DMI COLLEGE OF ENGINEERING

(An Autonomous Institution)

Palanchur – Nazarathpet P.O., Chennai – 600 123

Approved By AICTE, Affiliated to Anna University, Accredited by NBA

REGULATIONS 2024

CHOICE BASED CREDIT SYSTEM

M.E THERMAL ENGINEERING

CURRICULUM AND SYLLABUS

VISION OF THE INSTITUTE

To become an internationally reputed institution, by producing competent professions with exemplary skills and ethical values

MISSION OF THE INSTITUTE

IM 1. To achieve a higher level of technological and professional excellence.

IM 2. To impart quality and holistic professional education.

IM 3. To train professionals to be entrepreneurs and employment generators.

VISION OF THE DEPARTMENT

To produce Mechanical Engineering graduates with high standards, making them as committed professionals with ethical values.

MISSION OF THE DEPARTMENT

DM1. To impart quality technical education and to compete successfully in today's industrial requirements.

DM2. To develop the professional potential that leads to pursue research and higher studies.

DM3. To improve and sustain the professional behavior and ethical values.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO I: Analyze, design and evaluate thermal systems using state of the art engineering tools and techniques.

PEO II: Develop methods of energy conservation for sustainable growth.

PEO III: Communicate effectively and support constructively towards team work.

PEO IV: Pursue lifelong learning for professional growth with ethical concern for society and environment.

PROGRAM 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: Design, develop and analyze thermal systems for improved performance.

PO5: Identify viable energy sources and develop effective technologies to harness them.

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

PEOs/PSOs MAPPING

PEOs	POs					
	1	**2**	**3**	**4**	**5**	**6**
I	3	3	3	3	3	2
II	3	2	3	2	2	2
III	2	2	2	2	2	3
IV	3	3	3	3	3	3

EVALUATION PATTERN

Subject Type	Internal Marks	External Marks	Total Marks
Theory Courses	**40**	**60**	**100**
Laboratory Courses	**60**	**40**	**100**

CURRICULUM AND SYLLABI FOR I TO IV SEMESTERS

SEMESTER I

Sl.No	Course Code	Course Title	Category	Periods per Week L	T	P	Total Contact Periods	Credits
Theory Courses								
1	MA1113	Advanced Numerical Methods	FC	4	0	0	4	4
2	TE1105	Heat Transfer Mechanisms and Applications	PC	4	0	0	4	4
3	TE1106	Thermodynamic Analysis and Applications	PC	3	1	0	4	4
4	TE1107	Fluid Dynamics and Analysis	PC	3	0	0	3	3
5	RM1102	Research Methodology and IPR	RM	3	0	0	3	3
6		Professional Elective - I	PE	3	0	0	3	3
7		Professional Elective - II	PE	3	0	0	3	3
8		Audit Course I*	AC	2	0	0	2	0
Practical Courses								
7	TE1104	Thermal Engineering Laboratory	PC	0	0	4	**4**	**2**
Total				**25**	**1**	**4**	**30**	**26**

SEMESTER II

Sl.No	Course Code	Course Title	Category	Periods per Week L	T	P	Total Contact Periods	Credits
Theory Courses								
1	TE1151	Instrumentation for Thermal Engineering	PC	3	0	0	3	3
2	TE1152	Computational Fluid Dynamics	PC	3	0	0	3	3
3	TE1153	Fuels, Combustion and Emission Control	PC	3	0	0	3	3
4		Professional Elective - III	PE	3	0	0	3	3
5		Professional Elective - IV	PE	3	0	0	3	3
6		Professional Elective - V	PE	4	0	0	4	4
7		Audit Course II*	AC	2	0	0	2	0
Practical Courses								
8	TE1154	Thermal Systems Simulation Laboratory	PC	0	0	4	4	2
9	TE1155	Technical Seminar – I	EE	0	0	2	2	1
Total				**21**	**0**	**6**	**27**	**22**

SEMESTER III								
Sl.No	Course Code	Course Title	Category	Periods per Week			Total Contact Periods	Credits
				L	T	P		
Theory Courses								
1	TE1201	Design and Optimization of Thermal Energy Systems	PC	3	0	0	3	3
2		Professional Elective - VI	PE	3	0	0	3	3
3		Open Elective	OE	3	0	0	3	3
Laboratory Course								
4	TE1202	Technical Seminar – II	EE	0	0	2	2	1
5	TE1203	Project Work - I	EE	0	0	12	12	6
Total				**9**	**0**	**14**	**23**	**16**

SEMESTER IV								
Sl.No	Course Code	Course Title	Category	Periods per Week			Total Contact Periods	Credits
				L	T	P		
Laboratory Course								
1	TE1251	Project Work - II	EE	0	0	24	24	12
Total				**0**	**0**	**24**	**24**	**12**

AUDIT COURSES								
Sl.No	Course Code	Course Title	Category	Periods per Week			Total Contact Periods	Credits
				L	T	P		
1	MX1101	English for Research Paper Writing	AC	2	0	0		0
2	MX1102	Disaster Management	AC	2	0	0		0
3	MX1103	Constitution of India	AC	2	0	0		0
4	MX1104	நற்றமிழ் இலக்கியம்	AC	2	0	0		0

* Audit Course is optional

SEMESTER I, ELECTIVE I & II

Sl.No	Course Code	Course Title	Category	Periods per Week			Total Contact Periods	Credits
				L	T	P		
1	TE1911	Aircraft and Jet Propulsion	PE	3	0	0	3	3
2	TE1912	Hydrogen and Fuel Cell Technologies	PE	3	0	0	3	3
3	TE1913	Energy Resources	PE	3	0	0	3	3
4	TE1914	Advanced Internal Combustion Engines	PE	3	0	0	3	3
5	TE1915	Cryogenic Engineering	PE	3	0	0	3	3
6	TE1916	Refrigeration Systems	PE	3	0	0	3	3
7	TE1917	Electronic Engine Management Systems	PE	3	0	0	3	3
8	TE1918	Cogeneration and Waste Heat Recovery Systems	PE	3	0	0	3	3
9	TE1919	Composite Materials and Mechanics in Thermal Applications	PE	3	0	0	3	3

SEMESTER II, ELECTIVE III, IV & V

Sl.No	Course Code	Course Title	Category	Periods per Week			Total Contact Periods	Credits
				L	T	P		
1	TE1951	Design of Turbo Machines	PE	3	0	0	3	3
2	TE1952	Air Conditioning Systems	PE	3	0	0	3	3
3	TE1953	Alternate Fuels for IC Engines	PE	3	0	0	3	3
4	TE1954	Design of Heat Exchangers	PE	4	0	0	4	4
5	TE1955	Battery Thermal Management System	PE	3	0	0	3	3
6	TE1956	Advanced Energy Storage Technologies	PE	4	0	0	4	4
7	TE1957	Hybrid and Electric Vehicles	PE	3	0	0	3	3
8	TE1958	Advanced Power Plant Engineering	PE	3	0	0	3	3
9	TE1959	Advances in Materials	PE	3	0	0	3	3
10	TE1960	Materials Testing and Characterization Techniques	PE	4	0	0	4	4

SEMESTER III, ELECTIVE VI

Sl.No	Course Code	Course Title	Category	Periods per Week			Total Contact Periods	Credits
				L	T	P		
1	TE1921	Boundary Layer Theory and Turbulence	PE	3	0	0	3	3
2	TE1922	Steam Generator Technology	PE	3	0	0	3	3
3	TE1923	Fluidized Bed Systems	PE	3	0	0	3	3
4	TE1924	Energy Efficient Buildings	PE	3	0	0	3	3
5	TE1925	Engine Pollution and Control	PE	3	0	0	3	3
6	TE1926	Solar Thermal Technologies	PE	3	0	0	3	3

OPEN ELECTIVES								
Sl.No	**Course Code**	**Course Title**	**Category**	**Periods per Week**			**Total Contact Periods**	**Credits**
				L	**T**	**P**		
1	TE1701	Integrated Water Resources Management	OE	3	0	0	3	3
2	TE1702	Water, Sanitation and Health	OE	3	0	0	3	3
3	TE1703	Principles of Sustainable Development	OE	3	0	0	3	3
4	TE1704	Environmental Impact Assessment	OE	3	0	0	3	3
5	TE1705	Blockchain Technologies	OE	3	0	0	3	3
6	TE1706	Deep Learning	OE	3	0	0	3	3
7	TE1707	Sustainable Management	OE	3	0	0	3	3
8	TE1708	Micro and Small Business Management	OE	3	0	0	3	3
9	TE1709	Intellectual Property Rights	OE	3	0	0	3	3
10	TE1710	Ethical Management	OE	3	0	0	3	3
11	TE1711	IoT for Smart Systems	OE	3	0	0	3	3
12	TE1712	Machine Learning and Deep Learning	OE	3	0	0	3	3
13	TE1713	Renewable Energy Technology	OE	3	0	0	3	3
14	TE1714	Smart Grid	OE	3	0	0	3	3
15	TE1715	Security Practices	OE	3	0	0	3	3
16	TE1716	Cloud Computing Technologies	OE	3	0	0	3	3
17	TE1717	Design Thinking	OE	3	0	0	3	3
18	TE1718	Principles of Multimedia	OE	3	0	0	3	3
19	TE1719	Big Data Analytics	OE	3	0	0	3	3
20	TE1720	Internet of Things and Cloud	OE	3	0	0	3	3
21	TE1721	Medical Robotics	OE	3	0	0	3	3
22	TE1722	Embedded Automation	OE	3	0	0	3	3
23	TE1723	Environmental Sustainability	OE	3	0	0	3	3
24	TE1724	Textile Reinforced Composites	OE	3	0	0	3	3
25	TE1725	Nanocomposite Materials	OE	3	0	0	3	3
26	TE1726	IPR, Biosafety and Entrepreneurship	OE	3	0	0	3	3

CREDIT SUMMARY

M.E. THERMAL ENGINEERING						
S.No	Subject Area	Credits per Semester				Total Credits
		I	II	III	IV	
1	FC	4				4
2	PC	13	11	3		27
3	PE	6	10	3		19
4	OE			3		3
5	RM	3				3
6	AC					0
7	EE		1	7	12	20
Total		26	22	16	12	76

SEMESTER I

Course Code	Course Name	L	T	P	C
MA1113	ADVANCED NUMERICAL METHODS	4	0	0	4

COURSE OBJECTIVES:

1. To study various numerical techniques to solve linear and non-linear algebraic and transcendental equations.
2. To compare ordinary differential equations by finite difference and collocation methods.
3. To establish finite difference methods to solve Parabolic and hyperbolic equations.
4. To establish finite difference method to solve elliptic partial differential equations.
5. To provide basic knowledge in finite elements method in solving partial differential equations.

UNIT I ALGEBRAIC EQUATIONS 12

Systems of linear equations: Gauss elimination method – Pivoting techniques – Thomas algorithm for tri diagonal system – Jacobi, Gauss Seidel, SOR iteration methods – Conditions for convergence - Systems of nonlinear equations: Fixed point iterations, Newton's method, Eigenvalue problems: Power method and Given's method.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS 12

Runge - Kutta methods for system of IVPs – Numerical stability of Runge - Kutta method – Adams - Bashforth multistep method, Shooting method, BVP: Finite difference method, Collocation method and orthogonal collocation method.

UNIT III FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATIONS 12

Parabolic equations : Explicit and implicit finite difference methods – Weighted average approximation - Dirichlet's and Neumann conditions – Two dimensional parabolic equations – ADI method : First order hyperbolic equations – Method of numerical integration along characteristics – Wave equation : Explicit scheme – Stability.

UNIT IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS 12

Laplace and Poisson's equations in a rectangular region: Five-point finite difference schemes, Leibmann's iterative methods, Dirichlet's and Neumann conditions – Laplace equation in polar coordinates: Finite difference schemes – Approximation of derivatives near a curved boundary while using a square mesh.

UNIT V FINITE ELEMENT METHOD 12

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.

TOTAL: 60 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Solve an algebraic or transcendental equation, linear system of equations and differential equations using an appropriate numerical method.
CO2	Solving the initial boundary value problems and boundary value problems using finite difference and finite element methods.
CO3	Solving parabolic and hyperbolic partial differential equations by finite difference methods.
CO4	Compute solution of elliptic partial differential equations by finite difference methods.

CO5	Selection of appropriate numerical methods to solve various types of problems in engineering and science in consideration with the minimum number of mathematical operations involved, accuracy requirements and available computational resources.
REFERENCES:	
R1	Burden, R.L., and Faires, J.D., "Numerical Analysis – Theory and Applications", 9th Edition, Cengage Learning, New Delhi, 2016.
R2	Gupta S.K., "Numerical Methods for Engineers",4th Edition, New Age Publishers, 2019.
R3	Jain M. K., Iyengar S. R., Kanchi M. B., Jain, "Computational Methods for Partial DifferentialEquations", New Age Publishers ,1993.
R4	Sastry, S.S., "Introductory Methods of Numerical Analysis", 5th Edition, PHI Learning, 2015.
R5	Saumyen Guha and Rajesh Srivastava, "Numerical methods for Engineering and Science", Oxford Higher Education, New Delhi, 2010.
R6	Smith, G. D., "Numerical Solutions of Partial Differential Equations: Finite Difference Methods", Clarendon Press, 1985.

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	3	3	1	1		
2	3	3	1	1		
3	3	3	1	1	1	
4	3	3	1	1	1	
5	3	3	1	1	1	
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1105	**HEAT TRANSFER MECHANISMS AND APPLICATION**	**4**	**0**	**0**	**4**

COURSE OBJECTIVES:

1. To impart knowledge on conduction heat transfer associated with radiation.
2. To impart knowledge on the turbulent forced convective heat transfer.
3. To impart knowledge on the significance of Phase Change Heat Transfer and Mass Transfer.
4. To teach the heat exchanger design aspects including compact heat exchangers.
5. To impart knowledge on the significance of Phase Change Heat Transfer and Mass Transfer.

UNIT I CONDUCTION AND RADIATION HEAT TRANSFER 12

One dimensional energy equations and boundary condition - three-dimensional heat conduction equations - extended surface heat transfer- various pin profiles- pin optimization - transient conduction-- conduction with moving boundaries - radiation in gases and vapour. Gas radiation and radiation heat transfer in enclosures containing absorbing and emitting media – interaction of radiation with conduction and convection

UNIT II TURBULENT FORCED CONVECTIVE HEAT TRANSFER 12

Momentum and energy equations - turbulent boundary layer heat transfer - mixing length concept - turbulence model – k Є model - analogy between heat and momentum transfer – Reynolds, Colburn, Prandtl turbulent flow in a tube - high speed flows.

UNIT III PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGER 12

Condensation on bank of tubes - boiling – pool and flow boiling - heat Transfer Enhancement Techniques.

UNIT IV HEAT EXCHANGERS 12

Heat Exchanger – Є- NTU approach and design procedure – compact heat exchangers – Plate heat exchangers– Mini and Micro Channel heat exchangers, Heat transfer correlations for specific cases.

UNIT V MASS TRANSFER 12

Mass transfer - vaporization of droplets - combined heat and mass transfers applications – Cooling Towers, Evaporative condensers, solar pond, Cooling and dehumidification systems – porous media heat transfer

TOTAL: 60 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Analyze problems on heat transfer associated with conduction and convection and radiation through vapour and gases.
CO2	Analyze problems on turbulent heat transfer and also solve high speed flow problems.
CO3	Analyze problems on phase change heat transfer.
CO4	Estimate the performance of compact heat exchangers and also understand the use of correlations to predict heat transfer from specific devices
CO5	Understand and analyze the mass transfer associated with heat transfer in engineering

REFERENCES:

R1	Ghoshdastidar. P.S., Heat Transfer, Oxford University Press, 2004.
R2	Holman.J.P., Heat Transfer, Tata Mc Graw Hill, 2002.
R3	Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons, 2002.

R4	Nag.P.K., Heat Transfer, Tata McGraw-Hill, 2002.
R5	Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw-Hill Co., 1985.
R6	Yadav, R., Heat and Mass Transfer, Central Publishing House, 1995.
R7	Yunus A.Cengal., Heat and Mass Transfer – A practical Approach, 3rd edition, Tata McGraw - Hill, 2007.

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	2	1	3	2		3
2	2	2	3	2		3
3	2	1	3	2		3
4	2	2	3	2		3
5	2	2	2	2		3
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1106	**THERMODYNAMICS ANALYSIS AND APPLICATIONS**	**3**	**1**	**0**	**4**

COURSE OBJECTIVES:

1. To understand Thermodynamic Potentials and Relations
2. To study Real Gas Behavior and Multi-component Systems
3. To study the availability and irreversibility in thermodynamic processes
4. To analyze the Fuel-Air Cycles and Engine Processes
5. To Explore Thermochemistry and Chemical Equilibrium

UNIT I THERMODYNAMIC PROPERTY RELATIONS 12

Thermodynamic Potentials, Maxwell relations, Generalized relations for changes in Entropy, Internal Energy and Enthalpy, Generalized Relations for Cp and Cv, Clausius Clapeyron Equation, Joule Thomson Coefficient, Bridgeman Tables for Thermodynamic Relations.

