ANNA UNIVERSITY, CHENNAI

AFFILIATED INSTITUTIONS

REGULATIONS 2017

M.E. THERMAL ENGINEERING

CHOICE BASED CREDIT SYSTEM

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

I. To prepare students to excel in research or to succeed in Thermal engineering profession through global, rigorous post graduate education.

II. To provide students with a solid foundation in mathematical, scientific and engineering fundamentals required to solve thermal engineering problems.

III. To train students with good scientific and engineering knowledge so as to comprehend, analyze, design and create novel products and solutions for the real life problems.

IV. To inculcate students in professional and ethical attitude, effective communication skills, teamwork skills, multidisciplinary approach and an ability to relate thermal engineering issues to broader social context.

V. To provide student with an academic environment aware of excellence, leadership, written ethical codes and guidelines and the life-long learning needed for a successful professional career.

PROGRAMME OUTCOMES:

On successful completion of the programme,

1. Graduates will demonstrate knowledge of mathematics, science and engineering
2. Graduates will demonstrate an ability to identify , formulate and solve engineering problems.
3. Graduates will demonstrate an ability to design and conduct experiments, analyze and interpret data.
4. Graduates will demonstrate an ability a system, component or process as per needs and specifications.
5. Graduates will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.
6. Graduates will demonstrate skills to use modern engineering tools, software and equipment to analyze problems.
7. Graduates will demonstrate knowledge of professional and ethical responsibilities.
8. Graduates will be able to communicate effectively in both verbal and written form.
9. Graduates will show the understanding of impact of engineering solutions on the society and also will be aware of contemporary issues.
10. Graduates will develop confidence for self education and ability for life-long learning.

PEO / PO Mapping

Programme Educational Objectives	Programme Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
I	✓	✓		✓						
II					✓	✓	✓			
III				✓	✓	✓	✓			
IV							✓	✓	✓	
V		✓	✓						✓	✓

Semester Course wise PEO mapping

YEAR	SEM	Subject Name	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
YEAR I	SEM 1	Advanced Numerical Methods	✓	✓						✓	✓	✓
		Advanced Heat Transfer	✓	✓						✓	✓	✓
		Advanced Thermodynamics	✓	✓						✓	✓	✓
		Advanced Fluid Mechanics	✓	✓						✓	✓	✓
		Aircraft and Jet Propulsion	✓	✓		✓				✓		✓
		Hydrogen and Fuel Cell Technologies		✓						✓		✓
		Energy Resources	✓	✓		✓				✓		✓
		Advanced Internal Combustion Engines	✓	✓		✓	✓					✓
		Cryogenic Engineering	✓	✓		✓	✓					✓
		Refrigeration Systems	✓	✓		✓				✓		✓
		Thermal Engineering Laboratory	✓		✓		✓	✓		✓	✓	✓
	SEM 2	Instrumentation for Thermal Engineering	✓	✓		✓				✓		✓
		Environmental Engineering and Pollution Control		✓	✓				✓	✓	✓	✓
		Fuels and Combustion	✓	✓		✓				✓		✓
		Computational Fluid Dynamics for Thermal Systems	✓	✓						✓	✓	✓
		Fans, Blowers and Compressors	✓	✓						✓	✓	✓
		Food Processing, Preservation and		✓		✓			✓	✓		✓

		Transport										
		Nuclear Engineering		✓		✓			✓	✓		✓
		Automobile Engineering		✓		✓			✓	✓		✓
		Air Conditioning Systems	✓	✓		✓				✓		✓
		Energy Management in Thermal Systems			✓	✓			✓	✓		✓
		Alternative Fuels for IC Engines	✓	✓		✓				✓		✓
		Design of Heat Exchangers	✓	✓	✓					✓	✓	✓
		Thermal Systems Simulation Laboratory		✓			✓	✓			✓	✓
		Technical Seminar – I	✓	✓				✓			✓	✓
YEAR II	SEM 3	Design and Optimization of Thermal Energy Systems	✓	✓	✓					✓		✓
		Design and Analysis of Turbomachines	✓	✓	✓					✓		✓
		Boundary Layer Theory and Turbulence	✓	✓	✓					✓		✓
		Advanced Power Plant Engineering		✓	✓					✓		✓
		Steam Generator Technology		✓	✓					✓		✓
		Fluidized Bed Systems		✓	✓					✓		✓
		Advanced Thermal Storage Technologies	✓	✓	✓					✓		✓
		Cogeneration and Waste Heat Recovery Systems	✓	✓	✓					✓		✓
		Research Methodology	✓	✓	✓			✓	✓	✓		✓
		Technical Seminar – II	✓	✓				✓			✓	✓
		Project work Phase – I	✓	✓	✓		✓	✓		✓	✓	✓
	SEM 4	Project work Phase – II	✓	✓	✓		✓	✓		✓	✓	✓

ANNA UNIVERSITY, CHENNAI
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REGULATIONS 2017
M.E. THERMAL ENGINEERING
CHOICE BASED CREDIT SYSTEM
I TO IV SEMESTERS (FULL TIME) CURRICULUM AND SYLLABUS

SEMESTER I

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MA5153	Advanced Numerical Methods	FC	5	3	2	0	4
2.	TE5151	Advanced Heat Transfer	FC	4	4	0	0	4
3.	TE5101	Advanced Thermodynamics	FC	4	4	0	0	4
4.	TE5102	Advanced Fluid Mechanics	PC	3	3	0	0	3
5.		Professional Elective I	PC	3	3	0	0	3
6.		Professional Elective II	PC	3	3	0	0	3
PRACTICAL								
7.	TE5111	Thermal Engineering Laboratory	PC	4	0	0	4	2
			TOTAL	**26**	**20**	**2**	**4**	**23**

SEMESTER II

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	TE5201	Instrumentation for Thermal Engineering	PC	3	3	0	0	3
2.	TE5291	Environmental Engineering and Pollution Control	PC	3	3	0	0	3
3.	TE5202	Fuels and Combustion	PC	3	3	0	0	3
4.		Professional Elective III	PE	3	3	0	0	3
5.		Professional Elective IV	PE	3	3	0	0	3
6.		Professional Elective V	PE	3	3	0	0	3
PRACTICAL								
7.	TE5261	Thermal Systems Simulation Laboratory	PC	4	0	0	4	2
8.	TE5211	Technical Seminar – I	EEC	2	0	0	2	1
			TOTAL	**24**	**18**	**0**	**6**	**21**

SEMESTER III

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	TE5301	Design and Optimization of Thermal Energy Systems	PC	3	3	0	0	3
2.		Professional Elective VI	PE	3	3	0	0	3
3.		Professional Elective VII	PE	3	3	0	0	3
PRACTICAL								
4.	TE5311	Technical Seminar – II	EEC	2	0	0	2	1
5.	TE5312	Project Work Phase – I	EEC	12	0	0	12	6
			TOTAL	**23**	**9**	**0**	**14**	**16**

SEMESTER IV

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	TE5411	Project Work Phase – II	PE	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE =72

FOUNDATION COURSES (FC)

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	MA5153	Advanced Numerical Methods	FC	5	3	2	0	4
2.	TE5151	Advanced Heat Transfer	FC	4	4	0	0	4
3.	TE5101	Advanced Thermodynamics	FC	4	4	0	0	4

PROFESSIONAL CORE (PC)

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	TE5102	Advanced Fluid Mechanics	PC	3	3	0	0	3
2.	TE5111	Thermal Engineering Laboratory	PC	4	0	0	4	2
3.	TE5201	Instrumentation for Thermal Engineering	PC	3	3	0	0	3
4.	TE5291	Environmental Engineering and Pollution Control	PC	3	3	0	0	3
5.	TE5202	Fuels and Combustion	PC	3	3	0	0	3
6.	TE5261	Thermal Systems Simulation Laboratory	PC	4	0	0	4	2
7.	TE5301	Design and Optimization of Thermal Energy Systems	PC	3	3	0	0	3

LIST OF ELECTIVES FOR M.E THERMAL ENGINEERING

SEMESTER I (Elective I & II)

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	TE5001	Aircraft and Jet Propulsion	PE	3	3	0	0	3
2.	EY5071	Hydrogen and Fuel Cell Technologies	PE	3	3	0	0	3
3.	EY5152	Energy Resources	PE	3	3	0	0	3
4.	TE5002	Advanced Internal Combustion Engines	PE	3	3	0	0	3
5.	TE5003	Cryogenic Engineering	PE	3	3	0	0	3
6.	TE5004	Refrigeration Systems	PE	3	3	0	0	3

SEMESTER II (Elective III, IV & V)

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	TE5071	Computational Fluid Dynamics for Thermal Systems	PE	3	3	0	0	3
2.	TE5005	Fans, Blowers and Compressors	PE	3	3	0	0	3
3.	TE5006	Food Processing, Preservation and Transport	PE	3	3	0	0	3
4.	EY5091	Nuclear Engineering	PE	3	3	0	0	3
5.	IC5091	Automobile Engineering	PE	3	3	0	0	3
6.	TE5007	Air Conditioning Systems	PE	3	3	0	0	3
7.	TE5008	Energy Management in Thermal Systems	PE	3	3	0	0	3
8.	IC5251	Alternative Fuels for IC Engines	PE	3	3	0	0	3
9.	TE5072	Design of Heat Exchangers	PE	3	3	0	0	3

