St. PETER'S UNIVERSITY

St. Peter's Institute of Higher Education and Research
(Declared under section 3 of UGC Act 1956)
Avadi, Chennai – 600 054.

M.E. (THERMAL ENGINEERING) PROGRAMME

(I TO IV SEMESTERS)

REGULATIONS AND SYLLABI

(REGULATIONS – 2013)

(Effective from the Academic Year 2013-'14)

M.E. (THERMAL ENGINEERING)

Regulations and Syllabi

(Effective from the Academic Year 2013-'14)

1. **Eligibility:** Candidates Who Passed B.E (Mechanical / Production / Aeronautical / Automobile Engineering) of the University or any other equivalent examination thereto are eligible for admission to Two Year M.E.(Thermal Engineering) Programme.

2. **Duration:** Two Years Comprising 4 Semesters. Each semester has a minimum 90 working days with a minimum of 5 hours a day. Candidates who have completed the duration of the programme of study are permitted to appear for the arrear (subjects) examinations, if any within two years after the duration of the programme.

3. **Medium:** English is the medium of instruction and examination.

4. **Weightage for Internal and End Assessment:** The weightage for Continuous Assessment (CA) and End Assessment (EA) be 25:75 unless the ratio is specifically mentioned in the scheme of Examinations.

5. **Credit System:** Credit system be followed with 18 credits for each semester and each credit is equivalent to 25 hours of effective study provided in the Time Table.

6. **Scheme of Examinations:**

SEMESTER I

Code No.	Course Title	Credit (marks)	CA (marks)	EA (marks)	Total (marks)
Theory					
113TEPT01	Advanced Numerical Methods	2	25	75	100
113TEPT02	Advanced Heat Transfer	2	25	75	100
113TEPT03	Advanced Thermodynamics	3	25	75	100
113TEPT04	Advanced Engineering Fluid Mechanics	3	25	75	100
113TEPT05	Fuels and Combustion	3	25	75	100
113TEPT11	**Elective I:** Cryogenic Engineering	3	25	75	100
Practical3					
113TEPP01	Thermal Engineering Laboratory	2	25	75	100
	Total	**18**	**175**	**525**	**700**

SEMESTER II

Code No.	Course Title	Credit (marks)	CA (marks)	EA (marks)	Total (marks)
Theory					
213TEPT01	Design of Thermal Systems	3	25	75	100
213TEPT02	Instrumentation for Thermal Engineering	2	25	75	100
213TEPT03	Environmental Engineering and Pollution Control	2	25	75	100
213TEPT05	**Elective II:** Fans, Blowers and Compressors	3	25	75	100
213TEPT09	**Elective III:** Refrigeration Systems Design	3	25	75	100
213TEPT10	**Elective IV:** Energy Management in Thermal Systems	3	25	75	100
Practical					
213TEPP01	Simulation Laboratory	2	25	75	100
	Total	**18**	**175**	**525**	**700**

SEMESTER III

Code No.	Course Title	Credit (marks)	CA (marks)	EA (marks)	Total (marks)
Theory					
313TEPT01	**Elective V:** Design and Analysis of Turbo machines	3	25	75	100
313TEPT05	**Elective VI:** Fluidized Bed Systems	3	25	75	100
313TEPT07	**Elective VII:** Cogeneration and Waste Heat Recovery Systems	3	25	75	100
Project					
313TEPP01	Project Work (Phase I)	9	25	75	100
	Total	18	100	300	400

SEMESTER IV

Code No.	Course Title	Credit (marks)	CA (marks)	EA (marks)	Total (marks)
Project					
413TEPP01	Project Work (Phase II)	18	25	75	100
	Total	18	25	75	100

LIST OF ELECTIVES FOR M.E THERMAL ENGINEERING

CODE NO	COURSE TITLE	Credit
	Semester I	
113TEPT06	Design of Heat Exchangers	3
113TEPT07	Aircraft and Space Propulsion	3
113TEPT08	Hydrogen and Fuel Cell Technologies	3
113TEPT09	Energy Resources	3
113TEPT10	Advanced Internal Combustion Engineering	3
113TEPT11	**Cryogenic Engineering**	3
113TEPT12	Refrigeration Machinery and Components	3
	Semester II	
213TEPT04	Computational Fluid Dynamics	3
213TEPT05	Fans, Blowers and Compressors	3
213TEPT06	Food Processing, Preservation and Transport	3
213TEPT07	Nuclear Engineering	3
213TEPT08	Industrial Refrigeration Systems	3
213TEPT09	Refrigeration Systems Design	3
213TEPT10	Energy Management in Thermal Systems	3
	Semester III	
313TEPT01	**Design and Analysis of Turbomachines**	3
313TEPT02	Boundary Layer Theory and Turbulence	3
313TEPT03	Advanced Power Plant Engineering	3
313TEPT04	Steam Generator Technology	3
313TEPT05	**Fluidized Bed Systems**	3
313TEPT06	Advanced Thermal Storage Technologies	3
313TEPT07	**Cogeneration and Waste Heat Recovery Systems**	3

7. **Passing Requirements:** The minimum pass mark (raw score) be 50% in End Assessment (EA) and 50% in Continuous Assessment (CA) and End Assessment (EA) put together. No minimum mark (raw score) in Continuous Assessment (CA) be prescribed unless it is specifically mentioned in the scheme of Examination.