UNIT II REAL GAS BEHAVIOUR AND MULTI-COMPONENT SYSTEMS 12

Equations of State (mention three equations), Fugacity, Compressibility, Principle of Corresponding States, use of generalized charts for enthalpy and entropy departure, fugacity coefficient, Lee-Kesler 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, Gibb's phase rule for non-reactive components.

UNIT III AVAILABILITY ANALYSIS 12

Introduction, Reversible work, Availability, Irreversibility and Second - Law Efficiency for a closed System and Steady-State Control Volume. Availability Analysis of Simple Cycles. Chemical availability of closed and control volume. Fuel Chemical availability, Evaluation of the availability of hydrocarbon fuels.

UNIT IV FUEL – AIR CYCLES AND THEIR ANALYSIS 12

Ideal Models of Engine Processes, Fuel–Air Cycle Analysis – SI Engine Cycle Simulation, CI Engine Cycle Simulation, Results of Cycle Calculations, Availability Analysis of Engine Processes – Availability Relationships – Entropy changes in Ideal Cycles – Availability Analysis of Ideal Cycles.

UNIT V THERMO CHEMISTRY 12

Ideal gas laws and properties of Mixtures, Combustion Stoichiometry, Application of First Law of Thermodynamics – Heat of Reaction – Enthalpy of Formation – Adiabatic flame temperature. Second law of Thermodynamics applied to combustion – entropy, maximum work and efficiency Chemical equilibrium: - Equilibrium constant evaluation Kp & Kf, Equilibrium composition evaluation of ideal gas and real gas mixtures.

TOTAL: 60 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Apply the law of thermodynamics to thermal systems.
CO2	Analyze the actual thermodynamic cycles
CO3	Design and analyze a multi component thermodynamic system
CO4	Apply the thermodynamics concepts in automotive systems
CO5	Understand and analyze the combustion of different fuels

REFERENCES:

R1	Kenneth Wark., J.R, Advanced Thermodynamics for Engineers, McGraw-Hill Inc., 1995.
R2	K.Annamalai, I.K.Puri, M.A.Jog, Advanced Thermodynamics Engineering, Second Edition,CRC Press, 2011.
R3	Advanced Thermodynamics, S.S. Thipse, Narosa Publishing Home Pvt. Ltd., 2013
R4	Yunus A. Cengel and Michael A. Boles, Thermodynamics, McGraw-Hill Inc., 2006.
R5	B.P. Pundir, I.C. engine combustion and emissions. Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Sons, 1988.
R6	Holman,J.P., Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1988.

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	2		3	2		3
2	2	1	3	2		3
3	2		3	2		3
4	2	1	3	2		3
5	2	1	3	2		3
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1107	**FLUID DYNAMICS AND ANALYSIS**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1. To Understand Fundamental Principles of fluids and its properties
2. To apply Potential Flow Theory
3. To Apply Poiseuille's equation for laminar flow through pipes and the Darcy-Weisbach equation for turbulent flow.
4. To study boundary layer concepts and analyze laminar and turbulent flows over flat plates and surfaces.
5. To analyze one-dimensional compressible flow and shock waves using gas tables.

UNIT I BASIC EQUATIONS OF FLOW **9**

Three-dimensional continuity equation - differential and integral forms – equations of motion momentum and energy - Reynolds transport theorem – Navier – Stokes equation - Engineering Applications

UNIT II POTENTIAL FLOW THEORY **9**

Rotational and irrotational flows - circulation – vorticity - stream and potential functions for standard flows and combined flows – representation of solid bodies by flow patterns. Pressure distribution over stationery and rotating cylinders in a uniform flow - magnus effect - Kutta – Zhukovsky theorem. Complex potential functions. Conformal transformation to analyze the flow over flat plate, cylinder, oval body and airfoils. Thin airfoil theory – generalized airfoil theory forcambered and flapped airfoils.

UNIT III VISCOUS FLOW THEORY **9**

Laminar and turbulent flow - laminar flow between parallel plates - Poiseuille's equation for flow through circular pipes. Turbulent flow - Darcy Weisbach equation for flow through circular pipe - friction factor - smooth and rough pipes - Moody diagram – losses during flow through pipes. Pipes in series and parallel – transmission of power through pipes.

UNIT IV BOUNDARY LAYER CONCEPT **9**

Boundary Layer - displacement and momentum thickness - laminar and turbulent boundary layers in flat plates - velocity distribution in turbulent flows in smooth and rough boundaries - laminar sub layer.

UNIT V COMPRESSIBLE FLUID FLOW **9**

One dimensional compressible fluid flow – flow through variable area passage – nozzles and diffusers – fundamentals of supersonics – normal and oblique shock waves and calculation of flow and fluid properties over solid bodies (like flat plate, wedge, diamond) using gas tables

TOTAL: 45 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Understand and apply basic flow equations for analyzing fluid motion.
CO2	Analyze potential flow around bodies and apply airfoil theories.
CO3	Evaluate laminar and turbulent flow in pipes using standard equations.
CO4	Understand boundary layer concepts and flow behavior over surfaces.
CO5	Analyze compressible flow and shock waves using gas tables.

REFERENCES:

R1	Anderson J.D., Fundamentals of Aerodynamics, McGraw Hill, Boston, 2001.

R2	Bansal R.K., Fluid Mechanics, Saurabh and Co., New Delhi, 1985.
R3	Houghten E.L. and Carruthers N.B., Aerodynamics for Engineering Students, Arnold Publishers, 1993.
R4	Kumar K.L., Engineering Fluid Mechanics, Eurasia Publishing House, New Delhi, 2002.
R5	Munson B.R., Young D.F. and Okiisi, T.H., Fundamentals of Fluid Mechanics, John Wileyand Sons Inc., NewYork, 1990.
R6	Schlichting H., Boundary layer theory, Mc Graw Hill Book Company, 1979
R7	Shames, Mechanics of Fluids, Mc Graw Hill Book Company, 1962.
R8	Streeter V.L., Wylie E.B. and Bedford K.W., Fluid Mechanics, WCB McGraw Hill, Boston, 1998.

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	3	-	3	-	2	2
2	3	-	3	-	2	2
3	2	-	3	-	2	2
4	3	-	2	-	2	1
5	2	-	3	-	3	2
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
RM 1102	**RESEARCH METHODOLOGY AND IPR**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:		
1. To introduce the fundamental concepts of research and the research process.		
2. To familiarize students with various research designs and sampling techniques.		
3. To equip students with data collection methods and tools for effective measurement and analysis.		
4. To develop skills in analyzing data using both quantitative and qualitative approaches and reporting results accurately.		
5. To provide an understanding of Intellectual Property Rights (IPR) and patent processes in research and innovation.		
UNIT I	**INTRODUCTION TO RESEARCH METHODOLOGY**	**9**
The Nature of Research - Definition of research, Types of research (quantitative, qualitative, mixed methods), Characteristics of good research. Research Process - Steps involved in the research process, Importance of research planning, Ethical considerations in research.		
UNIT II	**RESEARCH DESIGN**	**9**
Research Design - Definition of research design, Types of research design (experimental, correlational, survey, case study), Selection of appropriate research design. Sampling Techniques - Probability sampling (simple random, stratified, cluster, systematic), Non-probability sampling (convenience, purposive, snowball), Factors Influencing Sampling Technique Selection, Sample size determination.		
UNIT III	**DATA COLLECTION**	**9**
Data Collection Methods - Primary data collection (surveys, interviews, observations, experiments), Secondary data collection (literature review, existing databases), Data collection instruments (questionnaires, interview guides, observation checklists). Measurement Scales - Nominal, ordinal, interval, and ratio scales, Reliability and validity of measurement.		
UNIT IV	**DATA ANALYSIS AND REPORTING**	**9**
Quantitative Data Analysis - Descriptive statistics (mean, median, mode, standard deviation), Inferential statistics (t-tests, ANOVA, correlation analysis, regression analysis). Qualitative Data Analysis - Thematic analysis, Content analysis, Narrative analysis. Research Reporting - Components of a research report, Writing style and clarity, Citation and referencing		
UNIT V	**INTELLECTUAL PROPERTY RIGHTS & PATENTS**	**9**
Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance. Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licenses, Licensing of related patents, patent agents, Registration of patent agents.		
		TOTAL: 45 PERIODS

COURSE OUTCOMES After successful completion of the course, the students will be able:	
CO	**COURSE OUTCOME**
CO1	Explain the nature, types, and characteristics of research and apply the research process effectively.
CO2	Select appropriate research designs and sampling techniques for specific research problems.
CO3	Utilize appropriate methods for collecting primary and secondary data using valid and reliable instruments.
CO4	Analyze and interpret data using statistical and qualitative analysis tools and prepare well-structured research reports.
CO5	Demonstrate knowledge of Intellectual Property Rights, including patents, trademarks, and the role of global organizations like WIPO and WTO.

REFERENCES:

R1	C R Kothari, "Research Methodology Methods and Techniques, New Age International (P) Limited Publishers (2004)
R2	Cooper Donald R, Schindler Pamela S and Sharma JK, "Business Research Methods", TataMcGraw Hill Education, (2012).
R3	Catherine J. Holland, "Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets",Entrepreneur Press, 2007.
	David Hunt, Long Nguyen, Matthew Rodgers, "Patent searching: tools & techniques",
R4	Wiley,2007.
R5	The Institute of Company Secretaries of India, Statutory body under an Act of parliament, "Professional Programme Intellectual Property Rights, Law and practice", September 2013.

COURSE ARTICULATION MATRIX

CO	PO					
	1	2	3	4	5	6
1	3	3				3
2	3	3				3
3	3	3				3
4	3	3				3
5	3	3				3
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1104	THERMAL ENGINEERING LABORATORY	0	0	4	2

COURSE OBJECTIVES:

1. To study and evaluate the performance and emission characteristics of multi-cylinder SI and CI engines operating on conventional and alternative fuels.
2. To investigate the thermal behavior and efficiency of variable compression ratio engines, heat pumps, and refrigeration systems under various operating conditions.
3. To analyze the performance of thermal energy systems such as solar water heaters, cooling towers, and boilers through hands-on experimentation.
4. To determine the physical, chemical, and thermal properties of various liquid and gaseous fuels and understand their application in energy systems.
5. To develop competency in calibrating thermal and pressure measurement instruments like RTDs, thermocouples, and pressure sensors for accurate experimental analysis.

LABORATORY

1. Performance and emission characteristics of multi cylinder Spark Ignition andCompression Ignition engines using alternate fuels.
2. Thermal performance of variable compression ratio engines.
3. Thermal analysis of natural / forced draught cooling towers.
4. Thermal analysis of heat pumps systems.
5. Experimental studies on vapor compression refrigeration systems using natural Refrigerants.
6. Overall performance of solar water heating system.
7. Physical, Chemical and thermal Properties of any liquid and gas fuels.
8. Experimental analysis of a Boiler.
9. Calibration of Temperature sensors (RTD / any thermocouple)
10. Calibration of Pressure sensors
11. Experimental studies on axial / centrifugal fan characteristics

TOTAL: 60 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Analyze the performance and emission characteristics of Spark Ignition (SI) and Compression Ignition (CI) engines using alternative fuels to evaluate their environmental and thermal efficiency.
CO2	Evaluate the thermal performance of variable compression ratio engines and other thermal systems such as heat pumps, boilers, and refrigeration units under different operating conditions.
CO3	Conduct experimental investigations on energy systems like solar water heaters, cooling towers, and fans, and interpret the system behavior using thermal and fluid dynamic principles.
CO4	Determine the physical, chemical, and thermal properties of liquid and gaseous fuels and

	assess their suitability for thermal applications.
CO5	Calibrate and validate thermal and pressure sensors (e.g., RTD, thermocouples, pressure transducers) to ensure accurate data acquisition in experimental setups.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

1. Single cylinder / multi cylinder Automotive Engine with data acquisition system	1 No
2. Flue gas analyzer	1 No
3. Smoke meter	1 No
4. Single cylinder variable Compression ratio petrol engine	1 No
5. Single cylinder variable Compression ratio Diesel engine	1 No
6. Cooling tower test rig	1 No
7. Refrigeration cum Heat Pump test rig	1 No
8. 100 LPD Solar flat plate water heater test rig	1 No
9. Pyranometer	1 No
10. Redwood / Say bolt viscometer	1 No
11. Bomb calorimeter apparatus	1 No
12. Gas calorimeter	1 No
13. Cloud & Pour point apparatus	1 No
14. IBR / Non-IBR Boiler test rig	1 No
15. Fan test rig	1 No
16. Pressure Calibrator	1 No
17. Temperature Calibrator	1 No

COURSE ARTICULATION MATRIX

CO	PO					
	1	**2**	**3**	**4**	**5**	**6**
1	3	-	3	3	2	2
2	3	-	2	3	2	3
3	3	-	2	2	2	2
4	2	-	2	2	2	1
5	2	-	3	2	3	2
Low (1); Medium (2); High (3)						

SEMESTER II

Course Code	Course Name	L	T	P	C
TE1151	**Instrumentation for Thermal Engineering**	3	0	0	3

COURSE OBJECTIVES:

1. To classify various measuring instruments.
2. To categorize temperature sensors and their applications in measurement.
3. To outline the advancements in pressure and volume measurements.
4. To explore the various measurement techniques for thermos physical properties.
5. To compare the different data acquisition systems

UNIT I MEASUREMENT CHARACTERISTICS **9**

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 TEMPERATURE MEASUREMENT **9**

Temperature, Types, materials, Accuracy - Selection of Temperature sensors - Effect of length of sensor on temperature measurements- calibration of thermocouple, RTD's & Thermistors- Standards for temperature measurement - Cryogenic & High Temperature measurement techniques.

UNIT III PRESSURE FLOW & VOLUME MEASUREMENTS **9**

Pressure Sensors: Types & materials - piezoelectric transducers- calibration of pressure sensors selection of pipes & fittings for pressure sensors. Volume sensors: Standard volumetric flask- Types, Density measurement instruments for liquids & gases. Flow Sensors: Caroli's mass flow measurements - flow measurements for water, gases, other oils & other chemicals.

UNIT IV MEASUREMENT OF THERMO PHYSICAL PROPERTIES **9**

Thermal Conductivity measurement of solids - liquids & gases- Sensors & calibration methods- Thermal conductivity of microbar nano composites - Specific heat of liquids, solids through DSC Analysis - viscosity measurement of Newtonian & non-Newtonian fluids through rheological analysis

UNIT V DATA ACQUISITION SYSTEM **9**

Data acquisition systems, Evolution of SCADA, Communication technologies, Monitoring and supervisory functions, SCADA applications in Utility Automation, Industries - SCADA System Components: Schemes- Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED), Communication Network, SCADA Server, SCADA/HMI Systems Various SCADA architectures.

TOTAL: 45 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	To Infer the role of uncertainty analysis in measuring instruments
CO2	To Select the appropriate temperature sensors based on specific applications
CO3	To Identify the suitable sensors for pressure and volume measurements.
CO4	To Evaluate thermos physical properties of media.
CO5	To Appraise the advantages of data acquisition systems.

REFERENCES:

R1	Holman J.P., Experimental methods for engineers, McGraw-Hill, 2012.
R2	Barnery, Intelligent Instrumentation, Prentice Hall of India, 2010.
R3	Bolton.W, Industrial Control & Instrumentation, Universities Press, Second Edition, 2001.
R4	John G Webster, The measurement, Instrumentation and sensors Handbook, CRC and IEE Press, 2014.
R5	Morris A.S, Principles of Measurements and Instrumentation Prentice Hall of India, 2004.
R6	Nakra, B.C., Choudhry K.K., Instrumentation, Measurements and Analysis Tata McGraw Hill,New Delhi, 2nd Edition 2003.
R7	T.G.Beekwith R.D., Marangoni and J.H. Lienhard, Mechanical Measurements, Pearson Education, 2001

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	-	1	-	-
2	2	-	2	1	2	1
3	2	-	2	1	2	1
4	2	-	2	2	2	1
5	2	-	1	1	2	-
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1152	COMPUTATIONAL FLUID DYNAMICS	3	0	0	3

COURSE OBJECTIVES:

1. This course aims to introduce numerical modeling and its role in the field of heat, fluid flow and combustion. It will enable the students to understand the various discretization methods and solving methodologies and to create confidence to solve complex problems in the field of heat transfer and fluid dynamics.
2. To develop finite volume discretized forms of the governing equations for diffusion processes.
3. To develop finite volume discretized forms of the convection-diffusion processes.
4. To develop pressure-based algorithms for flow processes.
5. To introduce various turbulence models, Large Eddy Simulation and Direct Numerical Simulation.

UNIT I GOVERNING DIFFERENTIAL EQUATIONS AND DISCRETISATION TECHNIQUES 9

Basics of Heat Transfer, Fluid flow – Mathematical description of fluid flow and heat transfer – Conservation of mass, momentum, energy and chemical species - Classification of partial differential equations – Initial and Boundary Conditions – Discretization techniques using finite difference methods – Taylor's Series - Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test.

