDUSTRIES**	**9**	**0**	**0**	**9**
Nuclear irradiation effects on structural materials – safe guards, safety and health protection					
Unit V	**STRATEGIC ISSUES IN NUCLEAR INDUSTRIES**	**9**	**0**	**0**	**9**
Strategic issues – current status and major needs, overview of nuclear scenario in India, nuclear scenario at international level.					
					Total (45L) = 45 Hours

Text Books:	
1	Benjamin M. M., Van Nostrand “Nuclear Reactor Materials and Applications”, Reinhold Company Inc, 1983
2	Henley E.J., & Herbert Kouts, “Advances in Nuclear Science and Technology”. Vol 2, 2014.
3	V.Gerasimov& A. Monakhov, Nuclear Engineering Materials, Mir Publishers, Moskow, 1983.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Classify the different types of materials used to produce nuclear energy.	L3: Applying
CO2	:	Analyze the properties of nuclear materials and applications.	L4: Analyzing
CO3	:	Describe the safety precautions of nuclear radiation and protection.	L2: Understanding
CO4	:	Explain the nuclear irradiation effects.	L2: Understanding
CO5	:	Discuss the scenario of strategic issues in nuclear industries.	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	2		1		1	1						1			1
CO2	2	2	1	1	1								1			1
CO3	2	1		1	1									2	1	
CO4	1	2		1	1									1	1	
CO5	1	2			1								1			1
Avg.	1.6	1.8	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.5	1.0	1.0

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

<table>
<tr><td>22MTH209</td><td colspan="4">AUTOMOTIVE AND AEROSPACE MATERIALS</td><td colspan="3">Semester</td><td></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">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="8">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="7">To understand the properties and applications for automobile and aircraft components.</td></tr>
<tr><td>Unit I</td><td colspan="3">MATERIALS FOR ENGINES AND TRANSMISSION SYSTEMS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Materials selection for IC engines: Piston, piston rings, cylinder, Engine block, Connecting rod, Crank shaft, Fly wheels, Gear box, Gears, Splines, Clutches.</td></tr>
<tr><td>Unit II</td><td colspan="3">MATERIALS FOR AUTOMOTIVE STRUCTURES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">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.</td></tr>
<tr><td>Unit III</td><td colspan="3">NON-FERROUS MATERIALS IN AIRCRAFT CONSTRUCTION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Aluminum and its alloys: Types and identification. Properties - Castings - Heat treatment processes - Surface treatments. Magnesium and its alloys: Cast and Wrought alloys - Aircraft application, features specification, fabrication problems, Special treatments.Titanium and its alloys: Applications, machining, forming, welding and heat treatment, Copper Alloys. Wood and fabric in aircraft construction and specifications - Glues Use of glass, plastics & rubber in Aircraft, Introduction to glass & carbon composite.</td></tr>
<tr><td>Unit IV</td><td colspan="3">FERROUS MATERIALS IN AIRCRAFT CONSTRUCTION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Steels: Plain and low carbon steels, various low alloy steels, aircraft steel specifications, corrosion and heat resistant steels, structural applications. Maraging Steels: Properties and Applications. Super Alloys: Use - Nickel base - Cobalt base - Iron base - Forging and Casting of Super alloys - Welding, Heat treatment.</td></tr>
<tr><td>Unit V</td><td colspan="3">CERAMICS AND COMPOSITES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Introduction, modern ceramic materials, cermets, glass ceramic, production of semi-fabricated forms, Carbon/Carbon composites, Fabrication processes and its aerospace applications involved in metal matrix composites, polymer composites</td></tr>
<tr><td colspan="8" align="right">Total (45L) = 45 Hours</td></tr>
</table>

<table>
<tr><td colspan="2">Reference Books:</td></tr>
<tr><td>1</td><td>ASM Handbook, “Selection of Materials Vol. 1 and 2”, ASM Metals Park, Ohio. USA, 1991.</td></tr>
<tr><td>2</td><td>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.</td></tr>
<tr><td>3</td><td>Material Science and Engineering, V. Raghavan, Prentice Hall of India, 4th Edition.</td></tr>
<tr><td>4</td><td>H Buhl, Advanced Aerospace Materials, Springer, Berlin 1992, ISBN-13: 978-3540558880</td></tr>
<tr><td>5</td><td>Balram Gupta, Aerospace material Vol. 1,2,3,4ARDB, S Chand & Co ,2009, ISBN-13: 978- 8121922005.</td></tr>
<tr><td>6</td><td>ASM Handbook. “Materials Selection and Design”, Vol. 20- ASM Metals Park Ohio.USA, 1997.</td></tr>
<tr><td>7</td><td>Cantor,“ Automotive Engineering: Lightweight, Functional, and Novel Materials”, Taylor & Francis Group, London, 2006</td></tr>
</table>

8	Ahmed E, ―Advanced composite materials for Automotive applications, Wiley, 2013
9	Don H Wright, Testing Automotive Materials and Components, SAE 1993.
10	Geoff Davis, ― Materials for Automobile bodies, Butter Worth Heinemann, 2012
11	Hiroshi Yamagata, ‒The Science and Technology of Materials in Automotive Engines, Elsvier, 2005

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the use of 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: Analyzing
CO3	:	Explain the mechanical behavior and heat treatment of aerospace nonferrous materials.	L2: Understanding
CO4	:	Discuss the properties and heat treatment of ferrous materials for aircraft materials.	L2: Understanding
CO5	:	Combine the properties of ceramics and composites for aircraft materials.	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	2	1	1	1									2	1	
CO2	2	2	1			1								1		1
CO3	2	2		1	1								1	2		
CO4	1	2		1	1								1	2		
CO5	1	1	1				1							1		1
Avg.	1.4	1.8	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.6	1.0	1.0