8. **Grading System:** Grading System on a 10 Point Scale be followed with1 mark = 0.1 Grade point to successful candidates as given below.

CONVERSION TABLE

(1 mark = 0.1 Grade Point on a 10 Point Scale)

Range of Marks	Grade Point	Letter Grade	Classification
90 to 100	9.0 to 10.0	O	First Class
80 to 89	8.0 to 8.9	A	First Class
70 to 79	7.0 to 7.9	B	First Class
60 to 69	6.0 to 6.9	C	First Class
50 to 59	5.0 to 5.9	D	Second Class
0 to 49	0 to 4.9	**F**	**Reappearance**

Procedure for Calculation

Cumulative Grade Point Average (CGPA) = $\frac{\text{Sum of Weighted Grade Points}}{\text{Total Credits}}$

$= \frac{\sum (CA+EA)\, C}{\sum C}$

Where Weighted Grade Points in each Course = Grade Points (CA+EA) multiplied by Credits

= (CA+EA)C

Weighted Cumulative Percentage of Marks(WCPM) = CGPAx10

C- Credit, CA-Continuous Assessment, EA- End Assessment

9. **Pattern of the Question Paper:** The question paper for End Assessment will be set for three hours and for the maximum of 100 marks with following divisions and details.

Part A: 10 questions (with equal distribution to all units in the syllabus). Each question carries 2 marks.

Part B: 5 questions with either or type (with equal distribution to all units in the syllabus). Each question carries 16 marks. The total marks scored by the candidates will be reduced to the maximum prescribed in the Regulations.

10. **Effective Period of Operation for the Arrear Candidates :** Two Year grace period is provided for the candidates to complete the arrear examination, if any.

Registrar

11.Syllabus

113TEPT01 - APPLIED MATHEMATICS FOR THERMAL ENGINEERS

OBJECTIVES:

- To develop the ability to apply the concepts of Matrix theory and Liner programming in Electrical Engineering problems.
- To familiarize the students in calculus of variations
- To improve knowledge on numerical methods that will come in handy to solve numerically the problems that arise in engineering and technology. This will also serve as precursor for further research

UNIT I CALCULAS OF VARIATION

Introduction – Euler's equation – several dependent variables Lagrange's equation of Dynamics – Integrals involving derivatives higher that the first – Problem with constrains – Direct methods and eigen value problems.

UNIT II MATRIX THEORY

Eigen values using QR transformations – generalized eigenvectors – canonical forms – singular value decomposition and applications – pseudo inverse – least square approximations.

UNIT III LINEAR PROGRAMMING PROBLEM

Graphical method – simplex method – Big M Technique – Integer programming.

UNIT IV ALGEBRAIC EQUATIONS

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm fortridiagonal system – Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations:fixed point iterations, Newton Method, Eigenvalue problems: power method, inverse power method,Faddeev – Leverrier Method.

UNIT V FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS

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

REFERENCES:

1.Gupta, A.S, Calculus of variations with Applications, Prentice – Hall of India New Delhi, 1997.
2.Broson, R., Matrix operations, Schaum's outline series, McGraw Hill, New York, 1989.
3.Taha H.A, "Operation Research – An Introduction", Prentice Hall of India, 2001.
3.Morton, K.W. and Mayers, D.F. Numerical solution of partial differential equations, Cambridge University press, Cambridge (2002).
4.Jain, M. K., Iyengar, S. R. K. and Jain, R. K. " Computational Methods for Partial Differential Equations", New Age International (P) Ltd., 2003.

113TEP02 - ADVANCED HEAT TRANSFER

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

OUTCOME:
On successful completion of this course the student will be able to apply the law of thermodynamics to engines.

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

113TEP03 - ADVANCED THERMODYNAMICS

UNIT I AVAILABILITY ANALYSIS AND THERMODYNAMIC PROPERTY RELATIONS
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 Cp and CV Clausius Clayperon equation, Joule – Thomson coefficient.Bridgeman tables for thermodynamic relations.

UNIT II REAL GAS BEHAVIOUR AND MULTI – COMPONENT SYSTEMS
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
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
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
Conjugate fluxes and forces - entropy production Onsager's reciprocity relations - thermo – electric phenomena, formulations.

TEXT BOOKS :

1. Kenneth Wark Jt.m, Advanced Thermodynamics for Engineers, McGrew – Hill Inc., 1995.
2. Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Cons, 1988.
3. Holman, J.P., Thermodynamics, Fourth Edition, McGraw – Hill Inc., 1988.

REFERENCES

1. Smith, J.M. and Van Ness., H.C., Introduction to Chemical Engineering Thermodynamics, Fourth Edition, McGraw – Hill Inc., 1987.
2. Sonntag, R.E., and Van Wylen, G, Introduction to Thermodynamics, Classical and Statistical Themodynamics, Third Edition, John Wiley and Sons, 1991.
3. Sears, F.W. and Salinger G.I., Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Third Edition, Narosa Publishing House, New Delhi, 1993.
4. DeHotf, R.T., Thermodynamics in Materials Science, McGraw – Hill Inc., 1993. Rao, Y.V.C., Postulational and Statistical Thermodynamics, Allied Publisher Limited, New Delhi, 1999.