SEMESTER III (Elective VI & VII)

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	EY5092	Design and Analysis of Turbomachines	PE	3	3	0	0	3
2.	TE5073	Boundary Layer Theory and Turbulence	PE	3	3	0	0	3
3.	TE5074	Advanced Power Plant Engineering	PE	3	3	0	0	3
4.	EY5072	Steam Generator Technology	PE	3	3	0	0	3
5.	EY5073	Fluidized Bed Systems	PE	3	3	0	0	3
6.	TE5009	Advanced Thermal Storage Technologies	PE	3	3	0	0	3
7.	TE5010	Cogeneration and Waste Heat Recovery Systems	PE	3	3	0	0	3
8.	MF5072	Research Methodology	PE	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	TE5211	Technical Seminar – I	EEC	2	0	0	2	1
2.	TE5311	Technical Seminar – II	EEC	2	0	0	2	1
3.	TE5312	Project Work Phase I	EEC	12	0	0	12	6
4.	TE5411	Project Work Phase II	EEC	24	0	0	24	12

MA5153 ADVANCED NUMERICAL METHODS **L T P C**

(Common to Environmental Science and Technology, Chemical Engineering and PRPC) **3 2 0 4**

OBJECTIVES :

The course will develop numerical methods aided by technology to solve algebraic, transcendental and differential equations and to apply finite element methods for solving the boundary value problems in differential equations. The course will further develop problem solving skills and understanding of the application of various methods in solving engineering problems. This will also serve as a precursor for future research.

UNIT I ALGEBRAIC EQUATIONS 12+3

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, Eigen value problems : Power method and Given's method.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS 12+3

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+3

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+3

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+3

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 +15 = 75 PERIODS

OUTCOMES :

After completing this course, students should demonstrate competency in the following skills:

- Solve an algebraic or transcendental equation, linear system of equations and differential equations using an appropriate numerical method.
- Solving the initial boundary value problems and boundary value problems using finite difference and finite element methods.
- 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 :

1. Burden, R.L., and Faires, J.D., “Numerical Analysis – Theory and Applications”, 9^{th} Edition, Cengage Learning, New Delhi, 2016.
2. Gupta S.K., “Numerical Methods for Engineers”, New Age Publishers, 1995.
3. Jain M. K., Iyengar S. R., Kanchi M. B., Jain, “Computational Methods for Partial Differential Equations”, New Age Publishers ,1993.
4. Sastry, S.S., “Introductory Methods of Numerical Analysis”, 5^{th} Edition, PHI Learning, 2015.
5. Saumyen Guha and Rajesh Srivastava, “Numerical methods for Engineering and Science”, Oxford Higher Education, New Delhi, 2010.
6. Smith, G. D., "Numerical Solutions of Partial Differential Equations: Finite Difference Methods", Clarendon Press, 1985.

TE5151	ADVANCED HEAT TRANSFER	L T P C
		4 0 0 4

OBJECTIVES

- To develop the ability to use the heat transfer concepts for various applications like finned systems, turbulence flows, high speed flows.
- To analyse the thermal analysis and sizing of heat exchangers and to learn the heat transfer coefficient for compact heat exchanges**.**
- To achieve an understanding of the basic concepts of phase change processes 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 - 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 with shears edge on bank of tubes - boiling – pool and flow boiling - heat exchanger -Є – NTU approach and design procedure - compact heat exchangers.

UNIT IV NUMERICAL METHODS IN HEAT TRANSFER 12

Finite difference formulation of steady and transient heat conduction problems – discretization schemes – explicit - Crank Nicolson and fully implicit schemes - control volume formulation - steady one-dimensional convection and diffusion problems - calculation of the flow field – SIMPLER Algorithm

UNIT V MASS TRANSFER AND ENGINE HEAT TRANSFER CORRELATION 12

Mass transfer - vaporization of droplets - combined heat and mass transfers - heat transfer correlations in various applications like I.C. engines, compressors and turbines.

TOTAL : 60 PERIODS

OUTCOMES

- On successful completion of this course the student will be able to understand the fundamental concept of heat transfer mechanisms.
- Understand the application of numerical methods in heat transfer applications.
- Knowledge in combined heat and mass transfer mechanisms in engine applications.

REFERENCES

1. Ghoshdastidar. P.S., Heat Transfer, Oxford University Press, 2004.
2. Holman.J.P., Heat Transfer, Tata Mc Graw Hill, 2002.
3. Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons, 2002.
4. Nag.P.K., Heat Transfer, Tata McGraw-Hill, 2002.
5. Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw-Hill Co., 1985.
6. Yadav, R., Heat and Mass Transfer, Central Publishing House, 1995.
7. Yunus A.Cengal., Heat and Mass Transfer – A practical Approach, 3rd edition, Tata McGraw - Hill, 2007.

TE5101	**ADVANCED THERMODYNAMICS**	**L T P C**
		4 0 0 4

OBJECTIVES

- To develop the ability to use the thermodynamics concepts for various applications like availability analysis and thermodynamic relations.
- To analyse the real gas behaviour and chemical thermodynamics.
- To achieve an understanding of the basic concepts of Statistical and Irreversible thermodynamics.

UNIT I — AVAILABILITY ANALYSIS AND THERMODYNAMIC PROPERTY RELATIONS — 12

Reversible work - availability - irreversibility and second – law efficiency for a closed system and steady – state control volume. Availability analysis of simple cycles. Thermodynamic potentials. Maxwell relations. Generalized relations for changes in entropy - internal energy and enthalpy - generalized relations for C_p and C_V. Clausius Clayperon equation, Joule–Thomson coefficient. Bridgeman tables for thermodynamic relations.

UNIT II — REAL GAS BEHAVIOUR AND MULTI – COMPONENT SYSTEMS — 12

Different equations of state – 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 liquid - activity - equilibrium in multi phase systems - Gibbs phase rule for non – reactive components.

UNIT III — CHEMICAL THERMODYNAMICS AND EQUILIBRIUM — 12

Thermochemistry - First law analysis of reacting systems - Adiabatic flame temperature - entropy change of reacting systems - Second law analysis of reacting systems - Criterion for reaction equilibrium. Equilibrium constant for gaseous mixtures - evaluation of equilibrium composition.

UNIT IV STATISTICAL THERMODYNAMICS 12

Microstates and Macrostates - thermodynamic probability - degeneracy of energy levels - Maxwell – Boltzman, Fermi – Diarc and Bose – Einstein statistics - microscopic interpretation of heat and work, evaluation of entropy, partion function, calculation of the Macroscopic properties from partition functions.

UNIT V IRREVERSIBLE THERMODYNAMICS 12

Conjugate fluxes and forces - entropy production Onsager's reciprocity relations - thermo – electric phenomena, formulations.

TOTAL : 60 PERIODS

OUTCOME

- After the completion of the syllabus students able to understanding the application of thermodynamics in real gas behaviour, availability analysis, statistical and irreversible thermodynamics.

REFERENCES

1. Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Cons, 1988.
2. DeHotf R.T., Thermodynamics in Materials Science, McGraw – Hill Inc., 1993.
3. Holman J.P., Thermodynamics, Fourth Edition, McGraw – Hill Inc., 1988.
4. Kenneth WarkJt.m., Advanced Thermodynamics for Engineers, McGrew – Hill Inc., 1995.
5. Rao Y.V.C., Postulational and Statistical Thermodynamics, Allied Publisher Limited, New Delhi, 1999.
6. Sears F.W. and Salinger G.I., Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Third Edition, Narosa Publishing House, New Delhi, 1993.
7. Smith J.M. and Van Ness H.C., Introduction to Chemical Engineering Thermodynamics, Fourth Edition, McGraw – Hill Inc., 1987.
8. Sonntag R.E. and Van Wylen, G., Introduction to Thermodynamics, Classical and Statistical Themodynamics, Third Edition, John Wiley and Sons, 1991.

TE5102 ADVANCED FLUID MECHANICS L T P C
3 0 0 3

OBJECTIVES

- To understand the laws of fluid flow for ideal and viscous fluids.
- To represent the real solid shapes by suitable flow patterns and to analyze the same for aerodynamics performances.
- To understand the changes in properties in compressible flow and shock expansion.

UNIT I BASIC EQUATIONS OF FLOW 6

Three dimensional continuity equation - differential and integral forms – equations of motion momentum and energy and their engineering applications.

UNIT II POTENTIAL FLOW THEORY 12

Rotational and irrorational flows - circulation – vorticity - stream and potential functions for standard flows and combined flows – representation of solid bodies by flow patters. 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 for cambered 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

OUTCOME

- After the completion of the syllabus students able to familiarized about the ideal and viscous fluid flow, boundary layer concepts and changes in properties in compressible flow and shock expansion.

REFERENCES

1. Anderson J.D., Fundamentals of Aerodynamics, McGraw Hill, Boston, 2001.
2. Bansal R.K., Fluid Mechanics, Saurabh and Co., New Delhi, 1985.
3. Houghten E.L. and Carruthers N.B., Aerodynamics for Engineering Students, Arnold Publishers, 1993.
4. Kumar K.L., Engineering Fluid Mechanics, Eurasia Publishing House, New Delhi, 2002.
5. Munson B.R., Young D.F. and Okiisi, T.H., Fundamentals of Fluid Mechanics, John Wiley and Sons Inc., NewYork, 1990.
6. Schlichting H., Boundary layer theory, Mc Graw Hill Book Company, 1979
7. Shames, Mechanics of Fluids, Mc Graw Hill Book Company, 1962.
8. Streeter V.L., Wylie E.B. and Bedford K.W., Fluid Mechanics, WCB McGraw Hill, Boston, 1998.