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

<table>
<tr><td>22MTH210</td><td colspan="2">PROCESSING OF NON FERROUS METAL ORES</td><td colspan="3">Semester</td><td></td></tr>
<tr><td colspan="2">PREREQUISITES</td><td></td><td>PE</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 study the processing of non ferrous metals ores.</td></tr>
<tr><td>2.</td><td colspan="6">To understand the fundamental principles and operations of non ferrous ores.</td></tr>
<tr><td>Unit I</td><td colspan="2">FUNDAMENTALS OF EXTRACTION METALLURGY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Principles of Pyrometallurgy - Drying, Calcination, Sintering, Roasting – Predominance Area Diagrams. Smelting and Converting.
Principles of Hydrometallurgy, Leaching – Properties of good solvent - Leaching methods – Solvent extraction, Ion exchange, Bioleaching, Gaseous reduction of metals in aqueous solutions.
Principles of Electrometallurgy - Aqueous and Fused salt electrolysis, Electrorefining and Electrowinning of metals. Purification of Crude metals produced in bulk – Distillation, Liquation, Fire refining, Electrolytic refining, Zone refining.</td></tr>
<tr><td>Unit II</td><td colspan="2">EXTRACTION AND REFINING OF METALS FROM SULPHIDE ORES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">COPPER: Principal Ore and Minerals; Matte smelting – Blast furnace, Reverberatory, Electric furnace, Flash; Converting; Continuous production of blister Copper; Fire refining; Electrolytic refining; Hydro-Metallurgical copper extraction; Leaching processes, Recovery of copper from leach solutions; Electrowinning - NICKEL: Simplified flow sheets for the extraction of nickel,- LEAD: Blast furnace smelting, Refining of lead bullion and ZINC: General Principles: Horizontal and vertical retort processes: Production in a Blast furnace: Leaching purification: Electrolysis, Refining.</td></tr>
<tr><td>Unit III</td><td colspan="2">EXTRACTION AND REFINING OF METALS FROM OXIDE ORES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">MAGNESIUM: Production of a hydrous Magnesium chloride from seawater and magnesite. Electro-winning practice and problem, refining, Pidgeon and Handspring processes - ALUMINIUM: Bayer process: Hall – Heroult process: Anode effect: Efficiency of the process: Refining, Alternative processes of aluminum production and TIN: Smelting of Tin concentrates, Refining of Tin-Fire refining of Tin and Electrolytic refining. TUNGSTEN: Flow sheets for the extraction of Tungsten.</td></tr>
<tr><td>Unit IV</td><td colspan="2">EXTRACTION AND REFINING OF METALS FROM HALIDE ORES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Extraction of metals rare earth metals from halides – TITANIUM: Upgrading of ilmenite, chlorination of titania, Kroll’s process. Refining. ZIRCONIUM - Treatment of Zircon, Method for separating HF from Zirconium, Reduction of Zr compound to metal and URANIUM, Acid and alkali processes for digestion of uranium ores, Purification of crude salt, Production of reactor grade UO2 and uranium</td></tr>
<tr><td>Unit V</td><td colspan="2">EXTRACTION OF PRECIOUS METALS AND BYPRODUCT FROM METALS RECOVERY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
</table>

Extraction and Refining of precious metals – GOLD: Amalgamation process, Chlorination process and Cyanidation process, SILVER: Chloridizing roasting, Cyanidation, Parke's process and recovery from base material ores, and PLATINUM: INCO process. Recovery of by-product metals and treatment of Metallurgical wastes - Secondary refining of Copper, Lead, Zinc, Aluminium, Non scrap sources of Aluminium, Tin, Vanadium – Utilization of metallurgical wastes.
Total (45L) = 45 Hours

Text Books:	
1.	Ray H.S, Sridhar R and Abraham K.P, Extraction of Non Ferrous Metals, Affiliated East-West Press Pvt Ltd, New Delhi, 2008.
2.	Ray H.S and Gosh A, Principles of Extractive Metallurgy, Prentice Hall of India, New Delhi, 1994
3.	Principles of Extractive Metallurgy-Gosh
Reference Books:	
4.	Text book of Metallurgy-A.R. Bailey.
5.	Terkel Rosenqvist, Principles of Extractive Metallurgy, 2nd Edition, McGraw-Hill International book Company, 1983
6.	Venkatachalam S, Hydrometallurgy, Narosa Publishing House, New Delhi, 1998
7.	R.Raghavan Extractive Metallurgy of Non - Ferrous Metals ,Vijay Nicole Imprints Private Limited, Chennai 2016.
8.	Pehlke R.D, Unit Processes in Extractive Metallurgy, American Elsevier Publishing Company, New York, USA, 1977.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the principles of extraction processes.	L2: Understanding
CO2	:	Explain the extraction of metals from sulphide ores.	L2: Understanding
CO3	:	Illustrate the extraction of metals from Oxides ores.	L2: Understanding
CO4	:	Discuss the extraction of metals from halide ores.	L2: Understanding
CO5	:	Apply the extraction of precious metals and byproducts from metals recovery.	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	2	2	1		1	1							1	2		
CO3	2	2		1	1								1	2		
CO4	1	1		1	1									2	1	
CO5	1	1	1		1		1					1		1		1
Avg.	1.4	1.4	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	1.0	1.6	1.0	1.0

