SYLLABUS

FOR

TWO-YEAR M. TECH. PROGRAMME

IN

THERMAL ENGINEERING

NAAC – A Grade

DEPARTMENT OF MECHANICAL ENGINEERING

COLLEGE OF ENGINEERING & TECHNOLOGY

(An Autonomous and Constituent College of BPUT, Odisha)

Techno Campus, Mahalaxmi Vihar, Ghatikia,

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COURSE: M. Tech. (ME – Thermal Engineering), Duration: 2 years (Four Semesters)

<u>Abbreviations Used:</u> **U= UG, I= Integrated,** **P= PG**
PC= Professional Core **PE= Professional Elective** **OE= Open Elective**
LC= Lab Course **MC= Mandatory Course** **AC= Audit Course**
L= Lectures **P= Practical/Laboratory** **IA*= Internal Assessment**
T= Tutorial **PA= Practical Assessment** **EA=End-Semester Assessment**
***Internal Assessment Max. Mark (30 marks) consists of Mid Semester (20 marks) and Quiz+Assignment (10 marks)**

Subject Code Format:

1	2	3	4	5	6	7	8
Prog (U/I/P)	Type (PC/PE/OE/LC/MC/AC)		Department (CE/EE/IE/ME/…)		Semester (1/2/…/0)	Serial No. (1/2/3/…/99)	

1st SEMESTER

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours L	T	P	Credit	Maximum Marks IA	EA	PA	Total
1	Core 1	PPCME103	Advanced Thermodynamics	3	0	0	3	30	70	-	100
2	Core 2	PPCME104	Conduction and Radiation Heat Transfer	3	0	0	3	30	70	-	100
3	Professional Elective 1 (Any One)	PPEME103	Experimental methods in Thermal Engineering	3	0	0	3	30	70	-	100
		PPEME105	Refrigeration Systems								
		PPEME106	Design of Thermal systems								
		PPEME107	Environmental pollution and Abetment								
4	Professional Elective 2 (Any One)	PPEME116	Automotive power	3	0	0	3	30	70	-	100
		PPEME117	Gas dynamics								
		PPEME118	Power plant practice and control								
		PPEME119	Heat exchanger analysis and design								
5	Mandatory	PMCMH101	Research Methodology & IPR	2	0	0	2	30	70	-	100
6	Lab 1	PLCME103	Thermal Software Lab	0	0	4	2	-	-	100	100
7	Lab 2	PLCME104	Advanced Thermal Engineering Lab-I	0	0	4	2	-	-	100	100
			Total	**14**	**0**	**8**	**18**	**150**	**350**	**200**	**700**
8	Audit 1	Any one subject from Appendix-I									100
										Grand Total	**800**

2nd SEMESTER

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours L	T	P	Credit	Maximum Marks IA	EA	PA	Total
1	Core-3	PPCME205	Advanced Fluid Mechanics (ME)	3	0	0	**3**	30	70	-	100
2	Core-4	PPCME206	Convective heat and Mass Transfer	3	0	0	**3**	30	70	-	100
3	Professional Elective 3 (Any One)	PPEME208	Air conditioning and Ventilation	3	0	0	**3**	30	70	-	100
		PPEME209	Gas turbine and jet propulsion								
		PPEME210	Theory of combustion and emission								
		PPEME211	Bio heat transfer and microfluidics								
4	Professional Elective 4 (Any One)	PPEME220	Computational methods in Thermal Engineering	3	0	0	**3**	30	70	-	100
		PPEME221	Computational Fluid Dynamics (ME)								
		PPEME222	Turbulent flows								
		PPEME223	Two-phase flow								
5	Common	PPRME201	Literature Review Seminar	0	0	4	**2**	-	-	100	100

6	Lab 3	PLCME204	Advanced Thermal Lab-II	0	0	3	**2**	-	-	100	100
7	Lab 4	PLCME202	Computational Techniques and Soft Computing Lab	0	0	3	**2**	-	-	100	100
			Total	**12**	**0**	**12**	**18**	**120**	**280**	**300**	**700**
8	Audit 2	Any one subject from Appendix-II									100
										Grand Total	**800**

3rd SEMESTER

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	Professional Elective 5 (Any One)	PPEME309	Renewable Energy systems	3	0	0	**3**	30	70	-	100
		PPEME310	Nuclear power generation and safety								
		PPEME311	Energy economics and auditing								
		PPEME312	Waste heat recovery								
2	Open Elective	Any one subject from Appendix-III		3	0	0	3	30	70	-	100
3	Project 1	PPRME301	Phase-I Dissertation	0	0	20	**10**	-	-	100	100
			Total	**6**	**0**	**20**	**16**	**60**	**140**	**100**	**300**