TE5111	THERMAL ENGINEERING LABORATORY	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To conduct experiments on various Thermal Engineering devices to study the performance and its applications.

LIST OF EXPERIMENTS

1. Performance test on Spark Ignition engine and Compression Ignition using the alternate fuels.
2. Emission measurement in Spark Ignition and Compression Ignition Engines
3. Performance test on variable compression ratio petrol and diesel engines.
4. Performance study in a cooling tower.
5. Performance study in a refrigeration and heat pump systems.
6. Performance Study in a solar water heater.

7. Properties of fuel oils, biomass, biogas.
8. Direct and diffused solar radiation measurements.
9. Performance study on Boiler.
10. Performance study on parallel and counter flow Heat Exchangers.
11 Performance and characteristics studies on fan.
12 Study on Fuel Cell Systems.
13 Study on Thermal Storage Systems

TOTAL: 60 PERIODS

OUTCOMES: Upon completion of the course, the students will be able to:
- Know the various alternate fuels are available for IC engines
- Understand the thermodynamic relations for thermal engineering devices.
- Understand the working principle of different renewable energy sources.
- Measure the properties of different fuels

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 / Saybolt viscometer	- 1 No
11. Bomb calorimeter apparatus	- 1 No
12. Gas colorimeter	- 1 No
13. Cloud & Pour point apparatus	- 1 No
14. Non-IBR Boiler test rig	- 1 No
15. Parallel flow / Counter flow Heat exchanger test rig	- 1 No
16. Fan test rig	- 1 No

TE5201	INSTRUMENTATION FOR THERMAL ENGINEERING	L T P C
		3 0 0 3

OBJECTIVES
- To provide knowledge on various measuring instruments for thermal engineering.
- To understand the various steps involved in error analysis and uncertainty analysis.
- To provide knowledge on advance measurement techniques.

UNIT I MEASUREMENT CHARACTERISTICS 12

Instrument Classification, Characteristics of Instruments – Static and dynamic, experimental error analysis, Systematic and random errors, Statistical analysis, Uncertainty, Experimental planning and selection of measuring instruments, Reliability of instruments

UNIT II MICROPROCESSORS AND COMPUTERS IN MEASUREMENT 5

Data logging and acquisition – use of sensors for error reduction, elements of micro computer interfacing, intelligent instruments in use.

UNIT III MEASUREMENT OF PHYSICAL QUANTITIES 10

Measurement of thermo-physical properties, instruments for measuring temperature, pressure and flow, use of sensors for physical variables.

UNIT IV ADVANCE MEASUREMENT TECHNIQUES 8

Shadowgraph, Schlieren, Interferometer, Laser Doppler Anemometer, Hot wire Anemometer, heat flux sensors, Telemetry in measurement.

UNIT V MEASUREMENT ANALYSIS 10

Chemical thermal, magnetic and optical gas analyzers, measurement of smoke, Dust and moisture, gas chromatography, spectrometry, measurement of pH, Review of basic measurement techniques.

TOTAL: 45 PERIODS

OUTCOME

- On the completion of the syllabus students get knowledge about the thermal engineering measuring devices, utilization of computers in measurement applications and advanced measuring systems.

REFERENCES

1. Barnery, Intelligent Instrumentation, Prentice Hall of India, 1988.
2. Bolton.W, Industrial Control & Instrumentation, Universities Press, Second Edition, 2001.
3. Doblin E.O, Measurement System Application and Design, Second Edition, McGraw Hill, 1978..
4. Holman J.P., Experimental methods for engineers, McGraw-Hill, 2012.
5. John G Webster, The measurement, Instrumentation and sensors Handbook, CRC and IEE Press, 1999.
6. Morris A.S, Principles of Measurements and Instrumentation Prentice Hall of India, 1998.
7. Nakra, B.C., Choudhry K.K., Instrumentation, Measurements and Analysis Tata McGraw Hill, New Delhi, 2nd Edition 2003.
8. T.G.Beekwith R.D., Marangoni and J.H. Lienhard, Mechanical Measurements, Pearson Education, 2001.

TE5291	ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL	L T P C
		3 0 0 3

OBJECTIVES

- To impart knowledge on the atmosphere and its present condition, global warming and eco-legislations.
- To detail on the sources of air, water and noise pollution and possible solutions for mitigating their degradation.
- To elaborate on the technologies available for generating energy from waste.

UNIT I INTRODUCTION 9

Global atmospheric change – green house effect – Ozone depletion - natural cycles - mass and energy transfer – material balance – environmental chemistry and biology – impacts – environmental. Legislations.

UNIT II AIR POLLUTION 9

Pollutants - sources and effect – air pollution meteorology – atmospheric dispersion – indoor air quality - control methods and equipments - issues in air pollution control – air sampling and measurement.

UNIT III WATER POLLUTION 9

Water resources - water pollutants - characteristics – quality - water treatment systems – waste water treatment - treatment, utilization and disposal of sludge - monitoring compliance with standards.

UNIT IV WASTE MANAGEMENT 9

Sources and Classification – Solid waste – Hazardous waste - Characteristics – Collection and Transportation - Disposal – Processing and Energy Recovery – Waste minimization

UNIT V OTHER TYPES OF POLLUTION FROM INDUSTRIES 9

Noise pollution and its impact - oil pollution - pesticides - instrumentation for pollution control - water pollution from tanneries and other industries and their control – environment impact assessment for various projects – case studies. Radiation pollution: types, sources, effects, control of radiation pollution.

TOTAL: 45 PERIODS

OUTCOME

- On successful Completion of this course the student will be understand Emission standards, waste management power generation and pollution from various industries.

REFERENCES

1. Arcadio P Sincero and G.A. Sincero, Environmental Engineering – A Design Apporach, Prentice Hall of India Pvt Ltd, New Delhi, 2002.
2. Bishop P., Pollution Prevention: Fundamentals and Practice, McGraw-Hill International Edition, McGraw-Hill book Co, Singapore, 2000.
3. G.Masters, Introduction to Environmental Engineering and Science Prentice Hall of India Pvt Ltd, New Delhi, 2003.
4. Gilbert M. Masters, Introduction to Environmental Engineering and Science, 2nd Edition, Prentice Hall, 1998.
5. H.Ludwig, W.Evans, Manual of Environmental Technology in Developing Countries, International Book Company, Absecon Highlands N.J. (1991).
6. H.S.Peavy, D.R.Rowe and G.Tchobanoglous, Environmental Engineering McGraw- Hill Book Company, NewYork, (1985).
7. Rao C.S., Environmental Pollution Control Engineering, 2nd Edition, New Age International Publishers, 2006.

TE5202	FUELS AND COMBUSTION	L T P C
		3 0 0 3

OBJECTIVES

- To understand the types of fuels.
- To understand the principles of combustion and combustion equipments.
- To understand the thermodynamic process behind the combustion.

UNIT I CHARACTERIZATION 8

Fuels - Types and Characteristics of Fuels - Determination of Properties of Fuels - Fuels Analysis - Proximate and Ultimate Analysis - Moisture Determination - Calorific Value - Gross & Net Calorific Values - Calorimetry - DuLong's Formula for CV Estimation - Flue gas Analysis - Orsat Apparatus - Fuel & Ash Storage & Handling - Spontaneous Ignition Temperatures.

UNIT II SOLID OF LIQUID FUELS 10

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

UNIT III GASEOUS FUEL 7

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 IV COMBUSTION : STOICHIOMETRY & KINETICS 12

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 V COMBUSTION EQUIPMENTS 8

Coal Burning Equipments – 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.

TOTAL: 45 PERIODS

OUTCOME

- On successful Completion of this course the student will be understand combustion, Types of Fuels, Combustion Equipments

REFERENCES

1. B.I. Bhatt and S.M. Vora, Stoichiometry, 2nd Edition, Tata Mcgraw Hill, 1984.
2. Blokh A.G., Heat Transfer in Steam Boiler Furnace, Hemisphere Publishing Corpn, 1988.
3. Civil Davies, Calculations in Furnace Technology, Pergamon Press, Oxford, 1966.
4. Holman J.P., Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1988.
5. Samir Sarkar, Fuels & Combustion, 2nd Edition, Orient Longman, 1990.
6. Sharma SP., Mohan Chander, Fuels & Combustion, Tata Mcgraw Hill, 1984.
7. Yunus A. Cengel and Michael A. Boles, Thermodynamics, McGraw-Hill Inc., 2006.

TE5261 **THERMAL SYSTEMS SIMULATION LABORATORY**

L	T	P	C
0	0	4	2

OBJECTIVES:

- To learn the modeling and simulation analysis of various thermal engineering application using analysis softwares.

LIST OF EXPERIMENTS

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

TOTAL: 60 PERIODS

OUTCOMES:

- On successful completion of this course the student will have knowledge in various heat transfer simulation study on different thermal engineering applications by using analysis softwares.