UNIT II DIFFUSION PROCESSES: FINITE VOLUME METHOD 9

Steady one-dimensional diffusion, Two- and three-dimensional steady state diffusion problems, Discretization of unsteady diffusion problems – Explicit, Implicit and Crank-Nicholson's schemes, Stability of schemes.

UNIT – III CONVECTION-DIFFUSION PROCESSES: FINITE VOLUME METHOD 9

One dimensional convection – diffusion problem, Central difference scheme, upwind scheme – Hybrid and power law discretization techniques – QUICK scheme.

UNIT IV FLOW PROCESSES: FINITE VOLUME METHOD 9

Discretization of incompressible flow equations – Pressure based algorithms, SIMPLE,SIMPLER & PISO algorithms

UNIT V TURBULENCE MODELS 9

Turbulence – RANS equation - Algebraic Models, One equation model, Two equation models – k & standard k – ϵ model, Low Reynold number models of k- ϵ, Large Eddy Simulation (LES), Direct Numerical Simulation (DNS) - Introduction. Solving simple cases using standard CFD codes.

TOTAL: 45 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	To Analyze the governing equations and boundary conditions.
CO2	To Analyze various discretization techniques for both steady and unsteady diffusion problems.
CO3	To Analyze the various convection-diffusion problems by Finite-Volume method.
CO4	To Analyze the flow processes by using different pressure bound algorithms.
CO5	To Select and use the different turbulence models according to the type of flows.

REFERENCES:

R1	Versteeg and Malalasekera, N, “An Introduction to computational Fluid Dynamics. The Finite Volume Method,” Pearson Education, Ltd., Second Edition, 2014.
R2	Ghosh dastidar, P.S., “Computer Simulation of Flow and Heat Transfer”, Tata McGraw-Hill Publishing Company Limited, New Delhi, 1998.
R3	Muralidhar, K., and Sundararajan, T., “Computational Fluid Flow and Heat Transfer”, Narosa Publishing House, New Delhi, 2003.
R4	Subas and V.Patankar “Numerical heat transfer fluid flow”, Hemisphere Publishing Corporation, 1980
R5	JiyuanTu, Guan Heng Yeoh, Chaogun Liu, “Computational Fluid Dynamics A Practical Approach” Butterworth – Heinemann An Imprint of Elsevier, Madison, U.S.A., 2008
R6	John D. Anderson. JR. “Computational Fluid Dynamics the Basics with Applications” McGraw-Hill International Editions, 1995.

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	2	1	3	-	-	-
2	2	1	3	-	-	-
3	3	1	3	-	3	-
4	3	1	3	-	3	-
5	3	1	3	-	3	-
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1153	FUELS, COMBUSTION AND EMISSION CONTROL	4	0	0	4

COURSE OBJECTIVES:

1. To understand the types of fuels.
2. To compare the fuels in specific point
3. To understand the principles of combustion and combustion equipment's.
4. To understand the thermodynamic process behind the combustion.
5. To Identify the level of emission standards

UNIT I SOLID FUELS **9**

Solid Fuel Types - Coal Family - Properties - Calorific Value - ROM, DMMF, DAF and Bone-Dry Basis - Ranking - Bulk & Apparent Density - Storage - Washability - Coking & Caking Coals – Renewable Solid Fuels - Biomass - Wood Waste - Agro Fuels - Manufactured Solid Fuels

UNIT II LIQUID AND GASEOUS FUELS **9**

Liquid Fuel Types - Sources - Petroleum Fractions - Classification - Refining - Properties of Liquid Fuels - Calorific Value, Specific Gravity, Flash & Fire Point, Octane Number, Cetane Number etc., -Alcohols - Tar Sand Oil - Liquefaction of Solid Fuels

Gaseous Fuel Classification - Composition & Properties - Estimation of Calorific Value - Gas Calorimeter. Rich & Lean Gas - Wobbe Index - Natural Gas - Dry & Wet Natural Gas - Stripped NG- Foul & Sweet NG - LPG - LNG - CNG - Methane - Producer Gas - Gasifiers - Water Gas - Town Gas - Coal Gasification - Gasification Efficiency - Non - Thermal Route - Biogas - Digesters - Reactions - Viability - Economics.

UNIT III COMBUSTION: STOICHIOMETRY & KINETICS **9**

Stoichiometry – Mass Basis & Volume Basis – Excess Air Calculation – Fuel & Flue Gas Compositions - Calculations – Rapid Methods – Combustion Processes – Stationary Flame – Surface or Flameless Combustion – Submerged Combustion – Pulsating & Slow Combustion Explosive Combustion. Mechanism of Combustion – Ignition & Ignition Energy – Spontaneous Combustion – Flame Propagation – Solid, Liquid & Gaseous Fuels Combustion – Flame Temperature – Theoretical, Adiabatic & Actual – Ignition Limits – Limits of Inflammability. Thermo Chemistry - Equilibrium combustion products. Low temperature combustion products – High temperature combustion products.

UNIT IV COMBUSTION EQUIPMENTS **9**

Coal Burning Equipment – Types – Pulverized Coal Firing – Fluidized Bed Firing – Fixed Bed & Recycled Bed – Cyclone Firing – Spreader Stokers – Vibrating Grate Stokers – Sprinkler Stokers, Traveling Grate Stokers. Oil Burners – Vaporizing Burners, Atomizing Burners – Design of Burners. Gas Burners – Atmospheric Gas Burners – Air Aspiration Gas Burners – Burners Classification according to Flame Structures – Factors Affecting Burners & Combustion.

UNIT V EMISSION CONTROL METHODS **9**

Emissions - Emission index - Corrected concentrations - Control of emissions for premixed and non-prefixed combustion**.** Flue gas Desulphurization**,** Coal Beneficiation, Coal Blending, Efficiency. Improvement Methods ($CO2$ reduction)– Super critical boilers, Integrated Gasification CombinedCycle Power Plant, Carbon Capture & Storage (CCS)

TOTAL: 45 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	To Identify to enable the fuels used for different purposes.
CO2	To Examine the fuels at different conditions.
CO3	To Summarize the fuels and its combustion levels.
CO4	To Select the correct Equipment on combustion techniques.
CO5	To Illustrate the emission control at a standard rate.
REFERENCES:	
R1	B.I. Bhatt and S.M. Vora, Stoichiometry, 2nd Edition, Tata McGraw Hill, 2010.
R2	Blokh A.G., Heat Transfer in Steam Boiler Furnace, Hemisphere Publishing Corpn,1988.
R3	Civil Davies, Calculations in Furnace Technology, Pergamon Press, Oxford, 1966.
R4	Holman J.P., Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1988.
R5	Samir Sarkar, Fuels & Combustion, 2nd Edition, Orient Longman, 1990.
R6	Sharma SP., Mohan Chander, Fuels & Combustion, Tata McGraw Hill, 1984.
R7	Yunus A. Cengel and Michael A. Boles, Thermodynamics, McGraw-Hill Inc., 2006

COURSE ARTICULATION MATRIX

CO	PO					
	1	**2**	**3**	**4**	**5**	**6**
1	1	-	2	1	-	3
2	1	-	2	2	-	1
3	1	-	2	1	-	1
4	-	-	2	1	-	1
5	-	-	-	-	-	-
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1154	THERMAL SYSTEMS SIMULATION LABORATORY	0	0	4	2

COURSE OBJECTIVES:

1. To introduce the fundamental principles and methods of heat exchanger analysis using NTU and LMTD approaches.
2. To develop a strong foundation in conduction, convection (internal and boundary layer flow), and radiation heat transfer.
3. To enable students to analyze transient heat transfer problems using lumped system and critical insulation concepts.
4. To provide insights into condensation and phase change phenomena as applied to heat transfer systems.
5. To equip students with practical computational skills by linking MATLAB with Ref Prop for solving basic CFD and heat transfer simulations.

LABORATORY

1. Heat exchanger analysis – NTU method
2. Heat exchanger analysis – LMTD method
3. Convection heat transfer analysis – Velocity boundary layer.
4. Convection heat transfer analysis – Internal flow
5. Radiation heat transfer analysis – Emissivity
6. Critical radius of insulation
7. Lumped heat transfer analysis
8. Conduction heat transfer analysis
9. Condensation heat transfer analysis
10. Dynamic Linking of Mat Lab and Ref Prop Software Simple CFD Problems For Practice

TOTAL: 60 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Apply analytical techniques such as NTU and LMTD methods to evaluate the performance of heat exchangers.
CO2	Analyze various modes of heat transfer including conduction, convection, and radiation in steady and transient conditions.
CO3	Evaluate insulation effectiveness and determine the critical radius for minimizing heat loss or gain.
CO4	Understand and model condensation processes and their impact on heat transfer performance.
CO5	Integrate computational tools such as MATLAB and Ref Prop for simulating basic CFD problems and enhancing thermal system design.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

SIMULATION LAB – REQUIREMENT:

1. Software - Modeling software like ProE, Gambit, Ansys, etc
   - Analysis software like Ansys, fluent, CFX, etc
   - Equation solving software like Matlab, Engg equation solver
2. Every student in a batch must be provided with a terminal
3. Hardware is compatible with the requirement of the above software.

COURSE ARTICULATION MATRIX

CO	PO					
	1	2	3	4	5	6
1	1	2	2	3	2	1
2	1	2	2	3	2	1
3						
4						
5						
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1155	**Technical Seminar – I**	**0**	**0**	**2**	**1**

COURSE OBJECTIVES:

1. To Enhance the ability of self-study
2. To Improve presentation and communication skills
3. To Increase the breadth of knowledge.

GUIDELINES:

1. The student is expected to present a seminar in one of the current topics in the field of Thermal Engineering related issues / technology.
2. The seminar shall be of 30 minutes duration and give presentation to the SeminarAssessment Committee (SAC).
3. A faculty guide is to be allotted and he / she will guide and monitor the progress of the student and maintain attendance also.
4. In a session of three periods per week, 4 students are expected to present the seminar.
5. Students are encouraged to use various teaching aids such as power point presentationand demonstrative models.
6. Students are required to prepare a seminar report in the prescribed format given by the Department.

EVALUATION:

Technical Seminar I evaluation is based on Regulations of Post graduate Programme of Anna University.

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Identify and choose appropriate topic of relevance.
CO2	Assimilate literature on technical articles of specified topic.
CO3	Develop comprehension.
CO4	Prepare technical report.
CO5	Design, develop and deliver presentation on specified technical topic.

COURSE ARTICULATION MATRIX

CO	PO					
	1	2	3	4	5	6
1	1	-	-	1	2	1
2	1	-	-	1	1	-
3	1	1	-	1	-	-
4	1	1	-	-	-	-
5	-	2	-	-	3	3
Low (1); Medium (2); High (3)						

SEMESTER III

Course Code	Course Name	L	T	P	C
TE1201	Design and Optimization of Thermal Energy Systems	3	0	0	3

COURSE OBJECTIVES:

1. To learn basic principles underlying pumping, heat exchangers; modeling and optimization in design of thermal systems.
2. To develop representational modes of real processes and systems.
3. To optimization concerning design of thermal systems.
4. To introduce the dynamic modeling of thermal systems using tools like Laplace transforms and stability analysis for evaluating control systems.
5. To develop the ability to apply optimization, uncertainty analysis, and energy-capital trade-off strategies to real-world thermal systems through case studies.

UNIT I DESIGN CONCEPTS **9**

Design Principles, Workable Systems, Optimal Systems, Matching of System Components, Economic Analysis, Depreciation, Gradient Present Worth factor, modelling overview – levels and steps in model development - Examples of models – curve fitting and regression analysis.

UNIT II MODELLING AND SYSTEMS SIMULATION **10**

Modelling of thermal energy systems – heat exchanger - solar collectors – distillation - rectification turbo machinery components - refrigeration systems - information flow diagram - solution of set of nonlinear algebraic equations - successive substitution - Newton Raphson method- examples of thermal systems simulation.

UNIT III OPTIMIZATION **10**

Objectives - constraints, problem formulation - unconstrained problems - necessary and sufficiency conditions. Constrained optimization - Lagrange multipliers, constrained variations, Linear Programming - Simplex tableau, pivoting, sensitivity analysis - New generation optimization techniques – examples.

UNIT IV DYNAMIC BEHAVIOUR **8**

Steady state Simulation, Laplace Transformation, Feedback Control Loops, Stability Analysis, Non-Linearities.

UNIT V APPLICATIONS AND CASE STUDIES **8**

Case studies of optimization in thermal systems problems- Dealing with uncertainty- probabilistic techniques – Trade-offs between capital and energy using Pinch analysis.

TOTAL: 45 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Apply fundamental design principles and economic analysis techniques such as depreciation and gradient present worth factor to evaluate thermal systems.
CO2	Develop and simulate mathematical models for various thermal energy systems, including heat exchangers, solar collectors, and refrigeration systems.
CO3	Formulate and solve thermal system optimization problems using classical and modern optimization techniques under constrained and unconstrained conditions.
CO4	Analyze the dynamic behavior of thermal systems using Laplace transforms, control theory, and stability analysis methods.
CO5	Evaluate real-world thermal systems through case studies using optimization, uncertainty modeling, and trade-off analysis techniques such as Pinch analysis.

REFERENCES:	
R1	B.K.Hodge, Analysis and Design of Thermal Systems, Prentice Hall Inc., 1990.
R2	Bejan A., George Tsatsaronis , Michael J. Moran , Thermal Design and Optimization, Wiley ,1996.
R3	D.J. Wide, Globally Optimal Design, Wiley- Interscience, 1978.
R4	Kapur J. N., Mathematical Modelling , Wiley Eastern Ltd , New York , 1989.
R5	Rao S. S., Engineering Optimization Theory and Practice, New Age Publishers, 2000.
R6	Stoecker W. F., Design of Thermal Systems, McGraw Hill Edition, 1989.
R7	YogeshJaluria , Design and Optimization of Thermal Systems , CRC Press , 2007.

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	2	1	3	-	-	-
2	2	1	3	-	-	-
3	3	1	3	-	3	-
4	3	1	3	-	3	-
5	3	1	3	-	3	-
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1202	**Technical Seminar – II**	**0**	**0**	**2**	**1**

COURSE OBJECTIVES:

1. To enhance the reading ability required for identification of his/her field of interest.
2. To develop skills regarding professional communication and technical report writing.
3. To establish the fact that student is not a mere recipient of ideas, but a participant in discovery and inquiry.
4. To learn how to prepare technical papers.
5. To learn how to publish technical papers.

GUIDELINES:

1. The student is expected to present a seminar in one of the current topics in the field of Thermal Engineering related issues / technology.
2. The seminar shall be of 30 minutes duration and give presentation to the Seminar Assessment Committee (SAC).
3. The committee shall evaluate the seminar based on the style of presentation, technical context, and coverage of the topic, adequacy of references, depth of knowledge and the overall quality.
4. A faculty guide is to be allotted and he / she will guide and monitor the progress of the student and maintain attendance also.
5. Each student has to submit a seminar report in the prescribed format given by the Institution.
6. In a session of three periods per week, 4 students are expected to present the seminar.
7. Students are encouraged to use various teaching aids such as power point presentation and demonstrative models.
8. It is recommended that the report for Technical Seminar II may be in the form of a technical paper which is suitable for publishing in Conferences / Journals as a review paper

EVALUATION:

Technical Seminar II evaluation is based on Regulations of Post Graduate Programme of Anna University.

TOTAL: 30 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Develop the capacity to observe intelligently and propose and defend opinions and ideas with tact and conviction.
CO2	Develop skills regarding professional communication and technical report writing.
CO3	Learn the methodology of publishing technical papers.
CO4	Develop the ability to structure and write technical papers with clarity, proper formatting, and appropriate referencing techniques.
CO5	Demonstrate understanding of the publication process by identifying suitable journals or conferences and adhering to submission and peer-review protocols.

COURSE ARTICULATION MATRIX

CO	PO					
	1	2	3	4	5	6
1	1	-	-	1	2	1
2	1	-	-	1	1	-
3	1	1	-	1	-	-
4	1	1	-	-	-	-
5	-	2	-	-	3	3
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1203	**Project Work - I**	0	0	12	6

COURSE OBJECTIVES:

1. To improve the skills in reading technical magazines, conference proceedings and journals.
2. To develop the skill of identifying research problems/projects in the field of Thermal Engineering.
3. To familiarize with the design and analysis tools required for the project work and plan the experimental platform, if any, required for project work.

GUIDELINES:

1. Each student has to identify the topic of project related to the field of Thermal Engineering.
2. 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
3. The topic has to be approved by a review committee constituted by the department.
4. The work has to be presented periodically in front of the review committee.
5. The preparation of report consisting of a detailed problem statement and a literature review.
6. The preliminary results (if available) of the problem may also be discussed in the report.
7. The project report should be presented in standard format as provided by the Anna University.

EVALUATION:

Project Work Phase - I evaluation is based on Regulations of Post graduate Programme of Anna University.

TOTAL: 90 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	The students would apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to the students to be creative, well planned, organized, coordinated in their project work phase – II.

