GOVERNMENT COLLEGE OF TECHNOLOGY

(An Autonomous Institution Affiliated to Anna University)
Coimbatore - 641 013

Curriculum For

M. E. THERMAL ENGINEERING

2023

Regulations

OFFICE OF THE CONTROLLER OF EXAMINATIONS
GOVERNMENT COLLEGE OF TECHNOLOGY
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GOVERNMENT COLLEGE OF TECHNOLOGY

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VISION AND MISSION OF THE INSTITUTION

VISION

To emerge as a centre of excellence and eminence by imparting futuristic technical education in keeping with global standards, making our students technologically competent and ethically strong so that they can readily contribute to the rapid advancement of society and mankind**.**

MISSION

- To achieve academic excellence through innovative teaching and learning practices.
- To enhance employability and entrepreneurship.
- To improve the research competence to address societal needs.
- To inculcate a culture that supports and reinforces ethical, professional behaviours for a harmonious and prosperous society.

GOVERNMENT COLLEGE OF TECHNOLOGY

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VISION

To create outstanding Mechanical Engineers with strong domain knowledge and skills capable of working in an Interdisciplinary environment with exemplary ethical values contributing to society through Innovation, Entrepreneurship and Leadership.

MISSION

- To develop in each student, a strong theoretical and practical knowledge, a global outlook for a sustainable future and problem solving skills.
- To make productive members of interdisciplinary teams, capable of adapting to changing environments of Engineering, technology and society.
- To inculcate critical thinking abilities among students to enhance innovative ideas and entrepreneurial skills, leadership qualities.
- To imbibe moral and ethical values along with leadership qualities in students.

GOVERNMENT COLLEGE OF TECHNOLOGY

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M.E. THERMAL ENGINEERING

PROGRAMME OUTCOMES (POs)

PO1 : An ability to independently carry out research / investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/ document.

PO3 : Demonstrate a degree of mastery over thermal engineering at a level higher than the Bachelor's program.

PO4: Identify feasible energy sources and develop adequate technologies to equipage them.

PO5: Design, develop and analyze thermal systems for recapitulation.

PO6: Engage in lifelong learning adhering to professional, ethical, legal, safety, environmental and societal aspects for career excellence.

GOVERNMENT COLLEGE OF TECHNOLOGY

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M.E. THERMAL ENGINEERING

PROGRAMME EDUCTAIONAL OBJECTIVES (PEOs)

PEO1 : Apply their knowledge in basic science, Mathematics and engineering to solve thermal, industrial and societal problems with a strong emphasis on innovation ethics and social responsibility.

PEO2: Apply state of the art of Thermal Engineering tools and techniques to develop products and processes.

PEO3: Ability to solve interdisciplinary problems by working in cross-functional teams.

PEO4: Develop and upgrade Thermal Engineering, intellectual and emotional skills for life-long learning to compete on the competitive world.

PEO5: Nurture entrepreneurial ventures and foster modern research accomplishments that support sustainable environmental and economical factors to improve the quality of life.

GOVERNMENT COLLEGE OF TECHNOLOGY, COIMBATORE – 641 013
M.E. THERMAL ENGINEERING

FIRST SEMESTER

Sl. No.	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
THEORY										
1	23TEFCZ1	RESEARCH METHODOLOGY AND IPR (Common to all branches)	FC	40	60	100	3	0	0	3
2	23TEFC02	ADVANCED MATHEMATICS FOR THERMAL ENGINEERING	FC	40	60	100	3	1	0	4
3	23TEPC01	ADVANCED THERMODYNAMICS	PC	40	60	100	3	1	0	4
4	23TEPC02	ADVANCED FLUID DYNAMICS	PC	40	60	100	3	1	0	4
5	23TEPEXX	PROFESSIONAL ELECTIVE I	PE	40	60	100	3	0	0	3
6	23TEPEXX	PROFESSIONAL ELECTIVE II	PE	40	60	100	3	0	0	3
7	23TEACXX	AUDIT COURSE I	AC	40	60	100	2	0	0	0
PRACTICAL										
8	23TEPC03	ADVANCED IC ENGINES AND SIMULATION LABORATORY	PC	60	40	100	0	0	4	2
TOTAL				**340**	**460**	**800**	**20**	**3**	**4**	**23**

SECOND SEMESTER

Sl. No.	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
THEORY										
1	23TEPC04	ADVANCED HEAT AND MASS TRANSFER	PC	40	60	100	3	1	0	4
2	23TEPC05	COMPUTATIONAL FLUID DYNAMICS	PC	40	60	100	3	1	0	4
3	23TEPC06	FUEL CELL TECHNOLOGY	PC	40	60	100	3	0	0	3
4	23TEPC07	MANUFACTURING AND TESTING OF IC ENGINES AND COMPONENTS	PC	40	60	100	3	0	0	3
5	23TEPEXX	PROFESSIONAL ELECTIVE III	PE	40	60	100	3	0	0	3
6	23TEACXX	AUDIT COURSE II	AC	40	60	100	2	0	0	0
PRACTICAL										
7	23TEPC08	ADVANCED COMBUSTION LABORATORY	PC	60	40	100	0	0	4	2
8	23TEEE01	MINI PROJECT	EEC	60	40	100	0	0	4	2
TOTAL				**360**	**440**	**800**	**17**	**2**	**8**	**21**

GOVERNMENT COLLEGE OF TECHNOLOGY, COIMBATORE – 641 013
B.E.MECHANICAL ENGINEERING

THIRD SEMESTER

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
THEORY										
1	23TEPEXX	PROFESSIONAL ELECTIVE IV	PE	40	60	100	3	0	0	3
2	23$$OEXX	OPEN ELECTIVE	OE	40	60	100	3	0	0	3
PRACTICAL										
3	23TEEE02	INTERNSHIP / INDUSTRIAL TRAINING	EEC	100	-	100	0	0	*	2
4	23TEEE03	PROJECT - I	EEC	60	40	100	0	0	24	12
TOTAL				**240**	**160**	**400**	**6**	**0**	**24**	**20**

*** Internship / Industrial Training Four Weeks**

FOURTH SEMESTER

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
THEORY										
1	23TEEE04	PROJECT - II	EEC	60	40	100	0	0	48	24
TOTAL				60	40	100	**0**	**0**	**48**	**24**

TOTAL NO. OF CREDITS: 88

LIST OF EMPLOYABILITY ENHANCEMENT COURSE

S. No	Course Code	Course Title	Category	Continuous Assessment Marks	End Sem Marks	Total Marks	L	T	P	C
1	23TEEE01	MINI PROJECT	EEC	60	40	100	0	0	4	2
2	23TEEE02	INTERNSHIP / INDUSTRIAL TRAINING	EEC	100	-	100	0	0	*	2
3	23TEEE03	PROJECT - I	EEC	60	40	100	0	0	24	12
4	23TEEE04	PROJECT - II	EEC	60	40	100	0	0	48	24
TOTAL				280	120	400	0	0	76	40

*** Internship / Industrial Training Four Weeks**

LIST OF PROFESSIONAL ELECTIVE										
S. No	**Course Code**	**Course Title**	**Category**	**Continuous Assessment Marks**	**End Sem Marks**	**Total Marks**	**L**	**T**	**P**	**C**
PROFESSIONAL ELECTIVE I										
1	23TEPE01	THERMODYNAMICS AND COMBUSTION	PE	40	60	100	3	0	0	3
2	23TEPE02	ARTIFICIAL INTELLIGENCE IN THERMAL SYSTEMS	PE	40	60	100	3	0	0	3
3	23TEPE03	ADVANCED GAS TURBINES	PE	40	60	100	3	0	0	3
4	23TEPE04	DESIGN OF CONDENSERS, EVAPORATORS AND COOLING TOWERS	PE	40	60	100	3	0	0	3
5	23TEPE05	INSTRUMENTATION IN THERMAL ENGINEERING	PE	40	60	100	3	0	0	3
PROFESSIONAL ELECTIVE II										
6	23TEPE06	ENGINE ELECTRONICS	PE	40	60	100	3	0	0	3
7	23TEPE07	FINITE ELEMENT METHODS IN THERMAL ENGINEERING	PE	40	60	100	3	0	0	3
8	23TEPE08	ADVANCED GAS DYNAMICS AND SPACE PROPULSION	PE	40	60	100	3	0	0	3
9	23TEPE09	STEAM ENGINEERING	PE	40	60	100	3	0	0	3
10	23TEPE10	SUPERCHARGING AND SCAVENGING	PE	40	60	100	3	0	0	3
PROFESSIONAL ELECTIVE III										
11	23TEPE11	REFRIGERATION AND CRYOGENICS	PE	40	60	100	3	0	0	3
12	23TEPE12	THERMAL ENERGY SYSTEMS	PE	40	60	100	3	0	0	3
13	23TEPE13	ENGINE POLLUTION AND CONTROL	PE	40	60	100	3	0	0	3
14	23TEPE14	AIR CONDITIONING SYSTEM DESIGN	PE	40	60	100	3	0	0	3
15	23TEPE15	SOLAR ENERGY AND WIND ENERGY	PE	40	60	100	3	0	0	3
PROFESSIONAL ELECTIVE IV										
16	23TEPE16	BIO-ENERGY CONVERSION TECHNIQUES	PE	40	60	100	3	0	0	3
17	23TEPE17	ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL	PE	40	60	100	3	0	0	3
18	23TEPE18	MODELING OF CI ENGINE PROCESSES	PE	40	60	100	3	0	0	3
19	23TEPE19	ENERGY AUDITING AND MANAGEMENT	PE	40	60	100	3	0	0	3
20	23TEPE20	ELECTRIC AND HYBRID VEHICLES	PE	40	60	100	3	0	0	3

LIST OF OPEN ELECTIVE COURSES

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	23SEOE01	BUILDING BYE-LAW AND CODES OF PRACTICE	OE	40	60	100	3	0	0	3
2	23SEOE02	PLANNING OF SMART CITIES	OE	40	60	100	3	0	0	3
3	23SEOE03	GREEN BUILDING	OE	40	60	100	3	0	0	3
4	23EEOE04	ENVIRONMENT HEALTH AND SAFETY MANAGEMENT	OE	40	60	100	3	0	0	3
5	23EEOE05	CLIMATE CHANGE AND ADAPTATION	OE	40	60	100	3	0	0	3
6	23EEOE06	WASTE TO ENERGY	OE	40	60	100	3	0	0	3
7	23GEOE07	ENERGY IN BUILT ENVIRONMENT	OE	40	60	100	3	0	0	3
8	23GEOE08	EARTH AND ITS ENVIRONMENT	OE	40	60	100	3	0	0	3
9	23GEOE09	NATURAL HAZARD AND MITIGATION	OE	40	60	100	3	0	0	3
10	23EDOE10	BUSINESS ANALYTICS	OE	40	60	100	3	0	0	3
11	23EDOE11	INTRODUCTION TO INDUSTRIAL SAFETY	OE	40	60	100	3	0	0	3
12	23EDOE12	OPERATIONS RESEARCH	OE	40	60	100	3	0	0	3
13	23MFOE13	OCCUPATIONAL HEALTH AND SAFETY	OE	40	60	100	3	0	0	3
14	23MFOE14	COST MANAGEMENT OF ENGINEERING PROJECTS	OE	40	60	100	3	0	0	3
15	23MFOE15	COMPOSITE MATERIALS	OE	40	60	100	3	0	0	3
16	23TEOE16	GLOBAL WARMING SCIENCE	OE	40	60	100	3	0	0	3
17	23TEOE17	INTRODUCTION TO NANO ELECTRONICS	OE	40	60	100	3	0	0	3
18	23TEOE18	GREEN SUPPLY CHAIN MANAGEMENT	OE	40	60	100	3	0	0	3
19	23PSOE19	DISTRIBUTION AUTOMATION SYSTEM	OE	40	60	100	3	0	0	3
20	23PSOE20	ELECTRICITY TRADING & ELECTRICITY ACTS	OE	40	60	100	3	0	0	3

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	L	L	L
21	23PSOE21	MODERN AUTOMOTIVE SYSTEMS	OE	40	60	100	3	0	0	3
22	23PEOE22	VIRTUAL INSTRUMENTATION	OE	40	60	100	3	0	0	3
23	23PEOE23	ENERGY MANAGEMENT SYSTEMS	OE	40	60	100	3	0	0	3
24	23PEOE24	ADVANCED ENERGY STORAGE TECHNOLOGY	OE	40	60	100	3	0	0	3
25	23AEOE25	DESIGN OF DIGITAL SYSTEMS	OE	40	60	100	3	0	0	3
26	23AEOE26	BASICS OF NANO ELECTRONICS	OE	40	60	100	3	0	0	3
27	23AEOE27	ADVANCED PROCESSOR	OE	40	60	100	3	0	0	3
28	23VLOE28	HDL PROGRAMMING LANGUAGES	OE	40	60	100	3	0	0	3
29	23VLOE29	CMOS VLSI DESIGN	OE	40	60	100	3	0	0	3
30	23VLOE30	HIGH LEVEL SYNTHESIS	OE	40	60	100	3	0	0	3
31	23CSOE31	ARTIFICIAL INTELLIGENCE	OE	40	60	100	3	0	0	3
32	23CSOE32	COMPUTER NETWORK MANAGEMENT	OE	40	60	100	3	0	0	3
33	23CSOE33	BLOCKCHAIN TECHNOLOGIES	OE	40	60	100	3	0	0	3

LIST OF AUDIT COURSE

S. No	Course Code	Course Title	Category	Continuous Assessment Marks	End Sem Marks	Total Marks	L	T	P	C
THEORY										
1	23TEACZ1	ENGLISH FOR RESEARCH PAPER WRITING	AC	40	60	100	2	0	0	0
2	23TEACZ2	DISASTER MANAGEMENT	AC	40	60	100	2	0	0	0
3	23TEACZ3	VALUE EDUCATION	AC	40	60	100	2	0	0	0
4	23TEACZ4	CONSTITUTION OF INDIA	AC	40	60	100	2	0	0	0
5	23TEACZ5	PEDAGOGY STUDIES	AC	40	60	100	2	0	0	0
6	23TEACZ6	STRESS MANAGEMENT BY YOGA	AC	40	60	100	2	0	0	0
7	23TEACZ7	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	AC	40	60	100	2	0	0	0
8	23TEACZ8	SANSKRIT FORTECHNICAL KNOWLEDGE	AC	40	60	100	2	0	0	0

CURRICULUM DESIGN

S.No	Course Work Subject Area	No of Credits					Percentage
		I	II	III	IV	Total	
1.	Foundation Course	7	-	-	-	07	**7.95 %**
2.	Professional Cores	10	16	-	-	26	**29.54%**
3.	Employability Enhancement Courses	0	2	**14**	24	**40**	**45.45%**
4.	Professional Electives	6	3	3	-	12	**13.63%**
5.	Audit courses	0	0	-	-	-	**-**
6.	Open Elective Courses	-	-	3	-	03	**3.40 %**
Total Credits		**23**	**21**	**20**	**24**	**88**	**100.00%**

23TEFCZ1	RESEARCH METHODOLOGY AND IPR	I

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

Course Objectives	• To impart knowledge on research methodology ,Quantitative methods for problem solving, data interpretation and report writing • To know the importance of IPR and patent rights.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Definition and objectives of Research – Types of research, Various Steps in Research process, Mathematical tools for analysis, Developing a research question-Choice of a problem Literature review, Surveying, synthesizing, critical analysis, reading materials, reviewing, rethinking, critical evaluation, interpretation, Research Purposes, Ethics in research – APA Ethics code.		
UNIT – II	**QUANTITATIVE METHODS FOR PROBLEM SOLVING**	**9 Periods**
Statistical Modelling and Analysis, Time Series Analysis Probability Distributions, Fundamentals of Statistical Analysis and Inference, Multivariate methods, Concepts of Correlation and Regression, Fundamentals of Time Series Analysis and Spectral Analysis, Error Analysis, Applications of Spectral Analysis.		
UNIT – III	**DATA DESCRIPTION AND REPORT WRITING**	**9 Periods**
Tabular and graphical description of data: Tables and graphs of frequency data of one variable, Tables and graphs that show the relationship between two variables , Relation between frequency distributions and other graphs, preparing data for analysis. Structure and Components of Research Report, Types of Report, Layout of Research Report, Mechanism of writing a research report, referencing in academic writing.		
UNIT – IV	**INTELLECTUAL PROPERTY**	**9 Periods**
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.		
UNIT – V	**PATENT RIGHTS**	**9 Periods**
Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.		
Contact Periods: **Lecture: 45 Periods Tutorial:0 Periods Practical: 0 Periods Total:45 Periods**		

REFERENCES:

1	*Stuart Melville and Wayne Goddard,* ***"Research methodology: an introduction for science & engineering students",*** *Juta Academic, 1996.*
2	*Donald H.McBurney and Theresa White,* ***"Research Methods",*** *9th Edition, engageLearning, 2013.*
3	*RanjitKumar,* ***"Research Methodology: A Step by Step Guide for Beginners",*** *5th Edition, 2014.*
4	*Dr. C. R. Kotharia and GauravGarg,* ***"Research Methodology: Methods and Trends",*** *New age international publishers, Fourth Edition, 2018.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Formulate research question for conducting research.	K4
CO2	Analyze qualitative and quantitative data.	K4
CO3	Interpret research findings and give appropriate conclusions.	K4
CO4	Develop a structured content to write technical report.	K4
CO5	Summarize the importance of IPR and protect their research work through intellectual property.	K4

COURSE ARTICULATION MATRIX					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	1	2	1	1	2
CO2	2	-	-	-	-
CO3	3	3	3	2	2
CO4	2	2	2	2	2
CO5	1	1	1	1	1
23TEFCZ1	2	2	1	2	2
1 – Slight, 2 – Moderate, 3 – Substantial					

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

23TEFC02	ADVANCED MATHEMATICS FOR THERMAL ENGINEERING	I

PREREQUISITES	CATEGORY	L	T	P	C
NIL	FC	3	1	0	4

Course Objective	• The course is designed to teach students various techniques to solve linear, nonlinear equations including boundary value problems occur in engineering them to the important mathematical tool of numerical methods.	
UNIT – I	**SYSTEM OF LINEAR AND NONLINEAR EQUATIONS**	**9 +3 Periods**
System of linear equation: Gauss elimination method, Gauss Jordan method, Choleski method, Gauss Jacobi method, Gauss-Seidel method-System of nonlinear equations: Iteration method, Newton-Raphson method for single variable-Eigen value problems: Power method.		
UNIT – II	**NUMERICAL DIFFERENTIATION AND INTEGRATION**	**9+3 Periods**
Interpolation: Newton's forward and backward interpolation, Newton's divided difference interpolation, Lagrange's Interpolation-Differentiation: Newton's Formula-Numerical integration: Trapezoidal rule, Simpson's 1/3rd and 3/8 rules-Gaussian two- and three-point quadrature formula.		
UNIT – III	**NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS**	**9+3 Periods**
First order differential equations: Taylor's series method-Euler and modified Euler's methods-Runge-Kutta method of fourth order- Milne's and Adam's predictor-corrector methods -Second order differential equations: Taylor's series method.		
UNIT – IV	**NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS**	**9+3 Periods**
Partial differential equations: Finite difference solution two dimensional Laplace equation and Poisson equation- Implicit and explicit methods for one dimensional heat equation (Bender-Schmidt and Crank-Nicholson methods)-Finite difference explicit method for wave equation.		
UNIT – V	**FINITE ELEMENT METHOD**	**9+3 Periods**
Basics of finite element method: Weak formulation, weighted residual method-Shape functions for linear and triangular element-Finite element method for two point boundary value problems, Laplace and Poisson equations.		
Contact Periods: **Lecture: 45 Periods Tutorial: 15 Periods Practical: 0 Periods Total: 60 Periods**		

REFERENCES:

1	*S.S. Sastry,* ***Introductory methods of numerical analysis****, PHI, New Delhi, 5th Edition, 2015.*
2	*Ward Cheney, David Kincaid,* ***Numerical Methods and Computing,*** *Cengage Learning****,*** *Delhi, 7th Edition 2013.*
3	*James.G, "****Advanced Modern Engineering Mathematics"****, Pearson Education Asia, 4th edition, 2011.*
4	*Grewal.B.S.,* **"*Numerical Methods In Engineering And Science"***, Khanna Publishers New Delhi, 2014.*
5	*Veerarajan.Tand* Ramachandran.T, **"*Numerical Methods With Programming C*"**, *Tata Mc Graw Hill Publishing Company Ltd., New Delhi, 2011.*
6	*S.R.K.Iyengar, R.K Jain,* ***"Numerical Methods"****, New Age International Publishers, New Delhi.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Solve the linear, non-linear equations and Eigenvalue problems using an appropriate numerical method.	K6
CO2	Gain the knowledge of numerical differentiation and integration.	K6
CO3	Construct one-step and linear multistep methods for the numerical solution of initial-value problems for ordinary differential equations and systems of such equations.	K6
CO4	Acquire the knowledge of principles for designing numerical schemes for PDEs in particular finite difference schemes, interpret solutions in a physical context of wave and heat equation in specified techniques.	K6
C05	Acquire the knowledge of principles for designing numerical schemes for PDEs in particular finite difference schemes, interpret solutions in a physical context of wave and heat equation in specified techniques.	K6

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	-	-	-	1
CO2	3	3	-	-	-	2
CO3	3	3	-	-	-	2
CO4	2	2	-	-	-	1
CO5	1	2	-	-	-	1
23TEFC02	3	3	-	-	-	1
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23TEPC01	**ADVANCED THERMODYNAMICS** *(Use of approved gas tables and charts are permitted)*	**I**

PREREQUISITES	CATEGORY	L	T	P	C
ENGINEERING THERMODYNAMICS	PC	3	1	0	4

Course Objective	• To make the students learn the advanced concepts thermodynamic properties, multi phase systems, chemical and statistical thermodynamics, energy at micro level, conversion of heat energy in thermodynamic systems.	
UNIT – I	**AVAILABILITY AND THERMODYNAMIC PROPERTY RELATIONS**	**9+3 Periods**
Reversible work, Availability, Irreversibility and Second-Law Efficiency for a closed System and Steady-State Control Volume. Thermodynamic Potentials, Maxwell relations, Generalized relations for changes in Entropy, Internal Energy and Enthalpy, C_p and C_v, Clausius Clayperon Equation, Joule-Thomson Coefficient, Bridgmann Tables for Thermodynamic relations.		
UNIT – II	**SINGLE AND MULTI PHASE SYSTEMS**	**9+3 Periods**
SINGLE-PHASE SYSTEMS: Simple System, Equilibrium Conditions, The Fundamental Relations, Legendre Transforms, Relations between Thermodynamic Properties, EXERGY ANALYSIS: Non flow Systems, Flow Systems, Generalized Exergy Analysis, Air Conditioning and its types. MULTIPHASE SYSTEMS: The Energy Minimum Principle, The Stability of a Simple System, The Continuity of the Vapor and Liquid States, Phase Diagrams, Corresponding States.		
UNIT – III	**REAL GAS AND MULTI-COMPONENT SYSTEMS**	**9+3 Periods**
Different Equations of State, Fugacity, Compressibility, Principle of Corresponding States, Use of generalized charts for enthalpy and entropy departure, fugacity coefficient, Lee-Kessler generalized three parameter tables, Fundamental property relations for systems of variable composition, partial molar properties, Real gas mixtures, Ideal solution of real gases and liquids, Equilibrium in multi - phase systems, Gibbs phase rule for non-reactive components.		
UNIT – IV	**CHEMICAL THERMODYNAMICS AND EQUILIBRIUM**	**9+3 Periods**
Thermo chemistry, First Law analysis of reacting systems, Adiabatic Flame temperature, Entropy change of reacting systems, Second Law analysis of reacting systems, Criterion for reaction equilibrium, Chemical availability, Equilibrium constant for gaseous mixtures, evaluation of equilibrium composition, Availability of reacting systems.		
UNIT – V	**STATISTICAL THERMODYNAMICS**	**9+3 Periods**
Microstates and Macrostates, Thermodynamic probability, Degeneracy of energy levels, Maxwell-Boltzman, Fermi-Dirac and Bose-Einstein Statistics, Microscopic Interpretation of heat and work, Evaluation of entropy, Calculation of the Macroscopic properties from partition functions, Equilibrium constant statistical thermodynamics approach.		
Contact Periods: **Lecture: 45 Periods Tutorial: 15 Periods Practical: 0 Periods Total: 60 Periods**		

TEXT BOOK:

1	*Yunus Cengel, Michael Boles,* ***"Thermodynamics: An Engineering Approach",*** *9th Edition, 2019.*
2	*P.K.Nag,* ***"Engineering Thermodynamics"****, Tata McGraw Hill Education, 6 th Edition, 2017.*

REFERENCES:

1	*Kenneth Wark Jr., **"Advanced Thermodynamics for Engineers**, McGraw-Hill Inc. New York, 1995.*
2	*Holman, J.P., **"Thermodynamics"**, McGraw-Hill Inc, 4th Edition, 1988.*
3	*Smith, J.M. and Van Ness., H.C., **"Introduction to Chemical Engineering Thermodynamics"**, McGraw-Hill Inc., 4thEdition, 2005.*
4	*Bejan, A.,"Advanced**"Engineering Thermodynamics"**, John Wiley and Sons, 3rd edition, 2006.*
5	*Domkundwar, Kothandaraman, **"A Course in Thermal Engineering"**, DhanpatRai and Co, 2008.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the thermodynamics property and relation between them.	K3
CO2	Understand the concepts of Thermodynamics Phase systems.	K5
CO3	Discuss the properties of different types of gases.	K2
CO4	Discuss the basic concepts of Irreversible and Chemical Thermodynamics.	K3
CO5	Derive equations and calculating the properties related to statistical thermodynamics.	K5

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	3	2
CO2	3	3	2	2	2	1
CO3	3	3	2	3	2	1
CO4	2	2	1	2	3	2
CO5	3	3	3	3	3	3
23TEPC01	3	3	2	2	3	2

1 – Slight, 2 – Moderate, 3 – Substantial

ASSESSMENT PATTERN – THEORY

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

23TEPC02	ADVANCED FLUID DYNAMICS *(use of approved gas tables and charts are permitted)*	I

PREREQUISITES	CATEGORY	L	T	P	C
FLUID MECHANICS AND HYDRAULIC MACHINERY	PC	3	1	0	4

Course Objective	• To make the students learn the advanced concepts and equations of various types of fluid flows and realize the special effects due to turbulence, friction and shock.	
UNIT – I	**BASIC LAWS OF FLUID FLOW**	**9+3 Periods**
Condition for irrotationality, circulation and vorticity Accelerations in Cartesian systems normal and tangential accelerations, Euler's, Bernoulli equations in 3D– Continuity and Momentum Equations, Ideal and non-ideal flows, general equations of fluid motion, Navier - stokes equations and their exact solutions. Boundary layer theory, wedge flows, laminar flow over plates and through cylinders.		
UNIT – II	**BOUNDARY LAYER THEORY**	**9+3 Periods**
Prandtl's contribution to real fluid flows – Prandtl's boundary layer theory -Boundary layer thickness for flow over a flat plate – Von-Karman momentum integral equation -Blasius solution- Laminar boundary layer – Turbulent Boundary Layer – Expressions for local and mean drag coefficients for different velocity profiles. – Total Drag due to Laminar & Turbulent Layers –Problems.		
UNIT – III	**TURBULENT FLOW**	**9+3 Periods**
Fundamental concept of turbulence – Time Averaged Equations –Boundary Layer Equations - Prandtl Mixing Length Model - Universal Velocity Distribution Law: Van Driest Model –Approximate solutions for drag coefficients – More Refined Turbulence Models – k-ε model - boundary layer separation and form drag – Karman Vortex Trail, Boundary layer control, lift on circular cylinders.		
UNIT – IV	**SHOCK WAVE**	**9+3 Periods**
Normal and oblique shocks – Prandtl – Meyer expansion – Rankine Hugnoit relation. Application of method of characteristics applied to two-dimensional case – simple supersonic wind tunnel Design of supersonic wind tunnel and nozzle.		
UNIT – V	**EXPERIMENTAL TECHNIQUES**	**9+3 Periods**
Role of experiments in fluid, layout of fluid flow experiments, sources of error in experiments, data analysis, design of experiments, review of probes and transducers, Introduction to Thermal Anemometry-Hot wire anemometer, Laser Doppler Velocimetry and Particle Image Velocimetry, Measurement of velocity components by 3 holes and 4 holes probes.		
Contact Periods: **Lecture: 45 Periods Tutorial: 15 Periods Practical: 0 Periods Total: 60 Periods**		

TEXT BOOK:

1	*Mohanty, A. K., **"Fluid Mechanics"**, Prentice Hall of India, 2nd edition, 2006.*
2	*Yunus A Cengel, John M.Cimbala, **"Fluid Mechanics: Fundamentals and Applications"**, McGraw-Hill, 4th Edition, 2019*

REFERENCES:

1	*Muralidhar, K and Biswas, G., **"Advanced Engineering Fluid Mechanics"**, Alpha Science International Ltd., 2015.*
2	*Pijush K. Kundu, Ira M Kohen and David R. Dawaling, **"Fluid Mechanics"**, Academic Press, 5th Edition 2011.*
3	*White, F. M., **"Viscous Fluid Flow",** 3rd Edition, Tata McGraw Hill Book Company, 2017.*
4	***"Advanced Fluid Mechanics"** by Dr. Suman Chakraborty (IIT Kharagpur), NPTEL Course (Link: https://nptel.ac.in/courses/112/105/112105218/#)*
5	***"Introduction to Turbulence"** by Prof. Gautam Biswas (IIT Kanpur), NPTEL Course (Link: https://nptel.ac.in/courses/112/104/112104120/)*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand fundamentals and Basic laws of Fluid Flows.	K3
CO2	Discuss the various laws pertaining to different Boundary layer concepts.	K5
CO3	Identify, formulate and solve problems related to fluid flows.	K5
CO4	Understand and Evaluate different wave phenomena.	K5
CO5	Apply fluid concepts in the experimental setups.	K5

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	3	2
CO2	3	3	2	2	2	1
CO3	3	3	2	3	2	1
CO4	2	2	1	2	3	2
CO5	3	3	3	3	3	3
23TEPC02	3	3	2	2	3	2

1 – Slight, 2 – Moderate, 3 – Substantial

ASSESSMENT PATTERN – THEORY

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

23TEPC03	ADVANCED IC ENGINES AND SIMULATION LABORATORY	I

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

Course Objective	• To make the students learn the importance of various types of I.C engines and analyze them using commercial open source software.