113TEP04 - ADVANCED ENGINEERING FLUID MECHANICS

AIM:
To introduce the advanced concepts of fluid mechanics and aerodynamics with the emphasis on

practical applications.

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

UNIT II POTENTIAL FLOW THEORY
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
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
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
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

TEXT BOOKS:
1. Houghten, E.L. and Carruthers, N.B., Aerodynamics for Engineering Students, Arnold Publishers, 1993.
2. Anderson, J.D., Fundamentals of Aerodynamics, McGraw Hill, Boston, 2001.

REFERENCES
1. Streeter, V.L., Wylie, E.B., and Bedford, K.W., Fluid Mechanics, WCB McGraw Hill, Boston, 1998.
2. Munson, B.R., Young, D.F. and Okiisi, T.H., Fundamentals of Fluid Mechanics, John Wiley and Sons Inc., NewYork, 1990
3. Kumar, K.L., Engineering Fluid Mechanics, Eurasia Publishing House, New Delhi, 2002
4. Bansal, R.K., Fluid Mechanics, Saurabh and Co., New Delhi, 1985.

113TEPT05 - FUELS AND COMBUSTION

UNIT I CHARACTERIZATION
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 FUELS & LIQUID FUELS

(a) 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.

(b) 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 FUELS

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

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.

UNIT V COMBUSTION EQUIPMENTS

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.

TEXT BOOKS :

1. Samir Sarkar, Fuels & Combustion, 2nd Edition, Orient Longman, 1990
2. Bhatt, Vora Stoichiometry, 2nd Edition, Tata Mcgraw Hill, 1984
3. Blokh AG,Heat Transfer in Steam Boiler Furnace, Hemisphere Publishing Corpn, 1988.

REFERENCES :

1. Civil Davies, Calculations in Furnace Technology, Pergamon Press, Oxford, 1966
2. Sharma SP, Mohan Chander, Fuels & Combustion, Tata Mcgraw Hill, 1984

113TEPP01 - THERMAL ENGINEERING LABORATORY

CYCLE 1

1. Performance test on Spark Ignition engines.
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

CYCLE 2

1. Properties of fuel oils, biomass, biogas
2. Solar Radiation measurement
3. Boiler efficiency testing
4. Performance of Heat Exchangers
5. Study on Fuel Cell Systems
6. Study on Thermal Storage Systems

II Semester

213TEPT01 DESIGN OF THERMAL SYSTEMS

AIM:
To provide review and use knowledge from thermodynamics, heat transfer and fluid mechanics, modeling and simulation techniques for thermal system component analysis and their synthesis in integral engineering systems and processes

OBJECTIVE:
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
Design Principles, Workable Systems, Optimal Systems, Matching of System Components, Economic Analysis, Depreciation, Gradient Present Worth factor.

UNIT II MATHEMATICAL MODELLING
Equation Fitting, Nomography , Empirical Equation , Regression Analysis , Different Modes of Mathematical Models , Selectio n, Computer Programmes for Models.

UNIT III MODELLING THERMAL EQUIPMENTS
Modelling Heat Exchangers , Evaporators , Condensers , Absorption and Rectification Columns , Compressors , Pumps , Simulation Studies , Information Flow Diagram , Solution Procedures.

UNIT IV OPTIMIZATION
Objective Function Formulation, Constraint Equations, Mathematical Formulation, Calculus Method, Dynamic Programming, Search Methods, ANN and Genetic Algorithm.

UNIT V DYNAMIC BEHAVIOUR
Steady state Simulation, Laplace Transformation, Feedback Control Loops, Stability Analysis, Non-Linearities.

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

TEXT BOOKS:
1. Stoecker W. F., Design of Thermal Systems, McGraw Hill Edition, 1989.
2. Bejan A., George Tsatsaronis , Michael J. Moran , Thermal Design and Optimization, Wiley , 1996.

REFERENCE:
1. Kapur J. N., Mathematical Modelling , Wiley Eastern Ltd , New York , 1989.
2. Yogesh Jaluria , Design and Optimization of Thermal Systems , CRC Press , 2007.
3. Rao S. S., Engineering Optimization Theory and Practice, New Age Publishers, 2000.

213TEPT02 - INSTRUMENTATION FOR THERMAL ENGINEERING

AIM:

To enhance the knowledge of the students about various measuring instruments, techniques and importance of error and uncertainty analysis.

OBJECTIVES:

(I) To provide knowledge on various measuring instruments.
(II) To provide knowledge on advance measurement techniques.
(III) To understand the various steps involved in error analysis and uncertainty analysis.

UNIT I MEASURMENT CHARACTERISTICS

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 MEASURMENT

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

UNIT III MEASURMENT OF PHYSICAL QUANTITIES

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

UNIT IV ADVANCE MEASURMENT TECHNIQUES

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

UNIT V MEASURMENT ANALYSERS

Orsat apparatus, Gas Analysers, Smoke meters, gas chromatography, spectrometry.