COURSE ARTICULATION MATRIX

CO	PO					
	1	2	3	4	5	6
1	1	-	-	1	2	3
Low (1); Medium (2); High (3)						

SEMESTER IV

Course Code	Course Name	L	T	P	C
TE1251	Project Work - II	0	0	24	12

COURSE OBJECTIVES:
1. To improve the skills in publishing technical papers in conference proceedings and journals.
2. To produce factual results of their applied research idea in the Thermal engineering, from phase – I.
GUIDELINES:
1. Each student has to complete project (phase II) under the guidance of a faculty member, as specified in Phase I.
2. The candidate has to be in regular contact with his guide and the topic of dissertation must bemutually decided by the guide and student
3. The topic has to be approved by a review committee constituted by the department.
4. The work has to be presented periodically in front of the review committee.
5. 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.
6. The report must bring out the conclusions of the work and future scope for the study.
7. The project report should be presented in standard format as provided by the Anna University.
EVALUATION:
Project Work Phase - II evaluation is based on Regulations of Post graduate Programme of Anna University.
TOTAL: 180 PERIODS
COURSE OUTCOMES After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	The students' would apply the knowledge gained from theoretical and practical courses in solving problems,so as to give confidence to the students to be creative, well planned, organized, coordinated project outcome of the aimed work.

COURSE ARTICULATION MATRIX

CO	PO					
	1	2	3	4	5	6
1	1	-	-	1	2	3
Low (1); Medium (2); High (3)						

PROFESSIONAL ELECTIVES

TE1911	AIRCRAFT AND JET PROPULSION	3	0	0	3

COURSE OBJECTIVES:

1. To analyze compressible flow phenomena and predict the behavior of gases under isentropic, Rayleigh, Fanno flow, and shock wave conditions.
2. To explain the thermodynamic cycles of various aircraft propulsion systems and evaluate their thrust and efficiency characteristics.
3. To assess the performance and design of engine components such as inlets and nozzles for different air-breathing engines.
4. To apply rocket motion equations to calculate thrust, velocity, and staging for space missions.
5. To describe the working of rocket thrust chambers, including combustion, propellant feed systems, and heat transfer processes.

UNIT I GAS DYNAMICS 9

Wave motion - Compressible fluid flow through variable area devices – Stagnation state Mach Number and its influence and properties, Isentropic Flow, Rayleigh and Fanno Flow. Deflagration and Detonation – Normal shock and oblique shock waves.

UNIT II THERMODYNAMICS OF AIRCRAFT ENGINES 9

Theory of Aircraft propulsion – Thrust – Various efficiencies – Different propulsion systems – Turboprop – Ram Jet – Turbojet, Turbojet with after burner, Turbo fan and Turbo shaft. Variable thrust- nozzles – vector control.

UNIT III PERFORMANCE CHARACTERISTICS OF AIRCRAFT ENGINES 9

Engine - Aircraft matching – Design of inlets and nozzles – Performance characteristics of Ramjet, Turbojet, Scramjet and Turbofan engines.

UNIT IV ROCKET PROPULSION 9

Theory of rocket propulsion – Rocket equations – Escape and Orbital velocity – Multi-staging of Rockets – Space missions – Performance characteristics – Losses and efficiencies.

UNIT V ROCKET THRUST CHAMBER 9

Combustion in solid and liquid propellant classification – rockets of propellants and Propellant Injection systems – Non-equilibrium expansion and supersonic combustion – Propellant feed systems – Reaction Control Systems - Rocket heat transfer.

TOTAL: 45 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Analyze compressible flows and apply shock and expansion theories to real-world propulsion systems.
CO2	Compare different aircraft propulsion systems and evaluate their thermodynamic efficiencies and applications.
CO3	Design and analyze the performance characteristics of engine components such as nozzles and inlets for various propulsion systems.
CO4	Apply rocket propulsion principles to calculate velocities, thrust, and staging for different space missions.
CO5	Evaluate combustion processes and thermal performance in rocket thrust chambers, including propellant injection and supersonic expansion

REFERENCES:	
R1	Bonney E.A., Zucrow N.J,. Principles of Guided Missile Design, Van Nostranc Co., 1956.
R2	Khajuria P.R. and Dubey S.P., Gas Turbines and Propulsive Systems, Dhanpat Rai Publications, 2003.
R3	Mattingly J.D., Elements of Gas turbine Propulsion, McGraw Hill, 1st Edition, 1997.
R4	Philip G. Hill and Carl R. Peterson, Mechanics and Thermodynamics of Propulsion, SecondEdition, Addition – Wesley Publishing Company, New York, 2009.
R5	S.M.Yahya, Fundamentals of Compressible Flow, Third edition, New Age International PvtLtd, 2003.
R6	Zucrow N.J., Principles of Jet Propulsion and Gas Turbines, John Wiley and Sons, NewYork, 1970.
R7	Zucrow N.J., Aircraft and Missile Propulsion, Vol. I and Vol. II, John Wiley and Sons Inc,

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	2	1	3	-	-	-
2	2	1	3	-	-	-
3	3	1	3	-	3	-
4	3	1	3	-	3	-
5	3	1	3	-	3	-
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1912	**HYDROGEN AND FUEL CELL TECHNOLOGIES**	3	0	0	3

COURSE OBJECTIVES:

1. To study in detail on the hydrogen production methodologies, possible applications and various storage options.
2. To understand the working principle of a typical fuel cell, its types and to elaborate on its thermodynamics and kinetics.
3. To study the cost effectiveness and eco-friendliness of Fuel Cells.
4. To study different types of fuel cells and compare their merits and demerits.
5. To explore fuel cell applications, economic aspects, and future trends.

UNIT I HYDROGEN – BASICS AND PRODUCTION TECHNIQUES 9

Hydrogen – physical and chemical properties, salient characteristics. Production of hydrogen – steam reforming – water electrolysis – gasification and woody biomass conversion – biological hydrogen production – photo dissociation – direct thermal or catalytic splitting of water.

UNIT II HYDROGEN STORAGE AND APPLICATIONS 9

Hydrogen storage options – compressed gas – liquid hydrogen – Hydride – chemical Storage – comparisons. Safety and management of hydrogen. Applications of Hydrogen.

UNIT III FUEL CELLS 9

History – principle - working - thermodynamics and kinetics of fuel cell process – performance evaluation of fuel cell – comparison on battery Vs fuel cell.

UNIT IV FUEL CELL – TYPES 9

Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits.

UNIT V APPLICATION OF FUEL CELL AND ECONOMICS 9

Fuel cell usage for domestic power systems, large scale power generation, Automobile, Space. Economic and environmental analysis on usage of Hydrogen and Fuel cell. Future trends in fuel cells.

TOTAL: 45 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Understanding different methods for producing and storing hydrogen, along with their applications.
CO2	Learning how different fuel cells work, including their thermodynamics and reactions.
CO3	Assessing the cost and environmental benefits of fuel cells.
CO4	Comparing the pros and cons of different types of fuel cells for various applications.
CO5	Exploring the current and future uses of fuel cells, including their economic potential.

REFERENCES:

R1	Viswanathan B. and Aulice Scibioh.M, Fuel Cells – Principles and Applications, UniversitiesPress, 2006.
R2	Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma, 2005.
R3	Bent Sorensen (Sørensen), Hydrogen and Fuel Cells: Emerging Technologies and Applications, Elsevier, UK 2005.

R4	Kordesch K. and G.Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany 1996.
R5	Hart A.B. and G.J.Womack, Fuel Cells: Theory and Application, Prentice Hall, New York Ltd.,London 1989.
R6	Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA 2002.
R7	Barclay F.J., Fuel Cells, Engines and Hydrogen, Wiley, 2009.

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	3		3	1	1	2
2	3		3	1	1	2
3	2		2	2		1
4	2		2	1		2
5	2		2	1	3	2
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1913	ENERGY RESOURCES	3	0	0	3

COURSE OBJECTIVES:

1. To learn about the use of conventional energy sources (coal, oil, natural gas, nuclear, hydro), their impact on the environment, and future energy trends.
2. To understand solar energy, how it's collected, and how solar power is used for things like heating, cooling, and electricity.
3. To explore wind energy, how it's harnessed, and how to choose the best locations for wind turbines.
4. To study biomass energy, how it's converted into usable energy, and its applications like biogas and biodiesel.
5. To learn about ocean energy, geothermal energy, small hydro, and fuel cells, and how they generate power.

UNIT I COMMERCIAL ENERGY 9

Coal, Oil, Natural gas, Nuclear power and Hydro - their utilization pattern in the past, present and future projections of consumption pattern - Sector-wise energy consumption – environmental impact of fossil fuels – Energy scenario in India – Growth of energy sector and its planning in India

UNIT II SOLAR ENERGY 9

Solar radiation at the earth's surface – solar radiation measurements – estimation of average solar radiation - solar thermal flat plate collectors - concentrating collectors – solar thermal applications - heating, cooling, desalination, drying, cooking, etc – solar thermal electric power plant - principle of photovoltaic conversion of solar energy, types of solar cells - Photovoltaic applications: battery charger, domestic lighting, street lighting, water pumping etc - solar PV power plant – Net metering concept.

UNIT III WIND ENERGY 9

Nature of the wind – power in the wind – factors influencing wind – wind data and energy estimation - wind speed monitoring - wind resource assessment - Betz limit - site selection – wind energy conversion devices - classification, characteristics, applications – offshore wind energy - Hybrid systems - safety and environmental aspects – wind energy potential and installation in India - Repowering concept.

UNIT IV BIO-ENERGY 9

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 Plant - applications - alcohol production from biomass – bio diesel production – Urban waste to energy conversion - Biomass energy programme in India.

UNIT V OTHER TYPES OF ENERGY 9

Ocean energy resources - principle of ocean thermal energy conversion (OTEC) - ocean thermal power plant - ocean wave energy conversion - tidal energy conversion – small hydro - geothermal energy - geothermal power plant – hydrogen production and storage - Fuel cell – principle of working - various types - construction and applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME

CO1	Know the patterns of energy use, environmental effects, and energy planning in India.
CO2	Understand how solar energy works, from collecting heat to generating electricity using solar panels.
CO3	Be able to assess wind energy potential and choose sites for wind turbines.
CO4	Understand how biomass is turned into energy and its uses like biogas and biodiesel.
CO5	Learn how ocean, geothermal, and small hydro energy systems work, along with how fuel cells produce and store hydrogen.
REFERENCES:	
R1	Sukhatme S.P., "Solar Energy", Tata McGraw Hill, 1984.
R2	Twidell J.W. and Weir A., "Renewable Energy Sources", EFN Spon Ltd., 1986.
R3	Kishore V.V.N., "Renewable Energy Engineering and Technology", Teri Press, New Delhi,2012
R4	Peter Gevorkian, "Sustainable Energy Systems Engineering," McGraw Hill,2007.
R5	Kreith F. and Kreider J.F., "Principles of Solar Engineering", McGraw-Hill, 1978.
R6	Godfrey Boyle, "Renewable Energy Power for a Sustainable Future", Oxford University Press,U.K, 1996.
R7	Veziroglu T.N., Alternative Energy Sources", Vol 5 and 6, McGraw-Hill, 1990.
R8	Anthony San Pietro, "Biochemical and Photosynthetic aspects of Energy Production", Academic Press, 1980.
R9	Bridgurater A.V., "Thermochemical processing of Biomass", Academic Press, 1981.
R10	Bent Sorensen , "Renewable Energy", Elsevier, Academic Press, 2011.

COURSE ARTICULATION MATRIX

CO	PO					
	1	**2**	**3**	**4**	**5**	**6**
1	2	1	3	-	-	-
2	2	1	3	-	-	-
3	3	1	3	-	3	-
4	3	1	3	-	3	-
5	3	1	3	-	3	-
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1914	ADVANCED INTERNAL COMBUSTION ENGINES	3	0	0	3

COURSE OBJECTIVES:

1. To understand the working principles and mixture requirements of spark ignition (SI) engines and different fuel injection systems.
2. To learn about the operation and combustion process in compression ignition (CI) engines, including fuel spray behavior and turbocharging.
3. To study the sources and formation of pollutants in engine exhaust and methods to control emissions.
4. To explore alternative fuels like alcohol, hydrogen, natural gas, and LPG, and understand their advantages, disadvantages, and required engine modifications.
5. To investigate recent advancements in engine technologies, such as lean burn, stratified charge, and plasma ignition engines, and the use of nanotechnology in IC engines.

UNIT I SPARK IGNITION ENGINES 9

Spark ignition Engine mixture requirements – Fuel – Injection systems – Monopoint, Multipoint injection, Direct injection – Stages of combustion – Normal and abnormal combustion – factors affecting knock – Combustion chambers.

UNIT II COMPRESSION IGNITION ENGINES 9

States of combustion in C.I. Engine – Direct and indirect injection systems – Combustion chambers – Fuel spray behaviour – spray structure, spray penetration and evaporation – air motion – Introduction to Turbo charging.

UNIT III POLLUTANT FORMATION AND CONTROL 9

Pollutant – Sources – Formation of carbon monoxide, Unburnt hydrocarbon, NOx, Smoke and Particulate matter – Methods of controlling Emissions – Catalytic converters and Particulate Traps – Methods of measurements and Introduction to emission norms and Driving cycles.

UNIT IV ALTERNATIVE FUELS 9

Alcohol, Hydrogen, Natural Gas and Liquefied Petroleum Gas- Properties, Suitability, Merits and Demerits as fuels, Engine Modifications.

UNIT V RECENT TRENDS 9

Lean Burn Engines – Stratified charge Engines – homogeneous charge compression ignition engines – Plasma Ignition – Measurement techniques – laser Doppler, Anemometry. Use of nano technology in IC Engines.

TOTAL: 45 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Understand the fuel mixture requirements, injection systems, and combustion process in spark ignition engines.
CO2	Explain the different combustion stages and injection systems in compression ignition engines, and understand the role of turbocharging.
CO3	Identify the pollutants formed in engine exhaust and know the methods to control emissions using technologies like catalytic converters.
CO4	Understand the properties of alternative fuels and how they affect engine performance, along with necessary engine modifications.

CO5	Learn about recent engine technologies and measurement techniques, such as lean burn engines and the use of nanotechnology in improving engine efficiency.
REFERENCES:	
R1	Duffy Smith, Auto fuel Systems, The Good Heart Willox Company, Inc., 1989.
R2	Heywood, J.B., Internal Combustion Engine Fundamentals, McGraw-Hill, 1988.
R3	K.K. Ramalingam, Internal Combustion Engine fundamentals, Scitech Publications, 2002.
R4	Kirpal Singh, Automobile Engineering Vol - I, Standard Publishers, Delhi 2013.
R5	R.B.
R6	V. Ganesan, Internal Combustion Engines, II Edition, Tata McGraw-Hill Education, 2002.
R7	Willard W. Pulkrabek, Engineering Fundamentals of the Internal Combustion Engine, Prentice Hall, 1997.

COURSE ARTICULATION MATRIX

CO	PO					
	1	**2**	**3**	**4**	**5**	**6**
1	2	1	3	-	-	-
2	2	1	3	-	-	-
3	3	1	3	-	3	-
4	3	1	3	-	3	-
5	3	1	3	-	3	-
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1915	CRYOGENIC ENGINEERING	3	0	0	3

COURSE OBJECTIVES:

1. To understand the basic principles of cryogenics, the properties of cryogenic fluids, and their applications in various fields like space programs and medicine.
2. To learn about the different liquefaction cycles, including the Carnot cycle, Joule-Thomson effect, and various liquefaction methods used in cryogenic systems.
3. To study the separation techniques for cryogenic gases, including rectification and adsorption methods for purification.
4. To explore different types of cryogenic refrigerators and their working principles, including J.T. Cryocoolers, Stirling cycle refrigerators, and pulse tube refrigerators.
5. To learn how cryogenic fluids are handled, including the use of Dewars, transfer lines, insulation techniques, and instrumentation for measuring flow, level, and temperature.

UNIT I INTRODUCTION 9

Insight on Cryogenics, Properties of Cryogenic fluids, Material properties at Cryogenic Temperatures. Applications of Cryogenics in Space Programs, Superconductivity, Cryo Metallurgy, Medical applications.

UNIT II LIQUEFACTION CYCLES 9

Carnot Liquefaction Cycle, F.O.M. and Yield of Liquefaction Cycles. Inversion Curve - Joule Thomson Effect. Linde Hampson Cycle, Precooled Linde Hampson Cycle, Claudes Cycle Dual Cycle, Ortho-Para hydrogen conversion, Eollins cycle, Simpson cycle, Critical Components in Liquefaction Systems.

UNIT III SEPARATION OF CRYOGENEIC GASES 9

Binary Mixtures, T-C and H-C Diagrams, Principle of Rectification, Rectification Column Analysis
- McCabe Thiele Method. Adsorption Systems for purification.

UNIT IV CRYOGENIC REFRIGERATORS 9

J. T. Cryocoolers, Stirling Cycle Refrigerators, G.M. Cryocoolers, Pulse Tube Refrigerators Regenerators used in Cryogenic Refrigerators, Dilution refrigerators, Magnetic Refrigerators.