LIST OF EXPERIMENTS **(60)**

1. Performance test on Spark Ignition and Compression Ignition engines using Alternative fuels such as ethanol and Biofuels.
2. Performance test using pressure transducers in CI and SI Engines.
3. Performance and Heat balance test on I. C. Engines using a water dynamometer.
4. Performance test on variable compression ratio petrol and diesel engines.
5. Emission measurement in Spark Ignition and Compression Ignition Engines using smoke meter and gas analyzer.
6. Determination of Temperature Distribution using Thermal Imager.
7. Performance test on computerized Two Stage Air Compressor Test Rig.
8. Study on Drawing of Engine Components with Dimensions, Assembly and Disassembly.
9. Performance test on the effect of Air Fuel Ratio of the Two Stroke Single Cylinder Petrol Engine.
10. Study on Meshing Techniques and Turbulent Modeling.
11. Flow analysis over a Flat Plate for Boundary layer characteristics using CFD.
12. Convection Heat transfer analysis in laminar flow inside 2D pipe

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

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Evaluate the performance of SI and CI engines.	K5
CO2	Analyze the emission characteristics of IC engines.	K4
CO3	Study the various equipment used for analysis.	K4
CO4	Apply the principles of CFD in fluid flow problems.	K5
CO5	Learn the various tools used in analysis.	K3

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	2	2	2
CO2	3	3	2	1	2	2
CO3	2	3	2	1	2	2
CO4	2	2	3	1	3	3
CO5	2	2	3	1	3	3
23TEPC03	2	3	3	1	2	2

1 – Slight, 2 – Moderate, 3 – Substantial

23TEPC04	**ADVANCED HEAT AND MASS TRANSFER** *(use of approved tables and charts are permitted)*	**II**

PREREQUISITES	CATEGORY	L	T	P	C
1. NUMERICAL METHODS **2. HEAT AND MASS TRANSFER**	**PC**	**3**	**1**	**0**	**4**

Course Objective	• To make the students learn the concepts of modes of heat transfer, heat exchangers along with numerical formulation of heat equations and to analyze various heat transfer correlations.	
UNIT – I	**CONDUCTION AND RADIATION HEAT TRANSFER**	**9+3 Periods**
One dimensional energy equations and boundary condition – Three dimensional heat conduction equations - Extended surface heat transfer - Conduction with moving boundaries - Porous-media heat transfer - Radiation in gases and vapour.		
UNIT – II	**TURBULENT FORCED CONVECTIVE HEAT TRANSFER**	**9+3 Periods**
Momentum and energy equations - Turbulent boundary layer heat transfer - Mixing length concept - Turbulence model - k-ε model - Analogy between heat and momentum transfer – Reynolds, Colburn analogy, Von-karman, turbulent flow in a tube - High speed flows.		
UNIT – III	**PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGER**	**9+3 Periods**
Condensation with shear edge on bank of tubes – Boiling, types – pool and flow boiling - heat exchanger – ε-NTU approach and design procedure - Compact heat exchangers.		
UNIT – IV	**NUMERICAL METHODS IN HEAT TRANSFER**	**9+3 Periods**
Finite difference formulation of steady and transient heat conduction problems – Discretization schemes – Explicit, Crank Nicolson and fully implicit schemes - Control volume formulation - Steady one-dimensional convection and diffusion problems - Calculation of the flow field – Simpler Algorithm.		
UNIT – V	**MASS TRANSFER AND ENGINE HEAT TRANSFER CORRELATION**	**9+3 Periods**
Mass Transfer - Vaporization of droplets - Combined heat and mass transfer problems – Heat transfer correlations in I.C. Engines.		
Contact Periods: **Lecture: 45 Periods Tutorial: 15 Periods Practical: 0 Periods Total: 60 Periods**		

TEXT BOOK:

1	*Frank P.Incropera, David P.Dewitt, Adrienne S.Lavine and Theodore L.Bergman,* ***"Fundamentals of Heat & Mass Transfer"****, John wiley, 7th Edition, 2011.*
2	*Suhas V.Patankar,* ***"Numerical Heat Transfer and Fluid Flow"****, CRC Press, 1st Edition, 2017.*

REFERENCES:

1	*Adrian Bejan,* ***"Convection Heat Transfer"****, John Wiley, 4th Edition, 2013.*
2	*Yunus A.Cengel and Afshin J.Ghajar,* ***"Heat and Mass Transfer: Fundamentals and Applications"****, McGraw Hill, 6th Edition, 2020.*
3	*Dr. D.S.Kumar,* ***"Heat & Mass Transfer"****, S.K.Kataria & Sons, 9th Edition, 2018.*
4	*Mahesh M.Rathore,* ***"Engineering Heat and Mass Transfer"****, University Science Press, 3rd Edition, 2016.*
5	*Yunus A.Cengel,* ***"Heat and Mass Transfer: A Practical Approach"****, Mcgraw Hill, 5th Edition, 2015.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Apply the heat transfer concepts for conduction, convection and radiation heat transfer.	K3
CO2	Learn mathematical models for various flows in heat transfer.	K4
CO3	Evaluate the concepts of phase change in heat transfer and heat exchanger.	K5
CO4	Apply numerical methods for solving heat and mass transfer problems.	K3
CO5	Understand relation between mass and heat transfer in engine.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	2	2	3	2
CO2	3	3	3	1	3	3
CO3	3	3	3	2	3	3
CO4	3	3	3	1	2	3
CO5	3	3	3	2	2	2
23TEPC04	3	3	3	2	3	2
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23TEPC05	COMPUTATIONAL FLUID DYNAMICS	II

PREREQUISITES	CATEGORY	L	T	P	C
1. NUMERICAL METHODS 2. HEAT AND MASS TRANSFER	PC	3	1	0	4

Course Objective	• To make the students learn finite difference and finite volume discretized forms of CFD equations and their solutions.	
UNIT – I	**GOVERNING EQUATIONS AND BOUNDARY CONDITION**	**9+3 Periods**
Basics of CFD - Governing equations of fluid dynamics – Continuity, momentum and energy equations - Physical boundary conditions - Mathematical behavior of PDEs on CFD – Elliptic, parabolic and hyperbolic equations.		
UNIT – II	**DISCRETISATION TECHNIQUES AND SOLUTION METHODOLOGIES**	**9+3 Periods**
Methods of deriving discretization equations – Finite difference & Finite volume methods - Finite difference discretization of wave equation - Laplace equation, Burger's equation, numerical error and stability analysis. Time dependent methods – Explicit, implicit, Crank – Nicolson methods, time split methods.		
UNIT – III	**CALCULATION OF FLOW-FIELD FOR N-S EQUATIONS**	**9+3 Periods**
Finite volume formulation of steady one - Dimensional convection and diffusion problems - Central, upwind, hybrid and power-law schemes – Discretization equations for two-dimensional convection and diffusion. Representation of the pressure – Gradient term and continuity equation – Staggered grid – Momentum equations – Pressure-Correction equation - SIMPLE algorithm and its variants.		
UNIT – IV	**TURBULENCE MODELING**	**9+3 Periods**
Time – Averaged equation for turbulent flow - Turbulence models – Zero equation model, one equation model, two equation K-I models and advanced models.		
UNIT – V	**GRID GENERATION**	**9+3 Periods**
Algebraic Methods – Methods – Differential Equation methods – Adaptive grids.		
Contact Periods: **Lecture:45 Periods Tutorial: 15 Periods Practical: 0 Periods Total:60 Periods**		

TEXT BOOK:

1	*John C.Tanne hill, Dale A.Anderson and Richard H.Pletcher,* ***"Computational Fluid Mechanics and Heat Transfer"****, CRC Press, 3rd Edition, 2011.*
2	*H.Versteeg and W.Malalasekra,* ***"An Introduction to Computational Fluid Dynamics: The Finite Volume Method"****, Pearson, 2nd Edition, 2007.*

REFERENCES*:*

1	*K.Muralidhar and T.Sundararajan,* ***"Computational Fluid Flow and Heat Transfer"****, Narosa Publishing House, 2nd Edition, 2014.*
2	*Sunil Kumar Chakrabartty, Manas Kumar Laha and Pradip Niyogi,* ***"Introduction to Computational Fluid Dynamics"****, Pearson, 1st Edition, 2009.*
3	*T.J.Chung,* ***"Computational Fluid Dynamics"****, Cambridge University Press, 2nd Edition, 2014.*
4	*Tapan Sen Gupta,* ***"Computational Fluid Dynamics"****, Universities Press, 1st Edition, 2004.*
5	*S.C.Gupta,* ***"Applied Computational Fluid Dynamics"****, Wiley, 1st Edition, 2019.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Appreciate different types of PDEs that arise in fluid flow and heat transfer problems.	K2
CO2	Develop finite volume discretized forms of the governing equations for diffusion processes.	K3
CO3	Analyze the consistency, stability and convergence of various discretization schemes for parabolic, elliptic and hyperbolic partial differential equations.	K4
CO4	Develop turbulent model for various engineering applications.	K3
CO5	Analyze various methods of grid generation techniques and application of finite difference and finite volume methods to various thermal problems.	K4

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	3	3	1	3	1
CO2	2	3	3	1	3	2
CO3	3	3	3	2	3	3
CO4	3	3	3	1	3	3
CO5	3	3	3	2	3	2
23TEPC05	3	3	3	1	3	2
1 – Slight, 2 – Moderate, 3 – Substantial						

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

22TEPC06	FUEL CELL TECHNOLOGY	II

PREREQUISITES	CATEGORY	L	T	P	C
1. ENGINEERING CHEMISTRY 2. THERMODYNAMICS 3. HEAT AND MASS TRANSFER	PC	3	0	0	3

Course Objective	• To provide the students about comprehensive understanding of fuel cell technology, enabling them to analyze, design and contribute to the development of efficient and sustainable energy systems.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Principle, working, components, types of fuel cells; AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – Relative merits and demerits - Performance evaluation of fuel cell - Comparison of battery and fuel cell.		
UNIT – II	**THERMODYNAMICS OF FUEL CELLS**	**9 Periods**
Electrochemical and electrolysis cell - Energy conversion in fuel cells - Change in Gibbs free energy - Effect of operating conditions - Efficiency of fuel cell - Fuel consumption and supply rates - Water production rate - Heat generation in fuel cell.		
UNIT – III	**HEAT AND MASS TRANSFER IN FUEL CELLS**	**9 Periods**
Fluid flow - Heat transfer modes and rate equations - Inlet and boundary conditions - Conservation of energy and heat equations - Mass transfer: Basic modes and transport rate equation - Mass species transport in fuel cell - Convective mass transfer - Diffusion coefficient.		
UNIT – IV	**FUELING**	**9 Periods**
Hydrogen storage technology – Pressure cylinders, liquid hydrogen, metal hydrides, carbon fibers – Reformer technology – Steam reforming, partial oxidation, auto thermal reforming water shift reaction, desulfurization, CO removal - Fuel cell technology from biomass.		
UNIT – V	**APPLICATIONS AND STANDARD CODES**	**9 Periods**
Stationary power applications - Transportation power, portable applications, landfills, military applications fuel cell codes and standards - Environmental effects - Emission and life cycle assessments.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Shripad T.Revankar and Pradip Majumdar, **"Fuel cells: Principles, Design and Analysis"**, CRC Press, 1st Edition, 2014.*
2	*Chris Rayment and Scott Sherwin, **"Introduction to Fuel Cell Technology"**, Notre Dame, 1st Edition, 2003.*

REFERENCES:

1	*Bent Sorensen, **"Hydrogen and Fuel Cells: Emerging Technologies and Applications"**, Elsevier Academic Press, 3rd Edition, 2018.*
2	*Rebecca L.Busby, **"Hydrogen and Fuel Cells: A Comprehensive Guide"**, PennWell Corporation, American ed. Edition, 2005.*
3	*Peter Hoffmann, **"Tomorrow's Energy: Hydrogen, Fuel cells and the prospects for a cleaner planet"**, The MIT Press, Revised and Expanded Edition, 2012.*

4	*Andrew Bocarsly and David Michael P.Mingos,* ***"Fuel Cells and Hydrogen Storage"****, Springer, 2011th Edition, 2011.*
5	*Zhigang Qi,* ***"Proton Exchange Membrane Fuel Cells"****, CRC Press, 1st edition, 2013.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Outline the performance and design characteristics and operating issues for various fuel cells.	K2
CO2	Apply principles of thermodynamics, electrochemistry, heat transfer, and fluid mechanics principles to design and analysis of fuel cells.	K3
CO3	Understand the opportunities for using hydrogen and the impact of this technology in a global and societal context.	K2
CO4	Understand the various types of fueling techniques.	K2
CO5	Gain the knowledge of various applications and standard codes in fuel cell technologies.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	3	3	2	3
CO2	1	1	3	1	1	1
CO3	2	2	3	3	3	2
CO4	2	2	2	3	3	2
CO5	2	2	3	3	2	2
23TEPC06	3	2	2	3	3	2
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	45	35	20	-	-	-	100
CAT2	35	35	30	-	-	-	100
Individual Assessment 1 / Case Study 1 / Seminar 1 / Project 1	30	40	30	-	-	-	100
Individual Assessment 2 / Case Study 2 / Seminar 2 / Project 2	30	40	30	-	-	-	100
ESE	35	40	25	-	-	-	100

23TEPC07	MANUFACTURING AND TESTING OF IC ENGINES AND COMPONENTS	II

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

Course Objective	• To make the students learn a comprehensive module on the aspects of materials, manufacturing and testing of engine piston assemblies, components, subsystems and International Standards.	
UNIT – I	**CYLINDER BLOCK AND CYLINDER HEAD**	**9 Periods**
Casting practice and special requirements - Materials, machining, methods of testing - Cylinder liners, types and manufacture.		
UNIT – II	**PISTON ASSEMBLY**	**9 Periods**
Types, requirements, casting, forging, squeeze casting, materials, machining, testing, manufacture piston rings – Material, types and manufacture – Surface treatment, bimetallic pistons, articulated pistons.		
UNIT – III	**DRIVE SYSTEMS**	**9 Periods**
Requirements, materials, forging practice, machining, balancing of crankshaft, testing - Connecting rod, crank shaft, cam shaft, valve timing.		
UNIT – IV	**COMPUTER INTEGRATED MANUFACTURING**	**9 Periods**
Integration of CAD, CAM and business functions – CIM, networking - CNC programming for machining of IC engines components.		
UNIT – V	**QUALITY AND TESTING**	**9 Periods**
SPC - Introduction to ISO 9000, ISO L4000, TS L6949, its importance - BIS codes for testing various types of engines - Equipments required, instrumentation, computer aided engine testing - Metrology for manufacturing IC engine components - In site measurement – Telemetry and sensors.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Mikell P.Groover, **"Automation, production Systems and Computer – Integrated Manufacturing"**, Pearson Education, 4th Edition, 2016.*
2	*Mahle GmbH, **"Cylinder components: Properties, Application, Materials",** Springer vieweg, 2nd Edition, 2016.*

REFERENCES:

1	*P.Radhakrishnan, S.Subramanian and V.Raju, **"CAD/CAM/CIM"**, New Age International Publishers, 4th Edition, 2018.*
2	*Carl R. Loper, Philip C. Rosenthal and Richard W. Heine, **"Principles of Metal Casting"**, McGrawHill, 2nd Edition, 2017.*
3	*Mikell P.Groover and Emory W.Zimmers, **"CAD/CAM: Computer-Aided Design and Manufacturing"**, Pearson Education, 1st Edition, 2003.*
4	*T.V.Ramana Rao, **"Metal Casting: Principles and Practice"**, New Age International Publishers, 2nd Edition, 2020.*
5	*Itay Abuhav, **"ISO 9001: 2015 - A Complete Guide to Quality Management Systems"**, CRC Press, 1st Edition, 2017.*

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COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Specify the component material and manufacturing method for a cylinder block and head of the IC engine.	K2
CO2	Specify the component material and manufacturing method for a piston of IC engine.	K2
CO3	Understand the basic concepts about IC engine drive system.	K2
CO4	Implement advanced computer integrated techniques in Manufacturing IC engine components.	K3
CO5	Relate and quality checks a component with International Standards.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	3	2	2	2	2
CO2	3	3	2	3	2	2
CO3	2	3	1	3	2	2
CO4	3	3	3	2	3	3
CO5	1	2	3	2	2	2
23TEPC07	2	3	2	2	2	2
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	45	55	-	-	-	-	100
CAT2	45	35	20	-	-	-	100
Individual Assessment 1 / Case Study 1 / Seminar 1 / Project 1	55	45	-	-	-	-	100
Individual Assessment 2 / Case Study 2 / Seminar 2 / Project 2	35	35	30	-	-	-	100
ESE	40	35	25	-	-	-	100

23TEPC08	ADVANCED COMBUSTION LABORATORY	II

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

Course Objective	• To make the students learn the various advancements in combustion research through experimental and analytical methods.

LIST OF EXPERIMENTS **(60)**

1. Studies on combustion kinetics and chemical dynamics.
2. Studies on low temperature combustion.
3. Experimental investigation on HCCI engine.
4. Experimental investigation on CRDI engine.
5. Particle ignition and char combustion characteristics of a solid fuel.
6. Modeling of large eddy simulation of IC engines.
7. Modeling of exhaust after treatment of IC engines.
8. Soot measurement using laser induced incandescence.
9. Stereoscopic and tomographic particle imaging velocimetry measurements.
10. Test on subsonic combustion tunnel.

Contact Periods:
Lecture: 0 Periods **Tutorial: 0 Periods** **Practical: 60 Periods** **Total: 60 Periods**

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Analyze the modern low temperature combustion strategies.	K4
CO2	Evaluate the combustion characteristics of CI engine fuelled with various fuels.	K5
CO3	Simulate the in-cylinder flows of IC engines.	K4
CO4	Analyze post combustion properties of flue gases.	K4
CO5	Explore and have insight on modern day analyzer and measuring instruments.	K3

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	3	2	1
CO2	3	2	3	2	2	2
CO3	3	3	3	1	3	2
CO4	2	2	3	2	1	2
CO5	3	2	3	2	2	2
23TEPC08	2	3	3	2	3	2

1 – Slight, 2 – Moderate, 3 – Substantial

23TEEE01	MINI PROJECT	II

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

Course Objective	• To provide the opportunity for self-learning beyond the syllabus content related to the thrust area of Engineering and Technology.
Course Content	1. Students can take up small problems in the field of thermal engineering as a Mini Project. 2. It can be related to solutions to a thermal engineering problem, verification and analysis of experimental data, conducting experiments on various thermal engineering domains, material characterization, studying a simulation software tool for analyzing thermal engineering problems.
Contact Periods: **Lecture: 0 Periods Tutorial: 0 Periods Practical: 60 Periods Total: 60 Periods**	

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Get an opportunity to work in an actual industrial environment during internship.	K3
CO2	Solve industrial problems related to thermal engineering using software / analytical / computational tools.	K5
CO3	Learn to be creative, well planned and innovative.	K6
CO4	Develop skills to present and defend their work in front of a technically qualified person.	K4
CO5	Learn to draft technical reports and research articles.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	3	2	1	1	2
CO2	3	2	3	1	2	2
CO3	1	2	1	1	1	2
CO4	2	2	2	1	2	1
CO5	2	3	2	1	2	2
23TEEE01	2	3	2	1	2	2
1 – Slight, 2 – Moderate, 3 – Substantial						

23TEEE02	INTERNSHIP / INDUSTRIAL TRAINING	III

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EE	0	0	*	2

Course Objective	• Each student will learn through "hands-on" experiences at a qualified place of employment (non-profit or governmental agency) about the daily expectations of employment within the agency. Students will engage in activities which are supervised by an agency employee, and will acquire the skills and knowledge base necessary to become successfully employed within the agency or a similar occupational or professional environment.
Course Content	1. Students must complete a minimum of 2 weeks of actual work-time to successfully complete the course. 2. Internship hours and activities must be documented each time in a log notebook. 3. Students should note the date, time, and activities of each agency experience. 4. Students should engage in activities which provide a quality experience and should not be treated as glorified copy machines or file clerks. 5. Students must maintain client confidentiality and act in an ethical and professional manner at all times while performing internship activities. The following activities must be completed and turned into the instructor of record by the last day of regular classes and before final exams begin. 1. Students must turn in the log book of activities, signed and dated by the supervisor, to the instructor of record. 2. Students must also write a report which discusses what the student gained from the internship experience and what problems they encountered during the experience. 3. Students shall obtain completed intern evaluation form from agency supervisor and submit it to concerned faculty.
Contact Periods: **Lecture: 0 Periods Tutorial: 0 Periods Practical: * Periods Total: 0 Periods**	

***Internship / Industrial Training Four Weeks**

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Maintain current knowledge of practical situations encountered in professional practice.	K3
CO2	Provide an entry level, professionally trained personnel resource for a specifically designated period of time.	K3
CO3	Learn from a qualified and experienced professional in the field.	K2
CO4	Acquire leadership experience in a professional setting by participating in daily operations and by planning and implementing a major project.	K6
CO5	Apply the concepts of human development and education by maintaining appropriate professional relationships with coworkers, and agencies.	K5

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	2	2	1	1	2
CO2	1	3	3	1	1	2
CO3	1	2	2	1	1	1
CO4	2	2	3	1	2	2
CO5	2	3	2	1	1	3
23TEEE02	1	3	2	1	1	2
1 – Slight, 2 – Moderate, 3 – Substantial						

23TEEE03	PROJECT - I	III

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EE	0	0	24	12

Course Objective	• To identify a specific problem for the current need of the society and collect information related to the same through detailed review of literature and to develop the methodology to solve the identified problem then publish paper at least in conferences or indexed journals.
Course Content	1. The project work will start in semester iii and should preferably be a problem with research potential and should involve scientific research in thermal engineering, generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution. 2. Seminars should be based on the area in which the candidate has undertaken the dissertation work as per the common instructions for all branches of M.Tech. Students should note the date, time, and activities of each agency experience. 3. The examination shall consist of the preparation of a report consisting of a detailed problem statement and a literature review. 4. The preliminary results (if available) of the problem may also be discussed in the report. 5. The work has to be presented in front of the examiners panel set by the Head and PG coordinator. 6. The candidate has to be in regular contact with his guide and the topic of dissertation must be mutually decided by the guide and student.
Contact Periods: **Lecture: 0 Periods** **Tutorial: 0 Periods** **Practical: 360 Periods** **Total: 360 Periods**	

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Provide innovative ideas for practical engineering problems.	K4
CO2	Carry out literature surveys from various journals, books and identify the research gaps.	K5
CO3	Solve complex thermal engineering problems through analytical and experimental studies	K6
CO4	Develop oral and written communication skills to present and defend their thesis in front of a technically qualified audience.	K3
CO5	Draft technical reports and research articles.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	3	1	3	3
CO2	2	3	3	2	2	3
CO3	3	3	3	1	3	2
CO4	1	1	3	2	1	3
CO5	1	3	2	1	2	3
23TEEE03	2	3	3	1	3	3
1 – Slight, 2 – Moderate, 3 – Substantial						

23TEEE04	PROJECT - II	IV

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EE	0	0	48	24

Course Objective	• To solve the identified problem based on the formulated Methodology and to develop skills to analyze and discuss the test results and make conclusions then publish paper at least in conferences or indexed journals.
Course Content	1. It is a continuation of project work started in semester III. 2. He / She has to submit the report in prescribed format and also present a seminar. 3. The dissertation should be presented in standard format as provided by the department. 4. The candidate has to prepare a detailed project report consisting of introduction of the problem, problem statement, literature review, objectives of the work, methodology (experimental set up or numerical details as the case may be) of solution and results and discussion. 5. The report must bring out the conclusions of the work and future scope for the study. 6. The work has to be presented in front of the examiners panel consisting of an approved external examiner, an internal examiner and a guide, co-guide etc as decided by the Head and PG coordinator. 7. The candidate has to be in regular contact with his guide.
Contact Periods: **Lecture: 0 Periods Tutorial: 0 Periods Practical: 720 Periods Total: 720 Periods**	

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Select suitable experimental techniques for given engineering problem.	K3
CO2	Select different software/computational/analytical tools for given problem statement.	K5
CO3	Work in different analytical equipment to obtain required output.	K4
CO4	Work in a research environment and industrial environment.	K3
CO5	Excel in technical report writing and present their work to the engineering community.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	3	2
CO2	3	2	3	2	3	3
CO3	2	1	2	1	2	3
CO4	2	2	3	1	2	2
CO5	2	2	3	2	1	2
23TEEE04	3	3	3	2	3	3
1 – Slight, 2 – Moderate, 3 – Substantial						

23TEPE01	THERMODYNAMICS AND COMBUSTION	I

PREREQUISITES	CATEGORY	L	T	P	C
ENGINEERING THERMODYNAMICS	PE	3	0	0	3

Course Objective	• To make the students learn advanced concepts like maximum energy and minimum energy, combustion principles, energy at micro level, conversion of heat energy into electrical flux of thermodynamic systems.	
UNIT – I	**BASIC CONCEPTS OF THERMODYNAMICS**	**9 Periods**
Entropy ,Work and Quantity of Heat: First Law of Thermodynamics ,Temperature ,Pressure, The Free Energy and the Thermodynamic Potentials , Enthalpy, Nernst's Theorem, Carnot's Cycle and Carnot's Theorem, Le Chatelier Principle, Dependence of the Thermodynamic Quantities on the Number of Particles, Ideal Gases ,Ideal Gases with Constant Specific Heat: Equation of Poisson Adiabatic.		
UNIT – II	**IDEAL, REAL GASES AND VAPOUR MIXTURES**	**9 Periods**
Introduction, The Equation of State for a Perfect Gas, p-V-T Surface of an Ideal Gas,Internal Energy and Enthalpy of a Perfect Gas, Specific Heat Capacities of an Ideal Gas , Real Gases ,Vander Waal's Equation, Virial Equation of State, Beattie-Bridgeman Equation, Reduced Properties, Law of Corresponding States, Compressibility Chart,Dalton's Law and Gibbs-Dalton Law,Volumetric Analysis of a Gas Mixture, The Apparent Molecular Weight and Gas Constant ,Specific Heats of a Gas Mixture, Adiabatic Mixing of Perfect Gases ,Gas and Vapour Mixtures		
UNIT – III	**FUNDAMENTALS OF COMBUSTION**	**9 Periods**
Thermodynamics, concepts of combustion – Combustion equations, heat of combustion Theoretical flame temperature, chemical equilibrium and dissociation, Combustion cycles. Stoichiometry, Theories of Combustion, Pre-flame reactions, Reaction rates, Rankine-Hugoniot relations – detonation branch-Analysis of the deflagration - Chapman- Jouguet waves, Laminar and Turbulent Flame propagation.		
UNIT – IV	**FLAME PHENOMENA IN PREMIXED COMBUSTIBLE GASES**	**9 Periods**
Introduction , Laminar flame structure, The laminar flame speed , Stability limits of laminar flames, Flame propagation through stratified combustible mixtures, Turbulent reacting flows and turbulent flames, The turbulent flame speed, Stirred reactor theory ,Flame stabilization in high-velocity streams, Combustion in small volumes .		
UNIT – V	**DETONATION AND ENVIRONMENTAL COMBUSTION CONSIDERATIONS**	**9 Periods**
Introduction, Detonation phenomena,Hugoniot relations and the hydrodynamic theory of detonations, Comparison of detonation velocity calculations with experimental results, The ZND structure of detonation waves, The structure of the cellular detonation front and other detonation phenomena parameters, The nature of photochemical smog, Formation and reduction of nitrogen oxides,SOx emissions .		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*R.K Rajput,* ***"Engineering Thermodynamics",*** *Laxmi Publications Ltd, 6th edition,2016.*
2	*Irvin Glassman, Richard A. Yetter ,* ***"Combustion"****, Elsevier Inc., 5th edition,2014.*

REFERENCES:

1	*R. M. Helsdon,* ***"Introduction to Applied Thermodynamics"*** *, Elsevier Science, 2013.*
2	*Kenneth Wark Jr.,* ***"Advanced Thermodynamics for Engineers"****, McGraw-Hill Inc. New York, 1995.*
3	*Michael Liberman,* ***"Introduction to Physics and Chemistry of Combustion"****, Springer-Verlag Berlin Heidelberg, 2008.*
4	*Fawzy El-Mahallawy, Saad El-Din Habik,* **"*Fundamentals and technology of Combustion"*** *, Elsevier Science Ltd, 2002.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the conceptsin thermodynamics and its relevant properties.	K3
CO2	Discuss the properties of various types of gases and vapour mixtures.	K4
CO3	Concept in combustion and its principles.	K5
CO4	Understand the concepts of flame phenomena during the combustion process.	K4
C05	Gain knowledge on environmental considerations of combustion.	K5

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	1	1
CO2	3	3	2	2	1	1
CO3	2	3	3	2	1	1
CO4	3	2	2	2	1	1
CO5	2	3	3	2	1	2
23TEPE01	3	3	2	2	1	1

1 – Slight, 2 – Moderate, 3 – Substantial

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (k1) %	Understanding (k2) %	Applying (k3) %	Analyzing (k4) %	Evaluating (k5) %	Creating (k6) %	Total %
CAT1	-	30	35	35	-	-	100
CAT2	10	25	25	20	20	-	100
Individual Assessment 1 / Case Study 1 / Seminar 1 / Project 135	-	30	35	35	-	-	100
Individual Assessment 2 / Case Study 2 / Seminar 2 / Project 2	10	25	25	20	20	-	100
ESE	10	20	25	25	20	-	100

23TEPE02	ARTIFICIAL INTELLIGENCE IN THERMAL SYSTEMS	I

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

Course Objective	• To present a research oriented in depth knowledge of artificial intelligence and to address the underlying concepts, methods and application of artificial intelligence.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Core of AI - Goals of AI - Fields of application - Global economic effects of artificial intelligence.		
UNIT – II	**BASICS AND DRIVERS OF ARTIFICIAL INTELLIGENCE**	**9 Periods**
Moore's law and the effects of exponential- digitalization and dematerialization of products, services and processes-connecting products, services, processes, animals and people- Big data- new technologies.		
UNIT – III	**ARTIFICIAL INTELLIGENCE IN HEAT TRANSFER ANALYSIS**	**9 Periods**
Application of New Artificial- Neural Network to Predict -Heat Transfer and Thermal Performance of heat exchangers.		
UNIT – IV	**ARTIFICIAL INTELLIGENCE IN COMBUSTION STUDIES**	**9 Periods**
Artificial-intelligence- based prediction and control of combustion instabilities in spark-ignition engines and combustion - ignition engines.		
UNIT – V	**ARTIFICIAL INTELLIGENCE IN THERMAL FLOW SIMULATION**	**9 Periods**
AI applications in thermal engineering – Artificial intelligence-based computational fluid dynamics approaches.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Adel Mellit, Soteris Kalogirou , **"Handbook of Artificial Intelligence Techniques in Photovoltaic Systems Modeling, Control, Optimization, Forecasting and Fault Diagnosis"**, Elsevier Science, 23 June 2022.*
2	*Ralf Herbrich, **"Learning Kernel classifiers theory and algorithm"**, MIT Press, Cambridge, London, England, 2022.*