TEXT BOOKS :

1. Holman, J.P., Experimental methods for engineers, McGraw-Hill, 1988.
2. Barnery, Intelligent Instrumentation, Prentice Hall of India, 1988.
3. Prebrashensky, V., Measurements and Instrumentation in Heat Engineering, Vol. 1 and 2, MIR Publishers, 1980.

REFERENCES

1. Raman, C.S., Sharma, G.R., Mani, V.S.V., Instrumentation Devices and Systems, Tata McGraw-Hill, New Delhi, 1983.
2. Holman, J.P., Experimental methods for engineers, McGraw-Hill, 1958.
3. Barney, Intelligent Instrumentation, Prentice Hall of India, 1988
4. Prebrashensky. V., Measurement and Instrumentation in Heat Engineering, Vol.1 and MIR Publishers, 1980.
5. Raman, C.S. Sharma, G.R., Mani, V.S.V., Instrumentation Devices and Systems,
6. Tata McGraw-Hill, New Delhi, 1983.
7. Doeblin, Measurement System Application and Design, McGraw-Hill, 1978.
8. Morris. A.S, Principles of Measurements and Instrumentation Prentice Hall of India, 1998.

213TEPT03 - ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL

AIM:
To create awareness among the student community on anthropogenic degradation of environment and technologies available to limit the degradation.

OBJECTIVES:
To impart knowledge on the atmosphere and its present condition, global warming and ecolegislations.
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
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
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
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
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
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.

TEXT BOOKS:
1. G.Masters (2003): Introduction to Environmental Engineering and Science Prentice Hall of India Pvt Ltd, New Delhi.
2. H.S.Peavy, D.R..Rowe, G.Tchobanoglous (1985):Environmental Engineering McGraw- Hill BookCompany, NewYork.

REFERENCES:
1. H.Ludwig, W.Evans (1991): Manual of Environmental Technology in Developing Countries, . International Book Company, Absecon Highlands, N.J.
2. Arcadio P Sincero and G. A. Sincero, (2002): Environmental Engineering – A Design Apporach, Prentice Hall of India Pvt Ltd, New Delhi.

213TEPP02 SIMULATION LABORATORY

FOCUS: USE OF STANDARD APPLICATION SOFTWARE FOR SOLVING

HEAT TRANSFER PROBLEMS
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

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
1. Every students in a batch must be provided with a terminal
2. Hardware are compatible with the requirement of the above software.

113TEPT06 DESIGN OF HEAT EXCHANGERS

AIM:

The course is intended to build up necessary background for the design of the various types of heat exchangers.

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

UNIT V CONDENSERS AND COOLING TOWERS
Design of surface and evaporative condensers – cooling tower – performance characteristics.

OUTCOME
Able to design the heat exchanger based on the information provided for a particular application and do the cost economic analysis.

TEXT BOOK:
1. Sadik Kakac and Hongtan Liu, Heat Exchangers Selection, Rating and Thermal Design, CRC Press, 2002.

REFERENCES
1. Arthur. P Frass, Heat Exchanger Design, John Wiley & Sons, 1988.
2. Taborek.T, Hewitt.G.F and Afgan.N, Heat Exchangers, Theory and Practice, McGraw-Hill Book Co. 1980.
3. Hewitt.G.F, Shires.G.L and Bott.T.R, Process Heat Transfer, CRC Press, 1994.

113TEPT07 - AIRCRAFT AND SPACE PROPULSION

AIM:

To enhance the knowledge of the students on aircrafts and space propulsion

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

UNIT IV ROCKET PROPULSION
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
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.

OUTCOME:
On successful completion of this course the student will be able to understand the working of different types of aircraft and rocket propulsion systems and their performance characteristics.

REFERENCES
1. Philip G. Hill and Carl R. Peterson, Mechanics and Thermodynamics of Propulsion, Second Edition, Addition – Wesley Publishing Company, New York, 2009.
2. Zucrow N.J. Principles of Jet Propulsion and Gas Turbines, John Wiley and Sons New York, 1970.
3. Zucrow N.J. Aircraft and Missile Propulsion, Vol. I and Vol. II, John Wiley and Sons Inc, New York, 1975.
4. S. M.Yahya, Fundamentals of Compressible Flow. Third edition, New Age International Pvt Ltd, 2003.
5. Bonney E.A. Zucrow N.J. Principles of Guided Missile Design, Van Nostranc Co., 1956.

113TEPT8 - HYDROGEN AND FUEL CELL TECHNOLOGIES

AIM:

To enlighten on various technological advancements, benefits and prospects of utilizing hydrogen/fuel cell for meeting the future energy requirements.