DYNAMIC LINKING OF MAT LAB AND REF PROP SOFTWARE
SIMPLE CFD PROBLEMS FOR PRACTICE

NOTE: The above exercises are only guidelines to maintain the standard for teaching and conduct of examination.

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 students in a batch must be provided with a terminal
3. Hardwares are compatible with the requirement of the above software.

TE5211 **TECHNICAL SEMINAR - I** **L T P C 0 0 2 1**

OBJECTIVES:

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

GUIDELINES

- The student is expected to present a seminar in one of the current topics in the field of Thermal Engineering related issues / technology.
- The seminar shall be of 30 minutes duration and give presentation to the Seminar Assessment Committee (SAC).
- A faculty guide is to be allotted and he / she will guide and monitor the progress of the student and maintain attendance also.
- In a session of three periods per week, 4 students are expected to present the seminar.
- Students are encouraged to use various teaching aids such as power point presentation and demonstrative models.
- 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 programmes of Anna University.

TOTAL: 30 PERIODS

OUTCOMES:

At the end of the course, the student will be able to

- Identify and choose appropriate topic of relevance.
- Assimilate literature on technical articles of specified topic and develop comprehension.
- Prepare technical report.
- Design, develop and deliver presentation on specified technical topic

TE5301 **DESIGN AND OPTIMIZATION OF THERMAL ENERGY SYSTEMS** **L T P C 3 0 0 3**

OBJECTIVES

- To learn basic principles underlying piping, pumping, heat exchangers; modeling and optimization in design of thermal systems.
- To develop representational modes of real processes and systems.
- To optimization concerning design of thermal systems.

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 lgebraic 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

OUTCOME

- On successful Completion of this course the student will be understand modeling and optimization of Thermal systems.

REFERENCES

1. B.K.Hodge, Analysis and Design of Thermal Systems, Prentice Hall Inc., 1990.
2. Bejan A., George Tsatsaronis , Michael J. Moran , Thermal Design and Optimization, Wiley , 1996.
3. D.J. Wide, Globally Optimal Design, Wiley- Interscience, 1978.
4. Kapur J. N., Mathematical Modelling , Wiley Eastern Ltd , New York , 1989.
5. Rao S. S., Engineering Optimization Theory and Practice, New Age Publishers, 2000.
6. Stoecker W. F., Design of Thermal Systems, McGraw Hill Edition, 1989.
7. YogeshJaluria , Design and Optimization of Thermal Systems , CRC Press , 2007.

TE5311	TECHNICAL SEMINAR - II	L	T	P	C
		0	0	2	1

OBJECTIVES:

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

GUIDELINES

- The student is expected to present a seminar in one of the current topics in the field of Thermal Engineering related issues / technology.
- The seminar shall be of 30 minutes duration and give presentation to the Seminar Assessment Committee (SAC).
- 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.

- A faculty guide is to be allotted and he / she will guide and monitor the progress of the student and maintain attendance also.
- Each student has to submit a seminar report in the prescribed format given by the Institution.
- In a session of three periods per week, 4 students are expected to present the seminar.
- Students are encouraged to use various teaching aids such as power point presentation and demonstrative models.
- 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 programmes of Anna University.

TOTAL: 30 PERIODS

OUTCOMES:

At the end of the course, the student will be able to

- Develop the capacity to observe intelligently and propose and defend opinions and ideas with tact and conviction.
- Develop skills regarding professional communication and technical report writing.
- Learn the methodology of publishing technical papers.

TE5312	PROJECT WORK PHASE – I	L	T	P	C
		0	0	12	6

OBJECTIVES:

- To improve the skills in reading technical magazines, conference proceedings and journals.
- To develop the skill of identifying research problems/projects in the field of Thermal Engineering.
- 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

- Each student has to identify the topic of project related to the field of Thermal Engineering.
- 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
- The topic has to be approved by a review committee constituted by the department.
- The work has to be presented periodically in front of the review committee.
- The preparation of report consisting of a detailed problem statement and a literature review.
- The preliminary results (if available) of the problem may also be discussed in the report.
- 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 programmes of Anna University.

TOTAL: 90 PERIODS

OUTCOMES:

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.

TE5411	PROJECT WORK PHASE – II	L T P C 0 0 24 12

OBJECTIVES:

- To improve the skills in publishing technical papers in conference proceedings and journals.
- To produce factual results of their applied research idea in the Thermal engineering, from phase – I.

GUIDELINES

- Each student has to complete project (phase II) under the guidance of a faculty member, as specified in Phase I.
- 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
- The topic has to be approved by a review committee constituted by the department.
- The work has to be presented periodically in front of the review committee.
- 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.
- The report must bring out the conclusions of the work and future scope for the study.
- 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 programmes of Anna University.

TOTAL: 180 PERIODS

OUTCOMES:

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.

TE5001	AIRCRAFT AND JET PROPULSION	L T P C 3 0 0 3

OBJECTIVES

To gain insight on the working principle of rocket engines, different feed systems, propellants and their properties and dynamics of rockets

UNIT I GAS DYNAMICS 8

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 10

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

OUTCOME

- On successful completion of this course the student will be able to understand the working of different types of Aircraft and Jet propulsion systems and their performance characteristics.

REFERENCES

1. Bonney E.A., Zucrow N.J,. Principles of Guided Missile Design, Van Nostranc Co., 1956.
2. Khajuria P.R. and Dubey S.P., Gas Turbines and Propulsive Systems, Dhanpat Rai Publications, 2003.
3. Mattingly J.D., Elements of Gas turbine Propulsion, McGraw Hill, 1st Edition, 1997.
4. Philip G. Hill and Carl R. Peterson, Mechanics and Thermodynamics of Propulsion, Second Edition, Addition – Wesley Publishing Company, New York, 2009.
5. S.M.Yahya, Fundamentals of Compressible Flow, Third edition, New Age International Pvt Ltd, 2003.
6. Zucrow N.J., Principles of Jet Propulsion and Gas Turbines, John Wiley and Sons, New York, 1970.
7. Zucrow N.J., Aircraft and Missile Propulsion, Vol. I and Vol. II, John Wiley and Sons Inc, New York, 1975.

EY5071 HYDROGEN AND FUEL CELL TECHNOLOGIES **L T P C**
3 0 0 3

OBJECTIVES

- To study in detail on the hydrogen production methodologies, possible applications and various storage options.
- To understand the working principle of a typical fuel cell, its types and to elaborate on its thermodynamics and kinetics.
- To study the cost effectiveness and eco-friendliness of Fuel Cells.

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

OUTCOME

After completion of the syllabus student able to :
Know the working of various fuel cells, their relative advantages / disadvantages and hydrogen generation/storage technologies.

REFERENCES

1. Viswanathan B. and Aulice Scibioh.M, Fuel Cells – Principles and Applications, Universities Press, 2006.
2. Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma, 2005.
3. Bent Sorensen (Sørensen), Hydrogen and Fuel Cells: Emerging Technologies and Applications, Elsevier, UK 2005.
4. Kordesch K. and G.Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany 1996.
5. Hart A.B. and G.J.Womack, Fuel Cells: Theory and Application, Prentice Hall, New York Ltd., London 1989.
6. Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA 2002.
7. Barclay F.J., Fuel Cells, Engines and Hydrogen, Wiley, 2009.

EY5152 **ENERGY RESOURCES** **L T P C**
3 0 0 3

OBJECTIVES

- To explain concept of various forms of Non-renewable and renewable energy.
- To outline division aspects and utilization of renewable energy sources for both domestics and industrial applications.
- To study the environmental and cost economics of using renewable energy sources compared to fossil fuels.

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

OUTCOMES

After completion of the syllabus student able to :

- Understand the commercial energy and renewable energy sources.
- Know the working principle of various energy systems.

REFERENCES

1. Sukhatme S.P., "Solar Energy", Tata McGraw Hill, 1984.
2. Twidell J.W. and Weir A., "Renewable Energy Sources", EFN Spon Ltd., 1986.
3. Kishore V.V.N., "Renewable Energy Engineering and Technology", Teri Press, New Delhi, 2012

4. Peter Gevorkian, “Sustainable Energy Systems Engineering,” McGraw Hill,2007.
5. Kreith F. and Kreider J.F., “Principles of Solar Engineering”, McGraw-Hill, 1978.
6. Godfrey Boyle, “Renewable Energy Power for a Sustainable Future”, Oxford University Press, U.K, 1996.
7. Veziroglu T.N., Alternative Energy Sources”, Vol 5 and 6, McGraw-Hill, 1990.
8. Anthony San Pietro, “Biochemical and Photosynthetic aspects of Energy Production”, Academic Press, 1980.
9. Bridgurater A.V., “Thermochemical processing of Biomass”, Academic Press, 1981.
10. Bent Sorensen , “Renewable Energy”, Elsevier, Academic Press, 2011.

TE5002 ADVANCED INTERNAL COMBUSTION ENGINES L T P C
3 0 0 3

OBJECTIVES

- To gain insight on the working principle of spark ignition engines and compression ignition engines.
- To study the pollutant formation and its control in IC engines.
- To study the recent technologies adopted in IC engine applications.

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

OUTCOME

On successful completion of this course the student will be able to understand the working principle of IC engines, source of pollution formation and its control and recent trends in IC engines.