REFERENCES:

1	*Ralf T. Kreutzer, Marie Sirrenberg,* ***"Understanding Artificial Intelligence Fundamentals, Use Cases and Methods for a Corporate AI Journey"****, Berlin, Germany Bad Wilsnack, Germany August 2019.*
2	*Amit Konar,* ***"Artificial Intelligence and Soft Computing Behavioral and Cognitive Modeling of the Human Brain" ,****CRC Press LLC, 2000 N.W. Corporate Blvd., Boca Raton, 8 October 2018.*
3	*Siddhartha Bhattacharyya, Vaclav Snasel,* ***"Hybrid Computational Intelligence challenges and applications A volume in hybrid computational intelligence for pattern analysis and understanding",*** *Springer, 2020. https://doi.org/10.1016/B978-0-12-818699-2.00009-3*
4	*Bryan Maldonado, Brian Kaul,****"Artificial Intelligence and Data Driven Optimization of Internal Combustion Engines",*** *Chapter 8, Springer, 2022. https://doi.org/10.1016/B978-0-323-88457-0.00006-0*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Obtain the fundamental knowledge of AI basics.	K2
CO2	Gain the knowledge on machine learning techniques	K3
CO3	Understand the role of Artificial Intelligence in numerical studies.	K5
CO4	Gain knowledge for combustion studies by using Artificial Intelligence	K3
CO5	Analyse the thermal flow simulations using Artificial Intelligence	K5

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	2	3	2
CO2	3	2	3	3	3	3
CO3	3	3	3	3	3	3
CO4	2	2	2	1	2	2
CO5	3	3	3	3	2	2
23TEPE02	3	2	3	3	3	2

1 – Slight, 2 – Moderate, 3 – Substantial

Assessment pattern – theory

Test / Bloom's Category*	Remembering (k1) %	Understanding (k2) %	Applying (k3) %	Analyzing (k4) %	Evaluating (k5) %	Creating (k6) %	Total %
CAT1	30	35	35	-	-	-	100
CAT2	10	30	30	-	30	-	100
Individual Assessment 1 / Case Study 1 / Seminar 1 / Project 1	30	35	35	-	-	-	100
Individual Assessment 2 / Case Study 2 / Seminar 2 / Project 2	10	30	30	-	30	-	100
ESE	15	25	20	20	20	-	100

23TEPE03	ADVANCED GAS TURBINES *(Use of approved tables and charts are permitted)*	I

PREREQUISITES	CATEGORY	L	T	P	C
THERMAL ENGINEERING	PE	3	0	0	3

Course Objective	• To make the students learn aircraft applications of power plant cycles and turbo machines like compressors, axial and radial flow turbines and combustors.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Power plant cycles for stationery and aircraft applications, component behaviors, Industrial applications, Marine and land transportation, Environmental issues, analysis of ramjet, turbojet and turbo-propeller, Inlets and nozzles.		
UNIT – II	**COMPRESSORS**	**9 Periods**
Principle and operations of Centrifugal and axial flow compressors momentum and energy transfer in rotors, velocity diagrams, calculation of stage performance, compressibility effects, cascade testing and characteristics.		
UNIT – III	**AXIAL AND RADIAL FLOW TURBINE**	**9 Periods**
Elementary theory of axial and radial flow turbine, Vortex theorem, choice of blade profile, Pitch and Chord Stage velocity diagrams, reaction stages, losses and coefficients, blade design principles, materials, testing and performance characteristics.		
UNIT – IV	**COMBUSTORS**	**9 Periods**
Different types and flow patterns, material requirements and cooling systems, air pollution and reduction.		
UNIT – V	**MATCHING**	**9 Periods**
Matching procedure of power plant components, engine off-design performance,Off-design performance of single shaft gas turbine, free turbine engine and jet engine, Methods of displacing the equilibrium running line, Design of Nozzles, afterburners, anti-icing mechanisms.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Dixon S.L., **"Fluid Mechanics and Thermodynamics of Turbomachinery"**, Pergamon Press, 7th edition 2013.*
2	*Ganesan V., **"Gas Turbines"**, Tata McGraw Hill, 3rd Edition, 2017.*

REFERENCES:

1	*Yahya S.M., **"Turbines, Compressors and Fans"**, Tata mcgraw-Hill, 4th edition, 2017.*
2	*Sarvanamuttoo, H.I.H., Rogers, G. F. C. and Cohen, **"Gas Turbine Theory"**, H., Pearson Prentice Hall, 7th Edition, 2019.*
3	*Kerrebrock J.L., **"Aircraft engines and gas turbines"**, The MIT Press, 2nd edition, 1992.*
4	*Gurrappa Injeti, **"Gas Turbines"**, IntechOpen, ISBN-978-953-51-1743-8, February 25th2015.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify, formulate and solve problems related to gas turbines and jet propulsion.	K5
CO2	Analyze the operational aspects and control, including the system interaction of compressors	K5
CO3	Discuss the various laws pertaining to different fluid flow applications	K2
CO4	Learn the components of a combustor and its performance.	K2
CO5	Knowledge on matching the components.	K5

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	2	2	3	2
CO2	3	3	2	2	2	1
CO3	3	3	2	3	2	1
CO4	2	2	1	2	3	2
CO5	3	3	3	3	3	3
23TEPE03	3	3	2	2	3	2
1 – Slight, 2 – Moderate, 3 – Substantial						

Assessment pattern – theory							
Test / Bloom's Category*	**Remembering (k1) %**	**Understanding (k2) %**	**Applying (k3) %**	**Analyzing (k4) %**	**Evaluating (k5) %**	**Creating (k6) %**	**Total %**
CAT1	15	25	20	20	20	-	100
CAT2	10	90	-	-	-	-	100
Individual Assessment 1 / Case Study 1 / Seminar 1 / Project 1	15	25	20	20	20	-	100
Individual Assessment 2 / Case Study 2 / Seminar 2 / Project 2	10	90	-	-	-	-	100
ESE	10	30	20	20	20	-	100

23TEPE04	DESIGN OF CONDENSERS, EVAPORATORS AND COOLING TOWERS	I

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

Course Objective	• To make the students learn the heat transfer processes and design of heat transfer equipment.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Principles of heat transfer, Types of heat exchangers, Standard Representation, Parts description, TEMA classifications, Applications.		
UNIT – II	**CONDENSERS**	**9 Periods**
Estimation of heat transfer coefficient, Fouling factor, Friction factor- Design procedures, Wilson plots, Design different types of condensers, BIS Standards.		
UNIT – III	**EVAPORATORS**	**9 Periods**
Different types of evaporators, Design procedure, Factors affecting the evaporator capacity, Thermal Stress calculations, matching of components, Design of evaporative condensers.		
UNIT – IV	**COOLING TOWERS**	**9 Periods**
Types of Cooling towers, Analytical and graphical design procedures, Tower Characteristics Parametric analysis, Range of cooling tower, Tower efficiency, cooling tower load, Energy conservation.		
UNIT – V	**SELECTION OF CONDENSERS, EVAPORATORS AND COOLING TOWER**	**9 Periods**
Condenser selection – Water cooled – Air cooled, Selection of evaporators, Selection of cooling tower, Selection of Pumps and Fans.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Lieke Wang, Bengt Sunden, Raj M. Manglik, **"Plate Heat Exchangers: Design, Applications and Performance"**, WIT Press, 2013.*
2	*Krishna P. Singh, Alan I. Soler, **"Mechanical Design of Heat Exchangers And Pressure Vessel Components",** Springer Berlin Heidelberg, 4 December 2014.*

REFERENCES:

1	*Manfred Nitsche, Raji Gbadamosi., **"Design of Heat exchangers, condensers and evaporators"**, 2015.*
2	*Kern K.H., **"Process heat transfer"**, McGraw-Hill, 2nd edition, 2017.*
3	*Wilfried Roetzel, Xing Luo, Dezhen Chen, **"Design and Operation of Heat Exchangers and Their Networks"**, Elsevier Science, 4 October 2019.*
4	*S Chand, R S Khurmi, J K Gupta, **"Modern Refrigeration and Air Conditioning"**, published, 2019.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Utilize the principles of heat transfer for industrial applications.	K2
CO2	Design the condenser, evaporators and cooling towers.	K2
CO3	Understand the concepts of evaporators.	K3
CO4	Gain the knowledge of cooling towers, Analytical and graphical design procedures	K3
CO5	Select the suitable heat transfer equipment	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	2	2	2	2
CO2	2	2	1	1	3	2
CO3	2	2	2	1	2	2
CO4	3	3	2	1	2	2
CO5	2	2	1	2	1	2
23TEPE04	2	2	2	1	2	2
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (k1) %**	**Understanding (k2) %**	**Applying (k3) %**	**Analyzing (k4) %**	**Evaluating (k5) %**	**Creating (k6) %**	**Total %**
CAT1	50	50	-	-	-	-	100
CAT2	25	35	40	-	-	-	100
Individual Assessment 1 / Case Study 1 / Seminar 1 / Project 1	50	50	-	-	-	-	100
Individual Assessment 2 / Case Study 2 / Seminar 2 / Project 2	25	35	40	-	-	-	100
ESE	25	25	50	-	-	-	100

23TEPE05	INSTRUMENTATION IN THERMAL ENGINEERING	I

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

Course Objective	• To learn different techniques involved in thermal quantity measurement and the concept of microprocessors in measurement, different kind of errors involved and the transducers for different types of thermo-physical quantities	
UNIT – I	**MEASUREMENT CHARACTERISTICS**	**9 Periods**
Instrument Classification, Characteristics of Instruments – Static and dynamic, experimental error analysis, Systematic and random errors, Statistical analysis, Uncertainty, Experimental planning and selection of measuring instruments, Reliability of instruments.		
UNIT – II	**MICROPROCESSORS AND COMPUTERS IN MEASUREMENT**	**9 Periods**
Basic Electrical measurements, Transducers and its types, Signal conditioning and processing-Measurement of temperature, pressure, velocity, flow – basic and advanced techniques, and radiation properties of surfaces.		
UNIT – III	**MEASUREMENT OF PHYSICAL QUANTITIES**	**9 Periods**
Thermo, Physical, Chemical and transport properties of solids, liquids and gaseous fuels, Analyses – Flame Ionization Detector, Non-Dispersive Infrared Analyses, Chemiluminescence detector, Smoke meters, and Gas chromatography.		
UNIT – IV	**CONTROL SYSTEM, COMPONENTS AND CONTROLLERS**	**9 Periods**
Introduction, Open and closed loop control systems, Transfer function. Types of feedback and feedback control system characteristics – Control system parameters – DC and AC servomotors, servo amplifier, potentiometer, synchronic transmitters, synchronic receivers, synchronic control transformer, stepper motors - Continuous, Discontinuous and Composite control modes – Analog and Digital controllers.		
UNIT – V	**DESIGN OF MEASUREMENT AND CONTROL SYSTEMS**	**9 Periods**
Data logging and acquisition - Sensors for error reduction, elements of computer interfacing, Timers, and Counters, Designing of measurement and control systems for specific applications - Fault finding – Computer based controls		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Holman, J.P., **"Experimental methods for engineers"**, McGraw-Hill, 8th edition 2011.*
2	*Rangan, C.S., Sharma, G.R., Mani, V.S.V, **"Instrumentation Devices and Systems"**, Tata McGraw Hill, 2nd edition, New Delhi, 2017.*

REFERENCES:

1	*Alan S. Morris, Reza Langari**, "Measurement and Instrumentation"**, Elsevier Science, 2015*
2	*Barney, **"Intelligent Instrumentation"**, Prentice Hall of India, 2012.*
3	*Preobrazhensky, V., **"Measurements and Instrumentation in Heat Engineering"**, Vol.1 and 2, MIR Publishers, 2013.*
4	*Doeblin, **"Measurement System Application and Design"**, McGraw Hill, 2012.*
5	*Morris.A.S, **"Principles of Measurements and Instrumentation",** Prentice Hall of India, 2006.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Gain the knowledge on various measuring instruments and advance measurement techniques.	K2
CO2	Evaluate the various steps involved in error analysis and uncertainty analysis.	K5
CO3	Analyze the various thermal and flow systems and their behaviour.	K5
CO4	Distinguish between measurement and control systems, and use appropriate control System for an application.	K2
CO5	Construct a complete control system for a thermal application.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	2	1	1	2
CO2	2	2	2	1	2	2
CO3	2	2	2	2	2	2
CO4	2	2	2	1	2	2
CO5	1	1	2	1	2	1
23TEPE05	2	2	2	1	2	2
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (k1) %**	**Understanding (k2) %**	**Applying (k3) %**	**Analyzing (k4) %**	**Evaluating (k5) %**	**Creating (k6) %**	**Total %**
CAT1	10	30	30	-	30	-	100
CAT2	10	20	20	20	30	-	100
Individual Assessment 1 / Case Study 1 / Seminar 1 / Project 1	10	30	30	-	30	-	100
Individual Assessment 2 / Case Study 2 / Seminar 2 / Project 2	10	20	20	20	30	-	100
ESE	10	20	30	30	10	-	100

23TEPE06	ENGINE ELECTRONICS	I

PREREQUISITES	CATEGORY	L	T	P	C
APPLIED ELECTRONICS	PE	3	0	0	3

Course Objective	• To make the students learn concepts of Automotive Electronics and its evolution and trends of sensor monitoring mechanisms to design and model various automotive ignition and injection systems control for different vehicles.	
UNIT – I	**SENSORS**	**9 Periods**
Types – Air flow, Pressure, Temperature, Speed Oxygen, Detonation, Position –Principle of Operation, Arrangement and material.		
UNIT – II	**GASOLINE INJECTION SYSTEM**	**9 Periods**
Open loop and closed loop systems, Mono point, Multi point and direct injection systems –Principles and Features, Bosch injection systems.		
UNIT – III	**DIESEL INJECTION SYSTEM**	**9 Periods**
Inline injection pump, Rotary pump and injector – Construction and principle of operation, Common rail and unit injector system – Construction and principle of operation.		
UNIT – IV	**IGNITION SYSTEMS**	**9 Periods**
Ignition fundamentals, Types of solid -state ignition systems, high energy ignition distributors, Electronic spark timing and control.		
UNIT – V	**ENGINE MAPPING**	**9 Periods**
Combined ignition and fuel management systems. Digital control techniques – Dwell angle calculation, Ignition timing calculation and Injection duration calculation, Hybrid vehicles and fuel cells.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Tom Denton, **"Automotive Electrical and Electronic Systems"**, Edward Amold, 5th edition 2017.*
2	*Robert N.Brady, **"Automotive Computers and Digital Instrumentation"**, Prentice Hall, 2011.*

REFERENCES:

1	*Ali Emadi, **"Handbook of Automotive Power Electronics and Motor Drives"**, CRC Press, 19 December 2017.*
2	*Konrad Reif, **"Fundamentals of Automotive and Engine Technology Standard Drives, Hybrid Drives, Brakes, Safety Systems"**, Springer Fachmedien Wiesbaden, 16 June 2014.*
3	*Akhilendra Pratap Singh, Avinash Kumar Agarwal, **"Novel Internal Combustion Engine Technologies for Performance Improvement and Emission Reduction"**, Springer Nature Singapore, 14 June 2021.*
4	*Heinz Heisler., **"Advanced Engine Technology"**, SAE Publications, 2011.*
5	*Ronald K. Jurgan, **"Electronic Engine Control"**, Edward Amold, 2017.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Obtain an overview on the types of sensors.	K2
CO2	Understand the various injection systems and its principal of operation.	K2
CO3	Develop the knowledge on ignition and fuel management systems.	K4
CO4	Gain the knowledge of Ignition fundamentals, types of solid, electronic sparking timing and control.	K3
CO5	Utilize the dwell angle calculation, Ignition timing calculation for engine mapping in hybrid vehicles and fuel cells.	K5

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	2	2	1	2
CO2	2	2	1	1	2	2
CO3	2	2	2	1	2	1
CO4	1	1	2	1	1	1
CO5	2	2	1	2	2	1
23TEPE06	2	2	2	1	2	2
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (k1) %**	**Understanding (k2) %**	**Applying (k3) %**	**Analyzing (k4) %**	**Evaluating (k5) %**	**Creating (k6) %**	**Total %**
CAT1	10	30	30	-	30	-	100
CAT2	10	20	20	20	30	-	100
Individual Assessment 1 / Case Study 1 / Seminar 1 / Project 1	10	30	30	-	30	-	100
Individual Assessment 2 / Case Study 2 / Seminar 2 / Project 2	10	20	20	20	30	-	100
ESE	10	20	30	30	10	-	100

23TEPE07	FINITE ELEMENT METHODS IN THERMAL ENGINEERING	I

PREREQUISITES	CATEGORY	L	T	P	C
HEAT AND MASS TRANSFER	PE	3	0	0	3

Course Objective	• To make the students learn different discretization methods for solving heat transfer and fluid flow problems.	
UNIT – I	**INTRODUCTION**	**5 Periods**
Overview of numerical methods - Discretized representation of physical systems - thermal resistance – Governing equations and Boundary conditions for thermal and flow systems.		
UNIT – II	**ONE DIMENSIONAL HEAT CONDUCTION**	**6 Periods**
Principles of variations calculus - applications of variational approach to one dimensional heat conduction – element matrix contribution and assembly.		
UNIT – III	**HEAT FUNCTIONS AND ANALYSIS**	**10 Periods**
Weighted residual methods - Galerkin's approach - Shape functions. Application of Galerkin's weighted residual approach to one dimensional heat conduction - Three noded triangular elements- 1-D steady state conduction using triangular elements - Radiation and natural convective boundary conditions – incorporation of variations in thermal properties.		
UNIT – IV	**CONVECTIVE HEAT TRANSFER**	**12 Periods**
Higher order elements and numerical integration solution of heat conduction and creeping flow using higher order element - Solution of convective heat transfer.		
UNIT – V	**HEAT EXCHANGER APPLICATIONS**	**12 Periods**
Incompressible laminar flow simulation - Stream function and Vorticity methods, Velocity Pressure formulation, mixed order interpolation for incompressible flow modifications for turbulent flow. Application to heat exchanger.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*S.S.Rao,* ***"The Finite Element Method in Engineering"****, Pergamon Press, 5th edition, 2013.*
2	*Larry Segerlind* ***"Applied Finite Element Analysis"****, John Wiley & Sons, 2nd edition, 2005.*

REFERENCES:

1	*C.S.Krishnamoorthy,* ***"Finite Element Analysis Theory and Programming",*** *Tata McGraw-Hill, 2nd edition, 2011.*
2	*J.N.Reddy,* ***"An Introduction to Finite Elements Methods"****, McGraw-Hill, 2020.*
3	*O.C.Zienkiewiez,* ***"Finite Element Methods",*** *McGraw-Hill, 2003.*
4	*T.R.Chandrapatla and Belegundu,* ***"Introduction to Finite Elements in Engineering"****, Prentice Hall of India, 2002.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the basic numerical methods and governing equations of heat transfer and fluid flow conditions.	K3
CO2	Evaluate temperature distribution in one and two-dimensional conduction and convection problems numerically.	K5
CO3	Analyze the various flow problems to evaluate the performance of heat exchangers.	K5
CO4	Apply higher order elements and numerical integration solutions of heat conduction and convective heat transfer.	K5
CO5	Analyze the laminar and turbulent flow problems to evaluate the performance of heat exchangers	K5

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	1	2	2	2	2
CO2	2	2	1	1	2	2
CO3	2	2	2	1	2	2
CO4	2	2	2	1	2	2
CO5	3	3	3	2	1	1
23TEPE07	2	1	2	1	2	2
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (k1) %**	**Understanding (k2) %**	**Applying (k3) %**	**Analyzing (k4) %**	**Evaluating (k5) %**	**Creating (k6) %**	**Total %**
CAT1	10	30	30	-	30	-	100
CAT2	-	25	25	30	20	-	100
Individual Assessment 1 / Case Study 1 / Seminar 1 / Project 1	10	30	30	-	30	-	100
Individual Assessment 2 / Case Study 2 / Seminar 2 / Project 2	-	25	25	30	20	-	100
ESE	10	25	25	20	20	-	100

23TEPE08	ADVANCED GAS DYNAMICS AND SPACE PROPULSION *(Use of approved tables and charts are permitted)*	I

PREREQUISITES	CATEGORY	L	T	P	C
GAS DYNAMICS AND JET PROPULSION	PE	3	0	0	3

Course Objective	• To make the students learn the compressible flow through different systems and propulsion systems for jet and space vehicles.	
UNIT – I	**BASIC CONCEPTS AND ISENTROPIC FLOWS**	**9 Periods**
Energy and momentum equations of compressible fluid flows – isentropic flow - Mach waves and Mach cone. Flow regimes, effect of Mach number on compressibility. Stagnation, static, critical properties and their interrelationship. Isentropic flow through variable area ducts – nozzles and diffusers. Use of Gas tables.		
UNIT – II	**FLOW THROUGH DUCTS**	**9 Periods**
The Shock Tube: Propagating Expansion Fan - Flows through constant area ducts with heat transfer and Friction - variation of flow properties Use of tables and charts - Unsteady Shock Waves: The Shock Tube - Applications, Method of Characteristics: Flow through a diverging channel.		
UNIT – III	**NORMAL AND OBLIQUE SHOCKS**	**9 Periods**
Governing equations - Rankine-Hugoniot Relation. Variation of flow parameters across the normal and oblique shocks- Supersonic Flow over a Wavy wall - Finite Wave Theory: An introduction to the Method of Characteristics. Prandtl – Meyer expansion and relation. Supersonic Flow past a HD Cone at an angle of attack - Bluff Body at an angle of attack - Flow Visualization-Use of table and charts.		
UNIT – IV	**JET PROPULSION**	**9 Periods**
Theory of jet propulsion – thrust equation – thrust power and propulsive efficiency. Operation, cycle analysis and performance of ramjet, turbojet, turbofan and turboprop engines.		
UNIT – V	**SPACE PROPULSION**	**9 Periods**
Types of rocket engines and propellants. Characteristic velocity, Theory of single and multistage rocket propulsion, Liquid fuel feeding systems, Solid propellant geometries. Space flights – orbital and escape velocity, Rocket performance calculations – nuclear and electrical rocket propulsion.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*S.M. Yahya, **"Fundamentals of Compressible Flow with Aircraft and Rocket propulsion"**, New Age International (P) Limited, 6th edition, 2018.*
2	*Radhakrishnan, E., **"Gas Dynamics"**, Prentice Hall of India, 7th edition, 2020.*

REFERENCES:

1	*H. Saravanamutto HIH, Cohen H., Rogers CEC&Straznicky PV, **"Gas Turbine Theory"**,Printice Hall, 7th edition, 2019.*
2	*L. Anderson, J.D., **"Modern Compressible Flow"**, McGraw Hill, 3rdedition, 2017.*
3	*Sutton, G.P., **"Rocket Propulsion Elements"**, John wiley, New York,9th edition, 2017.*
4	*Shapiro, **"Dynamics and Thermodynamics of Compressible Fluid Flow"**, Prentice hall of India, 7th edition, 2014.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the basic concepts of various flows.	K2
CO2	Analyze the application using ducts.	K5
CO3	Basic theorems derive to normal and oblique shocks.	K2
CO4	Know the concepts of various jet engines.	K5
CO5	Design and application of rocket science and engineering.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	1	1	1	2
CO2	2	2	1	1	1	2
CO3	2	2	2	1	2	2
CO4	2	2	2	1	2	2
CO5	2	2	2	1	2	2
23TEPE08	2	2	2	1	2	2
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (k1) %**	**Understanding (k2) %**	**Applying (k3) %**	**Analyzing (k4) %**	**Evaluating (k5) %**	**Creating (k6) %**	**Total %**
CAT1	15	35	50	-	-	-	100
CAT2	10	25	25	20	20	-	100
Individual Assessment 1 / Case Study 1 / Seminar 1 / Project 1	15	35	50	-	-	-	100
Individual Assessment 2 / Case Study 2 / Seminar 2 / Project 2	10	25	25	20	20	-	100
ESE	10	25	25	30	10	-	100

23TEPE09	STEAM ENGINEERING	I

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

Course Objective	• To make the students learn various power generation units, steam generators, heat balance and safety standards of various steam generating units.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Parameter of a steam Generator – Thermal calculations of Modern steam Generator – Tube Metal Temperature Calculation and choice of Materials – Steam purity Calculations and Water treatment.		
UNIT – II	**STEAM SYSTEM AND HEAT BALANCE**	**9 Periods**
Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system- Heat transfer in Furnace – Furnace Heat Balance –Calculation of Heating Surfaces – Features of Firing systems for solid – Liquid and Gaseous Fuels – Design of Burners.		
UNIT – III	**BOILER DESIGN**	**9 Periods**
Design of Boiler Drum – Steam Generator Configurations for Industrial Power and Recovery Boiler – Pressure Loss and Circulation in Boilers.		
UNIT – IV	**DESIGN OF ACCESSORIES**	**9 Periods**
Design of Air Preheaters – Economizer and Superheater for high pressure Steam Generators – Design Features of Fuel Firing Systems and Ash Removing Systems.		
UNIT – V	**BOILER CODE**	**9 Periods**
IBR and International Regulations – ISI Code's Testing and Inspection of Steam Generator – Safety Methods in Boilers – Factor of safety in the Design of Boiler Drum and Pressure parts-Safety of Fuel Storage and Handling – Safety Methods of Automatic Operation of Steam Boilers.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*P.K. Nag, **"Power Plant Engineering"**, McGraw Hill Education, 4th edition 2017.*
2	*Domkundwar, **"A Course in Power Plant Engineering"**, Dhanapat Rai & Co, 2016.*

REFERENCES:

1	*Kumar Rayaprolu, **"Boilers"**, A Practical Reference, CRC Press, 2012.*
	*Kayla Westra, Larry Drbal, Lawrence F. Drbal, Pat Boston, **"Power Plant Engineering",** Springer US,2012.*
3	*Kumar Rayaprolu , **"Boilers for Power and Process",** CRC Press, 2009.*
4	*Richard Dolezal, **"Large Boiler Furnaces"** Elsevier Company, 2008.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Learn the parameters and calculations of steam generators.	K5
CO2	Understand the steam systems and heat balance in steam generators.	K2
CO3	Gain the knowledge in various designs of boilers.	K4
CO4	Design the accessories of a steam generator.	K4
CO5	Understand the codes and standards.	K5

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	2	2	2	2
CO2	3	2	2	2	2	2
CO3	2	2	2	1	3	2
CO4	2	2	2	1	3	2
CO5	2	2	3	1	2	2
23TEPE09	2	2	2	1	2	2
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (k1) %**	**Understanding (k2) %**	**Applying (k3) %**	**Analyzing (k4) %**	**Evaluating (k5) %**	**Creating (k6) %**	**Total %**
CAT1	15	20	-	35	30	-	100
CAT2	-	35	35	30	-	-	100
Individual Assessment 1 / Case Study 1 / Seminar 1 / Project 1	15	20	-	35	30	-	100
Individual Assessment 2 / Case Study 2 / Seminar 2 / Project 2	-	35	35	30	-	-	100
ESE	10	35	30	15	10	-	100

23TEPE10	SUPERCHARGING AND SCAVENGING	I

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

Course Objective	• To make the students to learn effects of supercharging and scavenging in I.C engines and design of exhaust systems	
UNIT – I	**SUPERCHARGING**	**8 Periods**
Objectives - Effects on engine performance – engine modification required - Thermodynamics of Mechanical supercharging and Turbocharging - Turbo charging methods - Engine exhaust manifolds arrangements.		
UNIT – II	**COMPRESSORS**	**10 Periods**
Types of compressors – Positive displacement blowers - Centrifugal compressors - Performance characteristic curves- Suitability for engine application - Surging - Matching of supercharger compressor and Engine – Matching of compressor, Turbine Engine.		
UNIT – III	**SCAVENGING OF TWO STROKE ENGINES**	**12 Periods**
Peculiarities of two stroke cycle engines - Classification of scavenging systems - Mixture control through Reed valve induction - Charging Processes in two stroke cycle engine - Terminologies - Shankey diagram – Relation between scavenging terms - scavenging modeling - perfect displacement, Perfect mixing Complex scavenging models.		
UNIT – IV	**PORTS AND MUFFLER DESIGN**	**8 Periods**
Porting - Design considerations - Design of intake and Exhaust Systems - Tuning.		
UNIT – V	**EXPERIMENTAL METHODS**	**7 Periods**
Experimental techniques for evaluating scavenging - Firing engine tests - Non firing engine tests – Port flow characteristics - Kadenacy system - Orbital engine combustion system, Sonic system.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Obert, E.F., **"Internal Combustion Engines and Air Pollution",** McGraw-Hill, 2017.*
2	*Vincent,E.T., **"Supercharging the I.C.Engines",** Facsimile publishers, 2015.*

REFERENCES:

1	*Giancarlo Ferrari, Angelo Onorati, Gianluca D'Errico, **"Internal Combustion Engines"**, Società Editrice Esculapio, 21 July 2022.*
2	*K.A. Zinner, **"Supercharging of Internal Combustion Engines"**, 4 July 2012.*
3	*Evangelos G. Giakoumis, **"Turbochargers and Turbocharging Advancements, Applications and Research"** Nova Science Publishers, Incorporated, 2017.*
4	*JohnB. Heywood, **"Two-Stroke Cycle Engine its Development, Operation and Design"**, CRC Press, November 2017.*
5	*Schweitzer, P.H., **"Scavenging of Two Stroke Cycle Diesel Engine"**, MacMillan Co.2007.*
6	*John B.Heywood, **"Two Stroke Cycle Engine"**, SAE Publications 2010.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Design and make thermal analysis of the supercharging system and scavenging processes.	K4
CO2	Design and tune intake and exhaust systems to achieve desired performance results.	K5
CO3	Address specific issues arising in laboratory testing of modified engines.	K3
CO4	Develop and design of ports and muffler design consideration	K3
CO5	Evaluate the characteristics involved in non-firing engine tests using experimental techniques.	K5

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	2	1	2	2
CO2	2	2	2	1	3	2
CO3	2	2	2	1	2	2
CO4	2	2	2	1	1	2
CO5	3	3	2	1	1	2
23TEPE10	2	2	2	1	2	2
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (k1) %**	**Understanding (k2) %**	**Applying (k3) %**	**Analyzing (k4) %**	**Evaluating (k5) %**	**Creating (k6) %**	**Total %**
CAT1	-	30	30	20	20	-	100
CAT2	-	50	50	-	-	-	100
Individual Assessment 1 / Case Study 1 / Seminar 1 / Project 1	-	30	30	20	20	-	100
Individual Assessment 2 / Case Study 2 / Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	-	25	25	25	25	-	100