OBJECTIVES:
To detail on the hydrogen production methodologies, possible applications and various storage options
To discuss on the working of a typical fuel cell, its types and to elaborate on its thermodynamics and kinetics
To analyze the cost effectiveness and eco-friendliness of Fuel Cells

UNIT I HYDROGEN – BASICS AND PRODUCTION TECHNIQUES
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
Hydrogen storage options – compressed gas – liquid hydrogen – Hydride – chemical Storage – comparisons. Safety and management of hydrogen. Applications of Hydrogen

UNIT III FUEL CELLS
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
Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits

UNIT V APPLICATION OF FUEL CELL AND ECONOMICS
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

OUTCOME
Fundamentally strong understanding on the working of various fuel cells, their relative advantages, disadvantages and hydrogen generation/storage technologies.

REFERENCES
1. Viswanathan, B and M Aulice Scibioh, 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, NewYork Ltd., London (1989)
6. Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA (2002).

113TEPT09 - ENERGY RESOURCES

AIM:

To introduce and apply advanced concepts of thermodynamics to engineering systems To understand types and applications of various form of energy sources and its environmental impacts.

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 analysis the environmental and cost economics of using renewable energy sources compared to fossil fuels.

UNIT I COMMERCIAL ENERGY

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

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

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

Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - direct combustion – biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - types of biogas Plants - applications - alcohol production from biomass – bio diesel production – Urban waste to energy conversion - Biomass energy programme in India.

UNIT V OTHER TYPES OF ENERGY

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

OUTCOME:

Understanding of commercial energy and renewable energy sources
Knowledge in working principle of various energy systems
Capability to do basic design of renewable 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 VVN, 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

113TEPT10 - ADVANCED INTERNAL COMBUSTION ENGINEERING

UNIT I SPARK IGNITION ENGINES
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
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
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
Alcohol, Hydrogen, Natural Gas and Liquefied Petroleum Gas- Properties, Suitability, Merits and Demerits as fuels, Engine Modifications.

UNIT V RECENT TRENDS
Lean Burn Engines – Stratified charge Engines – homogeneous charge compression ignition engines – Plasma Ignition – Measurement techniques – laser Doppler, Anemometry.

TEXT BOOK
1. K.K. Ramalingam, Internal Combustion Engine Fundamentals, Scitech Publications, 2002.

REFERENCE BOOKS
1. R.B.Mathur and R.P. Sharma, Internal combustion Engines.
2. V. Ganesan, Int. Combustion Engines, II Edition, TMH, 2002.
3. Duffy Smith, auto fuel Systems, The Good Heart Willox Company, Inc., 198

113TEPT11 - CRYOGENIC ENGINEERING

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

REFERENCES:
1. Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering, Plenum Press, 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, 1969.
5.Robert W. Vance, Cryogenic Technology, Johnwiley & Sons, Inc., New York, London.

WEB REFERENCES
1. www.nasa.gov
2. www.cryogenicsociety.org/
3. www.iifiir.org/
4. www.linde.com
5. www.airliquide.com/
6. www.cern.ch
7. www.nist.gov

113TEPT12 - REFRIGERATION MACHINERY AND COMPONENTS

UNIT I REFRIGERANT COMPRESSORS
Hermetic compressors - Reciprocating, Rotary, Scroll Compressors, Open type compressors - Reciprocating, Centrifugal, Screw Compressors. Semi hermetic compressors - Construction, working and Energy Efficiency aspects. Applications of each type.

UNIT II DESIGN OF CONDENSERS
Estimation of heat transfer coefficient, Fouling factor, Friction factor. Design procedures, Wilson plots, Designing different types of condensers, BIS Standards, Optimisation studies.

UNIT III DESIGN OF EVAPORATORS
Different types of evaporators, Design procedure, Selection procedure, Thermal Stress calculations, Matching of components, Design of evaporative condensers.

UNIT IV REFRIGERATION SYSTEM COMPONENTS
Evaporators and condensers - Different types, capacity control, circuitry, Oil return, Oil separators - Different types Refrigerant driers strainers, Receivers, Accumulators, Low pressure receivers, Air Washers, Spray ponds.

UNIT V SYSTEM ACCESSORIES AND CONTROLS
Refrigerant Pumps, Cooling Tower fans, Compressor Motor protection devices, Oil equalising in multiple evaporators. Different Defrosting and capacity control methods and their implications - Testing of Air conditioners, Refrigerators, Visicoolers, Cold rooms, Calorimetric tests.

REFERENCES:
1. Chlumsky "Reciprocating & Rotary compressors", SNTL Publishers for Technical literaure, 1965.
2. Hains, J.B, " automatic Control of Heating & Airconditioning" Mc Graw Hill, 1981.
3. Althose, A.D. & Turnquist, C.H. " Modern Refrigeration and Airconditioning" Good Heart - Wilcox Co. Inc., 1985.
4. Recent release of BIS Code for relevant testing practice.
5. ASHRAE Hand book : Equipments, 1998
6. Cooper &Williams, B. " Commercial, Industrial, Institutional Refrigeration, Design, Installation and Trouble Shooting " Eagle Wood Cliffs (NT) Prentice Hall, 1989.
7. http://www.chensources.com/ctowers22.shtml
8. http://www.fortunecity.com/campus/german/201/ctowers.html
9. http://www.aquasystemsinsc.com/metric-files.html
10. http://www.ori.org
11. http://confex.com/store/ashrae/index-features.html

II Semester

213TEPT04 COMPUTATIONAL FLUID DYNAMICS

AIM:

This course aims to introduce numerical modeling and its role in the field of heat and fluid flow, it will enable the students to understand the various discrimination methods and solving methodologies and to create confidence to solve complex problems in the field of heat transfer and fluid dynamics.