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

ELECTIVES FOR MINOR

MINOR DEGREE - VERTICALS

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="4">BUILDING CONSTRUCTION & EQUIPMENT</td><td colspan="2">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">Able to gain basic knowledge in construction methods.</td></tr>
<tr><td>2</td><td colspan="7">Able to gain basic knowledge in equipment.</td></tr>
<tr><td>3</td><td colspan="7">Able to gain basic knowledge in machineries.</td></tr>
<tr><td>4</td><td colspan="7">Able to gain basic knowledge in fire safety principles.</td></tr>
<tr><td>5</td><td colspan="7">Able to gain basic knowledge in green technology.</td></tr>
<tr><td>Unit I</td><td colspan="3">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="8">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="3">DOORS, WINDOWS, LINTELS, SCAFFOLDING AND STAIRCASES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">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="3">ROOFS, FLOORINGS, PROTECTIVE AND DECORATIVE FINISHES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">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="3">CONSTRUCTION EQUIPMENTS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">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="3">GREEN BUILDING TECHNOLOGY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">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="8" align="right">Total= 45 Periods</td></tr>
</table>

<table>
<tr><td colspan="2">Text Books:</td></tr>
<tr><td>1</td><td>Building Construction by S.C.Rangawala</td></tr>
<tr><td>2</td><td>Construction Technology by Sarkar Oxford University Press</td></tr>
<tr><td>3</td><td>Building Material & Construction by S.P. Arora& S. P. Bindra</td></tr>
</table>

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)**															

<table>
<tr><td>22CEM05</td><td colspan="2">BASICS OF TRANSPORTATION ENGINEERING</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">The objective of the course is to educate the students on various components of highway engineering.</td></tr>
<tr><td>2</td><td colspan="6">To educate the geometric design concepts of highway engineering</td></tr>
<tr><td>3</td><td colspan="6">To develop skills on construction and maintenance of highway.</td></tr>
<tr><td>4</td><td colspan="6">Ability to plan various civil engineering aspects of railways and educate various components of railways</td></tr>
<tr><td>5</td><td colspan="6">The course enables the students to develop skill on evaluation and maintenance of railway track.</td></tr>
<tr><td>Unit I</td><td colspan="2">CROSS SECTIONAL ELEMENTS OF HIGHWAYS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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 -</td></tr>
<tr><td>Unit II</td><td colspan="2">GEOMETRIC DESIGN OF HIGHWAYS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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)</td></tr>
<tr><td>Unit III</td><td colspan="2">CONSTRUCTION AND MAINTENANCE OF HIGHWAY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Construction of Flexible and Rigid Pavements – Defects in Flexible and Rigid Pavements -Highway Drainage – Evaluation and Maintenance of Pavements.</td></tr>
<tr><td>Unit IV</td><td colspan="2">RAILWAY PLANNING AND DESIGN</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>Unit V</td><td colspan="2">RAILWAY TRACK CONSTRUCTION MAINTENANCE AND OPERATION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Points and Crossings – Turnouts, Track circuiting, Signaling, Interlocking, Lay Outs of Railway Stations and Yards, Rolling Stock, Tractive Power, Track Resistance, Level Crossings.</td></tr>
<tr><td colspan="7" align="right">Total= 45 Periods</td></tr>
</table>

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)**															

22CEM06	REPAIR AND REHABILITATION OF STRUCTURES				Semester		
PREREQUISITES		Category		OE	Credit		3
NIL		Hours/Week		L	T	P	TH
				3	0	0	3

Course Learning Objectives

1	Study the various types and properties of repair materials
2	Learn various distress and damages to concrete structures
3	Understand the importance of maintenance of structures
4	Assess the damage to structures using various tests
5	Learn various repair techniques of damaged structures, corroded structures

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	**SERVICEABILITY AND DURABILITY OF CONCRETE**	**9**	**0**	**0**	**9**
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.					
Unit III	**MATERIALS AND TECHNIQUES FOR REPAIR**	**9**	**0**	**0**	**9**
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.					
Unit IV	**REPAIRS, REHABILITATION AND RETROFITTING OF STRUCTURES**	**9**	**0**	**0**	**9**
Strengthening of Structural elements, deflection, cracking, chemical disruption, weathering corrosion, wear, fire, leakage and marine exposure.					
Unit V	**DEMOLITION TECHNIQUES**	**9**	**0**	**0**	**9**
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					
					Total= 45 Periods

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>22CEM07</td><td colspan="4">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="3">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="9">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="8">To Know various aspects of green buildings</td></tr>
<tr><td>2</td><td colspan="8">To Learn the principles of planning and orientation of buildings.</td></tr>
<tr><td>3</td><td colspan="8">To Relate the construction of green building with prevailing energy conservation policy and regulations.</td></tr>
<tr><td>4</td><td colspan="8">To Know and identify different green building construction materials.</td></tr>
<tr><td>5</td><td colspan="8">To Learn different rating systems and their criteria</td></tr>
<tr><td colspan="2">Unit I</td><td colspan="3">INTRODUCTION TO GREEN BUILDING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">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="3">SITE SELECTION AND PLANNING</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">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="3">ENERGY AND ENERGY CONSERVATION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">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="3">BUILDING MATERIALS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">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="3">RATING SYSTEM</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">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="9" align="right">Total= 45 Periods</td></tr>
</table>

Text Books:	
1	Kibert, C.J., Sustainable construction: Green Building design and Delivery, John Wiley Hobouken, NewJersey, 3rd Edition, 2012.