UNIT V HANDLING OF CRYOGENS 9

Cryogenic Dewar, Cryogenic Transfer Lines. Insulations used in Cryogenic Systems, Instrumentation to measure Flow, Level and Temperature.

TOTAL: 45 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Understand the properties and applications of cryogenic fluids in areas like space exploration, superconductivity, and medicine.
CO2	Explain various liquefaction cycles and how they are used to liquefy gases at cryogenic temperatures.
CO3	Understand the principles behind the separation of cryogenic gases and the methods used for purification, including rectification and adsorption systems.
CO4	Learn the working principles of different cryogenic refrigeration systems, such as J.T.

	Cryocoolers and Stirling refrigerators.
CO5	Understand the handling and storage techniques of cryogenic fluids, including Dewars, transfer lines, and the necessary instrumentation for flow, level, and temperature measurement.

REFERENCES:

R1	Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering, Plenum Press, New York, 1989
R2	Randall F. Barron, Cryogenic Systems, McGraw-Hill, 1985.
R3	Scott R.B., Cryogenic Engineering, Van Nostrand and Co., 1962.
R4	Herald Weinstock, Cryogenic Technology, Boston Technical Publishers, inc., 1969.
R5	Robert W. Vance, Cryogenic Technology, John wiley & Sons, Inc., New York, London.
R6	G.Venkatarathnam, Cryogenic Technolog
R7	J.G.Weisend, Hand Book of Cryogenic Engineering —II, Taylor and Francis, 1998.

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	2	1	3	-	-	-
2	2	1	3	-	-	-
3	3	1	3	-	3	-
4	3	1	3	-	3	-
5	3	1	3	-	3	-
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1916	REFRIGERATION SYSTEMS	3	0	0	3

COURSE OBJECTIVES:

1. To understand the principles of refrigeration, the classification of refrigerants, their properties, and environmental impact, including alternatives to HCFCs.
2. To learn about various refrigeration cycles, including vapor compression, absorption, and air refrigeration, and understand the conditions for optimizing system performance.
3. To study the components of refrigeration systems, such as compressors, evaporators, condensers, expansion devices, and their functions.
4. To explore system balancing techniques, including performance analysis and sensitivity analysis of refrigeration components and complete systems.
5. To understand electrical drives and control systems used in refrigeration, including refrigerant control devices, motors, thermostats, and microprocessor-based controls.

UNIT I INTRODUCTION AND REFRIGERANTS 9

Applications, Unit of refrigeration – Ideal cycles - Classification of Refrigerants, Refrigerant properties, Oil Compatibility, Environmental Impact-Montreal / Kyoto protocols-Eco Friendly Refrigerants, alternatives to HCFCS, Secondary Refrigerants.

UNIT II REFRIGERATION CYCLES – ANALYSIS 9

Development of Vapor Compression Refrigeration Cycle from Reverse Carnot Cycle-conditions for high COP-deviations from ideal vapor compression cycle, Multipressure System, Cascade Systems-Analysis. Vapor Absorption Systems-Aqua Ammonia & Li-Br Systems, Steam Jet Refrigeration Thermo Electric Refrigeration, Air Refrigeration cycles, Heat pumps.

UNIT III REFRIGERATION SYSTEM COMPONENTS 9

Compressor- Types, performance, Characteristics, Types of Evaporators & Condensers and their functional aspects, Expansion Devices and their Behaviour with fluctuating load, cycling controls, other components such as Accumulators, Receivers, Oil Separators, Strainers, Driers, Check Valves, Solenoid Valves Defrost Controllers, etc.

UNIT IV SYSTEM BALANCING 9

Balance points and system simulation - compressor, condenser, evaporator and expansion devices performance – Complete system performance; graphical and mathematical analysis – sensitivity analysis.

UNIT V ELECTRICAL DRIVES & CONTROLS 9

Electric circuits in Refrigeration systems, Refrigerant control devices, Types of Motors, Starters, Relays, Thermostats, Microprocessor based control systems, Pressure controls and other controls, Acoustics and noise controls.

TOTAL: 45 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Understand the applications, classification, and environmental impact of refrigerants, and be aware of eco-friendly alternatives.
CO2	Explain the working of various refrigeration cycles and methods to improve the coefficient of performance (COP) of refrigeration systems.
CO3	Understand the function and types of refrigeration system components, such as compressors, evaporators, condensers, and expansion devices.

CO4	Learn how to balance and optimize the performance of refrigeration systems through graphical and mathematical analysis.
CO5	Understand the electrical drives, control systems, and various devices used to regulate refrigeration systems, including noise control measures.

REFERENCES:

R1	Arora C.P., Refrigeration and Air conditioning, McGraw Hill, 3rd Ed., 2010.
R2	Dossat R.J., Principles of refrigeration, John Wiley, S.I. Version, 2001.
R3	Jordan and Priester, Refrigeration and Air conditioning 1985.
R4	Kuehn T.H., Ramsey J.W. and Threlkeld J.L., Thermal Environmental Engineering, 3rd Edition, Prentice Hall, 1998.
R5	Langley Billy C., ‘Solid state electronic controls for HVACR, Prentice-Hall 1986.
R6	Rex Milter, Mark R.Miller., Air conditioning and Refrigeration, McGraw Hill, 2006.
R7	Stoecker W.F., Refrigeration and Air conditioning, McGraw-Hill Book Company, 1989.

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	2	1	3	-	-	-
2	2	1	3	-	-	-
3	3	1	3	-	3	-
4	3	1	3	-	3	-
5	3	1	3	-	3	-
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1917	ELECTRONIC ENGINE MANAGEMENT SYSTEMS	3	0	0	3

COURSE OBJECTIVES:

1. To provide basic grounding on electronics
2. To learn the various sensors used in engine management systems
3. Give an overview of different types of ignition systems
4. To understand the significance of gasoline injection systems
5. To know the latest advancements in Diesel injection systems

UNIT I FUNDAMENTALS OF AUTOMOTIVE ELECTRONICS 9

Components for Electronic Engine Management System- Open and Closed Loop Control Strategies- PID Control- Look Up Tables- Introduction to Modern Control Strategies Like Fuzzy Logic and Adaptive Control. Switches- Active Resistors- Transistors- Current Mirrors/Amplifiers- Voltage and Current References- Comparator- Multiplier. Amplifier- Filters- A/D and D/A Converters.

UNIT II SENSORS AND ACTUATORS 9

Inductive- Hall Effect- Thermistor- Piezo Electric- Piezoresistive- Based Sensors. Throttle Position- Mass Air Flow- Crank Shaft Position- Cam Position- Engine Speed Sensor- Exhaust Oxygen Level (Two Step- Linear Lambda and Wideband)- Knock- Manifold Temperature and Pressure Sensors. Solenoid- Relay (Four and Five Pin)- Stepper Motor

UNIT III SI ENGINE MANAGEMENT 9

Layout and Working of SI Engine Management Systems. Group and Sequential Injection Techniques. MPFI- GDI- Advantages of Electronic Ignition Systems. Types of Solid-State Ignition Systems and Their Principle of Operation- Contactless (BREAKERLESS) Electronic Ignition System- Electronic Spark Timing Control

UNIT IV CI ENGINE MANAGEMENT 9

Fuel Injection System Parameters Affecting Combustion- Noise and Emissions in CI Engines. Electronically Controlled Unit Injection System. Common Rail Fuel Injection System. Working of Components Like Fuel Injector- Fuel Pump- Rail Pressure Limiter- Flow Limiter- EGR Valve

UNIT V DIGITAL ENGINE CONTROL SYSTEM 9

Cold Start and Warm Up Phases- Idle Speed Control- Acceleration and Full Load Enrichment- Deceleration Fuel Cut-off. Fuel Control Maps- Open Loop and Closed Loop Control – Integrated Engine Control System- Electromagnetic Compatibility – EMI Suppression Techniques – Electronic Dash Board Instruments – Onboard Diagnosis System.

TOTAL: 45 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Understand the basic electronic components and controls used in Sensors
CO2	Explain the different types of sensors used in an automobile engine
CO3	Describe the ignition and injection methods used in an SI engine
CO4	Describe the fuel injection systems in a diesel engine and the emission control systems

CO5	Explain the electronic systems used in the fuel control system and the dash board unit.
REFERENCES:	
R1	Understanding Automotive Electronics William B Ribbens, SAE 1998
R2	Automobile Electronics by Eric Chowanietz SAE
R3	Diesel Engine Management by Robert Bosch, SAE Publications, 3rd Edition, 2004
R4	Gasoline Engine Management by Robert Bosch, SAE Publications, 2nd Edition, 2004

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	2	2	3	-	2	-
2	3	2	3	-	3	-
3	3	2	3	-	3	-
4	3	2	3	-	3	-
5	3	-	3	-	2	-
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1918	COGENERATION AND WASTE HEAT RECOVERY SYSTEMS	3	0	0	3

COURSE OBJECTIVES:

1. To analyze the basic energy generation cycles.
2. To detail about the concept of cogeneration, its types and probable areas of applications.
3. To study the significance of waste heat recovery systems and carry out its economic analysis.

UNIT I INTRODUCTION 9

Introduction – principles of thermodynamics – cycles – topping – bottoming – combined cycle – organic rankine cycles – performance indices of cogeneration systems – waste heat recovery – sources and types – concept of tri and quad generation.

UNIT II COGENERATION TECHNOLOGIES 9

Configuration and thermodynamic performance – steam turbine congeneration systems – gas turbine cogeneration systems – reciprocating IC engines cogeneration systems – combined cycles cogeneration systems – advanced cogeneration systems: fuel cell, Stirling engines etc.,

UNIT III ISSUES AND APPLICATIONS OF COGENERATION TECHNOLOGIES 9

Cogeneration plants electrical interconnection issues – utility and cogeneration plant interconnection issues – applications of cogeneration in utility sector – industrial sector – building sector – rural sector – impacts of cogeneration plants – fuel, electricity and environment.

UNIT IV WASTE HEAT RECOVERY SYSTEMS 9

economizers – plate heat exchangers – thermic fluid heaters – Waste heat boilers – classification, location, service conditions, design Considerations – fluidized bed heat exchangers – heat pipe exchangers – heat pumps – sorption systems.

UNIT V ECONOMIC ANALYSIS 9

Investment cost – economic concepts – measures of economic performance – procedure for economic analysis – examples – procedure for optimized system selection and design – load curves – sensitivity analysis – regulatory and financial frame work for cogeneration and waste heat recovery systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Understand the basic principles of thermodynamics and cogeneration including various energy cycles and multi-generation concepts.
CO2	Explore different cogeneration technologies such as steam turbines, gas turbines, IC engines, and advanced systems like fuel cells and Stirling engines.
CO3	Analyze the applications and impacts of cogeneration in various sectors including

	utility, industrial, building, and rural areas.
CO4	Learn about waste heat recovery systems, their components, classifications, and design considerations.
CO5	Perform economic analysis and system optimization considering investment cost, performance measures, and regulatory frameworks.

REFERENCES	
R1	Charles H. Butler, Cogeneration, McGraw Hill Book Co., 1984.
R2	De Nevers, Noel, Air Pollution Control Engineering, McGraw Hill, New York,1995.
R3	EDUCOGEN – The European Educational tool for cogeneration, Second Edition, 2001. 4
R4	Energy Cogeneration Hand book, George Polimveros, Industrial Press Inc, New yark 1982.
R5	Horlock JH., Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford,1987.
R6	Institute of Fuel, London, Waste Heat Recovery, Chapman & Hall Publishers, London, 1963.
R7	Seagate Subrata, Lee SS EDS, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	2	2	3	-	2	-
2	3	2	3	-	3	-
3	3	2	3	-	3	-
4	3	2	3	-	3	-
5	3	-	3	-	2	-
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1919	**COMPOSITE MATERIALS AND MECHANICS IN THERMAL APPLICATIONS**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1. Study of different composite materials and finding its mechanical strength
2. Fabrication of FRP and other composites by different manufacturing methods
3. Stress analysis of fiber reinforced Laminates for different combinations of plies with different orientations of the fiber.
4. Calculation of stresses in the lamina of the laminate using different failure theories
5. Calculation of residual stresses in different types of laminates under thermo-mechanical load using the Classical Laminate Theory.

UNIT I INTRODUCTION TO COMPOSITE MATERIALS 9

Definition-Matrix materials-polymers-metals-ceramics - Reinforcements: Particles, whiskers, inorganic fibers, metal filaments-ceramic fibers-fiber fabrication-natural composite wood, Jute Advantages and drawbacks of composites over monolithic materials. Mechanical properties and applications of composites, Particulate-Reinforced composite Materials, Dispersion-Strengthened composite, Fiber-reinforced composites Rule of mixtures-Characteristics of fiber-Reinforced composites, Manufacturing fiber and composites

UNIT II MANUFACTURING OF COMPOSITES 9

Manufacturing of Polymer Matrix Composites (PMCs)-handlay-up, spray technique, filament winding, Pultrusion, Resin Transfer Moulding (RTM)-,bag moulding, injection moulding, Sandwich Mould Composites (SMC) - Manufacturing of Metal Matrix Composites (MMCs) - Solid state, liquid state, vapour state processing, Manufacturing of Ceramic Matrix Composites (CMCs)–hot pressing reaction bonding process-infiltration technique, direct oxidation-interfaces

UNIT III LAMINA CONSTITUTIVE EQUATIONS 9

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

UNIT IV LAMINA STRENGTH ANALYSIS AND ANALYSIS OF LAMINATED FLAT PLATES 9

Introduction- Maximum Stress and Strain Criteria. Von-Misses Yield criterion for Isotropic Materials. Generalized Hill's Criterion for Anisotropic materials. Tsai-Hill's Failure Criterion for Composites. Tensor Polynomial (Tsai-Wu) Failure criterion. Prediction of laminate Failure Equilibrium Equations of Motion. Energy Formulations. Static Bending Analysis. Buckling Analysis. Free Vibrations– Natural Frequencies

UNIT V	THERMO-STRUCURALANALYSIS	9
Fabrication stresses / Residual stresses in FRP laminated composites-Co-efficient of Thermal Expansion (C.T.E.) - Modification of Hooke's Law. Modification of Laminate Constitutive Equations. Orthotropic Lamina C.T.E's -Stress and Moment Resultants due cooling of the laminates during fabrication-Calculations for thermo-mechanical stresses in FRP laminates Case studies: Implementation of CLT for evaluating residual stresses in the components made with different isotropic layers such as electronic packages etc.		
		TOTAL: 45 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Calculate for mechanical strength of the composite material
CO2	Fabricate the FRP and other composites by different manufacturing methods
CO3	Analyze fiber reinforced Laminates for different combinations of plies with different orientations of the fiber.
CO4	Evaluate the stresses in the lamina of the laminate using different failure theories
CO5	Analyze thermo-mechanical behavior and evaluate residual stresses in different types of laminates using the Classical Laminate Theory.

REFERENCES

R1	Agarwal BD and Broutman LJ, "Analysis and Performance of Fiber Composites", John Wiley and Sons, New York,1990.
R2	Gibson RF, Principles of Composite Material Mechanics, CRC press,4th Edition,2015.
R3	Hyer MW and Scott R White, "Stress Analysis of Fiber – Reinforced Composite Materials",McGraw-Hill,1998
R4	Issac M Daniel and OriIshai, "Engineering Mechanics of Composite Materials", OxfordUniversityPress-2006,FirstIndian Edition-2007
R5	Madhujit Mukhopadhyay,"Mechanics of Composite Materials and Structures", University Press(India)Pvt.Ltd.,Hyderabad,2004(Reprinted 2008)
R6	Mallick PK, Fiber – Reinforced Composites: Materials, Manufacturing and Design, CRC Press, 3rd Edition,2007

COURSE ARTICULATION MATRIX

CO	PO					
	1	**2**	**3**	**4**	**5**	**6**
1	2	2	3	-	2	-
2	3	2	3	-	3	-
3	3	2	3	-	3	-
4	3	2	3	-	3	-
5	3	-	3	-	2	-
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1951	**DESIGN OF TURBO MACHINES**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1. To elucidate the energy transfer process, Fans laws in Turbo machines.
2. To illustrate the selection and working of Centrifugal Blowers.
3. To classify different types of axial fans and rotor design.
4. To outline the working different compressors and its performance characteristics.
5. To select different fans / blowers / compressors for specific applications.

UNIT – I INTRODUCTION 9

Energy transfer between fluid and rotor velocity triangles for a generalised turbo machines – velocity triangle. Euler's equation for turbo machines and its different forms. Degree of reaction in turbo- machines – various efficiencies – isentropic, mechanical, thermal, overall and polytropic – fan laws – Dimensionless parameters – Specific speed – Cordier Diagram.

UNIT – II CENTRIFUGAL BLOWERS 9

Centrifugal Blowers: Theoretical characteristic curves, velocity triangles, losses and hydraulic efficiency, flow through impeller casing, inlet, nozzle, volute, diffusers. Leakage losses, mechanical losses, multi-vane impellers, cross flow fans. Selection of Centrifugal blower for duct flow.