OBJECTIVE S:

To develop finite difference and finite volume discredited forms of the CFD equations.
To formulate explicit & implicit algorithms for solving the Euler Eqns & Navier Stokes Eqns.

UNIT I GOVERNING DIFFERENTIAL EQUATION AND FINITE DIFFERENCE METHOD

Classification, Initial and Boundary conditions, Initial and Boundary value problems. Finite difference method, Central, Forward, Backward difference, Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test.

UNIT II CONDUCTION HEAT TRANSFER

Steady one-dimensional conduction, Two and Three dimensional steady state problems, Transient one-dimensional problem, Two-dimensional Transient Problems.

UNIT III INCOMPRESSIBLE FLUID FLOW

Governing Equations, Stream Function – Verticity method, Determination of pressure for viscous flow, SIMPLE Procedure of Patankar and spalding, Computation of Boundary layer flow, Finite difference approach.

UNIT IV CONVECTION HEAT TRANSFER AND FEM

Steady One-Dimensional and Two-Dimensional Convection – Diffusion, Unsteady one-dimensional convection – Diffusion, Unsteady two-dimensional convection – Diffusion – Introduction to finite element method – Solution of steady heat conduction by FEM – Incompressible flow – Simulation by FEM.

UNIT V TURBULENCE MODELS

Algebraic Models – One equation model, K - □ Models, Standard and High and Low Reynolds number models, Prediction of fluid flow and heat transfer using standard codes.

REFERENCES

1. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 1995.
2. Ghoshdasdidar, P.S., "Computer Simulation of flow and heat transfer" Tata McGraw Hill Publishing Company Ltd., 1998.
3. Subas, V.Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation, 1980.
4. Taylor, C and Hughes, J.B. "Finite Element Programming of the Navier Stock Equation", Pineridge Press Limited, U.K., 1981.
5. Anderson, D.A., Tannehill, J.I., and Pletcher, R.H., "Computational fluid Mechanic and Heat Transfer " Hemisphere Publishing Corporation, Newyork, USA, 1984.
6. Fletcher, C.A.J. "Computational Techniques for Fluid Dynamics 1" Fundamental and General Techniques, Springer – Verlag, 1987.
7. Fletcher, C.A.J. "Computational Techniques for Fluid Dynamics 2" Specific Techniques for Different Flow Categories, Springer – Verlag, 1987.
8. Bose, T.X., "Numerical Fluid Dynamics" Narosa Publishing House, 1997.

213TEPT05 - FANS, BLOWERS AND COMPRESSORS

UNIT I PRINCIPLES OF TURBO MACHINERY
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
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, crossflow fans.

UNIT III ANALYSIS OF COMPRESSOR
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
Fan testing, noise control, materials and components blower regulation, speed control, throttling, control at discharge and inlet.

UNIT V APPLICATIONS OF BLOWERS
Applications of blowers, induced and forced draft fans for air conditioning plants, cooling towers, ventilation systems, booster systems.

REFERENCES
1. S.M. Yahya, " Fundamentals of Compressible Flow ", New Age International (P)Limited, New Delhi, 1996
2. Stepanoff A.J., Turboblowers, 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.

WEB REFERENCES
1.http://www.petropager.com
2.http://www.tamil.org
3 http://www.erichson.com
4 .http://www.apgate.com

213TEPT06 - FOOD PROCESSING, PRESERVATION AND TRANSPORT

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

UNIT V TRANSPORT 5
Refrigerated transportation, Refrigerated containers & trucks, Design features, Piping & Role of cryogenics in freezing & transport

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 Ed. 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 Ed. McGraw-Hill, Pub., 2000.
6. ASHRAE Handbook, Refrigeration, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. Atlanta, 1988.

213TEPT07 - NUCLEAR ENGINEERING

AIM
To provide in-depth knowledge on Nuclear reaction materials reprocessing techniques and also to understand nuclear waste disposal techniques and radiation protection aspects.

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
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
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
Nuclear fuel cycles - spent fuel characteristics - role of solvent extraction in reprocessing - solvent extraction equipment.

UNIT IV SEPARATION OF REACTOR PRODUCTS
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
Types of nuclear wastes - safety control and pollution control and abatement - international convention on safety aspects - radiation hazards prevention.

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

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

213TEPT8 - INDUSTRIAL REFRIGERATION SYSTEMS

UNIT I INTRODUCTION
Introduction to industrial refrigeration - difference from conventional system - applications - industrial and comfort air - conditioning - conditions for high COP.

UNIT II COMPRESSORS
Reciprocating and screw compressor: Multistage industrial applications, cylinder arrangement, cooling methods - oil injection and refrigeration injection, capacity regulations - Economizers.