4th SEMESTER

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	Project 2	PPRME401	Phase-II Dissertation	0	0	32	**16**	-	-	100	100
			Total	0	0	32	**16**	-	-	**100**	**100**

Abstract of Credit and Marks Distribution

Sl. No.	Semester	Maximum Credits	Maximum Marks
1	1st Semester	18	800
2	2nd Semester	18	800
3	3rd Semester	16	300
4	4th Semester	16	100
	Total	**68**	**2000**

NB:

- **Any one of the Courses in Appendix-I is to be Decided by the Concerned Department for Audit-1 (1st Sem)**
- **Any one of the Courses in Appendix-II is to be Decided by the Concerned Department for Audit-2 (2nd Sem)**
- **Any one of the Courses in Appendix-III is to be Decided by the Concerned Department for Open Elective (3rd Sem)**

Semester-1

Core 1: Advanced Thermodynamics (PPCME103)

Module I
Review of basic thermodynamics: Laws of thermodynamics, entropy, entropy balance for closed and open systems. Exergy: Concept of reversible work & irreversibility; Second law efficiency; Energy change of a system: closed & open systems, energy transfer by heat, work and mass, energy destruction, energy balance in closed & open systems; Energy analysis of industrial systems – power systems and refrigeration systems. Cycle analysis and optimization: Regenerative reheat Rankine cycle and Brayton cycle, combined cycle power plants, multi-stage refrigeration systems.

Module II
Thermodynamic optimization of irreversible systems: Finite time thermodynamics principles, optimization studies of various thermal systems, Minimization of entropy generation principle. Review of Ideal Gas, Ideal gas mixtures and mixing rules: Real gas behavior, Real gas equations of state, Property relations for mixtures and Psychrometry. Thermodynamic relations for homogeneous phase: Maxwell relations, Relations involving enthalpy, internal energy and entropy, Equilibrium between two-phases of a pure substance, Clausius- Clapeyron equation

Module III
Combustion: Combustion reactions – Stoichiometry, First law analysis, Heat calculations, Adiabatic flame temperature. Chemical Equilibrium: Chemical potential, Second law analysis of reacting systems, Chemical equilibrium, Free energies, Equilibrium flame temperature, Equilibrium products of combustion, non-equilibrium thermodynamics. Statistical-mechanical evaluation of thermodynamic properties of gases, liquids, and solids, Elementary kinetic theory of gases and evaluation of transport properties. Non-Equilibrium Thermodynamics of small scale systems. Onsager relation

Text Books

1. A. Bejan, Advanced Engineering Thermodynamics, 3rd edition, John Wiley and sons, 2006.
2. F.W.Searsand G. L. Salinger, Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Narosa Publishing House, New Delhi, 3rd edition,1998.
3. I. K. Puri and K. Annamalai, Advanced Engineering Thermodynamics, CRC Press,2001.

4. Sonntag, R. E, Borgnakke, C and Van Wylen, G. J. and., 1976, Fundamentals of Classical Thermodynamics, Wiley EasternLtd

References

1. M.J.Moranand, H.N.Shapiro, Fundamentals of Engineering Thermodynamics, John Wiley and Sons.
2. M. W. Zemansky and R. H. Dittman, Heat and Thermodynamics, McGraw Hill International Editions, 7th edition,2007.
3. Work, K. Advanced Thermodynamics for Engineers, Mc-Graw Hill,1995.
4. Jones, J. B. and Hawkins, G. A., 1986, Engineering Thermodynamics, John WileySons

Core 2: Conduction and Radiation Heat Transfer (PPCME104)

Module I

Conduction; Derivation of generalized conduction equation for anisotropic inhomogeneous solids, conductive tensor, concepts of isotropic and homogeneous conductivity; Steady state conduction: Recapitulation of fundamentals analysis and design variable and cross section and circumferential fins. Analysis of heat conduction in 2-D fins, 2-D and 3-D conduction in solids with complex boundary conditions and heat generation.;

Module II

Transient conduction: Recapitulation of transient conduction in simple systems. Analysis of transient heat conduction with complex boundary; Application of Duhamel‘s theorem and Special topics: Use of Laplace transformation in linear conduction problems. The use of green function in the solution of the equations of conduction; Numerical methods: Fundamentals of discrimination treatment of boundary conditions, on linearity of properties, anisotropy and complex boundaries.