2	Chauhan, D S Sreevasthava, S K., Non-conventional Energy Resources, New Age International Publishers, NewDelhi, 4th Edition, 2021

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)															

<table>
<tr><td>22CSM01</td><td colspan="6">PROGRAMMING IN C++</td><td colspan="3"></td><td></td></tr>
<tr><td colspan="5">PREREQUISITES</td><td>Category</td><td>OE</td><td colspan="3">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 colspan="2">P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td colspan="2">0</td><td>3</td></tr>
<tr><td colspan="11">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="10">To understand and develop the object oriented programming concepts.</td></tr>
<tr><td>2</td><td colspan="10">To familiarize and design the template functions and classes</td></tr>
<tr><td>3</td><td colspan="10">To disseminate and apply exception handling mechanisms.</td></tr>
<tr><td>4</td><td colspan="10">To learn and exploit stream classes.</td></tr>
<tr><td>Unit I</td><td colspan="5">INTRODUCTION</td><td>9</td><td>0</td><td colspan="2">0</td><td>9</td></tr>
<tr><td colspan="11">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.</td></tr>
<tr><td>Unit II</td><td colspan="5">INHERITANCE AND VIRTUAL FUNCTIONS</td><td>9</td><td>0</td><td colspan="2">0</td><td>9</td></tr>
<tr><td colspan="11">Classes and objects - friend functions- constructors and destructors- Operator overloading – binary and unary operator overloading using member function and friend function - Type conversions.</td></tr>
<tr><td>Unit III</td><td colspan="5">INHERITANCE AND VIRTUAL FUNCTIONS</td><td>9</td><td>0</td><td colspan="2">0</td><td>9</td></tr>
<tr><td colspan="11">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.</td></tr>
<tr><td>Unit IV</td><td colspan="5">TEMPLATES AND EXCEPTION HANDLING</td><td>9</td><td>0</td><td colspan="2">0</td><td>9</td></tr>
<tr><td colspan="11">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().</td></tr>
<tr><td>Unit V</td><td colspan="5">CONSOLE I/O AND FILE HANDLING</td><td>9</td><td>0</td><td colspan="2">0</td><td>9</td></tr>
<tr><td colspan="11">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.</td></tr>
<tr><td colspan="11">Total (45 L) =45 Periods</td></tr>
</table>

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

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	Title	L	T	P	TH
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, Memory Operations, 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, Booth Algorithm, 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 Editio 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 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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<table>
<tr><td>22CSM04</td><td colspan="2">ADVANCED OPERATING SYSTEMS</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"></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 structure and functions of Operating systems</td></tr>
<tr><td>2</td><td colspan="6">To understand the process concepts and scheduling algorithms</td></tr>
<tr><td>3</td><td colspan="6">To understand the concept of process synchronization and deadlocks</td></tr>
<tr><td>4</td><td colspan="6">To learn various memory management schemes</td></tr>
<tr><td>5</td><td colspan="6">To illustrate various file systems and disk management strategies</td></tr>
<tr><td>UNIT I</td><td colspan="2">INTRODUCTION AND OPERATING SYSTEM STRUCTURES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>UNIT II</td><td colspan="2">PROCESS MANAGEMENT</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>UNIT III</td><td colspan="2">PROCESS SYNCHRONIZATION AND DEADLOCKS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>UNIT IV</td><td colspan="2">MEMORY MANAGEMENT AND VIRTUAL MEMORY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Memory Management- Background, Swapping, Contiguous Memory Allocation, Paging, Segmentation, Segmentation with paging; Virtual Memory - Demand paging, Page Replacement, Thrashing.</td></tr>
<tr><td>UNIT V</td><td colspan="2">FILE SYSTEM AND MASS-STORAGE STRUCTURE</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7" align="right">Total (45 L) =45 Periods</td></tr>
</table>

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>22CSM05</td><td colspan="3">DATA COMMUNICATION AND COMPUTER NETWORKS</td><td colspan="3">Semester</td><td></td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>Category</td><td>OE</td><td colspan="3">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>
</table>

Course Learning 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, 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.					
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, Integrated Services.					
UNIT V	**PRESENTATION LAYER AND 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 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,
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)															

<table>
<tr><td>22EEM02</td><td colspan="2">MICROPROCESSOR AND MICROCONTROLLER</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">C Programing</td><td></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 study the architecture of µP8085 and µC 8051.</td></tr>
<tr><td>2.</td><td colspan="6">To study the Interrupt structure of 8085 and 8051.</td></tr>
<tr><td>3.</td><td colspan="6">To do simple applications development with programming 8085 and 8051.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT I</td><td colspan="2">8085 8 BIT MICROPROCESSOR</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT II</td><td colspan="2">8051 8 BIT MICROCONTROLLER</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT III</td><td colspan="2">INTERFACING WITH 8051 MICROCONTROLLER</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT IV</td><td colspan="2">EXTERNAL COMMUNICATION INTERFACE</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Synchronous and Asynchronous Communication. RS232, RS 485, SPI, I2C. Introduction and interfacing to protocols like Blue-tooth and Zig-bee.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT V</td><td colspan="2">APPLICATIONS OF MICROCONTROLLERS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Simple programming exercises- key board and display interface –Control of servo motor stepper motor control- Application to automation systems.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7" align="right">Total (45L+0T)= 45 Periods</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Text Books:</td></tr>
<tr><td>1.</td><td colspan="6">R.S. Gaonkar, ‘Microprocessor Architecture Programming and Application’, with 8085, Wiley Eastern Ltd., New Delhi, 2013.</td></tr>
<tr><td>2.</td><td colspan="6">K. J. Ayala, “8051 Microcontroller”, Delmar Cengage Learning, 2004.</td></tr>
<tr><td>3.</td><td colspan="6">Muhammad Ali Mazidi & Janice Gilli Mazidi, R.D.Kinely ‘The 8051 Micro Controller and Embedded Systems’, PHI Pearson Education, 5th Indian reprint, 2003.</td></tr>
<tr><td colspan="7">Reference Books:</td></tr>
<tr><td>1.</td><td colspan="6">R. Kamal, “Embedded System”, McGraw Hill Education, 2009.</td></tr>
<tr><td>2.</td><td colspan="6">D. V. Hall, “Microprocessors & Interfacing”, McGraw Hill Higher Education, 1991.</td></tr>
<tr><td colspan="7">E-References;</td></tr>
<tr><td>1.</td><td colspan="6">www.onlinecourses.nptel.ac.in/noc18_ee41</td></tr>
<tr><td>2.</td><td colspan="6">www.class-central.com</td></tr>
<tr><td>3.</td><td colspan="6">www.mooc-list.com</td></tr>
</table>