UNIT III EVAPORATORS AND CONDENSERS
Types of Evaporators, Liquid circulation: Mechanical pumping and gas pumping - advantage and disadvantage of liquid re-circulation - circulation ratio - top feed and bottom feed refrigerant - Net Positive Suction Head (NPSH) - two pumping vessel system - suction risers – design - piping loses. Different Industrial Condensers arrangement, Evaporators-Types and arrangement, liquid circulation, type of feed, refrigerant piping design , functional aspects. Lubricating oil: types - physical properties, types of circulation and oil separator.

UNIT IV VESSELS
Vessels in industrial refrigeration: High pressure receiver - flash tank - liquid and vapour separator - separation enhancers - low pressure receivers - surge drum - surge line accumulator - thermosyphon receiver - oil pots.

UNIT V ENERGY CONSERVATION
Energy conservation and design considerations - source of losses - energy efficient components - heat reclaim - thermal storage: ice builder and ice harvester. Insulation: critical thickness - insulation cost and energy cost - vapour barriers - construction methods of refrigerated spaces.

REFERENCES:
1. Wilbert F.Stoecker, Industrial Refrigeration Hand Book, McGraw-Hill, 1998.
2. ASHRAE Hand Book: Fundamentals, 1997.
3. ASHRAE Hand Book: Refrigeration, 1998.
4. ASHRAE Hand Book: HVAC Systems and Equipment, 1996.
5. Transport properties of SUVA Refrigerants, Du-Pont Chemicals, 1993.

213TEPT09 - REFRIGERATION SYSTEMS DESIGN

AIM:
To teach the students about Refrigeration System Design concepts.

OBJECTIVES:
Teaching cycle analysis pertaining to Refrigeration systems.
Teaching performance of system components and their balancing in cycles.

UNIT I REFRIGERATION CYCLES - ANALYSIS
Development of Vapor Compression Refrigeration Cycle from Reverse Carnot Cycle- conditions for high COP-deviations from ideal vapor compression cycle , Multipressure Systems , Cascade Systems-Analysis .

UNIT II MAIN SYSTEM COMPONENTS
Compressor- Types , performance , Characteristics of Reciprocating Compressors , Capacity Control , Types of Evaporators & Condensers and their functional aspects , Expansion Devices and their Behavior with fluctuating load.

UNIT III REFRIGERANTS
Classification of Refrigerants , Refrigerant properties , Oil Compatibility , Environmental Impact-Montreal / Kyoto protocols-Eco Friendly Refrigerants. Different Types of Refrigeration Tools , Evacuation and Charging Unit , Recovery and Recycling Unit , Vacuum Pumps.

UNIT IV SYSTEM BALANCING & CONTROLS
Estimation of Cooling Load , System Equilibrium and Cycling Controls , Electric Circuits in-Refrigerators , Window A/C , Types of motors , Relays.

UNIT V OTHER REFRIGERATION CYCLES
Vapor Absorption Systems-Aqua Ammonia & LiBr Systems, Steam Jet Refrigeration Thermo Electric Refrigeration, Air Refrigeration cycles..

TEXT BOOKS:
1. Dossat R.J., Principles of refrigeration, John Wiley, S.I. Version (2001).
2. Stoecker W.F., Refrigeration and Air conditioning, McGraw-Hill Book Company, 1989.

REFERENCES:
1. Jordan and Priester , Refrigeration and Air conditioning 1985.
2. Goshnay W.B., Principles and Refrigeration, Cambridge, University Press, 1985.
3. Langley , Billy C., 'Solid state electronic controls for HVACR' pentice-Hall 1986.

213TEPT10 - ENERGY MANAGEMENT IN THERMAL SYSTEMS

AIM :
To course is intended to introduce principles of energy auditing and to provide measures for energy conservation in thermal applications

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

UNIT IV THERMAL ENERGY TRANSMISSION / PROTECTION SYSTEMS
Steam traps – refractories – optimum insulation thickness – insulation – piping design.

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

TEXT BOOKS:
1. Smith, CB Energy Management Principles, Pergamon Press, NewYork, 1981
2. Hamies, Energy Auditing and Conservation; Methods Measurements, Management and Case study, Hemisphere, Washington, 1980.

REFERENCES
1. Trivedi, PR, Jolka KR, Energy Management, Commonwealth Publication, New Delhi, 1997
2. Write, Larry C, Industrial Energy Management and Utilization, Hemisphere Publishers, Washington, 1988.
3. Diamant, RME, Total Energy, Pergamon, Oxford, 1970
4. Handbook on Energy Efficiency, TERI, New Delhi, 2001
5 .Guide book for National Certification Examination for Energy Managers and Energy Auditors (Could be downloaded from www.energymanagertraining.com)

313TEPT01 DESIGN AND ANALYSIS OF TURBOMACHINES

AIM:
To design and analyse the performance of Turbo machines for engineering applications.

OBJECTIVES:
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 Turbo machines for power plant and aircraft applications

UNIT I INTRODUCTION
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
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
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
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
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.