UNIT – III AXIAL FLOW FANS 9

Rotor design using airfoil theory, vortex theory, cascade effects, degree of reaction, blade twist, stage design, surge and stall, stator and casing, mixed flow impellers. Selection of axial fans / blower for duct flow.

UNIT – IV COMPRESSORS 9

Reciprocating compressors, Construction Type – open, hermetic and semi sealed, effect of cylinder cooling, heating and friction. Dynamic compressor - centrifugal compressor, velocity triangles, performance characteristics, part load operation, Capacity control. Selection of compressor for different applications.

UNIT – V DESIGN AND APPLICATIONS 9

Special design and applications of blowers / compressors for air conditioning plants, cooling towers, ventilation systems, booster systems - turbocharger.

TOTAL: 45 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Analyse the fundamentals of Turbo machinery and solve the problems on Energy Transfer.
CO2	Categorise the Centrifugal Blowers and Fans for various applications.
CO3	Summarise the different types of axial fan design and performance.
CO4	Analyse various compressors based on its performance.
CO5	Select fans / blowers /compressors for the given applications.

REFERENCES:

R1	Austin H. Church, Centrifugal pumps and blowers, John Wiley and Sons, 2017

R2	Dixon, Fluid Mechanics, Thermodynamics of turbo machinery Pergamon Press, 1984
R3	Fans & Ventilation A practical guide (Bill) cory WTW, Elsevier, 2005.
R4	Jay Matley., Fluid Movers: Pumps,Compressors, Fans and Blowers, McGraw-Hill Publications, 1990..
R5	Royce N. Brown, Compressors: Selection and Sizing, Elsevier, 2005.
R6	Tony Giampaolo, Compressor Hand Book Principles and Practice, The Fairmont Press, 2010.
R7	Yahya S. M., Turbines compressors and fans(4th Edition), Tata McGraw-Hill, 2010.
R8	Forsthoffer's rotating equipment handbooks Volume 3: Compressors, Elsevier Advanced Technolgy, UK, 2005

COURSE ARTICULATION MATRIX

CO	PO					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	1	-	-	1
2	1	-	-	-	-	-
3	-	2	1	-	-	-
4	1	1	1	-	-	-
5	-	1	-	-	-	2
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1952	AIR CONDITIONING SYSTEMS	3	0	0	3

COURSE OBJECTIVES:

1. To learn the psychometric concepts underlying Air conditioning process.
2. To learn the design features and load estimation principles of specific Air conditioning system.
3. To learn about the critical auxiliary systems
4. To learn about the air distribution circuits, water distribution circuits etc.
5. To learn about the HVAC systems in air conditioning systems

UNIT I PSYCHROMETRY AND AIR CONDITIONING PROCESSES 9

Moist Air properties, use of Psychrometric Chart, Various Psychrometric processes, Air Washer, Adiabatic Saturation. Summer and winter Air conditioning, Enthalpy potential and its insights

UNIT II LOAD ESTIMATION 9

Thermal comfort – Design conditions – Solar Radiation-Heat Gain through envelopes – Infiltration and ventilation loads – Internal loads – Procedure for heating and cooling load estimation

UNIT III AIR CONDITIONING SYSTEMS 9

Thermal distribution systems – Single, multi zone systems, terminal reheat systems, Dual duct systems, variable air volume systems, water systems and Unitary type systems.

UNIT IV AIR DISTRIBUTION AND CONTROL 9

Flow through Ducts , Static & Dynamic Losses , Diffusers , Duct Design–Equal Friction Method, System Balancing , Fans & Duct System Characteristics , Fan Arrangement Variable Air Volume systems, Air Handling Units and Fan Coil units – Control of temperature, humidity, air flow and quality.

UNIT V HVAC SYSTEM IN AUTOMOBILES 9

Automotive System layout and Components- Commonly used Refrigerants- Safety devices – Climate control – Fuel efficiency aspects.

TOTAL: 45 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Analyse psychrometrically the Air conditioning processes.
CO2	Estimate the heat load for summer and winter Air conditioning applications.
CO3	Understand and appreciate the utility of different Air conditioning systems for different applications.
CO4	Design a fan-duct system for Air conditioning application.
CO5	Understand and appreciate the individual components of an automobile Air conditioning system. various HVAC system components for various applications in the building requirements

REFERENCES:

R1	ALI VEDAVARZ, SUNIL KUMAR, Mohammed Iqbal, Hussain Handbook of Heating, Ventilation and Air conditioning for Design Implementation, Industrial press Inc,2007.
R2	Arora C.P., Refrigeration and Air Conditioning, Tata McGraw Hill Pub. Company, 2010.
R3	ASHRAE , Fundamentals and equipment , 4 volumes-ASHRAE Inc. 2005.

R4	Carrier Air Conditioning Co., Handbook of Air Conditioning Systems design, McGrawHill, 1985.
R5	Jones, Air Conditioning Engineering, Edward Amold pub. 2001.
R6	Kuehn T.H., Ramsey, J.W. and Threlkeld, J.L., Thermal Environmental Engineering, 3rd Edition, Prentice Hall, 1998
R7	Langley, Billy C. ,Refrigeration and Air Conditioning Ed. 3, Engie wood Cliffs (N.J) Prentice Hall 1986

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	-	1	1	-
2	2	2	-	1	2	-
3	1	2	-	1	2	-
4	1	1	-	1	1	-
5	1	2	-	1	2	-
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1953	ALTERNATE FUELS FOR IC ENGINES	3	0	0	3

COURSE OBJECTIVES:

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

UNIT – I INTRODUCTION 9

Availability, Suitability, Properties, Merits and Demerits of Potential Alternative Fuels – Alcohols, Biodiesel, Hydrogen, Liquefied Petroleum Gas, Natural Gas, Biogas, Fuel standards – ASTM & EN

UNIT II SPECIAL AND SYNTHETIC FUELS 9

Different synthetic fuels, Merits, and demerits, Dual, Bi-fuel and Pilot injected fuel systems, Fuel additives – types and their effect on performance and emission characteristics of engines, Flexi-fuel systems, Ethers - as fuel and fuel additives, properties and characteristics

UNIT III ALCOHOL FUELS 9

Alcohols – Properties, Production methods and usage in engines. Blending, dual fuel operation, surface ignition, spark ignition and oxygenated additives. Performance, combustion and emission Characteristics in engines. Issues & limitation in alcohols

UNIT IV BIO-DIESEL FUELS 9

Vegetable oils and their important properties. Fuel properties characterization. Methods of using vegetable oils – Blending, preheating, Transesterification and emulsification – Performance, combustion and emission characteristics in diesel engines. Third generation biofuels, Ternary and Quaternary fuels, Issues & limitation of using vegetable oils in IC engines

UNIT V GASEOUS FUELS 9

Biogas, Natural gas, LPG, Hydrogen – Properties, problems, storage and safety aspects. Methods of utilisation in engines. Performance, combustion and emission characteristics in engines. Issues & limitation in Gaseous fuels

TOTAL: 45 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Expose potential alternate fuels and their characteristics
CO2	Use
CO3	Utilise alcohol fuels effectively for lower emissions
CO4	Elaborate on the utilisation of Bio-Diesel and its types as a suitable fuel in CI engines
CO5	Utilise different gaseous fuels and predict their performance and combustion characteristics

REFERENCES:

R1	Keith Owen and Trevor Eoley, Automotive Fuels Handbook, SAE Publications, 1990.
R2	Pundir B.P, I.C. Engines Combustion and Emission, 2010, Narosa Publishing House.

R3	Pundir B.P , Engine Combustion and Emission, 2011, Narosa Publishing House Keith
R4	Richard L. Bechtold, Automotive Fuels Guide Book, SAE Publications, 1997

COURSE ARTICULATION MATRIX

CO	PO					
	1	**2**	**3**	**4**	**5**	**6**
1	1	-	2	-	1	-
2	2	2	2	-	2	-
3	2	2	2	-	1	-
4	2	3	3	-	2	2
5	2	3	2	-	2	2
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE954	DESIGN OF HEAT EXCHANGERS	4	0	0	4

COURSE OBJECTIVES:

1. To make students familiarize with the various types of heat exchangers
2. To explain the importance of thermal and stress analysis of heat exchangers
3. To inculcate the thermal design aspects of tubular heat exchangers
4. To provide the details of design aspects of compact heat exchangers
5. To explain the function and design aspects of condensers and cooling towers

UNIT- I FUNDAMENTALS OF HEAT EXCHANGER 12

Temperature distribution and its implications types–shell and tube heat exchangers–regenerators and recuperators – analysis of heat exchangers–LMTD and effectiveness method

UNIT- II STRESS ANALYSIS 12

Effect of turbulence – friction factor – pressure loss – stress in tubes – header sheets and pressure vessels – thermal stresses, shear stresses –types of failures.

UNIT- III DESIGN ASPECTS 12

Heat transfer and pressure loss – flow configuration – effect of baffles – effect of deviations from ideality – design of double pipe – finned tube – shell and tube heat exchangers – simulation of heat exchangers

UNIT- IV COMPACT AND PLATE HEAT EXCHANGERS 12

Types–merits and demerits–design of compact heat exchangers, plate heat exchangers–performance influencing parameters– limitations.

UNIT- V CONDENSERS AND COOLING TOWERS 12

Design of surface and evaporative condensers–cooling tower –performance characteristics

TOTAL: 60 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Classify heat exchangers and illustrate the applications of various types of heat exchangers
CO2	Interpret the significance of stress analysis of heat exchangers
CO3	Analyse the design of tubular heat exchangers for various applications
CO4	Appraise the design of compact heat exchangers for industrial requirements
CO5	Evaluate the performance calculation of condensers and cooling towers

REFERENCES:

R1	SadikKakac, Hongtan Liu, Anchasa Pramuanjaroenkij, “Heat Exchangers Selection, Rating and Thermal Design”, CRC Press,Third Edition,2012.
R2	Ramesh K.Shah, Dušan P.Sekulić, ”Fundamentals of heat exchanger design”, John Wiley & Sons, 2003.
R3	Robert W. Serth, “Process heat transfer principles and applications”, Academic press, Elesevier, 2010.
R4	T. Kuppan, “Heat exchanger design hand book”,New York: Marcel Dekker,2009.
R5	Arthur.P Frass, “Heat Exchanger Design”, John Wiley & Sons,1989.

COURSE ARTICULATION MATRIX

CO	PO					
	1	2	3	4	5	6
1	3		1	3	1	
2	3		1	3	1	
3	3		3	2	1	
4	3		2	2	1	
5	3		3	1	1	
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1955	**BATTERY THERMAL MANAGEMENT SYSTEM**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1. The objective of this course is to introduce learner to batteries, its parameters,modelling and charging requirements.
2. The course will help learner to develop battery management algorithms for batteries
3. To analyse the battery state of charge and its functions
4. To evaluate models using the range of simulation.
5. To Examine the design standards of a battery.

UNIT – I INTRODUCTION 9

Introduction to Battery Management System, Cells & Batteries, Nominal voltage and capacity, C rate, Energy and power, Cells connected in series, Cells connected in parallel, Electrochemical and lithiumion cells, Rechargeable cell, Charging and Discharging Process, Overcharge and Undercharge, Modes of Charging

UNIT-II BATTERY MANAGEMENT SYSTEM REQUIREMENT 9

Introduction and BMS functionality, Battery pack topology, BMS Functionality, Voltage Sensing, Temperature Sensing, Current Sensing, BMS Functionality, High-voltage contactor control, Isolation sensing, Thermal control, Protection, Communication Interface, Range estimation, State-of- charge estimation, Cell total energy and cell total power.

UNIT-III BATTERY STATE OF CHARGE AND STATE OF HEALTH ESTIMATION, CELL BALANCING 9

Battery state of charge estimation (SOC), voltage-based methods to estimate SOC, Model-based state estimation, Battery Health Estimation, Lithium-ion aging: Negative electrode, Lithium-ion aging: Positive electrode, Cell Balancing, Causes of imbalance, Circuits for balancing

UNIT- IV MODELLING AND SIMULATION 9

Equivalent-circuit models (ECMs), Physics-based models (PBMs), Empirical modelling approach, Physics-based modelling approach, simulating an electric vehicle, Vehicle range calculations, simulating constant power and voltage, Simulating battery packs,

UNIT-V DESIGN OF BATTERY BMS: 9

Design principles of battery BMS, Effect of distance, load, and force on battery life and BMS, energy balancing with multi-battery system

TOTAL: 45 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Interpret the role of battery management system
CO2	Identify the requirements of Battery Management System
CO3	Interpret the concept associated with battery charging / discharging process
CO4	Calculate the various parameters of battery and battery pack
CO5	Design the model of battery pack

REFERENCES:

R1	Plett, Gregory L. Battery management systems, Volume I: Battery modeling. Artech House, 2015.

R2	Plett, Gregory L. Battery management systems, Volume II: Equivalent-circuit methods, Artech House, 2015.
R3	Bergveld, H.J., Kruijt, W.S., Notten, P.H.L "Battery Management Systems -Design by Modelling" Philips Research Book Series 2002.
R4	Davide Andrea," Battery Management Systems for Large Lithium-ion Battery Packs" ArtechHouse, 2010
R5	Pop, Valer, et al. Battery management systems: Accurate state-of-charge indication forbattery powered applications. Vol. 9. Springer Science & Business Media, 2008.

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	2	-	3	-
2	-	-	-	-	2	-
3	2	3	1	-	-	-
4	1	-	-	-	-	-
5	1	1	-	-	1	-
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1956	**ADVANCED ENERGY STORAGE TECHNOLOGIES**	**4**	**0**	**0**	**4**

COURSE OBJECTIVES:

1. To understand the various types of energy storage technologies and its applications.
2. To study the various modeling techniques of energy storage systems using TRNSYS.
3. To learn working concepts and types of batteries.
4. To make the students to get understand the concepts of Hydrogen and Biogas storage.
5. To provide the insights on super capacitor, Fly wheel and compressed energy storage system.

UNIT – I INTRODUCTION 12

Necessity of energy storage–types of energy storage–comparison of energy storage technologies– Applications. Design considerations of advanced energy storage systems.

UNIT– II THERMAL STORAGE SYSTEM 12

Thermal storage–Types–Modelling of thermal storage units–Simple water and rock bed storage system–pressurized water storage system–Modelling of phase change storage system –Simple units, packed bed storage units – Modelling using porous medium approach, Use of TRNSYS

UNIT–III ELECTRICAL ENERGY STORAGE 12

Fundamental concept of batteries–measuring of battery performance, modelling and design aspects, charging and discharging of a battery, storage density, energy density, and safety issues. Types of batteries – Lead Acid, Nickel–Cadmium, Zinc Manganese di oxide and modern batteries like zinc-Air battery, Nickel Hydride battery, Lithium battery.

UNIT– IV HYDROGEN AND BIOGAS STORAGE 1 2

Hydrogen storage options–compressed gas–liquid hydrogen–Metal Hydrides, chemical Storage, Biogas storage-comparisons. Design requirements, Performance analysis, Safety and management of hydrogen and Biogas storage- Applications.

UNIT– V ALTERNATE ENERGY STORAGE TECHNOLOGIES 12

Design challenges of Flywheel, Super capacitors & Methods– Principles a n d Applications, Compressed air Energy storage, Concept of Hybrid Storage – Applications.

TOTAL: 60 PERIODS

COURSE OUTCOMES

After successful completion of the course, the students will be able:

CO	COURSE OUTCOME
CO1	Identify the energy storage technologies for suitable applications.
CO2	Analyze the energy storage systems using TRNSYS.
CO3	Summarise the concepts and types of batteries.
CO4	Examine the principle of operation of Hydrogen and Biogas storage systems.
CO5	Explain the working of super capacitor, Flywheel and compressed energy storagesystems

REFERENCES:

R1	Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2010.
R2	Viswanathan, Fuel cell principle and applications university press,2006.
R3	Luisa F.Cabeza, Advances in Thermal Energy Storage Sy stems: Methods andApplications, Elsevier Wood head Publishing, 2015

R4	Robert Huggins, Energy Storage: Fundamentals, Materials andApplications,2ndedition, Springer,2015.
R5	Ru-shiliu, Leizhang, Xueliang sun, Electrochemical technologies for energy storage and conversion,,Wileypublications,2012.
R6	National Energy Technology Laboratory, U.S. Department of Energy, Fuel Cell Handbook (Seventh Edition).

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	2		1	2		
2	2		3	3		
3	2		1	2		
4	2		1	2		
5	2		1	2		
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1957	HYBRID AND ELECTRIC VEHICLES	3	0	0	3

COURSE OBJECTIVES:

1. To introduce the concept of hybrid and electric drive trains.
2. To elaborate on the types and utilisation of hybrid and electric drive trains
3. To expose on different types of AC and DC drives for electric vehicles
4. To understand and utilise different types of energy storage systems
5. To introduce concept of energy management strategies and drive sizing

UNIT I INTRODUCTION 9

Basics of vehicle performance, vehicle power source characterization, transmission characteristics, History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

UNIT II HYBRID ELECTRIC DRIVE TRAINS 9

Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.
Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

UNIT III CONTROL OF AC & DC DRIVES 9

Introduction to electric components used in hybrid and electric vehicles, Configuration and control - DC Motor drives, Induction Motor drives, Permanent Magnet Motor drive, and Switch Reluctance Motor drives, drive system efficiency.