REFERENCES
1. Duffy Smith, Auto fuel Systems, The Good Heart Willox Company, Inc., 1989.
2. Heywood, J.B., Internal Combustion Engine Fundamentals, McGraw-Hill, 1988.
3. K.K. Ramalingam, Internal Combustion Engine fundamentals, Scitech Publications, 2002.
4. Kirpal Singh, Automobile Engineering Vol - I, Standard Publishers, Delhi 2013.
5. R.B. Mathur and R.P.Sharma, Internal Combustion Engines, Dhanapat Rai Publications,1993.
6. V. Ganesan, Internal Combustion Engines, II Edition, Tata McGraw-Hill Education, 2002.
7. Willard W. Pulkrabek, Engineering Fundamentals of the Internal Combustion Engine, Prentice Hall, 1997.

TE5003 CRYOGENIC ENGINEERING L T P C
3 0 0 3

OBJECTIVES
- To give introductory knowledge of cryogenic Engineering.
- To impart knowledge in liquefaction, separation of cryogenics gases and working of cryocoolers.
- To embark on a research career in Cryogenic Engineering.

UNIT I INTRODUCTION 8
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 10
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 8
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 10
Cryogenic Dewar, Cryogenic Transfer Lines. Insulations used in Cryogenic Systems, Instrumentation to measure Flow, Level and Temperature.

TOTAL = 45 PERIODS

OUTCOME
On successful completion of this course the student will be able to understand Concepts of cryogenic, cryogenic refrigeration and handling of the cryogens.

REFERENCES
1. Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering,PlenumPress,New York, 1989.
2. Randall F. Barron, Cryogenic Systems, McGraw-Hill, 1985.

3. Scott R.B., Cryogenic Engineering, Van Nostrand and Co., 1962.
4. Herald Weinstock, Cryogenic Technology, Boston Technical Publishers, inc., 1969.
5. Robert W. Vance, Cryogenic Technology, John wiley & Sons, Inc., New York, London.
6. G.Venkatarathnam, Cryogenic Mixed Refrigerant Processes, Springer Publication, 2010.
7. J.G.Weisend,Hand Book of Cryogenic Engineering —II, Taylor and Francis, 1998.

TE5004 REFRIGERATION SYSTEMS L T P C
3 0 0 3

OBJECTIVES

- To study the cycle analysis pertaining to Refrigeration systems.
- To study the performance of system components and their balancing in cycles.
- To study the significance of Refrigerants and their impact on the environment.

UNIT I INTRODUCTION AND REFRIGERANTS 6

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 12

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

OUTCOME

- The student will be able to understand different refrigeration systems and do the design of the same for a particular applications.

REFERENCES
1. Arora C.P., Refrigeration and Air conditioning, McGraw Hill, 3rd Ed., 2010.
2. Dossat R.J., Principles of refrigeration, John Wiley, S.I. Version, 2001.
3. Jordan and Priester, Refrigeration and Air conditioning 1985.
4. Kuehn T.H., Ramsey J.W. and Threlkeld J.L., Thermal Environmental Engineering, 3rd Edition, Prentice Hall, 1998.
5. Langley Billy C., 'Solid state electronic controls for HVACR, Prentice-Hall 1986.
6. Rex Milter, Mark R.Miller., Air conditioning and Refrigeration, McGraw Hill, 2006.
7. Stoecker W.F., Refrigeration and Air conditioning, McGraw-Hill Book Company, 1989.

TE5071 COMPUTATIONAL FLUID DYNAMICS FOR THERMAL SYSTEMS **L T P C**
3 0 0 3

OBJECTIVES:
- 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 discretisation methods and solving methodologies and to create confidence to solve complex problems in the field of heat transfer and fluid dynamics.
- To develop finite volume discretised forms of the CFD equations.
- To formulate explicit & implicit algorithms for solving the Euler Equations & Navier Stokes Equations.

UNIT I GOVERNING DIFFERENTIAL EQUATIONS AND DISCRETISATION TECHNIQUES **8**
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 – Discretisation 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 **10**
Steady one-dimensional diffusion, Two and three dimensional steady state diffusion problems, Discretisation 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**
Discretisation of incompressible flow equations – Pressure based algorithms, SIMPLE, SIMPLER & PISO algorithms

UNIT V TURBULENCE AND ITS MODELING **9**
Description of turbulent flow, free turbulent flows, flat plate boundary layer and pipe flow. Algebraic Models, One equation model, $k - \varepsilon$ & $k - \omega$ models Standard and High and Low Reynolds number models.

TOTAL: 45 PERIODS

OUTCOME:

- On successful completion of this course the student will be able to apply concept of CFD to analyse flow in thermal systems.

REFERENCES

1. Anderson, D.A., Tannehill, J.I., and Pletcher, R.H., "Computational fluid Mechanics and Heat Transfer " Hemisphere Publishing Corporation, New York, USA, 2012.
2. Bose, T.K., "Numerical Fluid Dynamics" Narosa Publishing House, 1997.
3. Fletcher, C.A.J. "Computational Techniques for Fluid Dynamics 1" Fundamental and General Techniques, Springer – Verlag, 1991.
4. Fletcher, C.A.J. "Computational Techniques for fluid Dynamics 2" Specific Techniques for Different Flow Categories, Springer – Verlag, 1988.
5. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 2003.
6. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 2003.
7. Subas and V.Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation, 1980.
8. Taylor, C and Hughes, J.B. "Finite Element Programming of the Navier-Stokes Equation", Pineridge Press Limited, U.K., 1981.
9. Versteeg and Malalasekera, N, "An Introduction to computational Fluid Dynamics The Finite volume Method," Pearson Education, Ltd., 2007.

TE5005 FANS, BLOWERS AND COMPRESSORS

L	T	P	C
3	0	0	3

OBJECTIVES

- To develop knowledge about turbo machinery and its working principles.
- To formulate analysis of compressors, centrifugal blowers and testing of fans.

UNIT I PRINCIPLES OF TURBO MACHINERY 10

Introduction to turbo machines - Transfer of energy to fluids - Performance characteristics - fan laws - Dimensionless parameters - Specific speed - selection of centrifugal, axial, and mixed flow machines.

UNIT II ANALYSIS OF CENTRIFUGAL BLOWERS AND FANS 10

Centrifugal Blowers: Theoretical characteristic curves, Eulers characteristics and Eulers velocity triangles, losses and hydraulic efficiency, flow through impeller inlet volute, diffusers, leakage disc friction mechanical losses multivane impellers of impulse type, cross flow fans.

UNIT III ANALYSIS OF COMPRESSOR 14

Rotor design airfoil theory, vortex theory, cascade effects, degree of reaction, blade twist stage design, surge and stall, stator and casing, mixed flow impellers.

UNIT IV TESTING AND CONTROL OF FANS 5

Fan testing, noise control, materials and components blower regulation, speed control, throttling, control at discharge and inlet.

UNIT V APPLICATIONS OF BLOWERS 6

Applications of blowers, induced and forced draft fans for air conditioning plants, cooling towers, ventilation systems, booster systems.

TOTAL = 45 PERIODS

OUTCOME

- After completion of this course students get knowledge about Turbo machinery and its working principles, analysis of compressors and centrifugal blowers.

REFERENCES

1. S.M. Yahya, Turbines,Compressors and Fans , Tata McGraw-Hill Education, 1987.
2. Stepanoff A.J., Turbo blowers, John Wiley & Sons, 1970.
3. Brunoeck, Fans, Pergamon Press, 1973.
4. Austin H. Church, Centrifugal pumps and blowers, John Wiley and Sons, 1980.
5. Dixon, Fluid Mechanics, Thermodynamics of turbomachinery, Pergamon Press, 1984.
6. Dixon, Worked examples in turbomachinery, Pergamon Press, 1984.
7. Earl Logan Jr., Ramendra Roy,Handbook of Turbomachinery, Second Edition , Marcel Dekker, Inc, New York, 2003.

TE5006 FOOD PROCESSING, PRESERVATION AND TRANSPORT **L T P C**
3 0 0 3

OBJECTIVES

To develop knowledge about processing, preserving and storing of food products.

UNIT I INTRODUCTION 9

Microbiology of Food Products, Mechanism of food spoilage critical microbial growth requirements, Design for control of micro organisms, The role of HACCP, Sanitation, Regulation and standards.

UNIT II PROCESSING & PRESERVATION 12

Thermodynamic properties and Transfer properties, Water content, Initial freezing temperature, Ice fraction, Transpiration of fresh fruits & vegetables, Food processing techniques for Dairy products, Poultry, Meat, Fruits & Vegetables.

UNIT III FREEZING & DRYING 12

Precooling, Freeze drying principles, Cold storage & freezers, Freezing drying limitations, Irradiation techniques, Cryofreezing, Numerical and analytical methods in estimating Freezing, Thawing times, Energy conservation in food industry.

UNIT IV COLD STORAGE DESIGN & INSTRUMENTATION 7

Initial building consideration, Building design, Specialized storage facility, Construction methods, Refrigeration systems, Insulation techniques, Control & instrumentation, Fire protection, Inspection & maintenance

UNIT V PACKAGING AND TRANSPORT 5

Refrigerated transportation, Refrigerated containers & trucks, Design features, Piping & Role of cryogenics in freezing & transport. Basic packaging materials, types of packaging, Packaging design. Packaging for different types of foods.