23TEPE11	REFRIGERATION AND CRYOGENICS (use of approved tables and charts are permitted)	II

PREREQUISITES	CATEGORY	L	T	P	C
REFRIGERATION AND AIR CONDITIONING	PE	3	0	0	3

Course Objective	• To make the students learn different processes in cryogenic systems and to conduct activities related to design and the experimental study of low-temperature plant facilities and related industries.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Insight on cryogenics - Methods of producing cold - Thermodynamic basis, first and second law analysis - Vapour compression systems - Properties of cryogenic fluids and material properties at cryogenic temperatures.		
UNIT – II	**LIQUEFACTION CYCLES**	**9 Periods**
Carnot liquefaction cycle - F.O.M. and yield of liquefaction cycles - Inversion curve - Joule Thomson effect - Linde Hampson cycle – Precooled Linde Hampson cycle, Claude's cycle, Dual cycle - Helium refrigerated hydrogen liquefaction systems - Critical components in liquefaction systems.		
UNIT – III	**CRYOGENIC REFRIGERATORS**	**9 Periods**
Binary Mixtures - T-C and H- C Diagrams - Principle of rectification - Rectification column analysis – McCabe Thiele method - Adsorption systems for purification.		
UNIT – IV	**SEPARATION OF CRYOGENIC GASES**	**9 Periods**
J.T.Cryocoolers - Stirling cycle refrigerators - G.M.Cryocoolers - Pulse tube refrigerators - Regenerators used in cryogenic refrigerators - Magnetic refrigerators.		
UNIT – V	**HANDLING OF CRYOGENS AND APPLICATIONS**	**9 Periods**
Cryogenic storage dewar construction and design - Cryogenic transfer lines - Insulations used in cryogenic systems - Applications of cryogenics in space programmes.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Valery V.Kostionk and D.Bhaskara Rao, **"A Text book of Cryogenics"**, Discovery Publishing House, 1st Edition, 2019.*
2	*Klaus D.Timmerhaus and Thomas M.Flynn, **"Cryogenic Process Engineering"**, Plenum Press, Softcover reprint of the original 1st Edition, 2013.*

REFERENCES:

1	*Mamata Mukhopadhyay, **"Fundamentals of Cryogenic Engineering"**, PHI Publications, 2010.*
2	*G. Venkatarathnam, **"Cryogenic Mixed Refrigerant Processes"**, Springer Publication, 2010.*
3	*Beth Evans, Tom Bradshaw and John Vandore, **"Cryogenics: Fundamentals, Foundations and Applications"**, Institute of Physics Publishing, 1st Edition, 2022.*
4	*Dr. Zuyu Zhao and Dr. Chao Wang, **"Cryogenic Engineering and Technologies: Principles and Applications of Cryogen-Free Systems"**, CRC Press, 2019.*
5	*Thomas M.Flynn, **"Cryogenic Engineering"**, Marcel Dekker, 2nd Revise Edition, 2009.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the basic concepts of cryogenic systems.	K2
CO2	Learn the fundamentals of cycles and applications of liquefaction system.	K2
CO3	Understand the basic principle and working of cryogenic refrigerator.	K2
CO4	Perform analysis for a selecting suitable cryogenic refrigerator.	K5
CO5	Understand the concepts of storage systems and insulation techniques used in cryogenic applications.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	3	2	2	2
CO2	1	3	2	1	1	3
CO3	2	2	3	2	1	2
CO4	2	3	3	1	2	2
CO5	2	2	2	1	1	1
23TEPE11	2	2	3	1	1	2
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Rememberin g (K1) %**	**Understandin g (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluatin g (K5) %**	**Creating (K6) %**	**Total %**
CAT1	45	55	-	-	-	-	100
CAT2	10	20	30	30	10	-	100
Individual Assessment 1 / Case Study 1 / Seminar 1 / Project 1	55	45	-	-	-	-	100
Individual Assessment 2 / Case Study 2 / Seminar 2 / Project 2	10	30	20	30	10	-	100
ESE	25	40	15	10	10	-	100

23TEPE12	THERMAL ENERGY SYSTEMS	II

PREREQUISITES	CATEGORY	L	T	P	C
THERMAL ENGINEERING	PE	3	0	0	3

Course Objective	• To make the students able to design, model and optimize thermal energy systems used in various engineering applications and ensuring its stability.	
UNIT – I	**DESIGN OF THERMAL SYSTEMS**	**9 Periods**
Design systems, workable systems and optimal systems - Matching of system components - Economic analysis, depreciation and gradient present worth factor.		
UNIT – II	**MATHEMATICAL MODELLING**	**9 Periods**
Equation fitting – Nomography, empirical equation, regression analysis - Different modes of mathematical models, selection - Computer programmes for models.		
UNIT – III	**MODELLING THERMAL EQUIPMENTS**	**9 Periods**
Modelling of heat exchangers, evaporators, condensers, absorption and rectification columns, compressor and pumps - Simulation studies - Information flow diagram - Solution procedures.		
UNIT – IV	**OPTIMIZATION OF THERMAL SYSTEMS**	**9 Periods**
Objective function formulation - Constraint equations, mathematical formulation - Calculus methods, dynamic programming, linear programming methods - Solution procedures.		
UNIT – V	**DYNAMIC BEHAVIOUR OF THERMAL SYSTEMS**	**9 Periods**
Steady state simulation - Laplace transformation - Feedback control loops - Stability analysis - Non linearities.		
Contact Periods: **Lecture:45 Periods Tutorial: 0 Periods Practical: 0 Periods Total:45 Periods**		

TEXT BOOK:

1	*Steven G.Penoncello, **"Thermal Energy Systems: Design and Analysis"**, CRC Press, 2nd Edition, 2018.*
2	*W.F.Stoecker, **"Design of Thermal Systems"**, Mcgraw Hill, 3rd Edition, 2021.*

REFERENCES:

1	*Ibrahim Dinçer and Marc A. Rosen, **"Thermal Energy Storage: Systems and Applications"**, Wiley, 2nd Edition, 2011.*
2	*J.N.Kapur, **"Mathematical Modelling"**, New Age International Publisher, 2nd Edition, 2021.*
3	*Mcquiston, Parker and Spitler, **"Heating, Ventilating and Air conditioning: Analysis and Design"**, John Wiley & Sons, 6th Edition, 2011.*
4	*W.F.Stoecker, **"Refrigeration and Air Conditioning"**, TMH, 2nd Edition, 2014.*
5	*Fergus Nicol, Michael Humphreys and Susan Roaf, **"Adaptive Thermal Comfort: Principles and Practice"**, Routledge, 2012.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Develop simulate and integrate various components in thermal systems.	K5
CO2	Understand the modern engineering tools used in engineering practice.	K3
CO3	Develop mathematic models for thermal equipment.	K4
CO4	Optimize thermal energy systems.	K4
CO5	Analyze dynamic behavior of the thermal system.	K5

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	2	2	3	2
CO2	3	3	2	1	2	2
CO3	2	2	1	2	3	2
CO4	3	3	2	2	3	3
CO5	2	2	2	2	2	2
23TEPE12	3	3	2	2	2	2
1 – Slight, 2 – Moderate, 3 – Substantial						

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

22TEPE13	ENGINE POLLUTION AND CONTROL	II

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

Course Objective	• To make the students understand mechanism of engine pollution formation, control, Measurement techniques and its impact on the society.	
UNIT – I	**POLLUTION – ENGINES AND TURBINES**	**9 Periods**
Atmospheric pollution from piston engines and gas turbines - Global warming.		
UNIT – II	**POLLUTANT FORMATION**	**9 Periods**
Formation of oxides of nitrogen, carbon-monoxide, hydrocarbon, aldehydes and smoke particulate emission - effects of pollutants on environment.		
UNIT – III	**MEASUREMENT OF POLLUTANTS**	**9 Periods**
Non dispersive infrared gas analyzer - Gas chromatography - Chemi-luminescent analyzer and flame ionization detector - Smoke measurement - Noise pollution - Measurement and control.		
UNIT – IV	**CONTROL OF ENGINE POLLUTION**	**9 Periods**
Engine components - Fuel modification - Evaporative emission control, EGR and air injection in thermal reactors - In cylinders control of pollution - catalytic converter - Application of microprocessors in emission control.		
UNIT – V	**DRIVING CYCLES AND EMISSION STANDARDS**	**9 Periods**
Use of driving cycles for emission measurement - Chassis dynamometer - CVS system - National and International emission standards.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*G.Amba Prasad Rao and T.Karthikeya Sharma, **"Engine Emission Control Technologies"**, Apple Academic Press and CRC Press, 1st Edition, 2021.*
2	*Crouse William, **"Automotive Emission Control"**, Gregg Division / McGraw-Hill, 2000.*

REFERENCES:

1	*George, Springer and Donald J.Patterson, **"Engine emissions, pollutant Formation and Measurement"**, Plenum Press, 2012.*
2	*C.S.Rao, **"Environmental Pollution Control Engineering"**, New Age International Publishers, 2nd Edition, 2006.*
3	*B.P.Pundir, **"Engine Emissions: Fundamentals and Advances in Control"**, Alpha Science International, 2nd Edition, 2017.*
4	*Ernest S.Starkman, **"Combustion Generalized Air Pollutions"**, Plenum Press, 1993.*
5	*Eran Sher, **"Handbook of Air Pollution from Internal Combustion Engines"**, Academic Press, 1998.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify the various sources of pollution.	K2
CO2	Study the formation of various pollutants in the environment.	K2
CO3	Develop the knowledge on pollutant measurement techniques.	K2
CO4	Identify the strategies to control engine pollution.	K3
CO5	Develop the knowledge on environment pollution and its standards.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	2	3	2	2
CO2	2	2	2	2	2	2
CO3	3	2	3	2	3	2
CO4	3	3	2	2	2	2
CO5	3	2	2	1	1	1
23TEPE13	2	3	2	2	2	2
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23TEPE14	**AIR CONDITIONING SYSTEM DESIGN** *(use of approved tables and charts are permitted)*	**II**

PREREQUISITES	CATEGORY	L	T	P	C
REFRIGERATION AND AIR CONDITIONING	PE	3	0	0	3

Course Objective	• To make the students learn the design of air conditioning system components, equipments and their testing methods.	
UNIT – I	**AIR CONDITIONING SYSTEMS**	**9 Periods**
Packaged air conditioning systems - Centralized air conditioning systems - VAV systems - Underfloor distribution systems - Radiant cooling systems - Hydronic systems - Air handling systems.		
UNIT – II	**COMPONENTS TESTING AS PER BIS CODES**	**9 Periods**
Testing of condensers and evaporators - Testing of cold storages – Code of practice for fire safety, storage - Specification and testing of all types of air conditioners – Enthalpy deviation curve – psychrometry.		
UNIT – III	**AIR CONDITIONING SYSTEM DESIGN AND LOAD CALCULATION**	**9 Periods**
Design conditions - Air distribution, pressure drop, duct design, fans and blowers design - Load calculations -Thermal comfort - Solar radiation - Heat gain through envelopes - Infiltration and ventilation loads, Internal loads - Procedure for heating and cooling load estimation.		
UNIT – IV	**APPLICATIONS OF AIR CONDITIONING**	**9 Periods**
Air conditioning in automobiles - Railway wagons, marine vessels, aircraft and other commercial applications.		
UNIT – V	**AIR CONDITIONING ACCESSORIES AND CONTROL**	**9 Periods**
Performance and selection - Noise control, piping system, valves, receivers, oil trap, oil regenerators, driers and strainers - Control system of temperature, pressure and oil Flow - Compressor motor – Protection devices.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Roger Legg, **"Air Conditioning System Design"**, Butterworth-Heinemann, 1st Edition, 2017.*
2	*Herbert W. Stanford III and Adam F. Spach, **"Analysis and Design of Heating, Ventilating, and Air-Conditioning Systems"**, CRC Press, 2nd Edition, 2019.*

REFERENCES

1	*Dossat, R. J., **"Principles of Refrigeration and Air Conditioning"**, John Wiley & Sons, 4th Edition, 2010.*
2	*Manohar Prasad, **"Refrigeration & Air Conditioning"**, New Age Publishers, 3rd Edition, 2021.*
3	*Arora C.P., **"Refrigeration and Air Conditioning"**, Tata McGraw Hill, 4th Edition, 2021.*
4	*Grondzik W T., **"Air Conditioning System Design Manual"**, Elsevier Science, 2nd Edition, 2011.*
5	*Ashrae Press, **"Air Conditioning System Design Manual"**, Butterworth-Heinemann, 2nd Edition, 2020.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand different types of air conditioning systems.	K2
CO2	Understand the testing of components as per BIS codes.	K3
CO3	Impart the design and load calculations for air conditioning systems.	K5
CO4	Select the suitable air conditioning system for engineering applications.	K2
CO5	Study the performance of different air conditioning accessories.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	2	2	2	3
CO2	3	3	2	1	2	2
CO3	2	2	1	1	3	2
CO4	2	2	1	2	3	3
CO5	3	3	2	1	2	2
23TEPE14	2	3	2	1	2	2
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23TEPE15	SOLAR ENERGY AND WIND ENERGY	II

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

Course Objective	• To make the students learn properties, types, energy conversion techniques of solar and wind energy systems.	
UNIT – I	**SOLAR RADIATION**	**9 Periods**
Availability - Measurement and estimation - Capturing solar radiation-Isotropic and anisotropic model - Introduction to solar collectors - Flat-plate collectors, air heater, concentrating collectors and thermal storage - Steady state transient analysis - Solar Pond - Solar refrigeration.		
UNIT – II	**MODELLING AND SIMULATION OF SOLAR THERMAL SYSTEMS**	**9 Periods**
Design of active systems by f-chart and utilizability methods - Water heating systems – Active and passive - Passive heating and cooling of buildings - Solar distillation - Solar Drying.		
UNIT – III	**PHOTOVOLTAIC SOLAR CELL**	**9 Periods**
P-N Junction – Metal-Schottky junction – Electrolyte - Semiconductor junction - Types of solar cell and their applications - Experimental techniques to determine the characteristics of solar cells - Photovoltaic hybrid systems - Photovoltaic thermal systems – Storage battery – Solar array characteristics and evaluation – Solar chargeable battery.		
UNIT – IV	**WIND TURBINE**	**9 Periods**
Structure – Statistics – Measurements and data presentation – Wind turbine aerodynamics – Momentum theories – Basics of aerodynamics – Airfoils characteristics – HAWT – Blade element theory – Prandtl's lifting line theory – VAWT aerodynamic loads in steady operation – Wind turbulence – Yawed operation and tower shadow.		
UNIT – V	**WIND ENERGY CONVERSION SYSTEM**	**9 Periods**
Classification - Components - Yaw system – Synchronous and asynchronous generators and loads – Integration of wind energy into electrical systems –Testing of WECS – WECS control system -Energy conversion strategies for wind energy system – Applications - Future of WECS - Wind energy programmes.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Mukund R. Patel, Omid Beik, **"Wind and Solar Power Systems: Design, Analysis, and Operation"**, CRC Press, 3rd Edition, 2021.*
2	*S. P. Sukhatme, J. K. Nayak, **"Solar Energy: Principles of Thermal Collection and Storage"**, Tata MgGraw-Hill, 3rd Edition, 2010.*

REFERENCES:

1	*D.A.Spera, **"Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering"**, ASME Press, 2nd Edition, 2009.*
2	*F.A.Duffie and W.A.Beckman, **"Solar Engineering of Thermal Processes"**, John Wiley, 4th Edition, 2013.*
3	*Anup Goel, Mahesh A. Khot, Siddu Patil, **"Wind & Solar Energy"**, Technical Publications, 2022.*
4	*Mukund R. Patel, **"Wind and Solar Power Systems"**, CRC Press, 1999.*
5	*J.F.Krider and F.Kreith, **"Solar Energy Handbook"**, McGraw-Hill, 3rdEdition, 1986.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Familiarize with the methods to trap solar radiation for energy conversion.	K2
CO2	Able to model solar thermal systems.	K4
CO3	Impart knowledge on solar cells and its applications.	K3
CO4	Gain the knowledge of wind turbine systems.	K2
CO5	Familiarize with various wind energy conversion systems	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	3	2	2	2	2
CO2	3	1	2	2	2	2
CO3	3	3	3	1	1	1
CO4	2	3	3	3	2	1
CO5	2	2	2	1	3	2
23TEPE15	2	3	2	2	1	1
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23TEPE16	BIO-ENERGY CONVERSION TECHNIQUES	SEMESTER III

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

Course Objectives	To make the students understand the sources, properties and conversion methodologies of converting bio mass into sustainable biofuels.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Biomass as energy source – Sources – Biomass conversion processes – Application of biomass conversion products – Biomass properties for conversion process – Physical properties.		
UNIT – II	**BIOMASS ENERGY CONVERSION PATHWAYS**	**9 Periods**
Combustion, pyrolysis, gasification and liquefaction - Biological conversion – Methanol and ethanol production - Fermentation - Anaerobic digestion biodegradation and biodegradability of substrate - Hydrogen generation from algae – Biological pathways.		
UNIT – III	**POWER GENERATION TECHNIQUES**	**9 Periods**
Gasifier design – TOR, throughout, A/F ratio and equivalent ratio - Electrical power production – Bio mass combustion – Types of combustors, co-combustion and co-firing - Applications – Eutectic point of biomass ash.		
UNIT – IV	**INDUSTRIAL APPLICATIONS**	**9 Periods**
Industrial Applications - Viability of energy production - Wood gasifier system - Operation of spark ignition and compression ignition with wood gas - Operation and maintenance.		
UNIT – V	**ECONOMICS AND ENVIRONMENTAL ASPECTS**	**9 Periods**
Energy effectiveness and cost effectiveness - History of energy consumption and cost - Environmental aspects of bio-energy Conversion - Biomass energy programs in India.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK:

1	*Sergio C. Capareda, **"Introduction to Biomass Energy Conversions"**, CRC Press, 2019.*
2	*Bajbaipratima, **"Biomass to Energy Conversion Technologies"**, Elsevier Science Publishing Co Inc, 1st Edition, 2019.*

REFERENCES:

1	*Ozcan Konur, **"Bioenergy and Biofuels"**, CRC Press, 1st Edition, 2018.*
2	*Erik Dahlquist, **"Biomass as Energy Source: Resources, systems and applications"**, Sustainable Energy Developments series, CRC Press, 2012.*
3	*EL Halwagi.M.M., **"Biogas Technology: Transfer and Diffusion"**, Elsevier Applied Science, London, 1986.*
4	*Anju Dahiya, **"Bioenergy: Biomass to Biofuels"**, Academic press, 2014.*
5	*D.P.Kothari, K.C Singal and Rakesh Ranjan, **"Renewable Energy Sources And Emerging Technologies"**, PHI Learning Private Ltd, 2011.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Develop knowledge in properties of biomass for energy conversion process	K5
CO2	Gain the knowledge on pathways for converting biomass into energy.	K2
CO3	Assess the potential of electrical power production for biomass	K5
CO4	Analyze performance and emission of fueled with wood gas engines.	K5
CO5	Analyze energy and cost efficiency of biomass conversion techniques.	K5

Course Articulation Matrix						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	2	2	2	1
CO2	2	3	2	2	1	2
CO3	2	3	2	3	2	2
CO4	3	2	3	2	2	1
CO5	2	2	2	3	3	2
23TEPE16	2	3	2	2	2	1
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23TEPE17	ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL	SEMESTER III

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

Course Objectives	To make the students to learn sources and effects of air pollution, water pollution and soil contamination.	
UNIT – I	**AIR POLLUTION**	**9 Periods**
Definition - sources and effect - Ambient air quality standards-Air sampling and measurements – Dispersion of air pollutants – diurnal effects on the air pollutants dispersion – Meteorological aspects – Analysis of air pollutants - Control methods and equipment's - Issues in air pollution control-Emission limits.		
UNIT – II	**SOLID WASTE MANAGEMENT**	**9 Periods**
Soil pollution - Sources and classification - Characteristics of solid waste- Potential methods of solid waste disposal – Process and equipments for energy recovery from municipal solid waste and industrial solid waste– Hazardous waste disposal – Secure landfill-transformation technologies for waste treatment.		
UNIT – III	**WATER POLLUTION AND TREATMENT**	**9 Periods**
Water and wastewater – Standards of potable water for various purposes - Sources and classification of water pollutants - Characteristics wastewater – Waste water sampling techniques – Types of treatment and choice of wastewater treatment – Utilization and disposal of sludge.		
UNIT – IV	**OTHER TYPES OF POLLUTION AND LEGISLATIONS**	**9 Periods**
Sources - Health impact on humans, animals and plants - Control strategies for noise pollution and oil pollution – Pesticides pollution - Radioactive Pollution – Environmental laws for prevention of environmental pollution.		
UNIT – V	**CASE STUDIES**	**9 Periods**
Industrial process description – Pollution sources – Methods available in abatement of pollution – Treatment technologies for thermal power, nuclear power, automobile, aeronautical and mining plants.		
Contact Periods: **Lecture:45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total:45 Periods**		

TEXT BOOK:

1	*C.S.Rao, **"Environmental Pollution Control Engineering"**, New Age International Private Limited, 4th Edition, 2021.*
2	*HS Bhatia, **"A Text Book on Environmental Pollution and Control"**, JDM Publishers & Distributors, 2022.*

REFERENCES:

1	*G.Masters, **"Introduction to Environmental Engineering and Science"**, Prentice Hall of India Pvt Ltd, New Delhi, 3rdEdition, 2003.*
2	*S.S.Dara and D.D.Mishra, **"A Text Book of Environmental Chemistry & Pollution Control"**, S Chand & Company, 7th Edition, 2004.*
3	*O.P.Gupta, **"Elements of Environmental Pollution Control"**, Khanna Publishing, 1st Edition, 2022.*
4	*H.S.Peavy, D.R.Rowe and G.Tchobanoglous, **"Environmental Engineering"**, McGraw-Hill Book Company, 5th Edition, 1985.*
5	*S.M.Khopkar, **"Environmental Pollution Monitoring and Control"**,New Age International Publishers, 2ndEdition, 2007.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify and value the effect of the pollutants on the environment.	K5
CO2	Devise a potential strategy for effective solid waste management.	K5
CO3	Plan strategies to control, reduce and monitor water pollution in industrial area.	K2
CO4	Understand the Impacts of pollution and its control strategies.	K4
CO5	Understand the various environmental laws and act in accordance with them to reduce the environmental pollution.	K3

Course Articulation Matrix						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	3	2	2	2	2
CO2	2	2	2	3	1	2
CO3	3	2	2	2	1	1
CO4	2	3	3	1	1	1
CO5	2	2	2	2	1	2
23TEPE17	2	3	2	2	1	2
1 – Slight, 2 – Moderate, 3 – Substantial						

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

22TEPE18	MODELING OF CI ENGINE PROCESSES	SEMESTER III

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

Course Objectives	To make the students understand the concepts of combustion and flow modeling of CI engines.	
UNIT – I	**GENERAL CONSIDERATIONS OF MODELING**	**9 Periods**
Governing equations - conservation of mass, conservation of energy - Second law analysis -Numerical methodology - Computing mesh, discretization and grid Formation.		
UNIT – II	**SPRAY MODELING**	**9 Periods**
Spray equation models - Thin spray models - Thick spray models - Droplet turbulence inter- actions - Droplet impingement on walls.		
UNIT – III	**IN-CYLINDER FLOW MODELING**	**9 Periods**
Full Field Model - k-ε model - Laminar flow modeling - Probability density functions - Ekman layers roll-up vortex - Vortex structures - Compression generated turbulence - Effective viscosity turbulent diffusivity.		
UNIT – IV	**COMBUSTION SYSTEMS AND EFFICIENCIES**	**9 Periods**
Classification - zero-dimensional modeling - Quasi-dimensional modeling - Multidimensional modeling - Comparison of different combustion systems - Combustion efficiency - Applications.		
UNIT – V	**COMBUSTION MODELS**	**9 Periods**
Single zone models - Multi zone models - Kono's model - Cummins engine model - Hiroyasu's model - Premixed diffusive models - Single and double Wiebe function combustion model - Whitehouse-Way model.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*J.I.Ramos,* ***"Internal Combustion Engine Modeling"****, Hemisphere Publishing Corporation, 1989.*
2	*James N.Mattavi and Charles A.Amann,* ***"Combustion Modeling in Reciprocating Engines"****, Plenum Press, 1980*

REFERENCES:

1	*John.B.Heywood,* ***"Internal Combustion Engine Fundamentals"****, McGraw-Hill International Editions, Automotive technology Series, 2012*
2	*V. Ganesan,* ***"Computer Simulation of CI Engine Processes"****, Universities Press, 2000.*
3	*Avinash Kumar Agarwal, Dhananjay Kumar, Nikhil Sharma and Utkarsha Sonawane,* ***"Engine Modeling and Simulation"****, Springer, 2021.*
4	*Anthony J.Baxendale,* ***"Computational Fluid Dynamics in Exhaust System Design and Development",*** *SAE Paper, 1993.*
5	*Lino Guzzella and Christopher H.Onder,* ***"Introduction to Modeling and Control of Internal Combustion Engine Systems"****, Springer, 2010.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the generalized governing equation for engine modeling.	K3
CO2	Develop the flow modeling, spray modeling equations and solve it.	K4
CO3	Develop in cylinder flow models of CI Engines.	K4
CO4	Understand multidimensional combustion models and study the combustion efficiency.	K2
CO5	Select suitable combustion model based on nature of the problem.	K3

Course Articulation Matrix						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	1	2	3	2
CO2	3	2	2	2	3	2
CO3	3	3	2	1	2	3
CO4	2	2	3	2	2	2
CO5	3	2	2	2	3	2
23TEPE18	3	2	2	2	2	2
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23TEPE19	ENERGY AUDITING AND MANAGEMENT	SEMESTER III

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

Course Objectives	To make the students learn concepts of energy scenario, energy auditing thereby identifying the ways for energy conservation and management.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Global energy requirements – Depletion of conventional energy sources -Energy scenario – Principles and imperatives of energy conservation – Energy consumption pattern – Resource – Availability – Role of energy managers in industries - Duties and responsibilities of energy auditors - Energy conservation act.		
UNIT – II	**THERMAL ENERGY AUDITING**	**9 Periods**
Energy Audit - Purpose, methodology with respect to thermal industries – Power plants - Energy conservation in pumps, fans and compressors, air conditioning and refrigerating systems, steam traps – Types, function, necessity, heat distribution, temperature control, waste heat recovery.		
UNIT – III	**ROLE OF INSTRUMENTATION IN ENERGY CONSERVATION**	**9 Periods**
Total energy systems – Concept of total energy – Advantages and limitations – Total energy system and applications – Various possible schemes employing steam turbine movers used in total energy systems – Potential and economical of total energy systems - Energy conservation in transportation.		
UNIT – IV	**ELECTRICAL ENERGY AUDITING**	**9 Periods**
Potential areas for electrical energy conservation in various industries – Energy management opportunities in electrical heating, lighting system, cable selection – Energy efficient motors – Energy performance assessment of motors and variable speed drives.		
UNIT – V	**ENERGY MANAGEMENT**	**9 Periods**
Principles of Energy Management - Energy demand estimation - Importance of energy management- Energy pricing - Energy economics – Discount rate, Payback period, Internal rate of return, Life cycle costing.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Amlan Chakrabarti, **"Energy Engineering and Management"**, PHI Learning Private Limited, 2nd Edition, 2018.*
2	*L.Ashok Kumar, Gokul Ganesan, **"Energy Audit and Management: Concept, Methodologies, Procedures, and Case Studies"**, CRC Press, 1st Edition, 2022.*

REFERENCES:

1	*Roy L. Nersesian, **"Energy for the 21st Century"**, Yes Dee Publishing Pvt Ltd, 2011.*
2	*Craig B Smith, **"Energy Management Principles"**, Pergamon Press, 2nd Edition, 2015.*
3	*Doty S. and Turner W.C., **"Energy Management Hand book"**, Fairmont Press, 7th Edition, 2009.*
4	*Dhungel, Suresh Kumar and G. Krishnakumar, **"Energy Audit for Professionals"**, Daya Publishing House, 2013.*
5	*Mehmet Kanoğlu and Yunus A. Çengel, **"Energy Efficiency and Management for Engineers"**, McGraw-Hill Education, 1stEdition, 2020.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the role of energy manager and energy auditors in industries.	K2
CO2	Gain knowledge on the different energy auditing techniques and incorporate them accordingly.	K5
CO3	Select suitable instrument to conserve energy in industries.	K3
CO4	Suggest appropriate solution to conserve electric energy in industries.	K4
CO5	Estimate energy demand and life cycle costing.	K5

Course Articulation Matrix						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	2	3	1	3
CO2	2	2	3	2	2	3
CO3	3	3	2	2	1	2
CO4	2	2	3	3	3	2
CO5	2	2	2	2	2	3
23TEPE19	2	2	2	3	2	2
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23TEPE20	ELECTRIC AND HYBRID VEHICLES	SEMESTER III

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

Course Objectives	To present a comprehensive overview of electric and hybrid electric vehicles.	
UNIT – I	**ELECTRIC VEHICLES**	**9 Periods**
Introduction, Components, vehicle mechanics – Roadway fundamentals, vehicle kinetics, Dynamics of vehicle motion - Propulsion system design, Fuel cell EV, Solar powered vehicles.		
UNIT – II	**ENERGY STORAGE**	**9 Periods**
Introduction to energy storage requirements in hybrid and electric vehicles - Battery based energy storage and its analysis, Fuel cell based energy storage and its analysis - Super capacitor based energy storage and its analysis, Hybridization of different energy storage devices – Selection of energy storage technology.		
UNIT – III	**ENERGY MANAGEMENT STRATEGIES**	**9 Periods**
Communications, supporting subsystems: In vehicle networks – CAN - Energy Management Strategies - Introduction to energy management strategies used in hybrid and electric vehicles - Classification of different energy management strategies - Comparison of different energy management strategies.		
UNIT – IV	**ELECTRIC VEHICLE DRIVE TRAIN**	**9 Periods**
Transmission configuration, Components – gears, differential, clutch, brakes regenerative braking, motor sizing - Configuration and control of switched reluctance Motor drives - Drive system efficiency - Fuel efficiency analysis.		
UNIT – V	**HYBRID ELECTRIC VEHICLES**	**9 Periods**
Types – series, parallel and series, parallel configuration – Design – drive train, sizing of components - Drive-train topologies - Power flow control in hybrid drive-train topologies - Social and environmental importance of hybrid and electric vehicles.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK:

1	*Ehsani,* ***"Modern Electric, Hybrid Electric, and Fuel Cell Vehicles"****, CRC Press, 2019.*
2	*Iqbal Hussain,* ***"Electric & Hybrid Vehicles – Design Fundamentals"****, 2nd Edition, CRC Press, 2011.*

REFERENCES:

1	*A. K. Babu,* ***"Electric and Hybrid Vehicles"****, Khanna Publishing, 2022.*
2	*James Larminie and John Lowry,* ***"Electric Vehicle Technology Explained"****, Wiley, 1st Edition, 2012.*
3	*Tom Denton,* ***"Electric and Hybrid Vehicles"****,CBS Publishers and Distributors, 2nd Edition, 2020.*
4	*S. Onori, L. Serrao and G. Rizzoni,* ***"Hybrid Electric Vehicles: Energy Management Strategies"****, Springer, 2015.*
5	*Lino Guzzella and Antonio Sciarretta, "****Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design"****, CRC Press, 2nd Edition. 2009.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the components and mechanics of electric vehicles.	K2
CO2	Choose the proper energy storage systems for electric vehicle applications.	K3
CO3	Select the appropriate source of energy for the hybrid electric vehicle based on the driving cycle.	K3
CO4	Understand the electric vehicle drive system.	K2
CO5	Design drive trains for hybrid electric vehicles.	K6

Course Articulation Matrix						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	3	2	2	2	2
CO2	3	2	3	3	3	2
CO3	2	2	3	3	2	3
CO4	2	3	2	1	3	2
CO5	3	3	2	2	3	2
23TEPE20	2	2	2	2	2	2
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23SEOE01	**BUILDING BYE-LAWS AND CODES OF PRACTICE** *(Common to all Branches)*

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

Course Objective	• To impart knowledge on the building bye –laws and to emphasize the significance of codes of practice in construction sector.	
UNIT – I	**INTRODUCTION TO BUILDING BYE-LAWS**	**9 Periods**
Introduction to Building Bye Laws and regulation, their need and relevance, General definitions such as building height, building line, FAR, Ground Coverage, set back line. Introduction to Master Plan and understanding various land uses like institutional, residential etc. - Terminologies of Building bye-laws.		
UNIT – II	**ROLE OF STATUTORY BODIES**	**9 Periods**
Role of various statutory bodies governing building works like development authorities, municipal corporations etc. Local Planning Authority, Town and Country planning organisation, Ministry of urban development.		
UNIT – III	**APPLICATION OF BUILDING BYE-LAWS**	**9 Periods**
Interpretation of information given in bye laws including ongoing changes as shown in various annexure and appendices. Application of Bye-laws like structural safety, fire safety, earthquake safety, basement, electricity, water, and communication lines in various building types.		
UNIT – IV	**INTRODUCTION TO CODES OF PRACTICE**	**9 Periods**
Introduction to various building codes in professional practice - Codes, regulations to protect public health, safety and welfare - Codes , regulations to ensure compliance with the local authority.		
UNIT – V	**APPLICATION OF CODES OF PRACTICE**	**9 Periods**
Applications of various codes as per various building types. Bureau of Indian Standards, Eurocode – Introduction to other international codes.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

REFERENCES :

1	***"National Building Code of India 2016 – SP 7",*** *NBC 2016, Bureau of Indian Standards.*
2	***"Model Building Bye-Laws (MBBL) – 2016",*** *Town and Country Planning Organization, Ministry of Housing and Urban Affairs, Government of India.*
3	***"Unified Building Bye-laws for Delhi 2016",*** *Nabhi Publications, 2017.*
4	Mukesh *Mittal,* ***"Building Bye Laws",*** *Graphicart publishers, Jaipur, 2013.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Apply the building bye-laws in planning, design and construction works.	K3
CO2	Familiarize with the role of various statutory bodies.	K2
CO3	Execute safety related work practices in the construction sector.	K3
CO4	Ensure compliance with the rules and regulations in design and construction practices.	K3
CO5	Perform design and construction practices based on national and international codal provisions.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	3	1	1	2	3
CO2	1	3	1	1	2	3
CO3	1	3	1	1	2	3
CO4	2	3	1	1	2	3
CO5	2	3	1	1	2	3
23SEOE01	2	3	1	1	2	3
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23SEOE02	**PLANNING OF SMART CITIES** *(Common to all Branches)*

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

Course Objective	• To have an exposure on planning of smart cities with consideration of the recent challenges and to address the importance of sustainable development of urban area.	
UNIT – I	**SMART CITIES DEVELOPMENT POTENTIALS AND CHALLENGES**	**9 Periods**
Perspectives of Smart Cities: Introduction and Overview - Implementation Challenges - Methodological issues - Spatial distribution of startup cities – Re imagining postindustrial cities - Implementation Challenges for Establishing Smart Urban Information and Knowledge Management System.		
UNIT – II	**SUSTAINABLE URBAN PLANNING**	**9 Periods**
Optimising Green Spaces for Sustainable Urban Planning - 3D City Models for Extracting Urban Environmental Quality Indicators - Assessing the Rainwater Harvesting Potential - The Strategic Role of Green Spaces - Monitoring Urban Expansion.		
UNIT – III	**ENERGY MANAGEMENT AND SUSTAINABLE DEVELOPMENT**	**9 Periods**
Alternatives for Energy Stressed Cities - Social Acceptability of Energy - Efficient Lighting - Energy Management - Urban Dynamics and Resource Consumption - Issues and Challenges of Sustainable Tourism - Green Buildings: Eco-friendly Technique for Modern Cities.		
UNIT – IV	**MULTIFARIOUS MANAGEMENT FOR SMART CITIES**	**9 Periods**
Assessment of Domestic Water Use Practices - Issue of Governance in Urban Water Supply - Assessment of Water Consumption at Urban Household Level - Water Sustainability - Socio-economic Determinants and Reproductive Healthcare System - Problems and Development of Slums.		
UNIT – V	**INTELLIGENT TRANSPORT SYSTEM**	**9 Periods**
Introduction to Intelligent Transport Systems (ITS) - The Range of ITS Applications -Network Optimization - Sensing Traffic using Virtual Detectors - Vehicle Routing and Personal route information - The Smart Car - Commercial Routing and Delivery - Electronic Toll Collection - The Smart Card - Dynamic Assignment - Traffic Enforcement. Urban Mobility and Economic Development.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

REFERENCES

1	*Poonam Sharma, Swati Rajput,* ***"Sustainable Smart Cities In India Challenges And Future Perspectives"****, Springer 2017 Co.(P) Ltd. 2013.*
2	*Ivan Nunes Da Silva,* ***"Rogerio Andrade Flauzino-Smart Cities Technologies-Exli4eva"****, 2016.*
3	*Stan McClellan, Jesus A. Jimenez, George Koutitas* ***"Smart Cities_ Applications, Technologies, Standards"****, and Driving Factors-Springer International Publishing, 2018.*
4	*Stan Geertman, Joseph Ferreira, Jr., Robert Goodspeed, John Stillwell,* ***"Planning Support Systems And Smart Cities"****, Springer, 2015.*
5	*Pradip Kumar Sarkar and Amit Kumar Jain* ***"Intelligent Transport Systems"****, PHI Learning, 2018.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Indicate the potential challenges in smart city development.	K2
CO2	Select the different tools for sustainable urban planning.	K3
CO3	Choose appropriate energy conservation system for smart cities.	K3
CO4	Identify the proper method of water management system.	K3
CO5	Apply Intelligent Transport System concepts in planning of smart city.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	-	2	3	1	1
CO2	1	1	1	3	2	1
CO3	1	1		2	2	1
CO4	1	-	1	2	1	1
CO5	1	-	1	3	1	-
23SEOE02	1	1	2	3	2	1
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	25	45	30	-	-	-	100
CAT2	25	45	30	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	15	40	45	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	10	45	45	-	-	-	100
ESE	20	40	40	-	-	-	100

23SEOE03	**GREEN BUILDING** *(Common to all Branches)*

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

Course Objective	• To introduce the different concepts of energy efficient buildings, indoor environmental quality management, green buildings and its design.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Life cycle impacts of materials and products – sustainable design concepts – strategies of design for the Environment -The sun-earth relationship and the energy balance on the earth's surface, climate, wind – Solar radiation and solar temperature – Sun shading and solar radiation on surfaces – Energy impact on the shape and orientation of buildings – Thermal properties of building materials.		
UNIT – II	**ENERGY EFFICIENT BUILDINGS**	**9 Periods**
Passive cooling and day lighting – Active solar and photovoltaic- Building energy analysis methods- Building energy simulation- Building energy efficiency standards-Lighting system design- Lighting economics and aesthetics- Impacts of lighting efficiency – Energy audit and energy targeting- Technological options for energy management.		
UNIT – III	**INDOOR ENVIRONMENTAL QUALITY MANAGEMENT**	**9 Periods**
Psychrometry- Comfort conditions- Thermal comfort- Ventilation and air quality-Air conditioning requirement- Visual perception- Illumination requirement- Auditory requirement- Energy management options- Air conditioning systems- Energy conservation in pumps- Fans and blowers- Refrigerating machines- Heat rejection equipment- Energy efficient motors- Insulation.		
UNIT – IV	**GREEN BUILDING CONCEPTS**	**9 Periods**
Green building concept- Green building rating tools- Leeds and IGBC codes. – Material selection Embodied energy- Operating energy- Façade systems- Ventilation systems-Transportation- Water treatment systems- Water efficiency- Building economics		
UNIT – V	**GREEN BUILDING DESIGN - CASE STUDY**	**9 Periods**
Case studies - Building form, orientation and site considerations; conservation measures; energy modeling; heating system and fuel choices; renewable energy systems; material choices - construction budget		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

REFERENCES :

1	*Sam Kubba* ***"Handbook of Green Building Design and Construction: LEED, BREEAM, and Green Globes",*** *, Elsevier Science, 2012.*
2	*Yudelson, Jerry, McGraw-Hill,* ***"Greening existing buildings",*** *New York, 2010*
3	*Charles J. Kibert, John Wiley & Sons,* ***"Sustainable Construction: Green Building Design and Delivery****", 3rd Edition, 2012*
4	*R.S. Means, John Wiley & Sons,* ***"Green Building: Project Planning & Cost Estimating",*** *2010.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Apply the concepts of sustainable design in building construction.	K3
CO2	Execute green building techniques including energy efficiency management in the building design.	K3
CO3	Establish indoor environmental quality in green building.	K3
CO4	Perform the green building rating using various tools.	K3
CO5	Create drawings and models of green buildings.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	2	3	3	3
CO2	3	3	2	3	3	3
CO3	2	2	2	2	3	3
CO4	2	3	1	3	3	3
CO5	3	3	1	3	3	3
23SEOE03	3	3	2	3	3	3
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23EEOE04	ENVIRONMENT HEALTH AND SAFETY MANAGEMENT *(Common to all Branches)*

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

Course Objective	• To impart knowledge on occupational health hazards, safety measures at work place, accident prevention, safety management and safety measures in industries.	
UNIT – I	**OCCUPATIONAL HEALTH HAZARDS**	**9 Periods**
Occupation, Health and Hazards - Safety Health and Management: Occupational Health Hazards - Ergonomics - Importance of Industrial Safety - Radiation and Industrial Hazards: Types and effects - Vibration - Industrial Hygiene - Different air pollutants in industries and their effects - Electrical, fire and Other Hazards.		
UNIT – II	**SAFETY AT WORKPLACE**	**9 Periods**
Safety at Workplace - Safe use of Machines and Tools: Safety in use of different types of unit operations - Ergonomics of Machine guarding - working in different workplaces - Operation, Inspection and maintenance - Housekeeping, Industrial lighting, Vibration and Noise.		
UNIT – III	**ACCIDENT PREVENTION**	**9 Periods**
Accident Prevention Techniques - Principles of accident prevention - Hazard identification and analysis, Event tree analysis, Hazop studies, Job safety analysis - Theories and Principles of Accident causation - First Aid: Body structure and functions - Fracture and Dislocation, Injuries to various body parts.		
UNIT – IV	**SAFETY MANAGEMENT**	**9 Periods**
Safety Management System and Law - Legislative measures in Industrial Safety - Occupational safety, Health and Environment Management, Bureau of Indian Standards on Health and Safety, IS 14489 standards - OSHA, Process safety management (PSM) and its principles - EPA standards		
UNIT – V	**GENERAL SAFETY MEASURES**	**9 Periods**
Plant Layout for Safety - design and location, distance between hazardous units, lighting, colour coding, pilot plant studies, Housekeeping - Accidents Related with Maintenance of Machines - Work Permit System - Significance of Documentation - Case studies involving implementation of health and safety measures in Industries.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

REFERENCES:

1	***"Physical Hazards of the Workplace"****, Barry Spurlock, CRC Press, 2017.*
2	***"Handbook of Occupational Safety and Health",*** *S. Z. Mansdorf, Wiley Publications,2019*
3	***"Safety, Health, and Environment"****, NAPTA, 2nd Edition, Pearson Publications, 2019.*
4	*"**Occupational Health and Hygiene in Industries**", Raja Sekhar Mamillapalli, Visweswara Rao PharmaMed Press, 1st edition, 2021.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify the occupational health hazards.	K3
CO2	Execute various safety measures at workplace.	K3
CO3	Analyze and execute accident prevention techniques.	K3
CO4	Implement safety management as per various standards.	K3
CO5	Develop awareness on safety measures in Industries.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	2	2	2	3	2
CO2	2	2	2	1	2	2
CO3	2	3	2	1	2	2
CO4	1	1	1	2	2	2
CO5	1	1	1	1	1	2
23EEOE04	1	2	2	1	2	2
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	25	35	20	10	5	5	100
CAT2	25	35	20	10	5	5	100
Individual Assessment 1/ Case Study 1/ Seminar 1 / Project 1	20	40	30	10	-	-	100
Individual Assessment 2/ Case Study 2/ Seminar 2/ Project 2	20	40	30	10	-	-	100
ESE	25	35	20	10	5	5	100

23EEOE05	**CLIMATE CHANGE AND ADAPTATION** *(Common to all Branches)*

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

Course Objective	• To understand the Earth's climate system, changes and their effects on the earth, identifying the impacts, adaptation, mitigation of climate change and for gaining knowledge on clean technology, carbon trading and alternate energy sources.	
UNIT – I	**EARTH'S CLIMATE SYSTEM**	**9 Periods**
Introduction-Climate in the spotlight - The Earth's Climate Machine – Climate Classification- Global Wind Systems – Trade Winds and the Hadley Cell – The Westerlies – Cloud Formation and Monsoon Rains – Storms and Hurricanes - The Hydrological Cycle – Global Ocean Circulation – El Nino and its Effect - Solar Radiation – The Earth's Natural Green House Effect – Green House Gases and Global Warming – Carbon Cycle.		
UNIT – II	**OBSERVED CHANGES AND ITS CAUSES**	**9 Periods**
Observation of Climate Change – Changes in patterns of temperature, precipitation and sea level rise – Observed effects of Climate Changes – Patterns of Large-Scale Variability –Drivers of Climate Change – Climate Sensitivity and Feedbacks – The Montreal Protocol –UNFCCC – IPCC – Evidences of Changes in Climate and Environment – on a Global Scale and in India – climate change modeling.		
UNIT – III	**IMPACTS OF CLIMATE CHANGE**	**9 Periods**
Impacts of Climate Change on various sectors – Agriculture, Forestry and Ecosystem – Water Resources – Human Health – Industry, Settlement and Society – Methods and Scenarios –Projected Impacts for Different Regions – Uncertainties in the Projected Impacts of Climate Change – Risk of Irreversible Changes.		
UNIT – IV	**CLIMATE CHANGE ADAPTATION AND MITIGATION MEASURES**	**9 Periods**
Adaptation Strategy/Options in various sectors – Water – Agriculture –- Infrastructure and Settlement including coastal zones – Human Health – Tourism – Transport – Energy – Key Mitigation Technologies and Practices – Energy Supply – Transport – Buildings – Industry –Agriculture – Forestry - Carbon sequestration – Carbon capture and storage (CCS) – Waste (MSW & Bio waste, Biomedical, Industrial waste – International and Regional cooperation.		
UNIT – V	**CLEAN TECHNOLOGY AND ENERGY**	**9 Periods**
Clean Development Mechanism – Carbon Trading - examples of future Clean Technology –Biodiesel – Natural Compost – Eco- Friendly Plastic – Alternate Energy – Hydrogen – Biofuels– Solar Energy – Wind – Hydroelectric Power – Mitigation Efforts in India and Adaptation funding.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0Periods Practical: 0 Periods Total:45 Periods**		

REFERENCES

1	***"Impacts of Climate Change and Climate Variability on Hydrological Regimes",*** *Jan C. Van Dam, Cambridge University Press, 2003.*
2	*IPCC fourth assessment report - The AR4 synthesis report, 2007*
3	*IPCC fourth assessment report –Working Group I Report****, "The physical sciencebasis",****2007*
4	*IPCC fourth assessment report - Working Group II Report, "****Impacts, Adaptation and Vulnerability****", 2007*
5	*IPCC fourth assessment report – Working Group III Report" **Mitigation of Climate Change", 2007***
6	***"Climate Change and Water". Technical Paper of the Intergovernmental Panel on Climate Change,*** *Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds., IPCC Secretariat, Geneva, 2008.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Classify the Earths climatic system and factors causing climate change and global warming.	K2
CO2	Relate the Changes in patterns of temperature, precipitation and sea level rise and Observed effects of Climate Changes	K2
CO3	Illustrate the uncertainty and impact of climate change and risk of reversible changes.	K3
CO4	Articulate the strategies for adaptation and mitigation of climatic changes.	K3
CO5	Discover clean technologies and alternate energy source for sustainable growth.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	3	2	3	1
CO2	3	2	2	2	3	2
CO3	2	2	2	2	3	2
CO4	3	2	2	2	2	2
CO5	3	3	2	3	3	3
23EEOE05	3	3	3	3	3	3
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23EEOE06	**WASTE TO ENERGY** *(Common to all Branches)*

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

Course Objective	• To classify waste as fuel, introduce conversion devices, gain knowledge about Biomass Pyrolysis, demonstrate methods, factors for biomass gasification, and acquire knowledge about biogas and its development in India.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, Gasifiers, Digestors.		
UNIT – II	**BIOMASS PYROLYSIS**	**9 Periods**
Biomass Pyrolysis: Pyrolysis -Types, Slow Pyrolysis, Fast Pyrolysis – Manufacture of charcoal – Methods – Yields and Applications – Manufacture of Pyrolytic oils and gases, Yields and Applications.		
UNIT – III	**BIOMASS GASIFICATION**	**9 Periods**
Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, Construction and Operation – Gasifier burner arrangement for thermal heating – Gasifier Engine arrangement and electrical power – Equilibrium and Kinetic Considerations in gasifier operation.		
UNIT – IV	**BIOMASS COMBUSTION**	**9 Periods**
Biomass Combustion – Biomass Stoves – Improved Chullahs, types, some exotic designs, Fixed bed combustors, types – Inclined grate combustors – Fluidized bed combustors, design, construction and operation of all the above biomass combustors.		
UNIT – V	**BIOENERGY SYSTEM**	**9 Periods**
Biogas: Properties of biogas (Calorific value and composition) – Biogas plant technology and status – Bio energy system – Design and constructional features – Biomass resources and their classification - Biomass conversion processes – Thermo chemical conversion – Direct combustion – biomass gasification – pyrolysis and liquefaction – biochemical conversion – anaerobic digestion – Types of biogas plants – Applications – Alcohol production from biomass – Bio diesel production – Urban waste to energy conversion – Biomass energy programme in India.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

REFERENCES:

1	***"Energy Recovery from Municipal Solid Waste by Thermal Conversion Technologies",*** *P Jayaram Reddy, Taylor and Francis Publications, 2016.*
2	***"Waste – to – Energy: Technologies and project Implementations",*** *Marc J Rogoff, Francois Screve,ELSEVIER Publications, Third Edition, 2019.*
3	***"Biogas Technology and Principles"****, Brad Hill, NY RESEARCH PRESS Publications, Illustrated Edition, 2015.*
4	***"Biomass Gasification and Pyrolysis Practical Design and Theory"***,Prabir*ELSEVIER Publications, 2010.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Investigate solid waste management techniques.	K2
CO2	Get knowledge about biomass pyrolysis.	K3
CO3	Demonstrate methods and factors considered for biomass gasification.	K3
CO4	Identify the features of different facilities available for biomass combustion.	K4
CO5	Analyze the potential of different Bioenergy systems with respect to Indian condition.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	3	3	2	3	1
CO2	3	2	2	2	3	1
CO3	3	3	2	3	2	1
CO4	3	2	2	3	3	1
CO5	2	3	3	3	2	1
23EEOE06	3	3	3	3	3	1
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	20	20	25	15	10	100
CAT2	10	25	20	10	25	10	100
Individual Assessment 1/ Case Study 1/ Seminar 1 / Project 1	-	15	35	50	-	-	100
Individual Assessment 2/ Case Study 2/ Seminar 2/ Project 2	-	10	40	50	-	-	100
ESE	10	25	25	20	10	10	100

23GEOE07	**ENERGY IN BUILT ENVIRONMENT** *(Common to all Branches)*

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

Course Objective	• To understand constructional energy requirements of buildings, energy audit methods and conservation of energy.	
UNIT–I	**INTRODUCTION**	**9 Periods**
Indoor activities and environmental control - Internal and external factors on energy use – Characteristics of energy use and its management -Macro aspect of energy use in dwellings and its implications –Thermal comfort-Ventilation and air quality-Air-conditioning requirement-Visual perception-Illumination requirement-Auditory requirement.		
UNIT–II	**LIGHTING REQUIREMENTS IN BUILDING**	**9 Periods**
The sun-earth relationship - Climate, wind, solar radiation and temperature - Sun shading and solar radiation on surfaces-Energy impact on the shape and orientation of buildings–Lighting and day lighting :Characteristics and estimation, methods of day-lighting–Architectural considerations for day-lighting.		
UNIT–III	**ENERGY REQUIREMENTS IN BUILDING**	**9 Periods**
Steady and unsteady heat transfer through wall and glazed window-Standards for thermal performance of building envelope- Evaluation of the overall thermal transfer- Thermal gain and net heat gain-End-Use energy requirements-Status of energy use in buildings-Estimation of energy use in a building.		
UNIT–IV	**ENERGY AUDIT**	**9 Periods**
Energy audit and energy targeting-Technological options for energy management-Natural and forced ventilation–Indoor environment and air quality-Air flow and air pressure on buildings-Flow due to Stack effect.		
UNIT–V	**COOLING IN BUILT ENVIRONMENT**	**9 Periods**
Passive building architecture–Radiative cooling-Solar cooling techniques-Solar desiccant dehumidification for ventilation-Natural and active cooling with adaptive comfort–Evaporative cooling –Zero energy building concept.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Period Practical: 0 Period Total: 45 Periods**		

REFERENCES

1	*J.Krieder and A.Rabl**, "Heating and Cooling of Buildings: Design for Efficiency"**, McGraw-Hill, 2000.*
2	*S.M.Guinnes and Reynolds, "**Mechanical and Electrical Equipment for Buildings"**,Wiley, 1989.*
3	*A.Shaw, "**Energy Design for Architects"**, AEE Energy Books, 1991.*
4	*ASHRAE,"**Hand book of Fundamentals"**,ASHRAE,Atlanta,GA.,2001.*
5	*Reference Manuals of DOE-2 (1990), Orlando Lawrence-Berkeley Laboratory, University of California, and Blast, University of Illinois ,USA.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand energy and its usage	K2
CO2	Know lighting to be given to a building	K1
CO3	Analyse the energy requirements in a building	K3
CO4	Apply the energy audit concepts.	K3
CO5	Study architectural specifications of a building	K1

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	-	3	1	2	1
CO2	2	-	3	1	2	1
CO3	2	-	3	1	2	1
CO4	2	-	3	1	2	1
CO5	2	-	3	1	2	1
23GEOE07	2	-	3	1	2	1
1–Slight, 2–Moderate, 3–Substantial						

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

23GEOE08	**EARTH AND ITS ENVIRONMENT** *(Common to all Branches)*

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

Course Objective	• To know about the planet earth, the geosystems and the resources like ground water and air and to learn about the Environmental Assessment and sustainability.	
UNIT–I	**EVOLUTION OF EARTH**	**9 Periods**
Evolution of earth as habitable planet-Evolution of continents-oceans and landforms-evolution of life through geological times - Exploring the earth's interior - thermal and chemical structure - origin of gravitational and magnetic fields.		
UNIT–II	**GEOSYSTEMS**	**9 Periods**
Plate tectonics - working and shaping the earth - Internal geosystems – earthquakes – volcanoes - climatic excursions through time - Basic Geological processes - igneous, sedimentation – metamorphic processes.		
UNIT–III	**GROUND WATER GEOLOGY**	**9 Periods**
Geology of ground water occurrence –recharge process-Ground water movement-Ground water discharge and catchment hydrology – Ground water as a resource - Natural ground water quality and contamination-Modelling and managing ground water systems.		
UNIT–IV	**ENVIRONMENTAL ASSESMENT AND SUSTAINABILITY**	**9 Periods**
Engineering and sustainable development - population and urbanization - toxic chemicals and finite resources - water scarcity and conflict - Environmental risk - risk assessment and characterization – hazard assessment-exposure assessment.		
UNIT–V	**AIR AND SOLIDWASTE**	**9 Periods**
Air resources engineering-introduction to atmospheric composition–behaviour-atmospheric photo chemistry-Solid waste management–characterization-management concepts.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Period Practical: 0 Period Total: 45 Periods**		

REFERENCES

1	*John Grotzinger and Thomas H.Jordan, "**Understanding Earth",** Sixth Edition, W.H.Freeman, 2010.*
2	*Younger,P.L., "**Ground water in the Environment: An introduction"**, Blackwell Publishing,2007.*
3	*Mihelcic, J. R., Zimmerman, J. B., "**Environmental Engineering:Fundamentals, Sustainability and Design"**,Wiley,NJ, 2010.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	To know about evolution of earth and the structure of the earth.	K2
CO2	To understand the internal geosystems like earthquakes and volcanoes and the Various geological processes.	K2
CO3	To able to find the geological process of occurrence and movement of Ground water and the modeling systems.	K3
CO4	To assess the Environmental risks and the sustainability developments.	K3
CO5	To learn about the photochemistry of atmosphere and the solid waste Management concepts.	K1

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	-	-	2	2	-
CO2	3	-	3	3	-	3
CO3	2	-	-	-	-	-
CO4	-	2	-	-	1	-
CO5	2	2	-	1	-	-
23GEOE08	2	2	3	3	2	3
1–Slight, 2–Moderate, 3–Substantial						

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

23GEOE09	NATURAL HAZARDS AND MITIGATION *(Common to all Branches)*

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

Course Objective	• To get idea on the causes, effects and mitigation measures of different types of hazards with case studies.	
UNIT–I	**EARTH QUAKES**	**9 Periods**
Definitions and basic concepts-different kinds of hazards–causes-Geologic Hazards–Earthquakes-causes of earthquakes–effects-plate tectonics-seismic waves-measures of size of earthquakes-earthquake resistant design concepts.		
UNIT–II	**SLOPE STABILITY**	**9 Periods**
Slope stability and landslides-causes of landslides–principles of stability analysis-remedial and corrective measures for slope stabilization.		
UNIT–III	**FLOODS**	**9 Periods**
Climatic Hazards–Floods-causes of flooding-regional flood frequency analysis–flood control measures-flood routing-flood forecasting-warning systems.		
UNIT–IV	**DROUGHTS**	**9 Periods**
Droughts –causes - types of droughts –effects of drought -hazard assessment – decision making-Use of GIS in natural hazard assessment–mitigation-management.		
UNIT–V	**TSUNAMI**	**9 Periods**
Tsunami–causes–effects–under sea earthquakes–landslides–volcanic eruptions–impact of sea meteorite–remedial measures–precautions–case studies.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Period Practical: 0 Period Total: 45 Periods**		

REFERENCES

1	*Donald Hyndman and David Hyndman,* ***"Natural Hazards and Disasters",*** *Brooks/Cole Cengage Learning, 2008.*
2	*Edward Bryant,* ***"Natural Hazards"****, Cambridge University Press,2005.*
3	*J Michael Duncan and Stephan G Wright,* ***"Soil Strength and Slope Stability"****, John Wiley & Sons, Inc,2005.*
4	*AmrS.Elnashai and Luigi Di Sarno,****"Fundamentals of Earthquake Engineering"****, John Wiley & Sons,Inc,2008*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Learn the basic concepts of earthquakes and the design concepts of earthquake Resistant buildings.	K2
CO2	Acquire knowledge on the causes and remedial measures of slope stabilization.	K3
CO3	As certain the causes and control measures of flood.	K3
CO4	Know the types, causes and mitigation of droughts.	K2
CO5	Study the causes, effects and precautionary measures of Tsunami.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	-	3	2	3
CO2	3	1	2	3	3	3
CO3	3	2	3	-	-	3
CO4	3	-	-	3	2	3
CO5	3	-	2	2	-	3
23GEOE09	3	1	2	3	2	3
1–Slight, 2–Moderate, 3–Substantial						

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

23EDOE10	**BUSINESS ANALYTICS** *(Common to all Branches)*

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

Course Objectives	• To apprehend the fundamentals of business analytics and its life cycle. • To gain knowledge about fundamental business analytics. • To study modeling for uncertainty and statistical inference. • To apprehend analytics the usage of Hadoop and Map Reduce frameworks. • To acquire insight on other analytical frameworks.	
UNIT – I	**BUSINESS ANALYTICS AND PROCESS**	**9 Periods**
Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organization, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling andestimation methods overview.		
UNIT – II	**REGRESSION ANALYSIS**	**9 Periods**
Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.		
UNIT – III	**STRUCTURE OF BUSINESS ANALYTICS**	**9 Periods**
Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.		
UNIT – IV	**FORECASTING TECHNIQUES**	**9 Periods**
Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.		
UNIT – V	**DECISION ANALYSIS AND RECENT TRENDS IN BUSINESS ANALYTICS**	**9 Periods**
Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making. Recent Trends: Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism		
Lecture: 45 Periods	**Tutorial: 0 Periods**	**Practical:0Periods** **Total:45 Periods**

REFERENCES

1	*VigneshPrajapati,* ***"Big Data Analytics with R and Hadoop",****Packt Publishing, 2013.*
2	*Umesh R Hodeghatta, UmeshaNayak,* ***"Business Analytics Using R – A Practical Approach",****Apress, 2017.*
3	*AnandRajaraman, Jeffrey David Ullman,* ***"Mining of Massive Datasets",*** *Cambridge University Press, 2012.*
4	*Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson,* ***"Essentials of Business Analytics",*** *Cengage Learning, second Edition, 2016.*
5	*U. Dinesh Kumar,* ***"Business Analytics: TheScience of Data-Driven Decision Making",*** *Wiley, 2017.*
6	*Rui Miguel Forte,* ***"Mastering Predictive Analytics with R",*** *Packt Publication, 2015.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify the real world business problems and model with analytical solutions.	K4
CO2	Solve analytical problem with relevant mathematics background knowledge.	K4
CO3	Convert any real world decision making problem to hypothesis and apply suitable statistical testing.	K4
CO4	Write and Demonstrate simple applications involving analytics using Hadoop and Map Reduce	K4
CO5	Use open source frameworks for modeling and storing data.	K4