UNIT IV ENERGY STORAGE 9

Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Energy storage and its analysis - Battery based, Fuel Cell based, and Super Capacitor based, Hybridization of different energy storage devices.

UNIT V DRIVE SIZING AND ENERGY MANAGEMENT STRATEGIES 9

Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selection of appropriate energy storage technology, Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification and comparison of energy management strategies, implementation issues.

TOTAL : 45 PERIODS

COURSE OUTCOMES :

CO1	Characterize and configure hybrid drivetrains requirement for a vehicle
CO2	Design and apply appropriate hybrid and electric drive trains in a vehicle
CO3	Arrive at a suitable energy storage system for a hybrid / electric vehicle
CO4	Design and install suitable AC and DC drives for electric vehicles.
CO5	Apply energy management strategies to ensure better economy and efficiency

REFERENCES:

R1	Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
R2	James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003
R3	MehrdadEhsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
R4	Rand D.A.J, Woods, R & Dell RM Batteries for Electric vehicles, John Wiley & Sons, 1998

COURSE ARTICULATION MATRIX

CO	PO					
	1	2	3	4	5	6
1	2	3	4	5	6	
2						
3	-	2	3	-	2	-
4	3	2	3	-	2	2
5	3	2	3	-	2	2
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1958	ADVANCED POWER PLANT ENGINEERING	3	0	0	3

COURSE OBJECTIVES:	
1.	Understand the thermodynamics associated with power plants
2.	Detail on the role of various utilities in coal based thermal power plants
3.	Acquire know-how on the working of gas turbine and diesel power plants
4.	Appreciate the concept of Poly generation for total energy recovery from a system
5.	Brief on the working of hydro electric and nuclear power plants

UNIT– I INTRODUCTION 9

Energy scenario: India Vs. World – Load curves and–thermodynamic analysis of Conventional Power Plants (Coal, Gas Turbine and Diesel)-Advanced Power Cycles-Kalina Cycle, IGCC.

UNIT– II COAL BASED THERMAL POWER PLANTS 9

Basics of typical power plant utilities – Boilers, Nozzles, Turbines, Condensers, Cooling Towers, Water Treatment and Piping system – steam rate and heat rate – mean temperature of heat addition-Rankine cycle improvements–Superheat, Reheat, Regeneration, Supercritical, AFBC/PFBC – computation of per unit cost of power generation from coal/biomass

UNIT–III GAS TURBINE AND DIESEL POWER PLANTS 9

Brayton cycle – Open and Closed – Improvements – Intercooler, Reheating and Regeneration. Diesel power plant – Layout – Performance analysis and improvement – Techniques for starting, cooling and lubrication of diesel engines-computation of per unit cost of power generation

UNIT– IV CHP AND MHD POWER PLANTS 9

Cogeneration systems–types-heat to power ratio-Thermodynamic performance of steam turbine gas turbine and IC engine-based cogeneration systems–Poly Generation-Binary Cycle- Combined cycle. MHD –Open cycle and closed cycle-Hybrid MHD & steam power plants

UNIT– V HYDRO ELECTRIC & NUCLEAR POWER PLANTS 9

Hydroelectric Power plants – classifications – essential elements – pumped storage systems – micro and mini hydel power plants. General aspects of Nuclear Engineering – Components of nuclear power plants – Nuclear reactors & types – PWR, BWR, CANDU, Gas Cooled, Liquid Metal Cooled and Breeder reactor-nuclear safety–Environmental Issues-Computation of per Unit cost of power generation

TOTAL : 45 PERIODS

COURSE OUTCOMES :	
CO1	Evaluate appropriate power generation technologies for mitigating the energy gap
CO2	Appraise the steam rate, heat rate and cost for generating electricity from coal based thermal power plants
CO3	Analyse and suggest measures for improving the performance of gas turbine and diesel power plants
CO4	Assess the applicability and performance of a cogeneration system
CO5	Decide a suitable type of hydroelectric/nuclear power plant commensurate with the prevailing conditions

REFERENCES:

R1	Nag, P.K., Power Plant Engineering, Tata McGraw Hill Publishing Co Ltd, New Delhi,1998.
R2	Haywood, R.W., Analysis of Engineering Cycles,4th Edition, Pergamon Press,Oxford,1991.
R3	Wood, A.J., Wollen berg, B.F., Power Generation, operation and control, John Wiley, New York,1984.
R4	Gill, A.B., Power Plant Performance, Butter worths,1984.
R5	Lamarsh, J.R., Introduction to Nuclear Engg. 2nd edition, Addison-Wesley, 1983.

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	2		2			
2	2		2	2		1
3	2		2	2		1
4	2		2	2		1
5	2		2	1	2	
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1959	ADVANCES IN MATERIALS	3	0	0	3

COURSE OBJECTIVES:

1. Understand major types of special steels such as HSLA, TRIP, Dual and Tool steels and cast-irons
2. To study the polymer behaviour and develop polymer composites
3. To study energy conversion materials
4. To learn about various materials used for bio implants
5. To understand the advantage of materials at Nano scale

UNIT– I METALLIC MATERIALS 9

Classification of metallic materials - Ferrous and nonferrous.

Ferrous metals and alloys-Introduction to specifications – types of steels, alloy steels, tool steels; stainless steels, HSLA, TRIP steels, TWIP steels. Shape memory alloys – Intermetallic – Superalloys- Titanium and Magnesium alloys – Bulk metallic glass –high entropy alloys-metamaterials –topological materials

UNIT– II POLYMERS AND COMPOSITES 9

Structure of polymers, characterization and applications of polymers: mechanical behavior of polymers, strengthening of polymers, crystallization and glass transition phenomenon and types of polymers.

Composites: Particle reinforced composites, fiber reinforced composites – influence of fiber length, orientation and concentration. Fiber phase, matrix phase, metal matrix composites, polymer matrix composites, ceramic matrix composites, carbon – carbon composites, hybrid composites and structural composites.

UNIT–III ENERGY MATERIALS 9

Need for high performance energy materials - carbon nanostructure based energy conversion and storage materials - nanomaterials for solar cell applications - next generation energy storage materials – Li and Ni based batteries, fuel cells.

UNIT– IV BIO MATERIALS 9

Introduction to biomaterials; need for biomaterials; Salient properties of important material classes; Property requirement of biomaterials; Metallic implant materials, ceramic implant materials, polymeric implant materials, composites as biomaterials; Orthopaedic, dental and other applications. Biomaterials preparation and characterization; Processing and properties of different bio ceramic materials; Mechanical and physical properties evaluation of biomaterials; New and novel materials for biomedical applications. Design concept of developing new materials for bio-implant applications; Nanomaterials and nanocomposites for medical applications

UNIT– V NANO MATERIALS 9

Concept of nano materials – scale / dimensional aspects, Top-down and bottom-up approaches for preparing nano materials Advantages and limitations at the nano level – thermodynamic aspects at the nano level, health and environmental issues.

TOTAL : 45 PERIODS

COURSE OUTCOMES :

CO1	Understand the various ferrous alloys and their applications
CO2	Understand different types of composite materials and polymers
CO3	Understand Solar materials
CO4	Understand the properties of different biomaterials

CO5	Understand the structure and behaviour of Nano materials

REFERENCES:	
R1	Smith, W.F., Hashemi, J., and Prakash, R., Materials Science and Engineering, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2012.
R2	Callister, W.D. Jr., and Rethwisch, D.G., Materials Science and Engineering: An Introduction, Wiley, New York, 2014.
R3	Raghavan, V., Physical Metallurgy: Principles and Practice, Prentice Hall of India Pvt. Ltd., New Delhi, 2015.
R4	Bhat, N.V., Introduction to Nanoscience and Nanotechnology, Pearson Education, New Delhi, 2012.
R5	Ratner, B.D., Hoffman, A.S., Schoen, F.J., and Lemons, J.E., Biomaterials Science: An Introduction to Materials in Medicine, Academic Press, California, 2013.

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	2		2			
2	2		2	2		1
3	2		2	2		1
4	2		2	2		1
5	2		2	1	2	
Low (1); Medium (2); High (3)						

TE1960	**MATERIALS TESTING AND CHARACTERIZATION TECHNIQUES**	**4**	**0**	**0**	**4**

COURSE OBJECTIVES:

1. To understand the fundamentals of materials, material classification, and the importance of testing materials.
2. To learn various microscopic and crystallographic techniques used for analyzing material structure.
3. To explore the principles and applications of advanced material characterization tools like SEM, TEM, and AFM.
4. To study chemical and thermal analysis methods used to evaluate material properties.
5. To understand mechanical and non-destructive testing techniques for assessing material performance under various conditions.

UNIT– I INTRODUCTION, MICRO AND CRYSTAL STRUCTURE ANALYSIS 12

Introduction: Overview of materials, Classification of material testing, Purpose of testing, Selection of material, Development of testing, Testing organizations and its committee, Testing standards, Result Analysis, Advantages of testing. **Crystal Structure:** Principles of Optical Microscopy – Specimen Preparation Techniques – Polishing and Etching – Polarization Techniques – Quantitative Metallography – Estimation of grain size – ASTM grain size numbers – Microstructure of Engineering Materials - Elements of Crystallography – X- ray Diffraction – Bragg's law – Techniques of X-ray Crystallography Identification of Crystal Structure, Elements of Electron Diffraction.

UNIT– II MATERIAL CHARACTERIZATION TESTING 12

Interaction of Electron Beam with Materials – Transmission Electron Microscopy – Specimen Preparation- Scanning Electron Microscopy – Construction & working of SEM – various Imaging Techniques – Applications- Atomic Force Microscopy- Construction & working of AFM - Applications. Electrical and Magnetic Techniques- Principles, Types, Advantages and Limitations, Applications.

UNIT–III CHEMICAL AND THERMAL ANALYSIS 12

Chemical Testing: Basic Principles, Practice and Applications of X-Ray Spectrometry, Wave Dispersive X-Ray Spectrometry, Auger Spectroscopy, Secondary Ion Mass Spectroscopy, Fourier Transform Infra-Red Spectroscopy (FTIR)- Proton Induced X-Ray Emission Spectroscopy, Elemental Analysis by Inductively Coupled Plasma-Optical Emission Spectroscopy and Plasma-Mass Spectrometry. **Thermal Testing:** Differential scanning calorimetry, Differential thermal analysis and Thermo Gravimetric Analysis (TGA). Thermo-mechanical and Dynamic mechanical analysis: Principles, Advantages, Applications.

UNIT– IV MECHANICAL TESTING – STATIC AND DYNAMIC TESTS 12

Hardness – Brinell, Vickers, Rockwell and Micro Hardness Test – Tensile Test – Stress – Strain plot – Proof Stress – Torsion Test - Ductility Measurement – Impact Test – Charpy & Izod, Fracture Toughness Test, Codes and standards for testing metallic and composite materials.
Fatigue – Low & High Cycle Fatigues -S-N curve – LCF tests – Crack Growth studies – Creep Tests Applications of Dynamic Tests.

UNIT– V NON DESTRUCTIVE TESTING 12
Visual inspection, Liquid penetrant test, Magnetic particle test, Thermography test – Principles, Techniques, Advantages and Limitations, Applications. Radiographic test, Eddy current test, Ultrasonic test, Acoustic emission- Principles, Techniques, Methods, Advantages and Limitations, Applications.
TOTAL : 60 PERIODS

COURSE OUTCOMES :	
CO1	Explain the purpose of material testing and identify appropriate testing methods for different materials.
CO2	Demonstrate knowledge of crystal structure analysis techniques and microstructure observation methods.
CO3	Apply electron and atomic force microscopy techniques to study the internal structure of materials.
CO4	Analyze the chemical and thermal properties of materials using spectroscopy and thermal analysis methods.
CO5	Evaluate mechanical and non-destructive test results to assess the strength, durability, and safety of engineering materials.

REFERENCES:	
R1	Leng, Y., Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Wiley, Singapore, 2008.
R2	Callister, W.D. Jr., and Rethwisch, D.G., Materials Science and Engineering: An Introduction, Wiley, New York, 2014.
R3	Zhang, S., Li, L., and Kumar, A., Materials Characterization Techniques, CRC Press, Boca Raton, 2009.
R4	Dowling, N.E., Mechanical Behavior of Materials, Pearson Education, New Jersey, 2013.
R5	Hull, B., and John, V., Non-Destructive Testing, Springer, London, 2003.

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	2		2			
2	2		2	2		1
3	2		2	2		1
4	2		2	2		1
5	2		2	1	2	
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1921	BOUNDARY LAYER THEORY AND TURBULENCE	3	0	0	3

COURSE OBJECTIVES:

1. To introduce the fundamental concepts of boundary layer in real flows.
2. To distinguish between turbulent and laminar boundary layers.
3. To model turbulent flows using various approaches.
4. To analyze various flow parameters using statistical principles.
5. To introduce the types, characteristics of wall shear flows from free shear flows

UNIT I FUNDAMENTALS OF BOUNDARY LAYER THEORY 9

Basics of vehicle performance, vehicle power source characterization, transmission characteristics, History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

UNIT II TURBULENT BOUNDARY LAYERS 9

Internal Flows – Couette flow – Two-Layer Structure of the velocity Field – Universal Laws of the wall– Friction law – Fully developed Internal flows – Channel Flow, Couette – Poiseuille flows, Pipe Flow

UNIT III TURBULENCE AND TURBULENCE MODELS 9

Nature of turbulence – Averaging Procedures – Characteristics of Turbulent Flows – Types of Turbulent Flows – Scales of Turbulence, Prandtl's Mixing length, Two-Equation Models, Low – Reynolds Number Models, Large Eddy Simulation

UNIT IV STATISTICAL THEORY OF TURBULENCE 9

Ensemble Average – Isotropic Turbulence and Homogeneous Turbulence – Kinematics of Isotropic Turbulence – Taylor's Hypothesis – Dynamics of Isotropic Turbulence – Grid Turbulence and decay – Turbulence in Stirred Tanks.

UNIT V TURBULENT FLOWS 9

Wall Turbulent shear flows – Structure of wall flow – Turbulence characteristics of Boundary layer – Free Turbulence shear flows – Jets and wakes – Plane and axi-symmetric flows.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1	Analyze flow with the principles of boundary layer theory
CO2	Distinguish turbulent boundary layer for various types of flows
CO3	Select and use various turbulence models for the appropriate applications.
CO4	Apply the statistical theory for averaging various flow parameters.
CO5	Differentiate the characteristics of wall shear and free shear flows

REFERENCES:

R1	Philip G. Hill and Carl R. Peterson, Mechanics and Thermodynamics of Propulsion, Second Edition, Addition – Wesley Publishing Company, New York, 2009.
R2	Cohen, H. Rogers, G.F.C. and Saravanamuttoo, H.I.H, Gas Turbine Theory, Longman,1989
R3	G.C. Oates, "Aerothermodynamics of Aircraft Engine Components", AIAA Education Series 1985.
R4	S. M. Yahya, Fundamentals of Compressible Flow. Third edition, New Age International Pvt Ltd, 2003.

R5	George P. Sutton, Oscar Biblarz. Rocket Propulsion Elements, John Wiley & Sons, 8th Edition, 2010.
R6	Ramamurthy, Rocket Propulsion, Pan Macmillan (India) Ltd, 2010.
R7	W.P.Gill, H.J.Smith& J.E. Ziurys, "Fundamentals of Internal Combustion Engines as applied to Reciprocating, Gas turbine & Jet Propulsion Power Plants", Oxford & IBH Publishing Co., 1980

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	-	-	1	-	2	-
2	2	2	2	1	2	-
3	2	2	2	2	2	-
4	2	2	2	2	2	-
5	2	2	2	2	2	-
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1922	**STEAM GENERATOR TECHNOLOGY**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1. To educate the students on the types of boilers with their constructional and functional significance.
2. To understand the working and design of fuel preparation units and boilers.
3. To introduce the concept of boiler design, emission aspects.
4. To Classify the auxiliary Equipment in design.
5. To enumerate the technological design aspect in steam generator

UNIT I BASICS 9

Steam Cycle for Power Generation – Fuel Stoichiometry - Boiler Classification & Components – Specifications - Boiler Heat Balance – Efficiency Estimation (Direct & Indirect) – Sankey Diagram .

UNIT II FUELS AND BOILER TYPES 9

Solid Fuel: Coal Preparation – Pulverization – Fuel feeding arrangements, Fuel Oil: Design of oil firing system – components – Air regulators, Types of Boilers – Merits & Limitations – Specialty of Fluid Bed Boilers – Basic design principles (Stoker, Travelling Grate etc.,).

UNIT III COMPONENTS DESIGN 9

Furnace– Water Wall – Steam Drum – Attemperator - Superheaters – Reheaters – Air Preheaters – Economizers - Steam Turbines: Design Aspects of all these.

UNIT IV AUXILIARY EQUIPMENTS – DESIGN & SIZING 9

Forced Draft & Induced Draft Fans – PA / SA Fans – Water Pumps (Low Pressure & High Pressure) – Cooling Towers – Softener – DM Plant.