TOTAL = 45 PERIODS

OUTCOMES

- The student will be able to understand methods of food processing and preservation of foods.
- The student will be able to understand packing and transporting food products.

REFERENCES
1. Alan Rodes, Principles of Industrial Microbiology, Pregmon International Pub., 1989.
2. Ibraham Dincer, Heat Transfer in Food Cooling Applications, Tailor & Francis Pub., 1997.
3. Stanley E. Charm, Fundamentals of Food Engineering, III Edition, AVI Pub. Company Inc. 1989.
4. Clive V.I. Dellino, Cold and Chilled Storage Technology, Van Nostrand Reinhold Pub. New York, 1991.
5. Arora C.P., Refrigeration and Air conditioning II Edition, McGraw-Hill, Pub., 2000.
6. ASHRAE Handbook, Refrigeration, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. Atlanta, 1988.
7. Fellows P.J., Food processing Technology: Principle and Practices, Wood Head Publishing, 1997.

EY5091 NUCLEAR ENGINEERING L T P C
3 0 0 3

OBJECTIVES
- To describe fundamental study of nuclear reactions
- To learn nuclear fuels cycles, characteristics. Fundamental principles governing nuclear fission chain reaction and fusion
- To discuss future nuclear reactor systems with respect to generation of energy, fuel breeding, incineration of nuclear material and safety.

UNIT I NUCLEAR REACTIONS 9
Mechanism of nuclear fission - nuclides - radioactivity – decay chains - neutron reactions - the fission process - reactors - types of fast breeding reactor - design and construction of nuclear reactors - heat transfer techniques in nuclear reactors - reactor shielding.

UNIT II REACTOR MATERIALS 9
Nuclear Fuel Cycles - characteristics of nuclear fuels - Uranium - production and purification of Uranium - conversion to UF4 and UF6 - other fuels like Zirconium, Thorium – Berylium.

UNIT III REPROCESSING 9
Nuclear fuel cycles - spent fuel characteristics - role of solvent extraction in reprocessing - solvent extraction equipment.

UNIT IV SEPARATION OF REACTOR PRODUCTS 9
Processes to be considered - 'Fuel Element' dissolution - precipitation process – ion exchange - redox - purex - TTA - chelation -U235 - Hexone - TBP and thorax Processes - oxidative slaging and electro - refinng - Isotopes - principles of Isotope separation.

UNIT V WASTE DISPOSAL AND RADIATION PROTECTION 9
Types of nuclear wastes - safety control and pollution control and abatement - international convention on safety aspects - radiation hazards prevention.

TOTAL = 45 PERIODS

OUTCOME
- Understanding fundamentals of nuclear reactors and reactions.
- Knowledge in nuclear fission chain reaction and fusion.
- Awareness about reprocessing of spent fuel and waste disposal.

REFERENCES

1. Cacuci, Dan Gabriel, Nuclear Engineering Fundamentals, Springer, 2010.
2. Collier J.G. and G.F. Hewitt, Introduction to Nuclear Power , Hemisphere Publishing, New York, 1987.
3. Glasstone S. and Sesonske A., Nuclear Reactor Engineering, 3rd Edition, Von Nostrand, 1984.
4. J. Kenneth Shultis, Richard E. Faw, Fundamentals of Nuclear Science and Engineering, CRC Press, 2008.
5. Kenneth D. Kok, Nuclear Engineering, CRC Press, 2009.
6. Lalter A.E. and Reynolds A.B., Fast Breeder Reactor, Pergamon Press, 1981.
7. Lamarsh J.R., Introduction to Nuclear Reactor Theory, Wesley, 1996.
8. Tatjana Tevremovic, Nuclear Principles in Engineering, Springer, 2008
9. Winterton R.H.S., Thermal Design of Nuclear Reactors, Pergamon Press, 1981.

IC5091	AUTOMOBILE ENGINEERING	L T P C
		3 0 0 3

OBJECTIVES

- To understand the vehicle structure, engine and its auxiliary systems.
- To develop the knowledge about vehicle transmission system.
- To get knowledge about alternative sources for Vehicles.

UNIT I VEHICLE STRUCTURE AND ENGINES 10

Layout, Vehicle construction, Chassis, Frame and Body, Engine - types, construction, operation, performance, Air pollution and Pollution standards.

UNIT II ENGINE AUXILIARY SYSTEMS 10

Carburetors, Electronic Fuel Injection Systems – Monopoint, Multipoint and Direct Injection Systems, Electrical Systems – Battery, Generator, Starting Motor, and Ignition (Battery and Electronic Types).

UNIT III TRANSMISSION SYSTEMS 10

Clutch - Types and Construction, Fluid Flywheel and Torque Converter, Gear Boxes, Manual and Automatic - Overdrives – Propeller Shaft - Differential and Rear Axle.

UNIT IV RUNNING SYSTEMS 8

Steering Geometry and Types, Types of front axle, Suspension systems, Braking systems, Wheel and Tyres.

UNIT V ALTERNATIVE SOURCES FOR AUTOMOBILES 7

Electric vehicles and Fuel cells – Types, construction, principle of operation and characteristics.

TOTAL = 45 PERIODS

OUTCOME

- Students able to get knowledge about vehicle structure, auxiliary systems, transmission and recent alternative sources for vehicles.

REFERENCES
1. Duffy Smith, Auto Fuel Systems, The Good Heat Willcox Company Inc., 1987.
2. Kirpal Singh, Automobile Engineering Vol - I, Standard Publishers, Delhi 2013.
3. Kirpal Singh, Automobile Engineering Vol - II, Standard Publishers, Delhi 2014.
4. N.K.Giri, Automobile Mechanics, Khanna Publishers, 2008.
5. Newton and Steeds, Motor Vehicles, ELBS, 1985.
6. R.B. Gupta, Automobile Engineering, Satya Prakashan, 1993.
7. R.K.Rajput, A Text Book of Automobile Engg, Laxmi Publishers, 2015.

TE5007 AIR CONDITIONING SYSTEMS **L T P C**
3 0 0 3

OBJECTIVES
- To learn the psychometric concepts underlying Air conditioning process.
- To learn the design features and load estimation principles of specific Air conditioning system.
- To learn about the critical auxiliary systems such as air distribution circuits, water distribution circuits etc.

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 10
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 8
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 10
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 8
Automotive System layout and Components- Commonly used Refrigerants- Safety devices – Climate control – Fuel efficiency aspects.

TOTAL = 45 PERIODS

OUTCOME
On successful completion of this course the student will be able to understand conceptually the design of a HVAC system.

REFERENCES

1. ALI VEDAVARZ, SUNIL KUMAR, Mohammed Iqbal, Hussain Handbook of Heating, Ventilation and Air conditioning for Design Implementation, Industrial press Inc, 2007.
2. Arora C.P., Refrigeration and Air Conditioning, Tata McGraw Hill Pub. Company, 2010.
3. ASHRAE , Fundamentals and equipment , 4 volumes-ASHRAE Inc. 2005.
4. Carrier Air Conditioning Co., Handbook of Air Conditioning Systems design, McGraw Hill, 1985.
5. Jones, Air Conditioning Engineering, Edward Amold pub. 2001.
6. Kuehn T.H., Ramsey, J.W. and Threlkeld, J.L., Thermal Environmental Engineering, 3rd Edition, Prentice Hall, 1998
7. Langley, Billy C. ,Refrigeration and Air Conditioning Ed. 3, Engie wood Cliffs (N.J) Prentice Hall 1986.

TE5008 ENERGY MANAGEMENT IN THERMAL SYSTEMS **L T P C**
3 0 0 3

OBJECTIVES

- To learn the present energy scenario and the need for energy conservation.
- To learn the instruments suitable for energy auditing.
- To study the various measures for energy conservation and financial implications for various thermal utilities.

UNIT I INTRODUCTION 10

Energy Scenario – world and India. Energy Resources Availability in India. Energy consumption pattern. Energy conservation potential in various Industries and commercial establishments. Energy intensive industries – an overview. Energy conservation and energy efficiency – needs and advantages. Energy auditing – types, methodologies, barriers. Role of energy manager – Energy audit questionnaire – energy Conservation Act 2003.

UNIT II INSTRUMENTS FOR ENERGY AUDITING 8

Instrument characteristics – sensitivity, readability, accuracy, precision, hystersis. Error and calibration. Measurement of flow, velocity, pressure, temperature, speed, Lux, power and humidity. Analysis of stack, water quality, power and fuel quality.

UNIT III THERMAL UTILITIES: OPERATION AND ENERGY CONSERVARTION 10

(i) Boilers (ii) Thermic Fluid Heaters (iii) Furnaces
(iv) Waste Heat Recovery Systems (v) Thermal Storage.

UNIT IV THERMAL ENERGY TRANSMISSION / PROTECTION SYSTEMS 7

Steam traps – refractories – optimum insulation thickness – insulation – piping design.

UNIT V FINANCIAL MANAGEMENT 10

Investment – need, appraisal and criteria, financial analysis techniques – break even analysis – simple payback period, return on investment, net present value, internal rate of return, cash flows, DSCR, financing options, ESCO concept.

TOTAL = 45 PERIODS

OUTCOME

- After completion of the syllabus students able to audit the power plants, the various measures for energy conservation and financial implications for various thermal utilities.