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**	**PSO1**	**PSO2**	**PSO3**
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)

<table>
<tr><td>22EEM05</td><td colspan="2">ELECTRICAL MACHINES</td><td colspan="4">SEMESTER</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"></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 impart knowledge on construction, working and performance of DC generators and motors.</td></tr>
<tr><td>2.</td><td colspan="6">To deliberate the construction, working and performance of single phase and three phase transformers.</td></tr>
<tr><td>3.</td><td colspan="6">To impart knowledge on construction, working and performance of synchronous generators and motors.</td></tr>
<tr><td>4.</td><td colspan="6">To impart knowledge on construction, principle of operation and performance of single and three-phase induction motors.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT I</td><td colspan="2">DC GENERATORS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT II</td><td colspan="2">DC MOTORS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT III</td><td colspan="2">TRANSFORMER</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT IV</td><td colspan="2">SYNCHRONOUS GENERATOR AND MOTOR</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT V</td><td colspan="2">THREE PHASE AND SINGLE PHASE INDUCTION MOTOR</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Total (45L+0T)= 45 Periods</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Text Books:</td></tr>
</table>

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>
<tr><td colspan="7">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="6">To know about the operation analyse of chopper fed DC drive, both qualitatively and quantitatively.</td></tr>
<tr><td>2.</td><td colspan="6">To understand the operation and performance of AC motor drives.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT I</td><td colspan="2">DC MOTOR CHARACTERISTICS & CHOPPER FED DC DRIVES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT II</td><td colspan="2">MULTI-QUADRANT & CLOSED-LOOP CONTROL OF DC DRIVE</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT III</td><td colspan="2">INDUCTION MOTOR CHARACTERISTICS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT IV</td><td colspan="2">CONTROL OF SLIP RING INDUCTION MOTOR</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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. .</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT V</td><td colspan="2">CONTROL OF SRM AND BLDC MOTOR DRIVES.</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7" align="right">Total (45L+0T)= 45 Periods</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Text Books:</td></tr>
<tr><td>1.</td><td colspan="6">G. K. Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall, 1989.</td></tr>
<tr><td>2.</td><td colspan="6">R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control”, Prentice Hall,2010</td></tr>
<tr><td>3.</td><td colspan="6">Bose B K, "Modern Power Electronics and AC Drives", Pearson Education New Delhi, 2010.</td></tr>
<tr><td colspan="7">Reference Books:</td></tr>
<tr><td>1.</td><td colspan="6">G. K. Dubey, “Fundamentals of Electrical Drives”, CRC Press, 2012.</td></tr>
<tr><td>2.</td><td colspan="6">W. Leonhard, “Control of Electric Drives”, Springer Science & Business Media, 2001.</td></tr>
<tr><td colspan="7">E-Reference</td></tr>
<tr><td>1</td><td colspan="6">https://www.iith.ac.in/~ketan/drives.htmL</td></tr>
</table>

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**	**PSO1**	**PSO2**	**PSO3**
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)

22EEM08	ELECTRICAL ENERGY CONSERVATION AND AUDITING		SEMESTER			
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power Generation, Transmission and Distribution System		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

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”, 3^{rd} Edition, John Wiley and Sons, 2006.
2.	M.H. Rashid, “Power Electronics circuits, devices and applications”, 3^{rd} 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	PSO1	PSO2	PSO3
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)

22MEM01	**ENGINEERING THERMODYNAMICS** *(Use of standard thermodynamic tables, Mollier diagram are permitted)*					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

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

UNIT I	**BASIC CONCEPT AND FIRST LAW**	**9**	**0**	**0**	**9**

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

UNIT II	**SECOND LAW AND ENTROPY**	**9**	**0**	**0**	**9**

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

UNIT III	**PROPERTIES OF PURE SUBSTANCES**	**9**	**0**	**0**	**9**

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

UNIT IV	**STEAM POWER CYCLE**	**9**	**0**	**0**	**9**

Basic Rankine cycle, T-s & h-s diagrams - Performance Improvement - Reheat cycle, regenerative cycle and their combination cycles.

UNIT V	**IDEAL AND REAL GASES AND THERMO DYNAMIC RELATIONS**	**9**	**0**	**0**	**9**

Properties of ideal and real gases, equation of state of ideal and real gases, Avogadro’s law, Vander Waal’s equation of states, Principle of corresponding states, reduced properties and compressibility chart. Exact differentials, Maxwell relations, Specific heat equations, Tds, relations, Clausius Clapeyron equations and Joule Thomson Coefficient.

Total (45L)= 45 Periods

Text Books:

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

Reference Books:

1.	Cengel, “Thermodynamics- An Engineering Approach”, 3rd Edition, Tata McGraw Hill, 2015.
2.	Merala C, Pother, Craig W and Somerton, “Thermodynamics for Engineers”, Schaum Outline Series, Tata

	McGrawHill, New Delhi, 2004.