Module III

Radiation; Recapitulation of fundamentals of radiative heat transfer, radiative properties of surfaces, methods of estimating configuration factors, heat exchange between diffusively emitting and diffusively reflecting surfaces. Convective heat transfers of particles by cavitation effect due to ultrasonic frequency, Radiant energy transfer through absorbing, emitting and scattering media. Combined conduction and radiation systems: fins, Introduction to solar radiation in earth‘s atmosphere.

Books

1. V.S Arpaci – Conduction HeatTransfer
2. E.M Sparrow, R.D Cess – Radiation HeatTransf
3. R.Siegal and J.R Howell-Thermal radiation heattransfer.
4. Y.A.Sengel, Heat Transfer, TataMcGrawHill
5. Krith, Fundamentals of HeatTransfer
6. Ozisik, Heat Transfer, JohnWiley

PE 1: Experimental Methods in Thermal Engineering (PPEME103)

Module I
Theory and Experimentation in Engineering: Problem solving approaches, Types of engineering experiments, computer simulation and physical experimentation; Generalized measuring system, types of inputs, analog and digital signals, standards, calibration and uncertainty, Measurement System: Performance characteristics, static performance characteristics-static calibration-linearity, static sensitivity, repeatability, hysteresis- threshold- resolution, readability and span;

Module II
Analysis of Experimental Data : Causes and types of experimental error, un-certainty analysis, statistical analysis of data, probability distributions and curve fitting; Dynamic performance characteristics;Inputtypes;Instrumenttypes-zeroorderinstrument,firstorderinstrument,second order instrument; Experiment Plans: Model building; Measurement Methods and Applications : Measurement of force and torque; Measurement of strain and stress; Measurement of pressure; Flow measurement and flow visualization; measurement of temperature; optical methods of measurements;

Module III
Data Acquisition and Processing: Types and configurations of DAS, signal conditioning, A/D, D/A conversion; Design, Planning, Execution and Analysis of experimental projects.

Books:

1. Beckwith, Buck, and Marangoni, Mechanical Measurements, Narosa Publishing House, 1995.
2. Doeblin, Measurement Systems - Application and Design, 4e, McGraw-Hill,1990.
3. Holman, Experimental Methods for Engineers, 6e, McGraw-Hill,1994.
4. Doeblin, Engineering Experimentation, McGraw-Hill,1995.

PE 1: Refrigeration Systems (PPEME105)

Module I
Simple air refrigeration cycle, Analysis of aircraft refrigeration cycle with bootstrap, regeneration and reduced ambient and their applications. Vapor compression refrigeration (VCR) cycle with superheating and sub-cooling, thermodynamic calculation of VCR with numerical problems, actual vapor compression cycle, multi-pressure stage compression with flash cooler and intercooler, multi-evaporative systems, multi-expansion and cascade system. Manufacturing of dry-ice.

Module II
Thermodynamic Properties of pure and mixed refrigerants. Eco-friendly Refrigerants, vapour absorption cycle and its components. Ejector Refrigeration System, Vortex Tubes, Pulse tube-refrigeration system, Principle of liquefaction of gases, Magnetic Refrigeration Systems, thermo-electric refrigeration system, three-fluid refrigeration systems, steam-jet refrigeration system.

Module III
Analysis and thermal design of Refrigeration compressor, condenser, evaporator and flow control devices; Design, Lubrication, charging and testing of refrigeration plants, defrosting capacity control, system component balancing, Design and construction details of unitary refrigeration equipment.

Books

1. Refrigeration and Air conditioning, R. C. Arora, PHI PublishingHouse
2. Refrigeration and Air Conditioning, C.P. Arora, Tata McGraw Hill
3. Refrigeration and Air Conditioning, Stoecker and Jones, McGraw Hill
4. Refrigeration and Air Conditioning, Domkundwar and Arora, Dhanpat Rai andSons
5. Refrigeration and Air Conditioning, Manohar Prasad, East WestPress
6. Refrigeration and Air Conditioning, P.L. Balaney
7. Air conditioning and Refrigeration, S. K. Wang and Z. Lavan, CRC Press
8. ASHREE Hand book Series

PE 1: Design of Thermal Systems (PPEME106)

Module I
Modeling of Thermal Systems: types of models, mathematical modeling, curve fitting, linear algebraic systems, numerical model for a system, system simulation, methods for numerical simulation;