IC5251 **ALTERNATIVE FUELS FOR IC ENGINES** **L T P C**
3 0 0 3

AIM:

To impart knowledge on various alternative fuels for I.C. Engines

OBJECTIVES:

- Gain a working understanding of the engineering issues and perspectives affecting fuel and engine development
- Examine future trends and development, including hydrogen as an internal combustion engine fuel.
- Explore further fuel specification and performance requirements for advanced combustion systems.

UNIT I INTRODUCTION 12

Availability, Suitability, Properties, Merits and Demerits of Potential Alternative Fuels – Ethanol, Methanol, Diethyl ether, Dimethyl ether, Hydrogen, Liquefied Petroleum Gas, Natural Gas, Bio-gas and Bio-diesel.

UNIT II LIQUID FUELS FOR S.I. ENGINES 9

Requirements, Utilisation techniques – Blends, Neat form, Reformed Fuels, Storage and Safety, Performance and Emission Characteristics

UNIT III LIQUID FUELS FOR C.I. ENGINES 8

Requirements, Utilisation techniques - Blends, Neat fuels, Reformed fuels, Emulsions, Dual fuelling, Ignition accelerators and Additives, Performance and emission characteristics.

UNIT IV GASEOUS FUELS FOR S.I. ENGINES 8

Hydrogen, Compressed Natural gas, Liquefied Petroleum gas, and Bio gas in SI engines – Safety Precautions – Engine performance and emissions.

UNIT V GASEOUS FUELS FOR C.I. ENGINES 8

Hydrogen, Biogas, Liquefied Petroleum gas, Compressed Natural gas in CI engines. Dual fuelling, Performance and emission characteristics.

TOTAL: 45 PERIODS

OUTCOME:

- On successful completion of this course the student will be able to understand the various alternative fuel options available for conventional fuels and their performance and emission characteristics.

REFERENCES

1. Alcohols as motor fuels progress in technology - Series No.19 - SAE Publication USE, 1980.
2. Keith Owen and Trevor Eoley, Automotive Fuels Handbook, SAE Publications,1990.
3. Maheswar Dayal, Energy today a tomorrow - I and B, Horishr India, 1982.
4. Osamu Hirao and Richard K. Pefley, Present and Future Automotive Fuels, John Wiley and Sons,1988.
5. Richard L.Bechfold – Alternative Fuels Guide Book - SAE International Warrendale, 1997.
6. Roger F. Haycock and John E Hillier., Automotive Lubricants Reference Book, Second Edition, SAE International Publications, 2004.
7. Sharma SP, Mohan Chander, Fuels & Combustion, Tata Mcgraw Hill, 1984.

TE5072 DESIGN OF HEAT EXCHANGERS

	L	T	P	C
	3	0	0	3

OBJECTIVES

- To learn the thermal and stress analysis on various parts of the heat exchangers.
- To analyze the sizing and rating of the heat exchangers for various applications.

UNIT I FUNDAMENTALS OF HEAT EXCHANGER 9

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

UNIT II FLOW AND STRESS ANALYSIS 9

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 9

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 9

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

UNIT V CONDENSERS AND COOLING TOWERS 9

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

TOTAL = 45 PERIODS

OUTCOME

After completion of the syllabus student able to:

- Design the heat exchanger based on the information provided for a particular application and do the cost economic analysis

REFERENCES

1. Arthur P. Frass, Heat Exchanger Design, John Wiley & Sons, 1988.
2. Hewitt G.F., Shires G.L. and Bott T.R., Process Heat Transfer, CRC Press, 1994.
3. Nicholas Cheremisioff, Cooling Tower, Ann Arbor Science Pub 1981.
4. SadikKakac and Hongtan Liu, Heat Exchangers Selection, Rating and Thermal Design, CRC Press, 2002.
5. Sekulic D.P., Fundamentals of Heat Exchanger Design, John Wiley, 2003 .
6. TaborekT., Hewitt.G.F. and Afgan N., Heat Exchangers, Theory and Practice, McGraw-Hill Book Co. 1980.
7. Walker, Industrial Heat Exchangers - A Basic Guide, McGraw Hill Book Co., 1980

EY5092 DESIGN AND ANALYSIS OF TURBOMACHINES **L T P C**
3 0 0 3

OBJECTIVES:

- To design and analyse the performance of Turbo machines for engineering applications
- To understand the energy transfer process in Turbomachines and governing equations of various forms.
- To understand the structural and functional aspects of major components of Turbomachines.
- To design various Turbomachines for power plant and aircraft applications

UNIT I INTRODUCTION 12

Basics of isentropic flow – static and stagnation properties – diffuser and nozzle configurations - area ratio – mass flow rate – critical properties. Energy transfer between fluid and rotor velocity triangles for a generalized turbomachines - velocity diagrams. Euler's equation for turbomachines and its different forms. Degree of reaction in turbo-machines – various efficiencies – isentropic, mechanical, thermal, overall and polytropic

UNIT II CENTRIFUGAL AND AXIAL FLOW COMPRESSORS 9

Centrifugal compressor - configuration and working – slip factor - work input factor – ideal and actual work - pressure coefficient - pressure ratio. Axial flow compressor – geometry and working – velocity diagrams – ideal and actual work – stage pressure ratio - free vortex theory – performance curves and losses

UNIT III COMBUSTION CHAMBER 9

Basics of combustion. Structure and working of combustion chamber – combustion chamber arrangements - flame stability – fuel injection nozzles. Flame stabilization - cooling of combustion chamber

UNIT IV AXIAL AND RADIAL FLOW TURBINES 9

Elementary theory of axial flow turbines - stage parameters- multi-staging - stage loading and flow coefficients. Degree of reaction - stage temperature and pressure ratios – single and twin spool arrangements – performance. Matching of components. Blade Cooling. Radial flow turbines.

UNIT V GAS TURBINE AND JET ENGINE CYCLES 9

Gas turbine cycle analysis – simple and actual. Reheated, Regenerative and Intercooled cycles for power plants. Working of Turbojet, Turbofan, Turboprop, Ramjet, Scarmjet and Pulsejet Engines and cycle analysis – thrust, specific impulse, specific fuel consumption, thermal and propulsive efficiencies.

TOTAL: 45 PERIODS

OUTCOMES:

When a student completes this subject, he / she can

- Understand the design principles of the turbomachines
- Analyse the turbomachines to improve and optimize its performance

REFERENCES:

1. Austin H. Chruch, Centrifugal pumps and blowers, John wiley and Sons, 1980.
2. Cohen H., Rogers, G F C. and Saravanmotto H I H., Gas Turbine Theory-5th Edition, John Wiely, 2001.
3. Csanady G.T., Theory of Turbo machines, McGraw Hill, 1964.
4. Ganesan V., Gas Turbines, Tata McGrawHill, 2011.
5. Hill P G. and Peterson C R., Mechanics and Thermodynamics of Propulsion, Addition-Wesley, 1970.

6. Khajuria P.R. and Dubey S.P., Gas Turbines and Propulsive Systems, Dhanpat Rai Publications, 2003.
7. Mattingly J D., Elements of Gas turbine Propulsion-1st Edition, McGraw Hill, 1997.

TE5073 BOUNDARY LAYER THEORY AND TURBULENCE

L	T	P	C
3	0	0	3

OBJECTIVES

To understand the theory of turbulent flow and its modeling, structure types and a detailed insight about turbulence.

UNIT I FUNDAMENTALS OF BOUNDARY LAYER THEORY 9

Boundary Layer Concept, Laminar Boundary Layer on a Flat Plate at zero incidence, Turbulent Boundary Layer on a Flat plate at zero incidence, Fully Developed Turbulent Flow in a pipe, Boundary Layer on an airfoil, Boundary Layer separation.

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, Couettee – 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

OUTCOME

- On successful completion of this course the student will be able to apply the concepts of boundary layer theory and turbulence.

REFERENCES

1. David C. Wilcox, Turbulence Modeling for CFD, Publisher: D C W Industries, Nov 1, 2006.
2. G. Biswas and E. Eswaran, Turbulent Flows, Fundamentals, Experiments and Modelling,Narosa Publishing House, 2002.
3. H. Schlichting and Klaus Gersten, Boundary Layer Theory, Springer 2004.
4. Pope S B., Turbulent Flow, Cambridge University Press, Cambridge, U.K., 2001.
5. R.J. Garde,Turbulent Flow, New Age International (p) Limited, Publishers, 2006.
6. Schlichting H., Boundary layer theory, Mc Graw Hill Book Company, 1979.
7. Yunus A Cengel, John M.Cimbala, Fluid Mechanics: Fundamentals and Applications - Second Edition, McGraw-Hill,2013

TE5074 ADVANCED POWER PLANT ENGINEERING **L T P C**
3 0 0 3

OBJECTIVES

- To make the students to understand the energy scenario and the environmental issues related to the power plants.
- To create awareness to the students on the various utilities in the power plants and the avenues for optimizing them.

UNIT I INTRODUCTION 5

Overview of Indian power sector – load curves for various applications – types of power plants – merits and demerits – criteria for comparison and selection - Economics of power plants.