OUTCOME:
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. Ganesan, V., Gas Turbines, Tata McGrawHill, 2011.
2. Khajuria P.R and Dubey S.P., Gas Turbines and Propulsive Systems, Dhanpat Rai Publications, 2003
3. Cohen, H., Rogers, G F C and Saravanmotto, H I H, Gas Turbine Theory, John Wiely, 5th Edition 2001.
4. Hill P G and Peterson C R, Mechanics and Thermodynamics of Propulsion, Addition-Wesley, 1970.
5. Mattingly J D, Elements of Gas turbine Propulsion, McGraw Hill, 1st Edition. 1997

313TEPT02 - BOUNDARY LAYER THEORY AND TURBULENCE

AIM:
To enhance the students' knowledge on boundary layer theory and turbulence

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
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
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
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
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
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.

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

REFERENCES
1. G. Biswas and E. Eswaran, Turbulent Flows, Fundamentals, Experiments and Modelling,Narosa Publishing House, 2002.
2. H. Schlichting and Klaus Gersten, Boundary Layer Theory, Springer 2004.
3. R.J. Garde,Turbulent Flow, New Age International (p) Limited, Publishers, 2006.

313TEPT03 - ADVANCED POWER PLANT ENGINEERING

AIM:
To introduce the advances in operations and applications of different types of power plants.

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

UNIT I INTRODUCTION
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
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
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
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
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.

OUTCOME
Possible mitigation of anthropogenic emissions by optimizing the power plant cycles/utilities

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

313TEPT04 - STEAM GENERATOR TECHNOLOGY

AIM:
To understand the types, working of steam generator and their major components, along with design principles and calculations.

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

UNIT II FUELS & BOILER TYPES
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
Furnace – Water Wall – Steam Drum – Attemperator - Superheaters – Reheaters – Air Preheaters – Economisers - Steam Turbines : Design Aspects of all these.

UNIT IV AUXILIARY EQUIPMENTS – DESIGN & SIZING
Forced Draft & Induced Draft Fans – PA / SA Fans – Water Pumps (Low Pressure & High Pressure) – Cooling Towers – Softener – DM Plant.

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

OUTCOME:
1. Familiarization with Boiler cycles, components and will have specialized knowledge in steam boiler performance evaluation
2. 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
1. Prabir Basu, Cen Kefa and Louis Jestin, Boilers and Burners: Design and Theory, Springer, 2000.
2. Ganapathy, V., Industrial Boilers and Heat Recovery Steam Generators, Marcel Dekker Ink, 2003
3. David Gunn and Robert Horton, Industrial Boilers, Longman Scientific and Technical Publication, 1986
4. Carl Schields, Boilers: Type, Characteristics and Functions, McGraw Hill Publishers, 1982
5. Howard, J.R., Fluidized Bed Technology: Principles and Applications, Adam Hilger, NewYork, 1983

313TEPT05 - FLUIDIZED BED SYSTEMS

AIM:
To inspire the students with the theories of fluidization, heat transfer and design for various applications

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
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
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
Fluidized bed combustion and gasification – stages of combustion of particles – performance - startup methods. Pressurized fluidized beds.

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

UNIT V INDUSTRIAL APPLICATIONS
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.

OUTCOME:
When a student completes this subject, he / she can
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. Geldart, D., Gas Fluidization Technology, John Willey and Sons, 1986.
3. Kunii, D and Levespiel, O., Fluidization Engineering, John Wiley and Son Inc, New York,1969.
4. Howard, J.R. (Ed), Fluidized Beds: Combustion and Applications, Applied Science Publishers, New York, 1983.
5. Botteril, J.S.M., Fluid Bed Heat Transfer, Academic Press, London, 1975.
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

313TEPT06 - ADVANCED THERMAL STORAGE TECHNOLOGIES

AIM:
This course is intended to build up the necessary background to model and analyze the various types of thermal storage systems.

OBJECTIVES:
UNIT I INTRODUCTION
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
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
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
Modeling of phase change problems – temperature based model - enthalpy model - porous medium approach - conduction dominated phase change – convection dominated phase change.

UNIT V APPLICATIONS
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.

TEXT BOOK:
1. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002.

REFERENCES:
1. Schmidt.F.W and Willmott.A.J, Thermal Storage and Regeneration, Hemisphere Publishing Corporation, 1981.
2. Lunardini.V.J, Heat Transfer in Cold Climates, John Wiley and Sons 1981.

313TEPT07 - COGENERATION AND WASTE HEAT RECOVERY SYSTEMS

AIM:
To detail on the importance of Total Energy Concept, its advantages and cost effectiveness.

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 carryout its economic analysis

UNIT I INTRODUCTION
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 generation.

UNIT II CONGENERATION TECHNOLOGIES
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
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
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
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.

TEXT BOOKS:
1. Charles H. Butler, Cogeneration, McGraw Hill Book Co., 1984.11
2. EDUCOGEN – The European Educational tool for cogeneration, Second Edition, 2001

REFERENCES:
1. Horlock JH, Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford,1987.
2. Institute of Fuel, London, Waste Heat Recovery, Chapman & Hall Publishers,London, 1963.
3. Seagate Subrata, Lee SS EDS, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.
4. De Nevers, Noel., Air Pollution Control Engineering, McGrawHill, New York,1995

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