COURSE ARTICULATION MATRIX					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	1	2	1	2	1
CO2	1	1	1	2	1
CO3	2	2	1	1	-
CO4	2	2	1	-	-
CO5	1	2	-	-	-
23EDOE10	1	2	1	2	1
1 – Slight, 2 – Moderate, 3 – Substantial					

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

23EDOE11	**INTRODUCTION TO INDUSTRIAL SAFETY** *(Common to all Branches)*

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

Course Objectives	• Summarize basics of industrial safety. • Describe fundamentals of maintenance engineering. • Explain wear and corrosion. • Illustrate fault tracing. • Identify preventive and periodic maintenance.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc., Safety color codes. Fire prevention and firefighting, equipment and methods.		
UNIT – II	**FUNDAMENTALS OF MAINTENANCE ENGINEERING**	**9 Periods**
Definition and aim of maintenance engineering, Primary and secondary functions andresponsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.		
UNIT – III	**WEAR AND CORROSION AND THEIR PREVENTION**	**9 Periods**
Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.		
UNIT – IV	**FAULT TRACING**	**9 Periods**
Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault-finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.		
UNIT – V	**PERIODIC AND PREVENTIVE MAINTENANCE**	**9 Periods**
Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance		
Lecture: 45 Periods	**Tutorial: 0 Periods**	**Practical:0Periods** **Total:45 Periods**

REFERENCES

1	*Hans F. Winterkorn,* ***"Foundation Engineering Handbook",*** *Chapman & Hall London,2013.*
2	***"Maintenance Engineering"*** *by Dr. Siddhartha Ray, New Age International (P) Ltd., Publishers, 2017*
3	***"Industrial Safety Management",****McGraw Hill Education; New edition (1 July 2017)*
4	***"Industrial Engineering And Production Management",*** *S. Chand Publishing; Third edition ,2018*
5	***"Industrial Safety and Maintenance Engineering",****Parth B. Shah, 2021.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Ability to summarize basics of industrial safety	K4
CO2	Ability to describe fundamentals of maintenance engineering	K4
CO3	Ability to explain wear and corrosion	K4
CO4	Ability to illustrate fault tracing	K4
CO5	Ability to identify preventive and periodic maintenance	K4

COURSE ARTICULATION MATRIX					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2	1	1	-	-
CO2	2	2	1	-	1
CO3	1	2	1	1	1
CO4	2	1	1	1	1
CO5	2	1	2	1	1
23EDOE11	2	1	1	1	1
1 – Slight, 2 – Moderate, 3 – Substantial					

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

23EDOE12	**OPERATIONS RESEARCH** *(Common to all Branches)*

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

Course Objectives	• Solve linear programming problem and solve using graphical method. • Solve LPP using simplex method. • Solve transportation, assignment problems. • Solve project management problems. • Solve scheduling problems.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models		
UNIT – II	**LINEAR PROGRAMMING PROBLEM**	**9 Periods**
Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming		
UNIT – III	**NON-LINEAR PROGRAMMING PROBLEM**	**9 Periods**
Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT		
UNIT – IV	**SEQUENCING AND INVENTORY MODEL**	**9 Periods**
Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.		
UNIT – V	**GAME THEORY**	**9 Periods**
Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation		
Lecture: 45 Periods	**Tutorial: 0 Periods** **Practical:0Periods** **Total:45 Periods**	

REFERENCES

1	*H.A. Taha**"Operations Research, An Introduction",** PHI, 2017.*
2	***"Industrial Engineering and Management",** O. P. Khanna, 2017.*
3	***"Operations Research",** S.K. Patel, 2017.*
4	***"Operation Research",**AnupGoel, RuchiAgarwal, Technical Publications, Jan 2021.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Formulate linear programming problem and solve using graphical method.	K4
CO2	Solve LPP using simplex method.	K4
CO3	Formulate and solve transportation, assignment problems.	K4
CO4	Solve project management problems.	K4
CO5	Solve scheduling problems	K4

COURSE ARTICULATION MATRIX					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2	1	1	-	-
CO2	2	2	1	-	-
CO3	1	1	2	1	1
CO4	1	1	-	-	-
CO5	2	1	-	-	-
23EDOE12	2	1	1	1	1
1 – Slight, 2 – Moderate, 3 – Substantial					

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

23MFOE13	**OCCUPATIONAL HEALTH AND SAFETY** *(Common to all Branches)*

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

Course Objectives	• To gain knowledge about occupational health hazard and safety measures at work place. • To learn about accident prevention and safety management. • To learn about general safety measures in industries.	
UNIT – I	**OCCUPATIONAL HEALTH AND HAZARDS**	**9 Periods**
Safety- History and development, National Safety Policy- Occupational Health Hazards - Ergonomics - Importance of Industrial Safety Radiation and Industrial Hazards- Machine Guards and its types, Automation.		
UNIT – II	**SAFETY AT WORKPLACE**	**9 Periods**
Safety at Workplace - Safe use of Machines and Tools: Safety in use of different types of unit operations - Ergonomics of Machine guarding - working in different workplaces - Operation, Inspection and maintenance, Plant Design and Housekeeping, Industrial lighting, Vibration and Noise Case studies.		
UNIT – III	**ACCIDENT PREVENTION**	**9 Periods**
Accident Prevention Techniques - Principles of accident prevention - Definitions, Theories, Principles – Hazard identification and analysis, Event tree analysis, Hazop studies, Job safety analysis - Theories and Principles of Accident causation - First Aid : Body structure and functions - Fracture and Dislocation, Injuries to various body parts.		
UNIT – IV	**SAFETY MANAGEMENT**	**9 Periods**
Safety Management System and Law - Legislative measures in Industrial Safety: Various acts involved in Detail- Occupational safety, Health and Environment Management: Bureau of Indian Standards on Health and Safety, 14489, 15001 - OSHA, Process safety management (PSM) and its principles - EPA standards- Safety Management: Organisational & Safety Committee - its structure and functions.		
UNIT – V	**GENERAL SAFETY MEASURES**	**9 Periods**
Plant Layout for Safety -design and location, distance between hazardous units, lighting, colour coding, pilot plant studies, Housekeeping - Accidents Related with Maintenance of Machines - Work Permit System: Significance of Documentation Directing Safety, Leadership -Case studies involving implementation of health and safety measures in Industries.		
Lecture: 45 Periods	**Tutorial: 0 Periods**	**Practical:0 Periods** **Total:45 Periods**

REFERENCES:

1	*Benjamin O.Alli,* ***Fundamental Principles of Occupational Health and Safety*** *ILO 2008.*
2	*Danuta Koradecka,* ***Handbook of Occupational Health and Safety****, CRC, 2010.*
3	*Dr. Siddhartha Ray,* ***Maintenance Engineering,*** *New Age International (P) Ltd., Publishers, 2017*
4	*Deshmukh. L.M.,* ***Industrial Safety Management****, 3rd Edition, Tata McGraw Hill, New Delhi, 2008.*
5	*https://nptel.ac.in/courses/110105094*
6	*https://archive.nptel.ac.in/courses/110/105/110105094/*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Gain the knowledge about occupational health hazard and safety measures at work place.	K3
CO2	Learn about accident prevention and safety management.	K2
CO3	Understand occupational health hazards and general safety measures in industries.	K3
CO4	Know various laws, standards and legislations.	K2
CO5	Implement safety and proper management of industries.	K4

COURSE ARTICULATION MATRIX:					
Cos/Pos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2	1	1	1	1
CO2	2	2	1	1	1
CO3	1	2	1	1	1
CO4	2	1	1	1	1
CO5	2	1	2	1	1
23MFOE13	**2**	**1**	**1**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial					

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

23MFOE14	COST MANAGEMENT OF ENGINEERING PROJECTS *(Common to all Branches)*				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objectives	• To understand the costing concepts and their role in decision making. • To acquire the project management concepts and their various aspects in selection. • To gain the knowledge in costing concepts with project execution. • To develop knowledge of costing techniques in service sector and various budgetary control techniques. • To familiarize with quantitative techniques in cost management.	
UNIT – I	**INTRODUCTION TO COSTING CONCEPTS**	**9 Periods**
Introduction and Overview of the Strategic Cost Management Process, Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision - Making.		
UNIT – II	**PROJECT PLANNING ACTIVITIES**	**9 Periods**
Project: meaning, Different types, why to manage, cost overruns centers, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process.		
UNIT – III	**COST ANALYSIS**	**9 Periods**
Cost Behaviour and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis.		
UNIT – IV	**PRICING STRATEGIES AND BUDGETORY CONTROL**	**9 Periods**
Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing, Costing of service sector, Just-in - time approach, Material Requirement Planning, Enterprise Resource Planning. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.		
UNIT – V	**TQM AND OPERATIONS REASEARCH TOOLS**	**9 Periods**
Total Quality Management and Theory of constraints, Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.		
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods		

REFERENCES:

1	*Charles T. Horngren and George Foster,* ***Advanced Management Accounting****, 2018.*
2	*John M. Nicholas,****Project Management for Engineering, Business and Technology****, Taylor &Francis, 2016*
3	*Nigel J,* ***Engineering Project Management****, John Wiley and Sons Ltd, Smith 2015.*
4	*Charles T. Horngren and George Foster* ***Cost Accounting a Managerial Emphasis****, Prentice Hall of India, New Delhi, 2011.*
5	*https://archive.nptel.ac.in/courses/110/104/110104073/*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Apply the costing concepts and their role in decision making.	K3
CO2	Apply the project management concepts and analyze their various aspects in selection.	K4
CO3	Interpret costing concepts with project execution.	K4
CO4	Gain knowledge of costing techniques in service sector and various budgetary control techniques.	K2
CO5	Become familiar with quantitative techniques in cost management.	K3

COURSE ARTICULATION MATRIX:

COs/Pos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	1	1	2	1	1
CO2	2	1	1	1	-
CO3	2	2	2	-	-
CO4	1	1	1	1	1
CO5	1	2	1	1	-
23MFOE14	1	1	1	1	1
1 – Slight, 2 – Moderate, 3 – Substantial					

ASSESSMENT PATTERN – THEORY

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

23MFOE15	**COMPOSITE MATERIALS** *(Common to all Branches)*

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

Course Objectives	• To summarize the characteristics of composite materials and effect of reinforcement in composite materials. • To identify the various reinforcements used in composite materials. • To compare the manufacturing process of metal matrix composites. • To understand the manufacturing processes of polymer matrix composites. • To analyze the strength of composite materials.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement on overall composite performance.		
UNIT – II	**REINFORCEMENT**	**9 Periods**
Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isosteresconditions.		
UNIT – III	**MANUFACTURING OF METAL MATRIX COMPOSITES**	**9 Periods**
Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing- Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering–Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving- Properties and applications.		
UNIT – IV	**MANUFACTURING OF POLYMER MATRIX COMPOSITE**	**9 Periods**
Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method –Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.		
UNIT – V	**STRENGTH ANALYSIS OF COMPOSITES**	**9 Periods**
Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.		
Lecture: 45 Periods	**Tutorial: 0 Periods**	**Practical: 0 Periods** **Total: 45 Periods**

REFERENCES:

1	*Chawla K.K., **Composite Materials**, Springer, 2013.*
2	*Lubin.G, **Hand Book of Composite Materials**, Springer New York, 2013.*
3	*Deborah D.L. Chung, **Composite Materials Science and Applications**, Springer, 2011.*
4	*uLektz, **Composite Materials and Mechanics**, uLektz Learning Solutions Private Limited, Lektz, 2013.*
5	*https://nptel.ac.in/courses/112104168*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Know the characteristics of composite materials and effect of reinforcement in composite materials.	K2
CO2	Know the various reinforcements used in composite materials.	K2
CO3	Understand and apply the manufacturing processes of metal matrix composites	K3
CO4	Understand and apply the manufacturing processes of polymer matrix composites.	K3
CO5	Analyze the strength of composite materials.	K4

COURSE ARTICULATION MATRIX:					
COs/Pos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	1	2	1	1	1
CO2	2	2	1	1	2
CO3	2	1	2	1	1
CO4	1	2	2	2	1
CO5	1	2	1	1	1
23MFOE15	**1**	**2**	**2**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial					

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

23TEOE16	GLOBAL WARMING SCIENCE *(Common to all Branches)*

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

Course Objective	• To make the students learn about the material consequences of climate change, sea level change due to increase in the emission of greenhouse gases and to examine the science behind mitigation and adaptation proposals.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Terminology relating to atmospheric particles – Aerosols - Types, characteristics, measurements – Particle mass spectrometry - Anthropogenic-sources, effects on humans.		
UNIT – II	**CLIMATE MODELS**	**9 Periods**
General climate modeling- Atmospheric general circulation model - Oceanic general circulation model, sea ice model, land model concept, paleo-climate - Weather prediction by numerical process. Impacts of climate change - Climate Sensitivity - Forcing and feedback.		
UNIT – III	**EARTH CARBON CYCLE AND FORECAST**	**9 Periods**
Carbon cycle-process, importance, advantages - Carbon on earth - Global carbon reservoirs - Interactions between human activities and carbon cycle - Geologic time scales - Fossil fuels and energy - Perturbed carbon cycle.		
UNIT – IV	**GREENHOUSE GASES**	**9 Periods**
Blackbody radiation - Layer model - Earth's atmospheric composition and Green house gases effects on weather and climate - Radioactive equilibrium - Earth's energy balance.		
UNIT – V	**GEO ENGINEERING**	**9 Periods**
Solar mitigation - Strategies – Carbon dioxide removal - Solar radiation management - Recent observed trends in global warming for sea level rise, drought, glacier extent.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0Periods Practical: 0 Periods Total: 45 Periods**		

REFERENCES:

1	*Eli Tziperman,* ***"Global Warming Science: A Quantitative Introduction to Climate Change and Its Consequences"****, Princeton University Press, 1st Edition, 2022.*
2	*John Houghton,* ***"Global warming: The Complete Briefing"****, Cambridge University Press, 5th Edition, 2015.*
3	*David Archer,* ***"Global warming: Understanding the Forecast"****, Wiley, 2nd Edition, 2011.*
4	*David S.K. Ting, Jacqueline A Stagner,* ***"Climate Change Science: Causes, Effects and Solutions for Global Warming"****, Elsevier, 1st Edition, 2021.*
5	*Frances Drake,* ***"Global Warming: The Science of Climate Change"****,Routledge, 1st edition, 2000.*
6	*Dickinson,* ***"Climate Engineering-A review of aerosol approaches to changing the global energybalance"****, Springer, 1996.*
7	*Andreas Schmittner,* ***"Introduction to Climate Science"****, Oregon State University, 2018.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the global warming in relation to climate changes throughout the earth.	K2
CO2	Assess the best predictions of current climate models.	K4
CO3	Understand the importance of carbon cycle and its implication on fossil fuels.	K2
CO4	Know about current issues, including impact from society, environment, economy as well as ecology related to greenhouse gases.	K4
CO5	Know the safety measures and precautions regarding global warming.	K5

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	2	1	1	2
CO2	1	1	2	1	1	1
CO3	1	2	1	1	1	2
CO4	1	1	1	1	1	2
CO5	2	1	2	1	1	2
23TEOE16	1	1	1	1	1	2
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23TEOE17	**INTRODUCTION TO NANO ELECTRONICS** *(Common to all Branches)*

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

Course Objective	• To make the students provide strong, essential, important methods and foundations of quantum mechanics and apply quantum mechanics on engineering fields.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Particles and Waves - Operators in quantum mechanics - The Postulates of quantum mechanics - The Schrodinger equation values and wave packet Solutions - Ehrenfest's Theorem.		
UNIT – II	**ELECTRONIC STRUCTURE AND MOTION**	**9 Periods**
Atoms- The Hydrogen Atom - Many-Electron Atoms – Pseudopotentials, Nuclear Structure, Molecules, Crystals - Translational motion – Penetration through barriers – Particle in a box - Two terminal quantum dot devices - Two terminal quantum wire devices.		
UNIT – III	**SCATTERING THEORY**	**9 Periods**
The formulation of scattering events - Scattering cross section - Stationary scattering state - Partial wave stationary scattering events - multi-channel scattering - Solution for Schrodinger equation- Radial and wave equation - Greens' function.		
UNIT – IV	**CLASSICAL STATISTICS**	**9 Periods**
Probabilities and microscopic behaviours - Kinetic theory and transport processes in gases - Magnetic properties of materials - The partition function.		
UNIT – V	**QUANTUM STATISTICS**	**9 Periods**
Statistical mechanics - Basic Concepts - Statistical models applied to metals and semiconductors - The thermal properties of solids- The electrical properties of materials - Black body radiation - Low temperatures and degenerate systems.		
Contact Periods: **Lecture:45 Periods Tutorial: 0 Periods Practical: 0 Periods Total:45 Periods**		

REFERENCES:

1	*Vladimi V.Mitin, Viatcheslav A. Kochelap and Michael A.Stroscio,* **"*Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications"***, *Cambridge University Press, 1st Edition, 2007.*
2	*Vinod Kumar Khanna,* **"*Introductory Nanoelectronics: Physical Theory and Device Analysis"***, *Routledge, 1st Edition, 2020.*
3	*George W. Hanson,* **"*Fundamentals of Nanoelectronics"***, *Pearson Publishers, United States Edition, 2007.*
4	*Marc Baldo,* ***"Introduction to Nanoelectronics"****, MIT Open Courseware Publication, 2011.*
5	*Vladimi V.Mitin,* **"*Introduction to Nanoelectronics"***, *Cambridge University Press, South Asian Edition, 2009.*
6	*Peter L. Hagelstein, Stephen D. Senturia and Terry P. Orlando, "**Introductory Applied Quantum Statistical Mechanics"**, Wiley, 2004.*
7	*A. F. J. Levi, **"Applied Quantum Mechanics"**, 2nd Edition, Cambridge, 2012.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the postulates of quantum mechanics.	K2
CO2	Know about nano electronic systems and building blocks.	K2
CO3	Solve the Schrodinger equation in 1D, 2D and 3Ddifferent applications.	K4
CO4	Learn the concepts involved in kinetic theory of gases.	K2
CO5	Know about statistical models applies to metals and semiconductor.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	1	1	1	1	1
CO2	2	2	1	1	1	1
CO3	2	2	2	1	1	1
CO4	1	1	1	1	1	1
CO5	1	1	1	1	1	1
23TEOE17	1	1	1	1	1	1
1 – Slight, 2 – Moderate, 3 – Substantial						

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

22TEOE18	**GREEN SUPPLY CHAIN MANAGEMENT** *(Common to all Branches)*

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

Course Objective	• To make the students learn and focus on the fundamental strategies, tools and techniques required to analyze and design environmentally sustainable supply chain systems.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Intro to SCM – complexity in SCM, Facility location - Logistics – Aim, activities, importance, progress, current trends - Integrating logistics with an organization.		
UNIT – II	**ESSENTIALS OF SUPPLY CHAIN MANAGEMENT**	**9 Periods**
Basic concepts of supply chain management - Supply chain operations – Planning and sourcing - Making and delivering - Supply chain coordination and use of technology - Developing supply chain systems.		
UNIT – III	**PLANNING THE SUPPLY CHAIN**	**9 Periods**
Types of decisions – strategic, tactical, operational - Logistics strategies, implementing the strategy - Planning resources – types, capacity, schedule, controlling material flow, measuring and improving performance.		
UNIT – IV	**ACTIVITIES IN THE SUPPLY CHAIN**	**9 Periods**
Procurement – cycle, types of purchase – Framework of e-procurement - Inventory management – EOQ, uncertain demand and safety stock, stock control - Material handling – Purpose of warehouse and ownership, layout, packaging - Transport – mode, ownership, vehicle routing and scheduling models- Travelling salesman problems - Exact and heuristic methods.		
UNIT – V	**SUPPLY CHAIN MANAGEMENT STRATEGIES**	**9 Periods**
Five key configuration components - Four criteria of good supply chain strategies - Next generation strategies- New roles for end-to-end supply chain management - Evolution of supply chain organization – International issues in SCM – Regional differences in logistics.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

REFERENCES:

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

3	*Joseph Sarkis and Yijie Dou,* ***"Green Supply Chain Management"****, Routledge, 1st Edition, 2017.*
4	*Arunachalam Rajagopal,* ***"Green Supply Chain Management: A Practical Approach"****, Replica, 2021.*
5	*Mehmood Khan, Matloub Hussain and Mian M. Ajmal,* ***"Green Supply Chain Management for Sustainable Business Practice"****, IGI Global, 1st Edition, 2016.*
6	*S Emmett,* ***"Green Supply Chains: An Action Manifesto"****, John Wiley & Sons Inc, 2010.*
7	*Joseph Sarkis and Yijie Dou,* ***"Green Supply Chain Management: A Concise Introduction"****, Routledge, 1st Edition, 2017.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Integrate logistics with an organization.	K2
CO2	Evaluate complex qualitative and quantitative data to support strategic and operational decisions.	K5
CO3	Develop self-leadership strategies to enhance personal and professional effectiveness.	K3
CO4	Analyze inventory management models and dynamics of supply chain.	K4
CO5	Identify issues in international supply chain management and outsources strategies.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	1	1	1	1	3
CO2	2	2	1	1	1	1
CO3	2	1	2	1	1	1
CO4	2	2	1	1	2	2
CO5	1	1	2	1	1	3
23TEOE18	2	1	1	1	1	2
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23PSOE19	**DISTRIBUTION AUTOMATION SYSTEM** *(Common to all Branches)*

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

Course Objective	• To study about the distributed automation and economic evaluation schemes of power network	
UNIT – I	**INTRODUCTION**	**9 Periods**
Introduction to Distribution Automation (DA) - Control system interfaces- Control and data requirements- Centralized (vs) decentralized control- DA system-DA hardware-DAS software.		
UNIT – II	**DISTRIBUTION AUTOMATION FUNCTIONS**	**9 Periods**
DA capabilities - Automation system computer facilities- Management processes- Information management- System reliability management- System efficiency management- Voltage management- Load management.		
UNIT – III	**COMMUNICATION SYSTEMS**	**9 Periods**
Communication requirements - reliability- Cost effectiveness- Data requirements- Two way capability- Communication during outages and faults - Ease of operation and maintenance- Conforming to the architecture of flow. Distribution line carrier- Ripple control-Zero crossing technique- Telephone, cableTV, radio, AM broadcast, FM SCA,VHF radio, microwave satellite, fiber optics-Hybrid communication systems used in field tests.		
UNIT – IV	**ECONOMIC EVALUATION METHODS**	**9 Periods**
Development and evaluation of alternate plans- select study area – Select study period- Project load growth- Develop alternatives- Calculate operating and maintenance costs-Evaluate alternatives.		
UNIT – V	**ECONOMIC COMPARISON**	**9 Periods**
Economic comparison of alternate plans-Classification of expenses - capital expenditures-Comparison of revenue requirements of alternative plans-Book life and continuing plant analysis- Year by year revenue requirement analysis, Short term analysis- End of study adjustment-Break even analysis, sensitivity analysis - Computational aids.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

REFERENCES

1	*M.K. Khedkar, G.M. Dhole, **"A Textbook of Electric Power Distribution Automation"**, Laxmi Publications, Ltd., 2010.*
2	*Maurizio Di Paolo Emilio, **"Data Acquisition Systems: From Fundamentals to Applied Design"**, Springer Science & Business Media, 21-Mar-2013*
3	*IEEE Tutorial course **"Distribution Automation"**, IEEE Working Group on Distribution Automation, IEEE Power Engineering Society. Power Engineering Education Committee, IEEE Power Engineering Society. Transmission and Distribution Committee, Institute of Electrical and Electronics Engineers, 1988*
4	*Taub, **"Principles Of Communication Systems",** Tata McGraw-Hill Education, 07-Sep-2008*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Analyse the requirements of distributed automation	K1
CO2	Know the functions of distributed automation	K2
CO3	Perform detailed analysis of communication systems for distributed automation.	K3
CO4	Study the economic evaluation method	K4
CO5	Understand the comparison of alternate plans	K5

COURSE ARTICULATION MATRIX				
COs/Pos	**PO1**	**PO2**	**PO3**	**PO4**
CO1	2	-	1	3
CO2	3	-	3	2
CO3	3	-	3	2
CO4	3	-	3	1
CO5	2	-	1	2
23PS0E19	3	-	3	2
1 – Slight, 2 – Moderate, 3 – Substantial				

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Rememberin g (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20%	30%	20%	10%	20%	-	100%
CAT2	20%	20%	20%	20%	20%	-	100%
Individual Assessment1/ Case study1/ Seminar 1/Project1	20%	10%	30%	20%	20%	-	100%
Individual Assessment2/ Case study2/ Seminar 2 /Project2	20%	30%	10%	20%	20%	-	100%
ESE	30%	20%	20%	20%	10%	-	100%

23PSOE20	**ELECTRICITY TRADING AND ELECTRICITY ACTS** *(Common to all Branches)*

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

Course Objective	• To acquire expertise on Electric supply and demand of Indian Grid, gain exposure on energy trading in the Indian market and infer the electricity acts and regulatory authorities.	
UNIT – I	**ENERGY DEMAND**	**9 Periods**
Basic concepts in Economics - Descriptive Analysis of Energy Demand - Decomposition Analysis and Parametric Approach - Demand Side Management - Load Management - Demand Side Management - Energy Efficiency - Rebound Effect		
UNIT – II	**ENERGY SUPPLY**	**9 Periods**
Supply Behavior of a Producer - Energy Investment - Economics of Non-renewable Resources - Economics of Renewable Energy Supply Setting the context - Economics of Renewable Energy Supply - Economics of Electricity Supply		
UNIT – III	**ENERGY MARKET**	**9 Periods**
Perfect Competition as a Market Form - Why is the Energy Market not Perfectly Competitive? - Market Failure and Monopoly - Oil Market: Pre OPEC Era I - Oil Market: Pre OPEC Era II - Oil Market: OPEC		
UNIT – IV	**LAW ON ELECTRICITY**	**9 Periods**
Introduction of the Electricity Law; Constitutional Design - Evolution of Laws on Electricity Salient Features of Electricity Act, 2003 - Evolution of Laws on Electricity - Salient Features of the Electricity Act 2003		
UNIT – V	**REGULATORY COMMISSIONS FOR ELECTRICITY ACT**	**9 Periods**
Regulatory Commissions - Appellate Tribunal - Other Institutions under the Act - Electricity (Amendment) Bill 2020/2021. A Critical Comment - Renewable Energy - Role of Civil Society; Comments on Draft Renewable Energy Act, 2015		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

REFERENCES

1	*Bhattacharyya, Subhes. C. (2011).* ***"Energy Economics: Concepts, Issues, Markets and Governance"****. Springer.London, UK*
2	*Stevens, P. (2000).* ***"An Introduction to Energy Economics. In Stevens, P.(ed.) The Economics of Energy"****, Vol.1, Edward Elgar, Cheltenham, UK.*
3	*Nausir Bharucha,* ***"Guide to the Electricity Laws"****, LexisNexis, 2018*
4	*Mohammad Naseem,* ***"Energy Laws in India"****, Kluwer Law International, 3rd Edn, The Netherlands, 2017.*
5	*Alok Kumar & Sushanta K Chaterjee,* ***"Electricity Sector in India: Policy and Regulation"****, OUP, 2012.*
6	*Benjamin K Sovacool & Michael H Dowrkin,* ***"Global Energy Justice: Problems, Principles and Practices"****, Cambridge Univesity Press, 2014.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Describe electric supply and demand of power grid	K1
CO2	Summarize various energy trading strategies	K2
CO3	Relate the electricity acts practically	K3
CO4	Cite the electricity regulatory authorities	K2
CO5	Analyze/check the existing power grid for its technical and economical sustainability	K4

COURSE ARTICULATION MATRIX				
COs/Pos	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	-	3	3
CO2	3	-	1	1
CO3	3	-	2	2
CO4	3	-	1	2
CO5	3	-	3	3
23PSOE20	3	-	2	2
1 – Slight, 2 – Moderate, 3 – Substantial				

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20%	30%	20%	30%	-	-	100%
CAT2	20%	20%	20%	20%	20%	-	100%
Individual Assessment1/ Case study1/ Seminar 1/Project1	20%	30%	30%	20%	-	-	100%
Individual Assessment2/ Case study2/ Seminar 2 /Project2	20%	30%	-	20%	-	40%	100%
ESE	30%	30%	-	20%	20%	-	100%

23PSOE21	**MODERN AUTOMOTIVE SYSTEMS** *(Common to all Branches)*

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

Course Objective	• To expose the students with theory and applications of Automotive Electrical and Electronic Systems.	
UNIT – I	**INTRODUCTION TO MODERN AUTOMOTIVE ELECTRONICS**	**9 Periods**
Introduction to modern automotive systems and need for electronics in automobiles- Role of electronics and microcontrollers- Sensors and actuators- Possibilities and challenges in automotive industry- Enabling technologies and industry trends.		
UNIT – II	**SENSORS AND ACTUATORS**	**9 Periods**
Introduction- basic sensor arrangement- Types of sensors- Oxygen sensor, engine crankshaft angular position sensor – Engine cooling water temperature sensor- Engine oil pressure sensor- Fuel metering- vehicle speed sensor and detonation sensor- Pressure Sensor- Linear and angle sensors- Flow sensor- Temperature and humidity sensors- Gas sensor- Speed and Acceleration sensors- Knock sensor- Torque sensor- Yaw rate sensor- Tyre Pressure sensor- Actuators - Stepper motors – Relays.		
UNIT – III	**POWERTRAIN CONTROL SYSTEMS IN AUTOMOBILE**	**9 Periods**
Electronic Transmission Control - Digital engine control system: Open loop and close loop control systems- Engine cooling and warm up control- Acceleration- Detonation and idle speed control - Exhaust emission control engineering- Onboard diagnostics- Future automotive powertrain systems.		
UNIT – IV	**SAFETY, COMFORT AND CONVENIENCE SYSTEMS**	**9 Periods**
Cruise Control- Anti-lock Braking Control- Traction and Stability control- Airbag control system- Suspension control- Steering control- HVAC Control.		
UNIT – V	**ELECTRONIC CONTROL UNITS (ECU)**	**9 Periods**
Introduction to Energy Sources for ECU, Need for ECUs- Advances in ECUs for automotives - Design complexities of ECUs- V-Model for Automotive ECU's- Architecture of an advanced microcontroller (XC166 Family, 32-bit Tricore) used in the design of automobile ECUs- On chip peripherals, protocol interfaces, analog and digital interfaces.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