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

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2			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)

22MEM03	MANUFACTURING PROCESSES					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
1. Basic science, Engineering mathematics, Engineering Physics 2. Engineering Materials		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

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

UNIT I	**CASTING**	**9**	**0**	**0**	**9**
Concepts of Manufacturing Process -Sand casting -Patterns – Design of Pattern, mould and cores- gating and risering design, solidification time calculation - Moulding machines - Core making. Special moulding processes – CO2 moulding; shell moulding, investment moulding, pressure die casting, centrifugal casting, casting defects.					
UNIT II	**WELDING**	**9**	**0**	**0**	**9**
Classification of welding processes. Principles of Oxy-acetylene gas welding. Metal arc welding, resistance welding, submerged arc welding, tungsten inert gas welding, metal inert gas welding, plasma arc welding, thermit welding, electron beam welding, laser beam welding, defects in welding, Soldering and Brazing, Adhesive Bonding.					
UNIT III	**METAL FORMING**	**10**	**0**	**0**	**10**
Metallurgical aspects of metal forming, slip, twinning mechanics of plastic deformation, load estimation of bulk deformation processes, Hot working and cold working of metals, Forging processes – open, closed and impression die forging – forging operations. Rolling of metals– Types of Rolling mill – Flat strip rolling – shape rolling operations – Defects in rolled parts. Principle of rod and wire drawing – Tube drawing – Principles of Extrusion – Types.					
UNIT IV	**SHAPING OF PLASTICS**	**8**	**0**	**0**	**8**
Types of plastics - Characteristics of the forming and shaping processes – Moulding of Thermoplastics – Working principles and typical applications of - Injection moulding – Plunger and screw machines – Blow moulding – Rotational moulding – Film blowing – Extrusion - Typical industrial applications – Thermoforming – Processing of Thermosets – Working principles and typical applications - Compression moulding – Transfer moulding.					
UNIT V	**SHEET METAL FORMING AND POWDER METALLURGY**	**9**	**0**	**0**	**9**
Formability of Sheet Metal, load estimation of sheet metal processes - Shearing, Deep drawing, Bending operations- types of presses used, Super Plastic forming; Introduction to Powder Metallurgy– Principal steps involved – sintering and compacting techniques, Advantages, limitations and applications of powder metallurgy.					
					Total (45L) = 45 Periods

Text Books:	
1.	HajraChoudhury, "Elements of Workshop Technology", Vol. I and II, Media Promoters and Publishers Pvt., Ltd., Mumbai, 2005.
2.	NagendraParashar B.S. and Mittal R.K., "Elements of Manufacturing Processes", Prentice-Hall of India Private Limited, 2007.
Reference Books:	
1.	Serope Kalpajian, Steven R.Schmid, "Manufacturing Processes for Engineering Materials", 4/e, Pearson Education, Inc. 2007.
2.	Jain. R.K., and S.C. Gupta, "Production Technology", 16th Edition, Khanna Publishers, 2001.
3.	"H.M.T. "Production Technology – Handbook", Tata McGraw-Hill, 2000.
4.	Roy. A. Linberg, "Process and Materials of Manufacture", PHI, 2000.

5.	Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems.
E-References:	
1.	https://fdocuments.in/document/production-technology-55844cac00bfc.html?page=40

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

COURSE ARTICULATION MATRIX

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

22MEM06	HYDRAULICS AND PNEUMATICS					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

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

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

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

UNIT II	HYDRAULIC ACTUATORS AND CONTROL COMPONENTS	9	0	0	9

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

UNIT III	HYDRAULIC CIRCUITS AND SYSTEMS	9	0	0	9

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

UNIT IV	PNEUMATIC AND ELECTRO PNEUMATIC SYSTEMS	9	0	0	9

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

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

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

Total (45L) = 45 Periods

Text Books:

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

Reference Books:

1.	Andrew Parr, "Hydraulic and Pneumatics", Jaico Publications House, 2005.
2.	Bolton W. "Pneumatic and hydraulic system", Butterworth-Heinemann 1997

3.	Majumdar S.R., "Pneumatic systems – Principles and maintenance", Tata McGraw Hill, 2010
4.	Shanmugasundaram.K, "Hydraulic and Pneumatic controls", Chand & Co, 2006
5.	Srinivasan.R. "Hydraulic and Pneumatic Controls", Vijay Nicole Imprints, 2008.
E-References:	
1.	http://www.fluidpowerjournal.com
2.	http://14.139.160.15/courses/112102011/2
3.	https://www.nfpa.com/home.htm

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

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1										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>22MEM07</td><td colspan="2">DESIGN OF MACHINE ELEMENTS</td><td colspan="4"></td></tr>
<tr><td colspan="2">PRE-REQUISITE:</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">1. Student should study engineering mechanics.
2. Student should study kinematic of machinery.</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>

<table>
<tr><td colspan="2">Course Objectives:</td></tr>
<tr><td>1.</td><td>Understanding of background in mechanics of materials and design of machine components.</td></tr>
<tr><td>2.</td><td>An understanding of the origins, nature and applicability of empirical design principles, based on safety considerations</td></tr>
<tr><td>3.</td><td>An understanding the design of shafts and couplings.</td></tr>
<tr><td>4.</td><td>Familiarize the design of energy storing elements and engine components.</td></tr>
<tr><td>5.</td><td>An appreciation of the relationships between component level design and overall machine system design and performance</td></tr>
</table>