UNIT II STEAM POWER PLANTS 9

Basics of typical power plant utilities - Boilers, Nozzles, Turbines, Condensers, Cooling Towers, Water Treatment and Piping system - Rankine Cycle – thermodynamic analysis. Cycle improvements – Superheat, Reheat, Regeneration

UNIT III DIESEL AND GAS TURBINE POWER PLANTS 9

I.C Engine Cycles - Otto, Diesel & Dual –Theoretical vis-à-vis actual – Typical diesel power plant – Types – Components - Layout - Performance analysis and improvement - Combustion in CI engines - E.C cycles – Gas turbine & Stirling - Gas turbine cycles – thermodynamic analysis – cycle improvements - Intercoolers, Re heaters, regenerators.

UNIT IV ADVANCED POWER CYCLES 12

Cogeneration systems – topping & bottoming cycles - Performance indices of cogeneration systems – Heat to power ratio - Thermodynamic performance of steam turbine cogeneration systems – gas turbine cogeneration systems – reciprocating IC engines cogeneration systems- Binary Cycle - Combined cycle – IGCC – AFBC / PFBC cycles – Thermionic steam power plant. MHD – Open cycle and closed cycle- Hybrid MHD & steam power plants

UNIT V HYDROELECTRIC & NUCLEAR POWER PLANTS 10

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.

TOTAL = 45 PERIODS

OUTCOMES

- Understanding the concept of various power plant cycles.
- Possible mitigation of anthropogenic emissions by optimizing the power plant cycles/utilities.

REFERENCES

1. Arora and Domkundwar, A course in power Plant Engineering, Dhanpat Rai and CO, 2004.
2. Gill A.B., Power Plant Performance, Butterworths, 1984.
3. Haywood R.W., Analysis of Engineering Cycles, 4th Edition, Pergamon Press, Oxford, 1991.
4. Horlock J.H., Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford,1987.
5. Lamarsh J.R., Introduction to Nuclear Engineering - 2nd edition, Addison-Wesley, 1983.
6. Nag P.K., Power Plant Engineering, Tata Mcgraw Hill Publishing Co Ltd, New Delhi, 1998.
7. Wood A.J., Wollenberg B.F., Power Generation, operation and control, John Wiley, New York,1984.

EY5072 STEAM GENERATOR TECHNOLOGY L T P C
3 0 0 3

OBJECTIVES

- To educate the students on the types of boilers with their constructional and functional significance.
- To understand the working and design of fuel preparation units and boilers.
- To introduce the concept of boiler design, emission aspects.

UNIT I BASICS 8

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 8

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

UNIT III COMPONENTS DESIGN 12

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

UNIT IV AUXILIARY EQUIPMENTS – DESIGN & SIZING 10

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

UNIT V EMISSION ASPECTS 7

Emission Control – Low NO_x 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

OUTCOMES

- Familiarization with Boiler cycles, components and will have specialized knowledge in steam boiler performance evaluation.
- Emission related aspects in terms of CO_2 NOx emission, mitigation etc will make them to realize the impact of Coal / fuel burning in the society.

REFERENCES

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3. David Gunn and Robert Horton, Industrial Boilers, Longman Scientific and Technical Publication, 1986.
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EY5073 FLUIDIZED BED SYSTEMS L T P C
3 0 0 3

OBJECTIVES

- To introduce the concepts of fluidization and heat transfer in fluidized beds.
- To understand the design principles and apply the same for industrial applications.

UNIT I FLUIDIZED BED BEHAVIOUR 12

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 6

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 6

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 12

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

OUTCOME

- Understand the working principles, merits and limitations of fluidized bed systems.
- Apply fluidized bed systems for a specific engineering applications.
- Analyse the fluidized bed systems to improve and optimize its performance.

REFERENCES

1. Howard J.R., Fluidized Bed Technology: Principles and Applications, Adam Hilger, NewYork, 1983.
2. Botteril J.S.M., Fluid Bed Heat Transfer, Academic Press, London, 1975.
3. Geldart D., Gas Fluidization Technology, John Willey and Sons, 1986.
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6. Liang-Shih Fan, Gas-Liquid-Solid Fluidization Engineering, Butterworths Publishers,1989.
7. O. Levenspiel and D. Kunii, Fluidization Engineering, John Wiley, 1972.

TE5009 ADVANCED THERMAL STORAGE TECHNOLOGIES

L	T	P	C
3	0	0	3

OBJECTIVES

- To learn the various types of thermal storage systems and the storage materials.
- To develop the ability to model and analyze the sensible and latent heat storage units.
- To study the various applications of thermal storage systems.

UNIT I INTRODUCTION 8

Necessity of thermal storage – types-energy storage devices – comparison of energy storage technologies - seasonal thermal energy storage - storage materials.

UNIT II SENSIBLE HEAT STORAGE SYSTEM 9

Basic concepts and modeling of heat storage units - modeling of simple water and rock bed storage system – use of TRNSYS – pressurized water storage system for power plant applications – packed beds.

UNIT III REGENERATORS 10

Parallel flow and counter flow regenerators – finite conductivity model – non – linear model – transient performance – step changes in inlet gas temperature – step changes in gas flow rate – parameterization of transient response – heat storage exchangers.

UNIT IV LATENT HEAT STORAGE SYSTEMS 9

Modeling of phase change problems – temperature based model - enthalpy model - porous medium approach - conduction dominated phase change – convection dominated phase change.

UNIT V APPLICATIONS 9

Specific areas of application of energy storage – food preservation – waste heat recovery – solar energy storage – green house heating – power plant applications – drying and heating for process industries.

TOTAL: 45 PERIODS

OUTCOME

- On completing of the syllabus students can able understand the principles of heat storage systems, regenerators and its applications.

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1. Crabtree R.H., Energy Production and Storage, Wiley-VCH, 2010.
2. Huggins & Robert, Energy Storage Fundamentals, Materials and Applications, Springer, 2016.
3. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002.
4. Lunardini V.J., Heat Transfer in Cold Climates, John Wiley and Sons 1981.
5. S.P.Sukhatme, Solar Energy:Principles of Thermal Collection and Storage, Tata McGraw-Hill, 1984.
6. Schmidt.F.W. and Willmott A.J., Thermal Storage and Regeneration, Hemisphere Publishing Corporation, 1981.

TE5010 COGENERATION AND WASTE HEAT RECOVERY SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES

- To analyze the basic energy generation cycles.
- To detail about the concept of cogeneration, its types and probable areas of applications.
- 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

Selection criteria for waste heat recovery technologies – recuperators – Regenerators – 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

OUTCOME

- On completing of the syllabus students can able understand the principles of cogeneration systems, waste heat recovery systems, applications of cogeneration and economis analysis of waste heat recovery systems.

REFERENCES

1. Charles H. Butler, Cogeneration, McGraw Hill Book Co., 1984.
3. De Nevers, Noel, Air Pollution Control Engineering, McGraw Hill, New York,1995.
2. EDUCOGEN – The European Educational tool for cogeneration, Second Edition, 2001.
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7. Seagate Subrata, Lee SS EDS, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.

MF5072 **RESEARCH METHODOLOGY** **L T P C**
3 0 0 3

OBJECTIVES

To impart scientific, statistical and analytical knowledge for carrying out research work effectively.

UNIT I INTRODUCTION TO RESEARCH 9

The hallmarks of scientific research – Building blocks of science in research – Concept of Applied and Basic research – Quantitative and Qualitative Research Techniques – Need for theoretical frame work – Hypothesis development – Hypothesis testing with quantitative data. Research design – Purpose of the study: Exploratory, Descriptive, Hypothesis Testing.

UNIT II EXPERIMENTAL DESIGN 9

Laboratory and the Field Experiment – Internal and External Validity – Factors affecting Internal validity. Measurement of variables – Scales and measurements of variables. Developing scales – Rating scale and attitudinal scales – Validity testing of scales – Reliability concept in scales being developed – Stability Measures.

UNIT III DATA COLLECTION METHODS 9

Interviewing, Questionnaires, etc. Secondary sources of data collection. Guidelines for Questionnaire Design – Electronic Questionnaire Design and Surveys. Special Data Sources: Focus Groups, Static and Dynamic panels. Review of Advantages and Disadvantages of various Data-Collection Methods and their utility. Sampling Techniques – Probabilistic and non-probabilistic samples. Issues of Precision and Confidence in determining Sample Size. Hypothesis testing, Determination of Optimal sample size.

UNIT IV MULTIVARIATE STATISTICAL TECHNIQUES 9

Data Analysis – Factor Analysis – Culster Analysis -Discriminant Analysis – Multiple Regression and Correlation – Canonical Correlation – Application of Statistical(SPSS) Software Package in Research.

UNIT V RESEARCH REPORT 9

Purpose of the written report – Concept of audience – Basics of written reports. Integral parts of a report – Title of a report, Table of contents, Abstract, Synopsis, Introduction, Body of a report – Experimental, Results and Discussion – Recommendations and Implementation section – Conclusions and Scope for future work.

TOTAL = 45 PERIODS

OUTCOME

- After completion of the syllabus students will able to get knowledge about the different research techniques and research report.
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1. C.R.Kothari, Research Methodology, Wishva Prakashan, New Delhi, 2001.
2. Donald H.McBurney, Research Methods, Thomson Asia Pvt. Ltd. Singapore, 2002.
3. Donald R. Cooper and Ramela S. Schindler, Business Research Methods, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2000
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