REFERENCES

1	*Enrique Acha, Manuel Madrigal,* ***"Power System Harmonics: Computer Modeling and Analysis****", John Wiley and Sons, 2001.*
2	*M. H. J. Bollen,* ***"Understanding Power Quality Problems, Voltage Sag and Interruptions",*** *IEEE Press, series on Power Engineering, 2000.*
3	*Roger C. Dugan, Mark F. McGranaghan, Surya Santoso and Wayne Beaty H.,* ***"Electrical Power SystemQuality"****, Second Edition, McGraw Hill Publication Co., 2008.*
4	*G.T.Heydt,* ***"Electric Power Quality",*** *Stars in a Circle Publications, 1994(2nd edition).*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Acquire knowledge about conventional automotive control units and devices.	K1
CO2	Recognize the practical issues in the automotive control systems	K2
CO3	Analyze the impact of modern automotive techniques in various Engineering applications	K4
CO4	Develop modern automotive control system for electrical and electronics systems	K6
CO5	Understand the function of sensors and actuators	K2

COURSE ARTICULATION MATRIX				
COs/Pos	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	-	1	3
CO2	3	-	3	2
CO3	3	-	3	2
CO4	2	-	3	1
CO5	2	-	1	2
23PS0E21	3	-	2	2
1 – Slight, 2 – Moderate, 3 – Substantial				

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20%	30%	20%	30%	-	-	100%
CAT2	20%	20%	20%	20%	20%	-	100%
Individual Assessment1/ Case study1/ Seminar 1/Project1	20%	30%	-	20%	-	30%	100%
Individual Assessment2/ Case study2/ Seminar 2 /Project2	20%	30%	-	20%	-	40%	100%
ESE	30%	30%	20%	20%	-	-	100%

23PEOE22	**VIRTUAL INSTRUMENTATION** *(Common to all Branches)*

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

Course Objective	• To comprehend the Virtual instrumentation programming concepts towards measurements and control and to instill knowledge on DAQ, signal conditioning and its associated software tools	
UNIT – I	**INTRODUCTION**	**7 Periods**
Introduction - advantages - Block diagram and architecture of a virtual instrument - Conventional Instruments versus Traditional Instruments - Data-flow techniques, graphical programming in data flow, comparison with conventional programming.		
UNIT – II	**GRAPHICAL PROGRAMMING AND LabVIEW**	**9 Periods**
Concepts of graphical programming - LabVIEW software - Concept of VIs and sub VI - Display types - Digital - Analog - Chart and Graphs. Loops - structures - Arrays – Clusters- Local and global variables – String - Timers and dialog controls.		
UNIT – III	**MANAGING FILES & DESIGN PATTERNS**	**11 Periods**
High-level and low-level file I/O functions available in LabVIEW – Implementing File I/O functions to read and write data to files – Binary Files – TDMS – sequential programming – State machine programming – Communication between parallel loops –Race conditions – Notifiers & Queues – Producer Consumer design patterns		
UNIT – IV	**PC BASED DATA ACQUISITION**	**9 Periods**
Introduction to data acquisition on PC, Sampling fundamentals, ADCs, DACs, Calibration, Resolution, - analog inputs and outputs - Single-ended and differential inputs - Digital I/O, counters and timers, DMA, Data acquisition interface requirements - Issues involved in selection of Data acquisition cards - Use of timer-counter and analog outputs on the universal DAQ card.		
UNIT – V	**DATA ACQUISITION AND SIGNAL CONDITIONING**	**9 Periods**
Components of a DAQ system, Bus, Signal and accuracy consideration when choosing DAQ hardware – Measurement of analog signal with Finite and continuous buffered acquisition- analog output generation – Signal conditioning systems – Synchronizing measurements in single & multiple devices – Power quality analysis using Electrical Power Measurement tool kit.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

REFERENCES :

1	*Jeffrey Travis, Jim Kring, **"LabVIEW for Everyone: Graphical Programming Made Easy and Fun" (3rd Edition),** Prentice Hall, 2006***.**
2	*Jovitha Jerome, **"Virtual Instrumentation using LabVIEW",** PHI, 2010*
3	*Gary W. Johnson, Richard Jennings, **"LabVIEW Graphical Programming"**, McGraw Hill Professional Publishing, 2019*
4	*Robert H. Bishop, **"Learning with LabVIEW"**, Prentice Hall, 2013.*
5	*Kevin James, "**PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control"**, Newness, 2000*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Describe the graphical programming techniques using LabVIEW software.	K2
CO2	Explore the basics of programming and interfacing using related hardware.	K4
CO3	Analyse the aspects and utilization of PC based data acquisition and Instrument interfaces.	K4
CO4	Create programs and Select proper instrument interface for a specific application.	K6
CO5	Familiarize and experiment with DAQ and Signal Conditioning	K3

Course Articulation Matrix					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	-	3	2	1
CO2	3	-	3	2	1
CO3	3	-	2	2	2
CO4	3	1	3	3	1
CO5	3	1	3	3	2
23PEOE22	**3**	**1**	**3**	**2**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial					

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	40	15	15	-	-	100
CAT2	15	10	25	30	20	-	100
Individual Assessment1 / Case study1/ Seminar 1/Project1	10	10	20	30	20	10	100
Individual Assessment2 / Case study2/ Seminar 2 /Project2	25	40	20	15	-	-	100
ESE	30	25	15	20	5	5	100

23PEOE23	**ENERGY MANAGEMENT SYSTEMS** *(Common to all Branches)*

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

Course Objective	• To Comprehend energy management schemes, perform energy audit and execute economic analysis and load management in electrical systems.	
UNIT – I	**GENERAL ASPECTS OF ENERGY AUDIT AND MANAGEMENT**	**9 Periods**
Energy Conservation Act 2001 and policies – Eight National Missions - Basics of Energy and its forms (Thermal and Electrical) - Energy Management and Audit - Energy Managers and Auditors - Types and Methodology Audit Report - Material and energy balance diagrams - .Energy Monitoring and Targeting.		
UNIT – II	**STUDY OF BOILERS, FURNACES AND COGENERATION**	**9 Periods**
Boiler Systems - Types - Performance Evaluation of boilers - Energy Conservation Opportunity - Steam Distribution - Efficient Steam Utilisation - Furnaces:types and classification - Performance evaluation of a typical fuel fired furnace. Cogeneration: Need - Principle - Technical options - classification - Technical parameters and factors influencing cogeneration choice - Prime Movers - Trigeneration.		
UNIT – III	**ENERGY STUDY OF ELECTRICAL SYSTEMS**	**9 Periods**
Electricity Billing – Electricity load management - Maximum Demand Control - Power Factor improvement and its benefits - pf controllers - capacitors - Energy efficient transformers and Induction motors - rewinding and other factors influencing energy efficiency - Standards and labeling programme of distribution transformers and IM - Analysis of distribution losses - demand side management - harmonics - filters - VFD and its selection.		
UNIT – IV	**STUDY OF ELECTRICAL UTILITIES**	**9 Periods**
Compressor types - Performance - Air system components - Efficient operation of compressed air systems- Compressor capacity assessment - HVAC: psychrometrics and air-conditioning processes - Types of refrigeration system - Compressor types and applications - Performance assessment of refrigeration plants - Lighting Systems: Energy efficient lighting controls - design of interior lighting - Case study.		
UNIT – V	**PERFORMANCE ASSESSMENT FOR EQUIPMENT**	**9 Periods**
Performing Financial analysis: Fixed and variable costs – Payback period – ROI - methods – factors affecting analysis. Energy Performance Assessment: Heat exchangers - Fans and Blowers - Pumps. Energy Conservation in buildings and ECBC.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

REFERENCES:

1	*Murphy W.R. and G.Mckay Butter worth , "**Energy Management**", Heinemann Publications, 2007*
2	*Albert Thumann, Terry Niehus, William J. Younger, "**Handbook of Energy Audits"**, Ninth Edition, River Publishers, 2012.*
3	*Dr. Subhash Gadhave Anup Goel Siddu S. Laxmikant D. Jathar, **"Energy Audit & Management"**, Second edition, Technical Publications, 2019.*

4	*S. M. Chaudhari, S. A. Asarkar, M. A. Chaudhari, **"Energy Conservation and Audit"**, Second Edition, Nirali Prakashan Publications, 2021.*
5	www.em-ea.org/gbook1.asp

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Analyze the feature of energy audit methodology and documentation of report.	K3
CO2	Perform action plan and financial analysis	K4
CO3	Familiarize with thermal utilities.	K4
CO4	Familiarize with electrical utilities.	K4
CO5	Perform assessment of different systems.	K5

Course Articulation Matrix					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	2	2	1	1
CO2	3	2	2	1	1
CO3	3	2	2	1	1
CO4	3	2	2	1	1
CO5	3	2	2	1	1
23PEOE23	3	2	2	1	1
1 – Slight, 2 – Moderate, 3 – Substantial					

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	30	30	20	10	-	100
CAT2	10	30	30	20	10	-	100
Individual Assessment1/ Case study1/ Seminar 1/Project1	-	30	30	20	20	-	100
Individual Assessment2/ Case study2/ Seminar 2 /Project2	-	30	30	20	20	-	100
ESE	10	30	30	20	10	-	100

23PEOE24	**ADVANCED ENERGY STORAGE TECHNOLOGY** *(Common to all Branches)*

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

Course Objective	• To explore the fundamentals, technologies and applications of energy storage	
UNIT – I	**ENERGY STORAGE: HISTORICAL PERSPECTIVE, INTRODUCTION AND CHANGES**	**9 Periods**
Storage Needs- Variations in Energy Demand- Variations in Energy Supply- Interruptions in Energy Supply- Transmission Congestion - Demand for Portable Energy-Demand and scale requirements - Environmental and sustainability issues-conventional energy storage methods: battery-types.		
UNIT – II	**TECHNICAL METHODS OF STORAGE**	**9 Periods**
Introduction: Energy and Energy Transformations, Potential energy (pumped hydro, compressed air, springs)- Kinetic energy (mechanical flywheels)- Thermal energy without phase change passive (adobe) and active (water)-Thermal energy with phase change (ice, molten salts, steam)- Chemical energy (hydrogen, methane, gasoline, coal, oil)- Electrochemical energy (batteries, fuel cells)- Electrostatic energy (capacitors), Electromagnetic energy (superconducting magnets)- Different Types of Energy Storage Systems.		
UNIT – III	**PERFORMANCE FACTORS OF ENERGY STORAGE SYSTEMS**	**9 Periods**
Energy capture rate and efficiency- Discharge rate and efficiency- Dispatch ability and load flowing characteristics, scale flexibility, durability – Cycle lifetime, mass and safety – Risks of fire, explosion, toxicity- Ease of materials, recycling and recovery- Environmental consideration and recycling , Merits and demerits of different types of Storage.		
UNIT – IV	**APPLICATION CONSIDERATION**	**9 Periods**
Comparing Storage Technologies- Technology options- Performance factors and metrics- Efficiency of Energy Systems- Energy Recovery - Battery Storage System: Introduction with focus on Lead Acid and Lithium- Chemistry of Battery Operation, Power storage calculations, Reversible reactions, Charging patterns, Battery Management systems, System Performance, Areas of Application of Energy Storage: Waste heat recovery, Solar energy storage, Green house heating, Power plant applications, Drying and heating for process industries, energy storage in automotive applications in hybrid and electric vehicles.		
UNIT – V	**HYDROGEN FUEL CELLS AND FLOW BATTERIES**	**9 Periods**
Hydrogen Economy and Generation Techniques, Storage of Hydrogen, Energy generation - Super capacitors: properties, power calculations – Operation and Design methods - Hybrid Energy Storage: Managing peak and Continuous power needs, options - Level 1: (Hybrid Power generation) Bacitor "Battery + Capacitor" Combinations: need, operation and Merits; Level 2: (Hybrid Power Generation) Bacitor + Fuel Cell or Flow Battery operation-Applications: Storage for Hybrid Electric Vehicles, Regenerative Power, capturing methods.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

REFERENCES :

1	*DetlefStolten, "**Hydrogen and Fuel Cells: Fundamentals, Technologies and Applications**", Wiley, 2010.*
2	*Jiujun Zhang, Lei Zhang, Hansan Liu, Andy Sun, Ru-Shi Liu, "**Electrochemical Technologies for Energy Storage and Conversion**", John Wiley and Sons, 2012.*
3	*Francois Beguin and ElzbietaFrackowiak, "**Super capacitors**", Wiley, 2013.*
4	*Doughty Liaw, Narayan and Srinivasan, "**Batteries for Renewable Energy Storage**", The Electrochemical Society, New Jersy, 2010.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Recollect the historical perspective and technical methods of energy storage.	K1
CO2	Explain the basics of different storage methods.	K2
CO3	Determine the performance factors of energy storage systems.	K2
CO4	Identify applications for renewable energy systems.	K4
CO5	Outline the basics of Hydrogen cell and flow batteries.	K2

COURSE ARTICULATION MATRIX					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	1	3	3	3
CO2	3	1	3	3	3
CO3	3	1	3	3	3
CO4	3	1	3	3	3
CO5	3	1	3	3	3
23PEOE24	3	1	3	3	3
1 – Slight, 2 – Moderate, 3 – Substantial					

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	30	30	20	10	-	100
CAT2	10	30	30	20	10	-	100
Individual Assessment1/ Case study1/ Seminar 1/ Project1	-	30	30	20	10	10	100
Individual Assessment2/ Case study2/ Seminar 2 / Project2	-	30	30	20	20	-	100
ESE	10	30	30	20	10	-	100

23AEOE25	**DESIGN OF DIGITAL SYSTEMS** *(Common to all Branches)*

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

Course Objective

- To gain knowledge in the design and VHDL programming of synchronous and asynchronous sequential circuits, PLD's and the basic concepts of testing in VLSI circuits

UNIT–I SYNCHRONOUS SEQUENTIAL CIRCUIT DESIGN	**9 Periods**

Analysis of Clocked Synchronous Sequential Circuits - Modeling, state table reduction, state assignment, Design of Synchronous Sequential circuits, Design of iterative circuits- ASM chart –ASM realization.

UNIT–II ASYNCHRONOUS SEQUENTIAL CIRCUIT DESIGN	**9 Periods**

Analysis of Asynchronous Sequential Circuits - Races in ASC – Primitive Flow Table - Flow Table Reduction Techniques, State Assignment Problem and the Transition Table – Design of ASC – Static and Dynamic Hazards – Essential Hazards– Data Synchronizers.

UNIT–III SYSTEM DESIGN USING PLDS	**9 Periods**

Basic concepts – Programming Technologies - Programmable Logic Element (PLE) – Programmable Array Logic (PLA)-Programmable Array Logic (PAL) –Design of combinational and sequential circuits using PLDs– Complex PLDs (CPLDs).

UNIT– IV INTRODUCTION TO VHDL	**9 Periods**

Design flow -Software tools – VHDL: Data Objects-Data types – Operators –Entities and Architectures – Components and Configurations – Signal Assignment – Concurrent and Sequential statements ––Behavioral, Dataflow and Structural modeling– Transport and Inertial delays –Delta delays-Attributes - Generics– Packages and Libraries.

UNIT–V LOGIC CIRCUIT TESTING AND TESTABLE DESIGN	**9 Periods**

Digital logic circuit testing - Fault models - Combinational logic circuit testing - Sequential logic circuit testing-Design for Testability - Built-in Self-test, Board and System Level Boundary Scan - Case Study: Traffic Light Controller.

Contact Periods:

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

REFERENCES:

1	*Donald G.Givone, "**Digital principles and Design**", TataMcGrawHill, 2002.*
2	*Nelson, V.P., Nagale, H.T., Carroll, B.D., and Irwin, J.D., "**Digital Logic Circuit Analysis and Design**", Prentice Hall International, Inc., NewJersey, 1995.*
3	*VolneiA.Pedroni,"**Circuit Design withVHDL**",PHILearning,2011.*
4	*ParagK Lala,"**Digital Circuit Testing and Testability**",AcademicPress,1997.*
5	*CharlesHRoth,"**Digital Systems Design Using VHDL",**Cencage2ndEdition2012.*
6	*NripendraN.Biswas,"**Logic Design Theory**"PrenticeHallofIndia,2001.*

COURSEOUTCOMES: Upon completion of the course ,students will be able to/have:		**Bloom's Taxonomy Mapped**
CO1	To design synchronous sequential circuits based on specifications.	K3
CO2	To design asynchronous sequential circuits based on specifications	K3
CO3	Ability to illustrate digital design implementation using PLDs.	K2
CO4	To develop algorithm and VHDL code for design of digital circuits.	K3
CO5	Understand the different testing methods for combinational and sequential circuits.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	2	-	-	1
CO2	3	-	2	-	-	1
CO3	3	-	2	-	-	1
CO4	3	-	2	-	-	1
CO5	3	-	2	-	-	1
23AEOE25	3	-	2	-	-	1
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40%	40%	20%				100%
CAT2	40%	40%	20%				100%
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1		50%	50%				100%
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2		50%	50%				100%
ESE	20%	45%	35%				100%

23AEOE26	**BASICS OF NANO ELECTRONICS** *(Common to all Branches)*

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

Course Objective

- The students will be able to acquire knowledge about nano device fabrication technology, nano structures, nano technology for memory devices and applications of nano electronics in data transmission.

UNIT – I TECHNOLOGY AND ANALYSIS	**9 Periods**

Fundamentals : Dielectric, Ferroelectric and Optical properties - Film Deposition Methods – Lithography Material removing techniques - Etching and Chemical Mechanical Polishing - Scanning Probe Techniques.

UNIT – II CARBON NANO STRUCTURES	**9 Periods**

Principles and concepts of Carbon Nano tubes - Fabrication - Electrical, Mechanical and Vibration Properties - Applications of Carbon Nano tubes.

UNIT – III LOGIC DEVICES	**9 Periods**

Silicon MOSFET's: Novel materials and alternative concepts - Single electron devices for logic applications - Super conductor digital electronics - Carbon Nano tubes for data processing.

UNIT – IV MEMORY DEVICES AND MASS STORAGE DEVICES	**9 Periods**

Flash memories - Capacitor based Random Access Memories - Magnetic Random Access Memories - Information storage based on phase change materials - Resistive Random Access Memories - Holographic Data storage.

UNIT – V DATA TRANSMISSION AND INTERFACING DISPLAYS	**9 Periods**

Photonic Networks - RF and Microwave Communication System - Liquid Crystal Displays - Organic Light emitting diodes.

Contact Periods:

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

REFERENCES:

1	*Rainer Waser, **"Nano Electronics and Information Technology, Advanced Electronicmaterials and novel devices**", 3rd Edition, Wiley VCH, 2012.*
2	*T. Pradeep, "**Nano: The essentials**", Tata McGraw Hill, 2007.*
3	*Charles Poole, "**Introduction to Nano Technology**", Wiley Interscience, 2003*
4	*Vladimir V.Mitin, Viatcheslav A. Kochelap, Michael A. Stroscio, "**Introduction to Nano Electronics Science, Nanotechnology, Engineering and Applications**", Cambridge University Press, 2011.*
5	*C.Wasshuber Simon, "**Simulation of Nano Structures Computational Single-Electronics**",Springer, 2001.*
6	*Mark Reed and Takhee Lee, "**Molecular Nano Electronics, American Scientific Publisher, California**", 2003.*

COURSE OUTCOMES: Upon completion of the course, students will be able to/have:		**oom's Taxonomy Mapped**
CO1	Explain principles of nano device fabrication technology.	K2
CO2	Describe the concept of Nano tube and Nano structure.	K2
CO3	Explain the function and application of various nano devices	K3
CO4	Reproduce the concepts of advanced memory technologies.	K2
CO5	Emphasize the need for data transmission and display systems.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	2	-	-	1
CO2	3	-	2	-	-	1
CO3	3	-	2	-	-	1
CO4	3	-	2	-	-	1
CO5	3	-	2	-	-	1
23AEOE26	3	-	2	-	-	1
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23AEOE27	**ADVANCED PROCESSOR** *(Common to all Branches)*

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

Course Objective

- The students will be able to acquire knowledge about the high performance RISC, CISC and special purpose processors.

UNIT – I MICROPROCESSOR ARCHITECTURE	**9 Periods**
Instruction set – Data formats – Instruction formats – Addressing modes – Memory hierarchy – registerfile – Cache – Virtual memory and paging – Segmentation – Pipelining – The instruction pipeline – pipeline hazards – Instruction level parallelism – reduced instruction set – Computer principles – RISCversus CISC – RISC properties – RISC evaluation.	
UNIT – II HIGH PERFORMANCE CISC ARCHITECTURE –PENTIUM	**9 Periods**
The software model – functional description – CPU pin descriptions – Addressing modes – Processor flags – Instruction set – Bus operations – Super scalar architecture – Pipe lining – Branch prediction – Theinstruction and caches – Floating point unit– Programming the Pentium processor.	
UNIT – III HIGH PERFORMANCE CISC ARCHITECTURE – PENTIUM INTERFACE	**9 Periods**
Protected mode operation – Segmentation – paging – Protection – multitasking – Exception and interrupts - Input /Output – Virtual 8086 model – Interrupt processing.	
UNIT – IV HIGH PERFORMANCE RISC ARCHITECTURE: ARM	**9 Periods**
ARM architecture – ARM assembly language program – ARM organization and implementation – ARM instruction set - Thumb instruction set.	
UNIT – V SPECIAL PURPOSE PROCESSORS	**9 Periods**
Altera Cyclone Processor – Audio codec – Video codec design – Platforms – General purpose processor –Digital signal processor – Embedded processor – Media Processor – Video signal Processor – Custom Hardware – Co-Processor.	
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**	

REFERENCES:

1	*Daniel Tabak, "**Advanced Microprocessors**", McGraw Hill Inc., 2011.*
2	*James L. Antonakos, "**The Pentium Microprocessor**", Pearson Education, 1997.*
3	*Steve Furber, "**ARM System –On –Chip architecture**", Addison Wesley, 2009.*
4	*Gene. H. Miller, "**Micro Computer Engineering**", Pearson Education, 2003.*
5	*Barry. B. Brey, "**The Intel Microprocessors Architecture, Programming and Interfacing**", PHI, 2008.*
6	*Valvano, "**Embedded Microcomputer Systems**" Cencage Learing India Pvt Ltd, 2011.*
7	*Iain E.G. Richardson, "**Video codec design**", John Wiley & sons Ltd, U.K, 2002.*

COURSE OUTCOMES: Upon completion of the course, students will be able to		**Bloom's Taxonomy Mapped**
CO1	Describe the fundamentals of various processor architecture.	K2
CO2	Interpret and understand the high performance features in CISC architecture.	K2
CO3	Describe the concepts of Exception and interrupt processing.	K2
CO4	Develop programming skill for ARM processor.	K3
CO5	Explain various special purpose processor	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	2	-	-	1
CO2	3	-	2	-	-	1
CO3	3	-	2	-	-	1
CO4	3	-	2	-	-	1
CO5	3	-	2	-	-	1
23AEOE27	3	-	2	-	-	1
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23VLOE28	**HDL PROGRAMMING LANGUAGES** *(Common to all Branches)*

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

Course Objective	• To code and simulate any digital function in Verilog HDL and understand the difference between synthesizable and non-synthesizable codes.	
UNIT – I	**VERILOG INTRODUCTION AND MODELING**	**9 Periods**
Introduction to Verilog HDL, Language Constructs and Conventions, Gate Level Modeling, Modeling at Dataflow Level, Behavioral Modeling, Switch Level Modeling, System Tasks, Functions and Compiler Directives.		
UNIT – II	**SEQUENTIAL MODELING AND TESTING**	**9 Periods**
Sequential Models - Feedback Model, Capacitive Model, Implicit Model, Basic Memory Components, Functional Register, Static Machine Coding, Sequential Synthesis. Test Bench - Combinational Circuits Testing, Sequential Circuit Testing, Test Bench Techniques, Design Verification, Assertion Verification.		
UNIT – III	**SYSTEM VERILOG**	**9 Periods**
Introduction, System Verilog declaration spaces, System Verilog Literal Values and Built-in Data Types, System Verilog User-Defined and Enumerated Types, system Verilog Arrays, Structures and Unions, system verilog Procedural Blocks, Tasks and Functions.		
UNIT – IV	**SYSTEM VERILOG MODELING**	**9 Periods**
System Verilog Procedural Statements, Modeling Finite State Machines with System Verilog, System Verilog Design Hierarchy.		
UNIT – V	**INTERFACES AND DESIGN MODEL**	**9 Periods**
System Verilog Interfaces, A Complete Design Modeled with System Verilog, Behavioral and Transaction Level Modeling.		
Contact Periods: **Lecture: 45 Periods Tutorial:0 Periods Practical:0 Periods Total: 45 Periods**		

REFERENCES:

1	*T.R.Padmanabhan, B Bala Tripura Sundari, "**Design through Verilog HDL**",Wiley 2009.*
2	*Stuart Sutherland, Simon Davidmann ,Peter Flake , Foreword by Phil Moorby, "**System Verilog For Design Second Edition A Guide to Using System Verilog for Hardware Design and Modelling**", Springer 2006.*
3	*Samir Palnitkar, "**Verilog HDL**", 2nd Edition, Pearson Education, 2009.*
4	*ZainalabdienNavabi, "**Verilog Digital System Design**",TMH,2ndEdition,2005.*
5	*System Verilog 3.1a, Language Reference Manual, Accellera, 2004*
6	*Dr.SRamachandran, "**Digital VLSI Systems Design: A Design Manual for Implementation of Projects on FPGAs and ASICs Using Verilog**", Springer, 2007.*
7	*Chris Spear, "**System verilog for verification a guide to learning the test bench Language Features**", Springer 2006.*

6	*Stuart Sutherland, Simon Davidmann, Peter Flake, "**System Verilog For Design: A Guide to Using System Verilog for Hardware Design and Modeling**" 1st Edition, 2003*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the verilog coding and simulate any digital function using Verilog HDL	K2
CO2	Develop sequential modeling based Verilog HDL code and develop the test bench for the modeling	K3
CO3	Explain the system verilog modeling	K2
CO4	Differentiate the synthesizable and non-synthesizable code	K3
CO5	Apply good coding techniques on system verilog interfaces and complete design model	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3		2		2
CO2	3	3		2		2
CO3	3	3		2		2
CO4	3	3		2		2
CO5	3	3		2		2
23VLOE28	**3**	**3**		**2**		**2**
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23VLOE29	**CMOS VLSI DESIGN** *(Common to all Branches)*

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

Course Objective	• To gain knowledge on CMOS Circuits with its characterization and to design CMOS logic and sub-system with low power	
UNIT – I	**INTRODUCTION TO MOS CIRCUITS**	**9 Periods**
MOS Transistor Theory -Introduction MOS Device Design Equations -MOS Transistor as a Switches - Pass Transistor - CMOS Transmission Gate -Complementary CMOS Inverter - Static Load MOS Inverters - Inverters with NMOS loads - Differential Inverter - Tri State Inverter - BiCMOS Inverter.		
UNIT – II	**CIRCUIT CHARACTERIZATION AND PERFORMANCE ESTIMATION**	**9 Periods**
Delay Estimation, Logical Effort and Transistor Sizing, Power Dissipation, Sizing Routing Conductors, Charge Sharing, Design Margin and Reliability.		
UNIT – III	**CMOS CIRCUIT AND LOGIC DESIGN**	**9 Periods**
CMOS Logic Gate Design, Physical Design of CMOS Gate, Designing with Transmission Gates, CMOS Logic Structures, Clocking Strategies, I/O Structures.		
UNIT – IV	**CMOS SUBSYSTEM DESIGN**	**9 Periods**
DataPath Operations-Addition/Subtraction, Parity Generators, Comparators, Zero/One Detectors, Binary Counters, ALUs, Multipliers, Shifters, Memory Elements, Control-FSM, Control Logic Implementation.		
UNIT – V	**LOW POWER CMOS VLSI DESIGN**	**9 Periods**
Introduction to Low Power Design, Power Dissipation in FET Devices, Power Dissipation in CMOS, Low-Power Design through Voltage Scaling – VTCMOS Circuits, MTCMOS Circuits, Architectural Level Approach – Pipelining and Parallel Processing Approaches, Low Power Basics CMOS Gate and Adder Design.		
Contact Periods: **Lecture: 45 Periods Tutorial:0 Periods Practical:0 Periods Total: 45 Periods**		

REFERENCES:

1	*Sung Mo Kang,Yusuf Lablebici,**"CMOS Digital Integrated Circuits:Analysis & Design"**, Tata Mc-Graw Hill, 2011.*
2	*N.Weste and K.Eshranghian, **"Principles of CMOS VLSI Design"**, AddisonWesley,1998.*
3	*Neil H. E. Weste, David Harris, Ayan Banerjee, **"CMOS VLSI Design: A Circuits and Systems Perspective"**, Pearson Education 2013.*
4	*Kiat-Seng Yeo,Kaushik Roy,**"Low-Voltage, Low-Power VLSI Subsystems",** McGraw-Hill Professional, 2004.*
5	*Gary K.Yeap, **"Practical Low Power Digital VLSI Design"**, Kluwer Academic Press, 2002.*
6	*Jan M .Rabaey,**"Digital Integrated Circuits: A Design Perspective"**, Pearson Education, 2003.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the MOS circuits and Transmission gates	K2
CO2	Illustrate the CMOS Circuits with its characterization	K2
CO3	Design CMOS logic circuits	K3
CO4	Design CMOS sub-system	K3
CO5	Discuss low power CMOS VLSI Design	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	-	2	-	3
CO2	2	1	-	2	-	3
CO3	2	1	-	2	-	3
CO4	3	1	-	2	-	3
CO5	3	1	-	2	-	3
23VLOE29	**3**	**1**	**-**	**2**	**-**	**3**
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23VLOE30	**HIGH LEVEL SYNTHESIS** *(Common to all Branches)*

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

Course Objective	• To provide students with foundations in High level synthesis, verification and CAD Tools	
UNIT – I	**HIGH-LEVEL SYNTHESIS (HLS) FUNDAMENTALS**	**9 Periods**
Overview HLS flow, Scheduling Techniques, Resource sharing and Binding Techniques, Data-path and Controller Generation Techniques.		
UNIT – II	**HIGH LEVEL SYNTHESIS**	**9 Periods**
Introduction to HDL, HDL to DFG, operation scheduling: constrained and unconstrained scheduling, ASAP, ALAP, List scheduling, Force directed Scheduling, operator binding, Static Timing Analysis: Delay models, setup time, hold time, cycle time, critical paths, Topological mvs. Logical timing analysis, False paths, Arrival time (AT), Required arrival Time (RAT), Slacks.		
UNIT – III	**HIGH-LEVEL SYNTHESIS VERIFICATION**	**9 Periods**
Simulation based verification - Formal Verification of digital systems- BDD based approaches, functional equivalence, finite state automata, ω-automata, FSM verification.		
UNIT – IV	**CAD TOOLS FOR SYNTHESIS**	**9 Periods**
CAD tools for synthesis, optimization, simulation and verification of design at various levels as well as for special realizations and structures such as microprogrammes, PLAs, gate arrays etc. Technology mapping for FPGAs. Low power issues in high level synthesis and logic synthesis.		
UNIT – V	**ADVANCED TOPICS**	**9 Periods**
Relative Scheduling, IO scheduling modes - cycle fixed scheduling modes, super-fixed scheduling modes, free-floating scheduling mode, Pipelining, Handshaking, System Design, High-Level Synthesis for FPGA.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