Module II
Acceptable Design of a Thermal System: initial design, design strategies, design of systems from different application areas, additional considerations for large practical systems; Economic Considerations: calculation of interest, worth of money as a function of time, series of payments, raising capital, taxes, economic factor in design, application to thermal systems;

Module III
Problem Formulation for Optimization: optimization methods, optimization of thermal systems, practical aspects in optimal design, Lagrange multipliers, optimization of constrained and unconstrained problems, applicability to thermal systems; search methods: single-variable problem, multivariable constrained optimization, examples of thermal systems; geometric, linear, and dynamic programming and other methods for optimization, knowledge-based design and additional considerations, professional ethics.

Text Books
1. W.F. Stoecker, Design of Thermal Systems - McGraw-Hill, 1971

References
1. Y. Jaluria, Design and Optimization of Thermal Systems –CRC Press, 2007.
2. Bejan, G. Tsatsaronis, M.J. Moran, Thermal Design and Optimization - Wiley, 1996.
3. R. F. Boehm, Developments in the Design of Thermal Systems - Cambridge University Press, 1997.
4. N. V. Suryanarayana, Design & Simulation of Thermal Systems - MGH,2002.

PE 1: Environmental Pollution and Abetment (PPEME107)

Module I
Introduction: Industrial pollution, Different types of wastes generated in an industry, Different water pollutants, Air pollutants and solid wastes from industry, Their effects on living and non-living things, Environmental regulatory legislations and standards, Importance of industrial pollution abatement, Concept of sustainable development, Greenhouse gases, Global warming and climate change, Mass and energy balance with and without reaction.

Module II
Water Pollution: Identification, quantification and analysis of wastewater, Classification of different treatment methods into physico-chemical and biochemical techniques, Physico-chemical methods, General concept of primary treatment, Liquid-solid separation, Design of a settling tank, Neutralization and flocculation, Disinfection, Biological methods, Concept of aerobic digestion, Design of activated sludge process, Concept of anaerobic digestion, Biogas plant layout, Different unit operations and unit processes involved in conversion of polluted water topotable standards.

Module III
Air Pollution: Classification of air pollutants, Nature and characteristics of gaseous and particulate pollutants, Analysis of different air pollutants, Description of stack monitoring kit and high volume sampler, Atmospheric dispersion of air pollutants, Gaussian model for prediction of concentration of pollutant down wind direction, Plume and its behavior, Operating principles and simple design calculations of particulate control devices, Brief concepts of control of gaseous emissions by absorption, adsorption, chemical transformation and combustion.
Solid Wastes: Analysis and quantification of hazardous and non-hazardous wastes, Treatment and disposal of solid wastes, Land filling, Leachate treatment, Incineration.
Environmental Management System: Environment impact assessment, Its concept and constituents, Environmental audit, ISO-14000 system.

Text Books:
1. Peavy, H.S., Rowe, D.R., and Tchobanoglous, G. Environmental Engineering, McGraw Hill International (1985).

2. Metcalf & Eddy, Wastewater Engineering, Tata McGraw-Hill Education Private Limited (2009).

Reference Books:

1. Masters, G.M., Introduction to Environmental Engineering and Science, Prentice Hall of India, (2008).
2. Rao, C.S., Environmental Pollution Control Engineering, Wiley Eastern (2010). 3. De Nevers, N., Air Pollution Control Engineering, McGraw-Hill (2000).

PE 2: Automotive Power (PPEME116)

Module I

Introduction – Historical Review- Effect of design and operating parameters of cycle efficiency. Modified fuel-air cycle considering heat losses and valve timing. Engine dynamics and torque analysis. Use of Combustion chart. Thermodynamic cycle with supercharging both S.I. and C.I. Engines. Limits of Supercharging. Methods of Supercharging and Superchargers. Effect on Lubricating oils, Gaseous Alternative Fuels, Hydrogen, Compressed Natural Gas, Liquified petroleum Gas, Di-methyl ether, Hythane, Multi-fuel engines,

Module II

Electronic fuel injection system (MPFI, different sensors etc.) Fuels and combustion in S.I. engines, knocking and fuel rating. Delay period, Energy balance, volumetric efficiency, measurement of indicated and brake power. Advanced theory of carburetion. Fuel Injection Systems for S.I. and C.I. Engines. Ignition system: conventional and electronic. Variable compression ratio engine. Theoretical analysis, methods of obtaining variable compression ratio, Wankel rotary combustion engine, Stratified charged engine, Methods of charge stratification, Dual fuel and Multifuel engines, Biofuels, Variable Valve timing engines, Exhaust emissions, its measurement and control. Fault diagnosis of S.I. Engines.