UNIT V EMISSION ASPECTS 9

Emission Control – Low NOx Burners– Boiler Blow Down - Control & Disposal: Feed Water Deaeration & Deoxygenation – Reverse Osmosis - Ash Handling Systems Design – Ash Disposal– Chimney Design to meet Pollution std – Cooling Water Treatment & Disposal

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1	Familiarization with Boiler cycles, components and will have specialized knowledge in steam boiler performance evaluation.
CO2	Emission related aspects in terms of CO2 NOx emission, mitigation etc will make them to realize the impact of Coal / fuel burning in the society.
CO3	Familiarization with Boiler cycles, components and in Design.
CO4	Illustrate a specialized knowledge in steam boiler performance evaluation.
CO5	Emission related aspects in terms of CO2 NOx emission, mitigation etc will make them to realize the impact of Coal / fuel burning in the society

REFERENCES:

R1	Blokh A.G., Heat Transfer in Steam Boiler Furnace, Hemisphere Publishing Corporation, 2017.
R2	Carl Schields, Boilers: Type, Characteristics and Functions, McGraw Hill Publishers, 1982.

R3	David Gunn and Robert Horton, Industrial Boilers, Longman Scientific and Technical Publication, 1986. .
R4	Ganapathy V., Industrial Boilers and Heat Recovery Steam Generators, Marcel Dekker Ink, 2003
R5	Howard J.R., Fluidized Bed Technology: Principles and Applications, Adam Hilger, New York, 1983.
R6	Mosoon Kwauk, Fluidization Idealized and Bubbleless, with Applications, Science Press, 1992.
R7	Prabir Basu, Cen Kefa and Louis Jestin, Boilers and Burners: Design and Theory, Springer, 2000. Mapping of CO with PO

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	1	2	-	-	-	-
2	2	-	-	-	-	-
3	1	-	-	-	-	-
4	-	-	-	1	2	-
5	-	-	1	-	2	-
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE1923	FLUIDIZED BED SYSTEMS	3	0	0	3

COURSE OBJECTIVES:

1. To understand the behavior of fluidized beds
2. To learn about the heat transfer process.
3. To differentiate the combustion and gasification, and appreciate the relative merits.
4. To design components of fluidized bed systems.
5. To understand the industrial applications of fluidized bed systems

UNIT I FLUIDIZED BED BEHAVIOUR 9

Characterization of bed particles–comparison of different methods of gas–solid contacts. Fluidization phenomena – regimes of fluidization – bed pressure drop curve. Two phase and well- mixed theory of fluidization. Particle entrainment and elutriation – unique features of circulating fluidized beds.

UNIT II HEAT TRANSFER 9

Different modes of heat transfer in fluidized bed– bed to wall heat transfer – gas to solid heat transfer – radiant heat transfer – heat transfer to immersed surfaces. Methods for improvement – external heat exchangers– heat transfer and part load operations

UNIT III COMBUSTION AND GASIFICATION 9

Fluidized bed combustion and gasification–stages of combustion of particles–performance–start – up methods. Pressurized fluidized beds.

UNIT IV DESIGN CONSIDERATIONS 9

Design of distributors–stoichiometric calculations–heat and mass balance–furnace design–design of heating surfaces–gas solid separators.

UNIT V INDUSTRIAL APPLICATIONS 9

Physical operations like transportation, mixing of fine powders, heat exchange, coating, drying and sizing. Cracking and reforming of hydrocarbons, carbonization, combustion and gasification. Sulphur retention and oxides of nitrogen emission Control.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO 1	Illustrate the behavior of fluidized bed particles and explain the theory of fluidization.
CO 2	Analyze the heat transfer process in fluidized beds
CO 3	Apply concepts of combustion and gasification in fluidized beds
CO 4	Interpret the design consideration for components of fluidized bed system.
CO 5	Evaluate fluidized bed systems for various industrial applications.

REFERENCES:

R1	Howard,J.R.,FluidizedBedTechnology:PrinciplesandApplications,AdamHilger,NewYork,1983.

R2	Geldart, D., Gas Fluidization Technology, John Willey and Sons, 1986.
R3	Kunii,D and Levespiel,O., Fluidization Engineering, John Wiley and Son Inc, New York,1969.
R4	Howard,J.R.(Ed), Fluidized Beds: Combustion and Applications, Applied Science Publishers, New York, 1983.
R5	Botteril,J.S.M., Fluid Bed Heat Transfer, Academic Press, London,1975.

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	3	-	2	3	-	-
2	3	-	3	3	-	-
3	3	-	2	3	2	2
4	3	-	3	3	2	2
5	3	-	2	3	2	2
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE 1924	**ENERGY EFFICIENT BUILDINGS**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1. To learn the green buildings concepts applicable to alternate design
2. To be familiar with basic terminologies related to buildings
3. To learn the building (air) conditioning techniques
4. To know the methods to evaluate the performance of buildings
5. To incorporate Renewable energy systems in buildings

UNIT I INTRODUCTION 9

Climate and Building, Historical perspective, Aspects of green building design – Sustainable Site, Water, Energy, Materials and IAQ, ECBC Standards

UNIT II LANDSCAPE AND BUILDING ENVELOPES 9

Energy efficient Landscape design – Microclimate, Shading, Arbors, Windbreaks, Xeriscaping, Building envelope – Thermal comfort, Psychrometry, Comfort indices, Thermal Properties of Building Materials – Thermal Resistance, Thermal Time Constant (TTC), Diurnal Heat Capacity (DHC), Thermal Lag, Decrement Factor, Effect of Solar Radiation – Sol-air Temperature, Processes of heat exchange of building with environment, Insulation

UNIT III PASSIVE HEATING AND COOLING 9

HVAC introduction, Passive Heating – Solar radiation basics, Sun Path Diagram, Direct Heating, Indirect Heating and Isolated heating, Concept of Daylighting, Passive Cooling – Natural Ventilation (Stack and Wind), Evaporative Cooling and Radiative Cooling.

UNIT IV THERMAL PERFORMANCE OF BUILDINGS 9

Heat transfers due to fenestration/infiltration, Calculation of Overall Thermal Transmittance, Estimation of building loads: Steady state method, network method, numerical method, correlations, Thermal Storage integration in buildings

UNIT V RENEWABLE ENERGY IN BUILDINGS 9

Introduction of renewable sources in buildings, BIPV, Solar water heating, small wind turbines, standalone PV systems, Hybrid system – Economics.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1	Understand the principles of climate-responsive building design.
CO2	Identify and use basic building-related terminologies.
CO3	Apply passive air-conditioning techniques in building design.
CO4	Evaluate building performance based on environmental and energy factors.
CO5	Gain knowledge of renewable energy systems used in buildings

REFERENCES:

R1	ASHRAE Handbook -2009 - Fundamentals.
R2	Baruch Givoni: Climate considerations in building and Urban Design, John Wiley & Sons, 1998
R3	Baruch Givoni: Passive Low Energy Cooling of Buildings by, John Wiley & Sons, 15-Jul-1994
R4	JA Duffie and WA Beckman: Solar Engineering of Thermal Processes, Third Edition, John Wiley & Sons, 2006.

R5	Jan F. Kreider, Peter S. Curtiss, Ari Rabl, Heating and Cooling of buildings: Design for Efficiency, Revised Second Edition, CRC Press, 28-Dec-2009.

COURSE ARTICULATION MATRIX

CO	PO					
	1	**2**	**3**	**4**	**5**	**6**
1	3	2	1	2	-	1
2	-	1	1	2	-	1
3	-	-	-	-	-	-
4	-	-	2	3	-	1
5	-	-	2	2	-	3
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE 1925	ENGINE POLLUTION AND CONTROL	3	0	0	3

COURSE OBJECTIVES:

1. To provide an insight about effect of engine out emissions on human health and environment
2. To impart the knowledge on various pollutant species formations in SI and CI engine
3. To divulge about various emission measurement techniques in engines and its significance
4. To provide a discernment about various emission control methods
5. To impart the knowledge about international and national driving cycles and emission standards

UNIT I AIR POLLUTION – ENGINES 9

Atmospheric pollution from automotive, stationary engines and gas turbines, Global warming – Greenhouse effect, Effects of engine pollution on human health and environment.

UNIT II POLLUTANT FORMATION 9

Formation of Oxides of nitrogen, Carbon monoxide, Hydrocarbon, Aldehydes, Smoke and Particulate matter emissions. Effects of Engine design and operating variables on emission formation, Noise pollution.

UNIT III EMISSION MEASUREMENT TECHNIQUES 9

CO, CO2 - Non dispersive infrared gas analyzer, NOx - Chemiluminescent analyzer, HC - Flame ionization detector, Smoke – Opacity and filter paper measurements, Particulate Matter – Full flow and Partial flow dilution tunnel, Gas chromatography, Noise measurement.

UNIT IV EMISSION CONTROL TECHNIQUES 9

Engine design modifications, Fuel modification, Evaporative emission control, EGR, Air injection, Thermal reactors, Water injection, Common rail direct injection and Gasoline direct injection system, After treatment systems - Catalytic converters, Diesel oxidation catalyst, Particulate traps, De-NOx catalysts, SCR systems. Low temperature combustion concepts

UNIT V DRIVING CYCLES AND EMISSION STANDARDS 9

Transient dynamometer, Test cells, Driving cycles for emission measurement, chassis dynamometer, CVS system, National and International emission standards.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1	Understand about atmospheric pollution from engines and its impact on human health and environment.
CO2	Understand the formation of emissions in both SI and CI engines.
CO3	Understand the various measurement techniques used globally for the measurement of automotive and stationary engine out emissions.
CO4	Learn the various control methods/techniques used in IC engine to control the engine out emissions
CO5	Learn the transient and steady state driving cycles performed on automotive and stationary engines and emission standards that are followed in the national and international level.

REFERENCES:

R1	Ganesan V., “Internal Combustion Engines”, V Edition, Tata McGraw Hill, 2012.

R2	John. B. Heywood, "Internal Combustion engine fundamentals" McGraw – Hill, 1988.
R3	Crouse William, Automotive Emission Control, Gregg Division /McGraw-Hill,1980
R4	Pundir B. P., "IC Engines Combustion and Emission" Narosa publishing house, 2010.
R5	George Springer and Donald J Patterson, Engine emissions, Pollutant Formation and Measurement, Plenum press, 2013

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	3	2	1	2	-	1
2	-	1	1	2	-	1
3	-	-	-	-	-	-
4	-	-	2	3	-	1
5	-	-	2	2	-	3
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE 1926	SOLAR THERMAL TECHNOLOGIES	3	0	0	3

COURSE OBJECTIVES:

1. To clarify impression of various solar thermal energy collectors
2. To delineate the other applications and the devices used to collect solar energy
3. To study the various types and configurations of solar space conditioning system
4. To learn the various solar applications.
5. To summarize the basic economics of solar energy collection system.

UNIT I SOLAR COLLECTORS 9

Collectors: Flat plate: Water, Air - Evacuated tube – Concentrated – Construction – Function - Suitability – Comparison – Design of Storage Tank - Solar Fluids.

UNIT II SOLAR WATER HEATING SYSTEMS 9

Integral Collector Storage System - Thermosyphon System - Open Loop, Drain Down, Drain Back, Antifreeze Systems - Refrigerant Solar Water Heaters - Solar Heated Pools - Solar Heated Hot Tubs and Spas.

UNIT III SOLAR SPACE CONDITIONING SYSTEMS 9

Liquid Type Solar Heating System With / Without Storage - Heat Storage Configurations – Heat Delivery Methods - Air-Type Solar Heating Systems - Solar Refrigeration and Air Conditioning.

UNIT IV OTHER SOLAR APPLICATIONS 9

Solar Cooking – Distillation - Desalination - Solar Ponds – Solar Passive Architecture – Solar Drying – Solar Chimney.

UNIT V SOLAR ECONOMICS 9

Application of economic methods to analyze the feasibility of solar systems to decide project / policy alternatives - Net energy analysis - and cost requirements for active and passive heating and cooling - for electric power generation - and for industrial process-heating. Economics – Fixed and variable cost - Payback period - Net Present Value - Internal Rate of Return - Carbon credit – Embodied energy analysis.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1	Explain the technical and physical principles of different solar collectors
CO2	Measure and evaluate different solar energy technologies through knowledge of the physical function of the devices
CO3	Articulate the technical and economic fundamentals of solar thermal energy conversion useful to society and industry
CO4	Describe the spectrum of possible solar thermal technologies to assist industrial processing or power production
CO5	Communicate technological and socio-economic issues around solar energy in a concise and an accessible way to a target group with basic technical skills.

REFERENCES:

R1	Duffie, J.A., and Beckman, W.A. Solar Energy Thermal Process - 4 th Edition (2013), John Wiley and Sons, New York, ISBN: 978-0-470-87366-3, Solar Energy Laboratory, University of Wisconsin-Madison, pp. 944.
R2	H P Garg, M Dayal, G Furlan, Physics and Technology of Solar Energy- Volume I: Solar Thermal Applications, Springer, 2007.
R3	Sukhatme S.P. J K Nayak, Solar Energy, Tata McGraw Hills P Co., ISBN: 9789352607112, 4th Edition, 2017, pp. 568.

R4	Charles Christopher Newton - Concentrated Solar Thermal Energy- Published by VDM Verlag, 2008.
R5	H.P.Garg, S.C.Mullick, A.K.Bhargava, D.Reidal, Solar Thermal Energy Storage Springer, 2005

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	3	2	1	2	-	1
2	-	1	1	2	-	1
3	-	-	-	-	-	-
4	-	-	2	3	-	1
5	-	-	2	2	-	3
Low (1); Medium (2); High (3)						

Course Code	Course Name	L	T	P	C
TE 1713	RENEWABLE ENERGY TECHNOLOGY	3	0	0	3

COURSE OBJECTIVES:

1. Different types of renewable energy technologies
2. Standalone operation, grid connected operation of renewable energy systems

UNIT I INTRODUCTION **9**

Classification of energy sources – Co2 Emission - Features of Renewable energy - Renewable energy scenario in India -Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment Per Capital Consumption - CO_2 Emission - importance of renewable energy sources, Potentials – Achievements– Applications.

UNIT II PHOTOVOLTAIC SYSTEM DESIGN **9**

Solar Energy: Sun and Earth-Basic Characteristics of solar radiation- angle of sunrays on solar collector-Estimating Solar Radiation Empirically - Equivalent circuit of PV Cell- Photovoltaic cell characteristics: P-V and I-V curve of cell-Impact of Temperature and Insolation on I-V characteristics-Shading Impacts on I-V characteristics-Bypass diode -Blocking diode.

UNIT III SOLAR PHOTOVOLTAICS PHOTOVOLTAIC SYSTEM **9**

Block diagram of solar photo voltaic system : Line commutated converters (inversion mode) - Boost and buck-boost converters - selection of inverter, battery sizing, array sizing - PV systems classification- standalone PV systems - Grid tied and grid interactive inverters- grid connection issues.

UNIT IV WIND ENERGY CONVERSION SYSTEMS **9**

Origin of Winds: Global and Local Winds- Aerodynamics of Wind turbine-Derivation of Betz's limit- Power available in wind-Classification of wind turbine: Horizontal Axis wind turbine and Vertical axis wind turbine-Aerodynamic Efficiency-Tip Speed-Tip Speed Ratio-Solidity-Blade Count-Power curve of wind turbine - Configurations of wind energy conversion systems: Type A, Type B, Type C and Type D Configurations- Grid connection Issues - Grid integrated SCIG and PMSG based WECS.

UNIT V OTHER RENEWABLE ENERGY SOURCES **9**

Qualitative study of different renewable energy resources: ocean, Biomass, Hydrogen energy systems, Fuel cells, Ocean Thermal Energy Conversion (OTEC), Tidal and wave energy, Geothermal Energy Resources.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1	Demonstrate the need for renewable energy sources.
CO2	Develop a stand-alone photo voltaic system and implement a maximum power point tracking in the PV system.
CO3	Design a stand-alone and Grid connected PV system.
CO4	Analyze the different configurations of the wind energy conversion systems.
CO5	Realize the basic of various available renewable energy sources

REFERENCES:

R1	S.N.Bhadra, D. Kastha, & S. Banerjee "Wind Electrical Systems", Oxford UniversityPress, 2009.
R2	Rai. G.D, "Non conventional energy sources", Khanna publishes, 1993. Rai. G.D," Solar energy utilization", Khanna publishes, 1993.
R3	Chetan Singh Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications", PHI Learning Private Limited, 2012.

R4	John Twideu and Tony Weir, “Renewal Energy Resources” BSP Publications, 2006 Gray, L. Johnson, “Wind energy system”, prentice hall of India, 1995.
R5	B.H.Khan, " Non-conventional Energy sources", , McGraw-hill, 2nd Edition, 2009.

COURSE ARTICULATION MATRIX

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	3	-	2	2	2	1
2	3	-	2	3	3	3
3	3	-	2	3	3	3
4	3	-	2	3	3	2
5	3	-	2	2	2	2
Low (1); Medium (2); High (3)						