REFERENCES :

1	*Philippe Coussy and Adam Morawiec, "**High-level Synthesis from Algorithm to Digital Circuit**", Springer, 2008.*
2	*Sherwani, N., "**Algorithms for VLSI Physicsl Design Automation**", Springer, 3rd ed., 2005.*
3	*D. Micheli,"**Synthesis and optimization of digital systems**", Mc Graw Hill, 2005.*
4	*Dutt, N. D. and Gajski, D. D., "**High level synthesis**", Kluwer, 2000.*
5	*Gerez S.H., "**Algorithms for VLSI Design Automation**", John Wiley (1998)*
6	*David. C. Ku and G. De Micheli, "**High-level Syntehsis of ASICs Under Timing and Synchronization Constraints**", Kluwer Academic Publishers, 1992.*
7	*K. Parhi, "**VLSI Digital Signal Processing Systems: Design and Implementation**", Jan 1999, Wiley.*
8	*Egon Boerger and Robert Staerk "**Abstract State Machines: A Method for High-Level System Design and Analysis**", Springer,2006.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the fundamentals of High level synthesis	K2
CO2	Synthesis the HDL for operation scheduling	K2
CO3	Simulate and verify any digital systems	K2
CO4	Apply CAD tools for synthesis	K2
CO5	Have knowledge on various scheduling modes	K2

COURSE ARTICULATION MATRIX :

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	-	2	2	-
CO2	2	2	-	2	2	-
CO3	2	2	-	2	2	-
CO4	2	2	-	2	2	-
CO5	2	2	-	2	2	-
23VL0E30	**2**	**2**	**-**	**2**	**2**	**-**
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23CSOE31	**ARTIFICIAL INTELLIGENCE** *(Common to all Branches)*

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

Course Objectives	Identify and apply AI techniques in the design of systems that act intelligently, making automatic decisions and learn from experience.	
UNIT – I	**SEARCH STRATEGIES**	**9 Periods**
Uninformed Strategies – BFS, DFS, Djisktra, Informed Strategies – A* search, Heuristic functions, Hill Climbing, Adversarial Search – Min-max algorithm, Alpha-beta Pruning		
UNIT – II	**PLANNING AND REASONING**	**9 Periods**
State Space search, Planning Graphs, Partial order planning, Uncertain Reasoning – Probabilistic Reasoning, Bayesian Networks, Dempster Shafer Theory, Fuzzy logic		
UNIT – III	**PROBABILISTIC REASONING**	**9 Periods**
Probabilistic Reasoning over Time - Hidden Markov Models, Kalman Filters, Dynamic Bayesian Networks. Knowledge Representations – Ontological Engineering, Semantic Networks and description logics.		
UNIT – IV	**DECISION MAKING**	**9 Periods**
Utility Theory, Utility Functions, Decision Networks – Sequential Decision Problems – Partially Observable MDPs – Game Theory.		
UNIT – V	**REINFORCEMENT LEARNING**	**9 Periods**
Reinforcement Learning - Passive and active reinforcement learning - Generations in Reinforcement Learning - Policy Search – Deep Reinforcement Learning.		
Contact Periods: **Lecture: 3 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

REFERENCES :

1	*Deepak Khemani, **"A First Course in Artificial Intelligence",** Tata Mc Graw Hill Education 2013*
2	*Yang Q, **" Intelligent Planning: A decomposition and Abstraction based Approach",** Springer, 2006*
3	*Russell and Norvig, **"Artificial Intelligence, A Modern Approach**", 3rd edition, Pearson Prentice Hall,2010.*
4	*Elaine Rich,Kevin Knight,Shivashankar B. Nair, **"Artificial Intelligence",** 3rd edition, TataMcGraw Hill, 2009.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Use search techniques to solve AI problems	K2
CO2	Reason facts by constructing plans and understand uncertainty efficiently.	K3
CO3	Examine data using statistical codes and solve complex AI problems	K6
CO4	Apply techniques to make apt decisions.	K4
CO5	Use deep reinforcement learning to solve complex AI problems	K6

COURSE ARTICULATION MATRIX						
COs/ POs	**PO 1**	**PO2**	**PO 3**	**PO 4**	**PO5**	**PO6**
CO1	3		2		3	3
CO2	3		2		3	3
CO3	3		3		3	3
CO4	3		3		3	3
CO5	3		3		3	3
23CSOE31	**3**		**3**		**3**	**3**
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23CSOE32	**COMPUTER NETWORK MANAGEMENT** *(Common to all Branches)*

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

Course Objective	• After the completion of the course, the students will be able to understand the concept of layering in networks, functions of protocols of each layer of TCP/IP protocol suite, concepts related to network addressing and routing and build simple LANs, perform basic configurations for routers and switches, and implement IPv4 and IPv6 addressing schemes using Cisco Packet Tracer.	
UNIT – I	**INTRODUCTION AND APPLICATION LAYER**	**9 Periods**
Building network – Network Edge and Core – Layered Architecture – OSI Model – Internet Architecture (TCP/IP) Networking Devices: Hubs, Bridges, Switches, Routers, and Gateways – Performance Metrics - Ethernet Networking – Introduction to Sockets – Application Layer protocols – HTTP – FTP Email Protocols – DNS.		
UNIT – II	**TRANSPORT LAYER AND ROUTING**	**9 Periods**
Transport Layer functions –User Datagram Protocol – Transmission Control Protocol – Flow Control – Retransmission Strategies – Congestion Control - Routing Principles – Distance Vector Routing – Link State Routing – RIP – OSPF – BGP – Introduction to Quality of Service (QoS).Case Study: Configuring RIP, OSPF BGP using Packet tracer		
UNIT – III	**NETWORK LAYER**	**9 Periods**
Network Layer: Switching concepts – Internet Protocol – IPV4 Packet Format – IP Addressing – Subnetting – Classless Inter Domain Routing (CIDR) – Variable Length Subnet Mask (VLSM) – DHCP – ARP – Network Address Translation (NAT) – ICMP – Concept of SDN.Case Study: Configuring VLAN, DHCP, NAT using Packet tracer		
UNIT – IV	**INTERNETWORK MANAGEMENT**	**9 Periods**
Introduction to the Cisco IOS - Router User Interface – CLI - Router and Switch Administrative Functions - Router Interfaces - Viewing, Saving, and Erasing Configurations - Switching Services - Configuring Switches - Managing Configuration Registers - Backing Up and Restoring IOS - Backing Up and Restoring the Configuration - Using Discovery Protocol (CDP) - Checking Network Connectivity		
UNIT – V	**TRAFFIC MANAGEMENT AND WAN PROTOCOLS**	**9 Periods**
Managing Traffic with Access Lists: Introduction to Access Lists - Standard Access Lists - Extended Access Lists - Named Access Lists - Monitoring Access Lists - Wide Area Networking Protocols: Introduction to Wide Area Networks - Cabling the Wide Area Network - High-Level Data-Link Control (HDLC) Protocol - Point-to-Point Protocol (PPP) - Frame Relay: Frame Relay Implementation and Monitoring - Integrated Services Digital Network (ISDN) - Dial-on-Demand Routing (DDR): Configuring DDR		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

REFERENCES :

1	*James F. Kurose, Keith W. Ross,* ***"Computer Networking: A Top-Down Approach",*** *Seventh Edition, Pearson Education, 2017.*
2	*William Stallings,* ***"Data and Computer Communications",*** *Tenth Edition, Pearson Education, 2014*
3	*Larry L. Peterson, Bruce S. Davie,* ***"Computer Networks: A Systems Approach",*** *Fifth Edition, Morgan Kaufmann Publishers Inc., 2011.*
4	*Todd Lammle,* ***"CCNA™: Cisco® Certified Network Associate Study Guide",*** *5th Edition, Sybex, 2003*
5	*Ying-Dar Lin, Ren-Hung Hwang, Fred Baker,* ***"Computer Networks: An Open Source Approach",*** *McGraw Hill, 2012.*
6	*Ron Gilster, Jeff Bienvenu, and Kevin Ulstad,* ***"CCNA for Dummies",*** *IDG Books Worldwide, 2000*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Highlight the significance of the functions of each layer in the network.	K1
CO2	Identify the devices and protocols to design a network and implement it.	K4
CO3	Apply addressing principles such as subnetting and VLSM for efficient routing.	K3
CO4	Build simple LANs, perform basic configurations for routers and switches	K6
CO5	Illustrate various WAN protocols	K2

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3		3		2	1
CO2	3		3		2	2
CO3	3		3		3	2
CO4	3		3		3	3
CO5	3		3		3	3
23CSOE32	**3**		**3**		**3**	**2**
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23CSOE33	**BLOCKCHAIN TECHNOLOGIES** *(Common to all Branches)*

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

Course Objective	• The objective of the course is to explore basics of block chain technology and its application in various domain	
UNIT – I	**INTRODUCTION OF CRYPTOGRAPHY AND BLOCKCHAIN**	**9 Periods**
History of Blockchain - Types of blockchain- CAP theorem and blockchain – benefits and Limitations of Blockchain – Decentalization using blockchain – Blockchain implementations- Block chain in practical use - Legal and Governance Use Cases		
UNIT – II	**BITCOIN AND CRYPTOCURRENCY**	**9 Periods**
Introduction to Bitcoin, The Bitcoin Network, The Bitcoin Mining Process, Mining Developments, Bitcoin Wallets, Decentralization and Hard Forks, Ethereum Virtual Machine (EVM), Merkle Tree, Double-Spend Problem, Blockchain and Digital Currency, Transactional Blocks, Impact of Blockchain Technology on Cryptocurrency		
UNIT – III	**ETHEREUM**	**9 Periods**
Introduction to Ethereum, Consensus Mechanisms, Metamask Setup, Ethereum Accounts, , Transactions, Receiving Ethers, Smart Contracts		
UNIT – IV	**HYPERLEDGER AND SOLIDITY PROGRAMMING**	**9 Periods**
Introduction to Hyperledger, Distributed Ledger Technology & its Challenges, Hyperledger & Distributed Ledger Technology, Hyperledger Fabric, Hyperledger Composer. Solidity – Programming with solidity		
UNIT – V	**BLOCKCHAIN APPLICATIONS**	**9 Periods**
Ten Steps to build your Blockchain application – Application: Internet of Things, Medical Record Management System, Domain Name Service and Future of Blockchain, Alt Coins		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

REFERENCES:

1	*Imran Bashir,* ***"Mastering Blockchain: Distributed Ledger Technology, Decentralization, and Smart Contracts Explained"****, Second Edition, Packt Publishing, 2018.*
2	*Joseph J. Bambara Paul R. Allen,* ***"Blockchain A Practical Guide to Developing Business, Law, and Technology Solutions"****,McGraw Hill Education ,2018.*
3	*Narayanan, J. Bonneau, E. Felten, A. Miller, S. Goldfeder,* ***"Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction"*** *Princeton University Press, 2016.*
4	*Manav Gupta* ***"Blockchain for Dummies",*** *IBM Limited Edition 2017.*
5	*Antonopoulos and G. Wood,* ***"Mastering Ethereum: Building Smart Contracts and Dapps",*** *O'Reilly Publishing, 2018*
6	***NPTEL Course : Blockchain and its applications*** *https://archive.nptel.ac.in/courses/106/105/106105235/*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Comprehend the working of Blockchain technology	K2
CO2	Narrate working principle of smart contracts and create them using solidity for given scenario.	K3
CO3	Comprehend the working of Hyperledger in an real time application	K2
CO4	Apply the learning of solidity to build de-centralized apps on Ethereum	K3
CO5	Develop applications on Blockchain	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2		3	2		3
CO2	2	3	3	3	2	3
CO3	3		3	2		3
CO4	3	3	3	3	2	3
CO5	3	3	3	3	2	3
23CSOE33	**3**	**3**	**3**	**3**	**2**	**3**
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23VLACZ1	**ENGLISH FOR RESEARCH PAPER WRITING** *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	AC	2	0	0	0

Course Objective	• The objective of the course is to make the learners understand the format and intricacies involved in writing a research paper.	
UNIT – I	**PLANNING AND PREPARATION**	**6 Periods**
Need for publishing articles, Choosing the journal, Identifying a model journal paper, Creation of files for each section, Expectations of Referees, Online Resources.		
UNIT – II	**SENTENCES AND PARAGRAPHS**	**6 Periods**
Basic word in English, Word order in English and Vernacular, placing nouns, Verbs, Adjectives, and Adverb suitably in a sentence, Using Short Sentences, Discourse Markers and Punctuations- Structure of a Paragraph, Breaking up lengthy Paragraphs.		
UNIT – III	**ACCURACY, BREVITY AND CLARITY (ABC) OF WRITING**	**6 Periods**
Accuracy, Brevity and Clarity in Writing, Reducing the linking words, Avoiding redundancy, Appropriate use of Relative and Reflexive Pronouns, Monologophobia, verifying the journal style, Logical Connections between others author's findings and yours.		
UNIT – IV	**HIGHLIGHTING FINDINGS, HEDGING AND PARAPHRASING**	**6 Periods**
Making your findings stand out, Using bullet points headings, Tables and Graphs- Availing non-experts opinions, Hedging, Toning Down Verbs, Adjectives, Not over hedging, Limitations of your research.		
UNIT – V	**SECTIONS OF A PAPER**	**6 Periods**
Titles, Abstracts, Introduction, Review of Literature, Methods, Results, Discussion, Conclusions, References.		
Contact Periods: **Lecture: 30 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 30 Periods**		

REFERENCES :

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

COURSE OUTCOMES : Upon completion of this course the learners will be able to		**Bloom's Taxonomy Mapped**
CO1	**U**nderstand the need for writing good research paper.	K2
CO2	Practice the appropriate word order, sentence structure and paragraph writing.	K4
CO3	Practice unambiguous writing.	K3
CO4	Avoid wordiness in writing.	K2
CO5	Exercise the elements involved in writing journal paper.	K3

COURSE ARTICULATION MATRIX :						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	1	1	1	1
CO2	3	3	1	1	1	1
CO3	3	3	1	1	1	1
CO4	3	3	1	1	1	1
CO5	3	3	1	1	1	1
23VLACZ1	**3**	**3**	**1**	**1**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23VLACZ2	**DISASTER MANAGEMENT** *(Common to all branches)*

Course Objectives	• To become familiar in key concepts and consequences about hazards, disaster and area of occurrence. • To know the various steps in disaster planning. • To create awareness on disaster preparedness and management.	
UNIT – I	**INTRODUCTION**	**6 Periods**
Disaster: Definition, Factors and Significance; Difference between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude. Areas proneto ,Earthquakes Floods,Droughts, Landslides ,Avalanches ,Cyclone and Coastal Hazards with Special Reference to Tsunami.		
UNIT – II	**REPERCUSSIONS OF DISASTERS AND HAZARDS**	**6 Periods**
Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides and Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks and Spills, Outbreaks of Disease and Epidemics, War and Conflicts.		
UNIT – III	**DISASTER PLANNING**	**6 Periods**
Disaster Planning-Disaster Response Personnel roles and duties, Community MitigationGoals, Pre-Disaster Mitigation Plan, Personnel Training, Comprehensive Emergency Management, Early Warning Systems.		
UNIT – IV	**DISASTER PREPAREDNESS AND MANAGEMENT**	**6 Periods**
Preparedness: Monitoring of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological and other Agencies, Media Reports: Governmental and Community Preparedness.		
UNIT – V	**RISK ASSESSMENT**	**6 Periods**
Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment, Strategies for Survival.		
Contact Periods: **Lecture:30 Periods Tutorial: 0 Periods Practical: 0Periods Total: 30 Periods**		

REFERENCES:

1	*R. Nishith, Singh AK, **"Disaster Management In India: Perspectives, Issues And Strategies"**, New Royal book Company, 2007.*
2	*Sahni, PardeepEt.Al. (Eds.), **"Disaster Mitigation Experiences And Reflections"**, Prentice Hall Of India, New Delhi, 2010*
3	*Goel S. L, **"Disaster Administration And Management Text And Case Studies"**, Deep &Deep Publication Pvt. Ltd., New Delhi, 2008.*
4	*Jagbir Singh, **"Disaster Management: Future Challenges And Opportunities"**, I.K. International Publishing House Pvt. Ltd., New Delhi, 2007.*
5	*Damon Coppola **"Introduction To International Disaster Management"**, Butterworth-Heinemann, 2015*
6	*Ryan Lanclos **"Dealing With Disasters: Gis For Emergency Management"**,ESRI Press 2021.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Differentiate hazard and disaster with their significance.	K4
CO2	Analyse the causes and impact of natural and manmade disaster.	K4
CO3	Execute the steps involved in disaster planning.	K4
CO4	Predict vulnerability of disaster and to prevent, mitigate their impact.	K4
CO5	Prepare risk assessment strategy for national and global disaster.	K4

COURSE ARTICULATION MATRIX					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2	1	1	2	2
CO2	1	2	1	1	1
CO3	1	1	1	2	2
CO4	1	1	1	2	2
CO5	2	1	1	2	2
23VLACZ2	**1**	**1**	**1**	**2**	**2**
1 – Slight, 2 – Moderate, 3 – Substantial					

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

23VLACZ3	**VALUE EDUCATION** *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	AC	**2**	**0**	**0**	**0**

Course Objectives	• Value of education and self- development • Requirements of good values in students • Importance of character	
UNIT – I	**ETHICS AND SELF-DEVELOPMENT**	**6 Periods**
Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non-moral valuation. Standards and principles. Value judgements.		
UNIT – II	**PERSONALITY AND BEHAVIOR DEVELOPMENT**	**6 Periods**
Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour. Universal brotherhood and religious tolerance.		
UNIT – III	**VALUES IN HUMAN LIFE**	**6 Periods**
Importance of cultivation of values, Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature,Discipline.		
UNIT – IV	**VALUES IN SOCIETY**	**6 Periods**
True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature.		
UNIT – V	**POSITIVE VALUES**	**6 Periods**
Character and Competence –Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively.		
Contact Periods: **Lecture: 30 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 30 Periods**		

REFERENCES :

1	*Chakroborty, S.K.* ***"Values and Ethics for organizations Theory and practice"****, Oxford University Press, New Delhi,1998*
2	*Dr. Yogesh Kumar Singh,* ***"Value Education"****, A.P.H Publishing Corporation, New Delhi,2010*
3	*R.P Shukla,* ***"Value Education and Human Rights"****, Sarup and Sons, NewDelhi,2004*
4	*https://nptel.ac.in/courses/109104068/36*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Know the values and work ethics.	K3
CO2	Enhance personality and behaviour development.	K3
CO3	Apply the values in human life.	K3
CO4	Gain Knowledge of values in society.	K3
CO5	Learn the importance of positive values in human life.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	-	3	1	1	1
CO2	-	-	3	1	2	1
CO3	-	-	3	1	2	1
CO4	-	-	3	1	1	1
CO5	-	-	3	1	1	2
23VLACZ3	**-**	**-**	**3**	**1**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23VLACZ4	**CONSTITUTION OF INDIA** *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	AC	**2**	**0**	**0**	**0**

Course Objectives	• To address the importance of constitutional rights and duties • To familiarize about Indian governance and local administration. • To know about the functions of election commission.	
UNIT – I	**INDIAN CONSTITUTION**	**6 Periods**
History of Making of the Indian Constitution: History Drafting Committee, (Composition & Working) - Philosophy of the Indian Constitution: Preamble Salient Features.		
UNIT – II	**CONSTITUTIONAL RIGHTS & DUTIES**	**6 Periods**
Contours of Constitutional Rights & Duties: Fundamental Rights , Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.		
UNIT – III	**ORGANS OF GOVERNANCE**	**6 Periods**
Organs of Governance: Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.		
UNIT – IV	**LOCAL ADMINISTRATION**	**6 Periods**
Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Panchayat raj: Introduction, PRI: Zila Panchayat. Elected officials and their roles, CEO Zila Panchayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy.		
UNIT – V	**ELECTION COMMISSION**	**6 Periods**
Election Commission: Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.		
Contact Periods: **Lecture: 30 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 30 Periods**		

REFERENCES:

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

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Discuss the growth of the demand for civil rights in India.	K2
CO2	Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.	K2
CO3	Understand the various organs of Indian governance.	K2
CO4	Familiarize with the various levels of local administration.	K2
CO5	Gain knowledge on election commission of india.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	-	1	1	1	1
CO2	-	-	1	1	1	2
CO3	-	-	1	1	2	1
CO4	-	-	1	1	1	1
CO5	-	-	1	1	1	1
23VLACZ4	**-**	**-**	**1**	**1**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23VLACZ5	**PEDAGOGY STUDIES** *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	AC	2	0	0	0

Course Objectives	• To Understand of various theories of learning, prevailing pedagogical practices and design of curriculum in engineering studies. • Application of knowledge in modification of curriculum, its assessment and introduction of innovation in teaching methodology.	
UNIT – I	**INTRODUCTION**	**6 Periods**
Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions. Overview of methodology and Searching.		
UNIT – II	**PEDAGOGICAL PRACTICES**	**6 Periods**
Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. Curriculum, Teacher education. Evidence on the effectiveness of pedagogical practices Methodology for the in depth stage: quality assessment of included studies		
UNIT – III	**PEDAGOGICAL APPROACHES**	**6 Periods**
How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices. Pedagogic theory and pedagogical approaches. Teacher's attitudes and beliefs and Pedagogic strategies.		
UNIT – IV	**PROFESSIONAL DEVELOPMENT**	**6 Periods**
Professional development: alignment with classroom practices and follow-up support. Peer support Support from the head teacher and the community. Curriculum and assessment Barriers to learning: limited resources and large class sizes.		
UNIT – V	**CURRICULUM AND ASSESSMENT**	**6 Periods**
Research gaps and future directions Research design Contexts Pedagogy Teacher education Curriculum and assessment Dissemination and research impact.		
Contact Periods: **Lecture: 30 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 30 Periods**		

REFERENCES:

1	*Ackers J, Hardman F ,**Classroom interaction in Kenyan primary schools,Compare**, 31 (2): 245-261, 2001.*
2	*Alexander RJ ,**Culture and pedagogy: International comparisons in primary education**. Oxford and Boston: Blackwell, 2001*
3	*Akyeampong K, Lussier K, Pryor J, Westbrook J, **Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count?** International Journal Educational Development, 33 (3): 272–282, 2013.*
4	*Agrawal M ,**Curricular reform in schools: The importance of evaluation**, Journal of Curriculum Studies, 36 (3): 361-379, 2004*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the concept of curriculum, formal and informal education systems and teacher education.	K3
CO2	Explain the present pedagogical practices and the changes occurring in pedagogical approaches	K3
CO3	Understand the relation between teacher and community, support from various levels of teachers to students and limitation in resources and size of the class.	K3
CO4	Perform research in design a problem in pedagogy and curriculum development.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	-	1	1	2	1
CO2	-	-	1	1	1	2
CO3	-	-	1	1	2	1
CO4	-	-	1	1	2	1
23VLACZ5	**-**	**-**	**1**	**1**	**2**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23VLACZ6	**STRESS MANAGEMENT BY YOGA** *(Common to All Branches)*

PREREQUISITES :	CATEGORY	L	T	P	C
NIL	AC	2	0	0	0

Course Objectives	1. To create awareness on the benefits of yoga and meditation. 2. To understand the significance of Asana and Pranayama.	
UNIT – I	**PHYSICAL STRUCTURE AND ITS FUNCTIONS**	**6 Periods**
Yoga - Physical structure, Importance of physical exercise, Rules and regulation of simplified physical exercises, hand exercise, leg exercise, breathing exercise, eye exercise, kapalapathy, maharasana, body massage, acupressure, body relaxation.		
UNIT – II	**YOGA TERMINOLOGIES**	**6 Periods**
Yamas - Ahimsa, satya, astheya, bramhacharya, aparigrahaNiyamas- Saucha, santosha, tapas, svadhyaya, Ishvarapranidhana.		
UNIT – III	**ASANA**	**6 Periods**
Asana - Rules & Reg		
UNIT – IV	**PRANAYAMA**	**6 Periods**
Regularization of breathing techniques and its effects-Types of pranayama		
UNIT – V	**MIND**	**6 Periods**
Bio magnetism & mind - imprinting & magnifying – eight essential factors of living beings, Mental frequency and ten stages of mind, benefits of meditation, such as perspicacity, magnanimity, receptivity, adaptability, creativity.		
Contact Periods: **Lecture: 30 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 30 Periods**		

REFERENCES :

1	*Janardan Swami Yogabhyasi Mandal**, "Yogic Asanas for Group Training-Part-I",** Nagpur.*
2	*Swami Vivekananda,"**Rajayoga or conquering the Internal Nature**", AdvaitaAshrama (Publication Department), Kolkata.*
3	*Pandit Shambu Nath, "**Speaking of Stress Management Through Yoga and Meditation",** New Dawn Press, New Delhi, 2016.*
4	*K. N. Udupa ,**"Stress and its management by Yoga",** Motilal Banarsidass Publishers, New Delhi, 2007.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Practice physical exercises and maintain good health.	K3
CO2	Attain knowledge on the various concepts of Yoga.	K2
CO3	Perform various asanas with an understanding on their benefits.	K3
CO4	Practice breathing techniques in a precise manner.	K3
CO5	Attain emotional stability and higher level of consciousness.	K2

COURSE ARTICULATION MATRIX :						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	-	2	-	-	-
CO2	-	-	2	-	-	-
CO3	-	-	2	-	-	-
CO4	-	-	2	-	-	-
CO5	-	-	2	-	-	-
23VLACZ6	**-**	**-**	**2**	**-**	**-**	**-**
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23VLACZ7	**PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS** *(Common to All Branches)*

PREREQUISITES :	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	AC	**2**	**0**	**0**	**0**

Course Objectives	• To familiar with Techniques to achieve the highest goal in life. • To become a person with stable mind, pleasing personality and determination.	
UNIT – I		**6 Periods**
Neetisatakam-Holistic development of personality-Verses- 19,20,21,22 (wisdom)-Verses29,31,32 (pride & heroism)-Verses- 26,28,6.		
UNIT – II		**6 Periods**
Verses- 52,53,59 (dont's)-Verses- 71,73,75,78 (do's). - Approach to day to day work and duties.-Shrimad BhagwadGeeta - Chapter 2-Verses 41, 47,48,		
UNIT – III		**6 Periods**
Shrimad BhagwadGeeta -Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,-Chapter 18-Verses 45, 46, 48.		
UNIT – IV		**6 Periods**
Statements of basic knowledge.-Shrimad BhagwadGeeta: -Chapter2-Verses 56, 62, 68 -Chapter 12 -Verses 13, 14, 15, 16,17, 18-Personality of Role model.		
UNIT – V		**6 Periods**
Shrimad BhagwadGeeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42, Chapter 4-Verses 18, 38,39-Chapter18 – Verses 37,38,63.		
Contact Periods: **Lecture: 30 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 30 Periods**		

REFERENCES :

1	*Swami SwarupanandaAdvaita Ashram "**Srimad Bhagavad Gita**",AdvaitaAshrama, Kolkata,2016*
2	*P.Gopinath, Rashtriya Sanskrit Sansthanam "**Bhartrihari's Three Satakam**" (Niti-sringar-vairagya), New Delhi, 1986.*
3	*Swami Mukundananda, JagadguruKripalujiYog "**Bhagavad Gita: The Song Of God**", USA,2019*
4	*A.C. Bhaktivedanta Swami Prabhupada "**Bhagavad-Gita As It Is**",Bhaktivedanta Book Trust Publications,2001*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Apply the Holistic development in life	K4
CO2	Effective Planning of day to day work and duties	K4
CO3	Identify mankind to peace and prosperity	K4
CO4	Develop versatile personality.	K4
CO5	Awakening wisdom in life	K4

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	-	1	-	-	-
CO2	-	-	1	-	-	-
CO3	-	-	1	-	-	-
CO4	-	-	1	-	-	-
CO5	-	-	1	-	-	-
23VLACZ7	**-**	**-**	**1**	**-**	**-**	**-**
1 – Slight, 2 – Moderate, 3 – Substantial						

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

23VLACZ8	SANSKRIT FOR TECHNICAL KNOWLEDGE *(Common to all Branches)*

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	AC	2	0	0	0

Course Objectives	• To get a working knowledge in illustrious Sanskrit, the scientific language in the world. • Learning of Sanskrit to improve brain functioning. • Enhancing the memory power. • Learning of Sanskrit to develop the logic in mathematics, science & other subjects.	
UNIT – I	**BASICS OF SANSKRIT**	**6 Periods**
Alphabets in Sanskrit, Past/Present/Future Tense.		
UNIT – II	**SENTENCES AND ROOTS**	**6 Periods**
Simple Sentences - Order, Introduction of roots		
UNIT – III	**SANSKRIT LITERATURE**	**6 Periods**
Technical information about Sanskrit Literature		
UNIT – IV	**TECHNICAL CONCEPTS -1**	**6 Periods**
Technical concepts of Engineering-Electrical, Mechanical		
UNIT – V	**TECHNICAL CONCEPTS -2**	**6 Periods**
Technical concepts of Engineering-Architecture, Mathematics		
Contact Periods: **Lecture: 30 Periods Tutorial: 0 Periods Practical: 30 Periods Total: 30 Periods**		

REFERENCES:

1	*Dr.Vishwas, "**Abhyaspustakam",** Samskrita -Bharti Publication, New Delhi, 2020.*
2	*Prathama Deeksha Vempati Kutumbshastri, "**Teach Yourself Sanskrit**", Rashtriya Sanskrit Sansthanam, New Delhi, Publication, 2009.*
3	*Suresh Soni, **"India's Glorious Scientific Tradition**" , Ocean books (P) Ltd., New Delhi,2006.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Recognize ancient literature and their basics	K3
CO2	Formulate the sentences with order and understand the roots of Sanskrit	K2
CO3	Acquire familiarity of the major traditions of literatures written in Sanskrit	K3
CO4	Distinguish the Technical concepts of Electrical & Mechanical Engineering	K2
CO5	Categorize the Technical concepts of Architecture & Mathematics	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	-	-	1	2	1
CO2	-	-	-	1	2	-
CO3	-	-	-	1	1	1
CO4	-	-	-	2	1	1
CO5	-	-	-	1	2	1
23VLACZ8	**-**	**-**	**-**	**1**	**2**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial						

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