Module III

Modern developments in IC Engines-SI and CI Engine Simulation. Lean Burning and Adiabatic concepts - Rotary Engines - Modification in I.C engines to suit Bio – fuels. HCCI and GDI concepts, Reactivity controlled compression ignition (RCCI), Premixed Charge Compression Ignition (PCCI) Engines, Hybrid electric vehicles (HEVs), EGR, MPFI, Turbocharged engines, Optical Measurement techniques, Fuel atomization and spray visualization techniques, Laser doppler Anemometry, Particle image velocimetry, 3D and Holographic PIV, optical engines etc.

Books

1. Fundamentals of I.C. Engines by H.B. Heywood, McGraw Hill
2. Engineering fundamentals of the Internal Combustion Engine, Willard W. Pulkrabek, Pearson New International Edition

3. I.C. Engine Theory and Practices, Vol. I & II C.F. Taylor, MIT Press I.C. Engine, Mathur and Sharma, Dhanpat Rai and Sons Fundamentals of I.C. Engine by Ganeshan, Tata McGraw Hill
4. Computer Simulation of Spark Ignition Engine Processes, V. Ganesan, Universities Press.
5. Introduction to Modeling and Control of Internal Combustion Engine Systems, Lino Guzzella, Christopher Onde, Springer,2010.

PE 2: Gas Dynamics (PPEME117)

Module I

Fundamental Aspects of Gas Dynamics: Introduction, Isentropic flow in a stream tube, speed of sound, Mach waves; One dimensional Isentropic Flow: Governing equations, stagnation conditions, critical conditions, maximum discharge velocity, isentropic relations; Normal Shock Waves: Shock waves, stationary normal shock waves, normal shock wave relations in terms of Mach number;

Module II

Oblique Shock Waves: Oblique shock wave relations, reflection of oblique shock waves, interaction of oblique shock waves, conical shockwaves; Expansion Waves: Prandtl-Meyer flow, reflection and interaction of expansion waves, flow over bodies involving shock and expansion waves; Variable Area Flow: Equations for variable area flow, operating characteristics of nozzles, convergent-divergent supersonic diffusers; Adaiabatic Flow in a Duct with Friction: Flow in a constant area duct, friction factor variations, the Fanno line;

Module III

Flow with Heat addition or removal: One-dimensional flow in a constant area duct neglecting viscosity, variable area flow with heat addition, one-dimensional constant area flow with both heat exchanger and friction; Generalized Quasi-One-Dimensional Flow: Governing equations and influence coefficients, solution procedure for generalized flow with and without sonic point; Two- Dimensional Compressible Flow: Governing equations, vorticity considerations, the velocity potential, linearized solutions, linearized subsonic flow, linearized supersonic flow, method of characteristics.

Text Books

1. L. D. Landau and E. M. Lifshitz, Fluid Mechanics. 2nd ed., Butterworth-Heinemann, 1995.
2. H. W. Liepmann, and A. Roshko, Elements of Gas Dynamics, Dover Pub, 2001.

References

1. P. H. Oosthuizen and W. E. Carscallen. Compressible Fluid Flow. NY, McGraw-Hill, 1997.
2. M. A. Saad, Compressible Fluid Flow. 2nd ed. Upper Saddle River, NJ: Prentice-Hall, 1993.
3. F. M. White, Viscous Fluid Flow. 2nd ed. New York: McGraw-Hill, 1991.
4. A. H. Shapiro, Compressible Fluid Flow 1 and 2. Hoboken NJ: John Wiley.

PE 2: Power Plant Practice and Control (PPEME118)

Module I

Overview of the Indian power sector, Thermodynamic analysis of conventional power plants. Advanced cycles, (combined cycles), IGCC, AFBC/PFBC, Overview of Nuclear power plants, Radio activity, Cross section, Fission process, reaction rates, diffusion theory, elastic scattering and showing down, criticality calculations, critical heat flux, power reactors, nuclear safety.