<table>
<tr><td>UNIT I</td><td>STEADY STRESSES AND VARIABLE STRESSES IN MACHINE MEMBERS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="6">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 .</td></tr>
<tr><td>UNIT II</td><td>DESIGN OF SHAFTS AND COUPLINGS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="6">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.</td></tr>
<tr><td>UNIT III</td><td>DESIGN OF THREADED FASTENERS, RIVETED AND WELDED JOINTS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="6">Threaded fasteners - Design of bolted joints including eccentric loading – Design of riveted and welded joints for pressure vessels and structures- theory of bonded joints.</td></tr>
<tr><td>UNIT IV</td><td>DESIGN OF ENERGY STORING ELEMENTS AND ENGINE COMPONENTS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="6">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.</td></tr>
<tr><td>UNIT V</td><td>DESIGN OF BEARINGS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="6">Sliding contact and rolling contact bearings - Hydrodynamic journal bearings, Sommerfeld Number - Selection of Rolling Contact bearings.</td></tr>
<tr><td colspan="6" align="right">Total (45L) = 45 Periods</td></tr>
</table>

<table>
<tr><td colspan="2">Text Books:</td></tr>
<tr><td>1.</td><td>Bhandari V.B, “Design of Machine Elements”, Tata McGraw Hill Book Co, 2020</td></tr>
<tr><td>2.</td><td>Md.Jalaludeen.S, “A text book of Machine Design”, Anuradha Publications, 2006</td></tr>
<tr><td colspan="2">Reference Books:</td></tr>
<tr><td>1.</td><td>Shigley, J.E. and Mischke, C.R., Mechanical Engineering Design, Fifth Edition, McGraw-Hill International; 1989.</td></tr>
<tr><td>2.</td><td>Deutschman, D., Michels, W.J. and Wilson, C.E., Machine Design Theory and Practice, Macmillan, 1992.</td></tr>
<tr><td>3.</td><td>Juvinal, R.C., Fundamentals of Machine Component Design, John Wiley, 1994.</td></tr>
<tr><td>4.</td><td>PSG Tech, “Design Data Handbook”, M/s.DPV Printers, Coimbatore, 2009</td></tr>
<tr><td colspan="2">E-References:</td></tr>
<tr><td>1.</td><td>https://nptel.ac.in/courses/112105124</td></tr>
</table>

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)															

22MEM09	METROLOGY AND QUALITY CONTROL					
PREREQUISITES		CATEGORY	PE	Credit		3
		Horus/Week	L	T	P	TH
			3	0	0	3
COURSE OBJECTIVES						
1.	Explaining the importance of measurements in engineering and the factors affecting measurements and to compute measurement uncertainty					
2.	Applying the applications of linear and angular measuring instruments					
3.	Interpretation of various tolerance symbols.					
4.	Applying the SQC methods in manufacturing.					
5.	Applying the advances in measurements for quality control.					
UNIT-I	**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&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 for machines. 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: 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.						
						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**			**2.25**	**1.5**	**1.5**				**1.6**	**1.4**	
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

22MEMI10	DYNAMICS OF MACHINERY					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Engineering Mechanics, Kinematics of Machinery, Strength of Materials		**Hours\Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To impart students with the knowledge about motion, masses and forces in machines and the Principle of Virtual Work.
2.	To facilitate 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)															

22MTM01	ADVANCED PHYSICAL METALLURGY			Semester			
PREREQUISITES		**Category**	**OE**	**Credit**		**3**	
Engineering physics		**Hours/Week**	**L**	**T**	**P**	**TH**	
			3	**0**	**0**	**3**	
Course Learning Objectives							
1	To impart knowledge on the crystal structure, diffusion, phase diagrams for various engineering materials.						
Unit I	**CRYSTAL STRUCTURES**		**9**	**0**	**0**	**9**	
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							
Unit II	**CRYSTALLINE IMPERFECTIONS**		**9**	**0**	**0**	**9**	
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.							
Unit III	**ATOMIC DIFFUSION IN SOLIDS AND SOLIDIFICATION OF METAL**		**9**	**0**	**0**	**9**	
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.							
Unit IV	**PHASE DIAGRAMS**		**9**	**0**	**0**	**9**	
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.							
Unit V	**IRON-CARBON PHASE DIAGRAM**		**9**	**0**	**0**	**9**	
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.							
Total (45L) = 45 Hours							

Text Books:	
1	Donald R. Askeland,"The Science and Engineering of Materials", Thomson Learning, India Edition, 2007.
2	William D.Callister, "Materials Science and Engineering – An Introduction", 4th edition, JohnWiley & Sons, New York, USA, 1997.
Reference Books:	

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	:	Diagnose the diffusion mechanism in solidification of materials under different conditions.	L4: Analyzing
CO4	:	Apply the concept of phase diagrams in equilibrium transformation of materials phases.	L3: Applying
CO5	:	Construct the Fe-Fe_3C 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	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0

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

<table>
<tr><td>22MTM02</td><td colspan="4">THERMODYNAMICS AND KINETICS IN METALLURGY</td><td colspan="3">Semester</td><td></td></tr>
<tr><td colspan="3">PREREQUISITES</td><td colspan="2">Category</td><td>OE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="3" rowspan="2">Engineering physics and Engineering chemistry</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 Learning Objectives</td></tr>
<tr><td>1</td><td colspan="8">To learn the basic principles and concepts of thermodynamics in the field of Metallurgy and materials; and to learn about equations and their applications.</td></tr>
<tr><td>Unit I</td><td colspan="4">FUNDAMENTAL CONCEPT AND INTERNAL ENERGY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td>Unit II</td><td colspan="4">ENTROPY AND AUXILIARY FUNCTIONS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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</td></tr>
<tr><td>Unit III</td><td colspan="4">THERMODYNAMIC POTENTIALS AND PHASE EQUILIBRIA</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">Thermodynamic potentials: Fugacity, Activity and Equilibrium constant. Clausius - Clapeyron equation, Trouton’s rule. Le Chatelier's principle, Van’t 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.</td></tr>
<tr><td>Unit IV</td><td colspan="4">THERMODYNAMICS OF SOLUTIONS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td>Unit V</td><td colspan="4">THERMODYNAMICS OF REACTIONS AND KINETICS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">Electrochemical 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.</td></tr>
<tr><td colspan="9" align="right">Total (45L) = 45 Hours</td></tr>
</table>

<table>
<tr><td colspan="2">Text Books:</td></tr>
<tr><td>1</td><td>Upadhyaya G S andDube R K., "Problems in Metallurgical Thermodynamics & Kinetics",Pergamon, 1977.</td></tr>
<tr><td>2</td><td>Ahindra Ghosh, Textbook of Materials & MetallurgicalThermodynamics, Prentice Hall India, 2002</td></tr>
<tr><td>3</td><td>. David R Gaskell, "Introduction to the Thermodynamics of Materials", Fifth Edition, Taylor & Francis, 2008</td></tr>
<tr><td colspan="2">Reference Books:</td></tr>
<tr><td>1</td><td>David V Ragone, "Thermodynamics of Materials - Volume-1", John Wiley & Sons, Inc. 1995.</td></tr>
<tr><td>2</td><td>Dr S.K Dutta,Prof A.B.Lele – Metallurgical thermodynamics kinetics and numericals,S.Chand& co Ltd.,New Delhi 2011</td></tr>
</table>

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 auxiliary functions.	L2: Understanding
CO3	:	Identify the basic laws, chemical potential and phase equilibria.	L4: Analyzing
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	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0

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

22MTM03	MECHANICAL BEHAVIOUR OF MATERIALS		Semester			
PREREQUISITES			**OE**	**Credit**		**3**
Engineering physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To know the fundamental concepts of deformation behaviour for structural engineering applications.

Unit I	**DISLOCATIONS AND PLASTIC DEFORMATION**	**9**	**0**	**0**	**9**

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 – Peierls 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.

Unit II	**STRENGTHENING MECHANISMS**	**9**	**0**	**0**	**9**

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; Severe plastic deformation.

Unit III	**FRACTURE AND FRACTURE MECHANICS**	**9**	**0**	**0**	**9**

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.

Unit IV	**FATIGUE BEHAVIOUR AND TESTS**	**9**	**0**	**0**	**9**

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.

Unit V	**CREEP BEHAVIOUR AND TESTS**	**9**	**0**	**0**	**9**

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, parametric methods of extrapolation. Deformation Mechanism Maps

Total (45L) = 45 Hours

Text Books:

1	George. E. Dieter, "Mechanical Metallurgy", 3rd Edition, McGraw-Hill Publications, New York, SI Edition, 2004
2	Marc Andre 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	0.0	0.0	0.0	0.0	0.0	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 (45L) = 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

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	0.0	0.0	0.0	0.0	0.0	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 corrosion and surface engineering, with its application in the 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 Electrochemical 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 (45L) = 45 Hours</td></tr>
</table>

Reference Books:	
1.	Fontana. G., Corrosion Engineering, McGraw Hill, 1985.
2.	Kenneth G. Budinski, Surface Engineering for Wear Resistance, Prentice hall, 1992.
3.	ASM Metals HandBook –Vol. 5, Surface Engineering, 1996.
4.	Denny A Jones, “Principles and prevention of corrosion”, 2nd 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: Analyzing
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	0.0	0.0	0.0	0.0	0.0	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 microanalyzer (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-gravimetric 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 (45L) = 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: Analyzing
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

<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			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	0.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0

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

<table>
<tr><td>22MTM07</td><td colspan="2">AUTOMOTIVE, AEROSPACE AND DEFENCE 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 understand the properties and applications various materials suitable for automobile, aircraft and defence industries and its components.</td></tr>
<tr><td>Unit I</td><td colspan="2">MATERIALS FOR ENGINES AND TRANSMISSION SYSTEMS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Materials selection for IC engines: Piston, piston rings, cylinder, Engine block, Connecting rod, Crank shaft, Fly wheels, Gear box, Gears, Splines, Clutches.</td></tr>
<tr><td>Unit II</td><td colspan="2">MATERIALS FOR AUTOMOTIVE STRUCTURES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>Unit III</td><td colspan="2">AEROSPACE METALS AND ALLOYS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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</td></tr>
<tr><td>Unit IV</td><td colspan="2">CERAMICS AND COMPOSITES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td>Unit V</td><td colspan="2">NUCLEAR WASTE AND RADIATION PROTECTION, IRRADIATION EFFECTS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7" align="right">Total (45L) = 45 Hours</td></tr>
</table>

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.	H Buhl, Advanced Aerospace Materials, Springer, Berlin 1992, ISBN-13: 978-3540558880
4.	Balram Gupta, Aerospace material Vol. 1,2,3,4ARDB, S Chand & Co ,2009, ISBN-13: 978- 8121922005.

5.	Jason Rowe, ―Advanced Materials in Automotive Engineering, WoodHead Publishing, 2012.
6.	Ahmed E, ―Advanced composite materials for Automotive applications, Wiley, 2013
7.	Don H Wright, Testing Automotive Materials and Components, SAE 1993.
8.	Ahmed E, ―Advanced composite materials for Automotive applications, Wiley, 2013
9.	V.Gerasimov& A. Monakhov, Nuclear Engineering Materials, Mir Publishers, Moskow, 1983.
10.	Benjamin M. M., Van Nostrand "Nuclear Reactor Materials and Applications", Reinhold Company Inc, 1983

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: Analyzing
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: Analyzing
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	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0

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