Module II

Steam Turbine- superheater, reheater and partial condenser vacuum. Combined feed heating and Reheating Regenerative Heat Exchangers, Reheaters and Intercoolers in Gas turbine power plants. Hydro power plants
– turbine characteristic. Auxiliaries – water treatment systems, Electrostatic precipitator, Flue gas desulphurisation –coal crushing /preparation – Ball mills/ pulverisers, ID/FD fans, Chimney cooling Towers, Power plants control systems -Review of control principles, combustion control, pulveriser control, control of airflow, furnace pressure and feedwater, steam temperature control, safety provision/ Interlocks. Analysis of system load curve- plant load factor, Energy Auditing, Methodology

Module III

Environmental impacts of energy Use-Air pollution –SOX, NOX, CO, particulates solid and water pollution formation of pollutants measurement and controls; sources of emission effect of operating and design parameters on emission, control method, exhaust emission test, procedure standards and legislation; environmental audits; emission factors and inventories Global warming, CO emission, impacts, mitigation sustainability, externalities, future energy Systems.

BOOKS:

1. Power Plant Technology, M. M. Wakill, Tata McGraw Hill
2. Power Plant Engineering, P. K. Nag Tata McGraw Hill
3. Boiler Control Systems, Lindsay, McGraw Hill International, London
4. Power Generation Operation and Control, A.J. Wood and B.F. Woolenberg, John Wiley, New York

PE 2: Heat Exchanger Analysis and Design (PPEME119)

Module I
Introduction to Heat Exchangers: Classification, Significance, Applications, fluid flow arrangement, Recuperators and Regenerators, Performance evaluation of Heat Exchangers: Overall heat transfer coefficient, LMTD method for parallel, counter, multi-pass and cross flow heat exchanger, effectiveness-NTU method for heat exchanger analysis, fouling factor, Effects, techniques to control fouling, Rating and sizing problems.

Module II
Flow distribution: Effect of turbulence, Heat exchanger Pressure drop in tube side, tube bundles, bends, fittings, pumping power. Standards (TEMA). Flow induced vibrations.
Design of Shell and Tube Heat Exchanger: Basic components, basic design procedure of heat exchanger, J-factors, Tinker's, Kern's and Bell Delaware's method Design of Compact Heat Exchangers.

Module III
Design of Plate Heat Exchanger: Thermal Design of plate Heat Exchangers; condensers, boilers, cooling towers, Design of Compact Heat Exchangers.
Heat Transfer Enhancement and Performance Evaluation: Enhancement of heat transfer, Performance evaluation of Heat Transfer Enhancement technique

Text Books:
1. Sadik Kakac, and Hongtan Liu, "Heat Exchangers: Selection, Rating and Thermal Design", 2nd edition, CRC Press, 2002
2. R. K. Shah, D. P. Sekulic, "Fundamentals of Heat Exchanger Design", John Wiley and Sons, Inc., 2003.
3. D. C. Kern, "Process Heat Transfer", McGraw Hill,1950.
4. W. M. Kays and A.L. London., Compact Heat Exchangers', 3rd Ed., Tata McGraw Hill

Reference Books:

1. T. Kuppan, “Hand Book of Heat Exchanger Design”.
2. “T.E.M.A. Standard”, New York, 1999
3. Yonous A. Cengel, Heat transfer: A Practical Approach, Tata McGrawHill,2002

MC: Research Methodology & IPR (PMCMH101)

Module I:

Introduction to RM: Meaning and significance of research. Importance of scientific research in decision making. Types of research and research process. Identification of research problem and formulation of hypothesis. Research Designs.

Types of Data: Primary data Secondary data, Design of questionnaire; Sampling fundamentals ad sample designs, Methods of data collection, Measurements and Scaling Techniques, Validity & Reliability Test.

Module II:

Data Processing and Data Analysis-I, Data editing, Coding, Classification and Tabulation, Descriptive and Inferential Analysis, Hypothesis Testing- Parametric Test (z test, t test, F test) and non-parametric test (Chi square Test, sign test, Run test, Krushall-wallis test).

Module III:

Data Analysis II: Multivariate Analysis- Factor Analysis, Multiple Regression Analysis. Discriminant Analysis, Use of Statistical Packages.

Reference Books:

1. Research Methodology, Chawla and Sondhi, Vikas
2. Research Methodology, Paneerselvam, PHI

Course Outcomes:

CO1: Understood the Meaning of research problem, Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.
CO2: Got the knowledge of How to get new ideas (Criticizing a paper) through the Literature Survey (i.e. Gap Analysis).
CO3: Understood the Filing patent applications- processes, Patent Search, Various tools of IPR, Copyright, Trademarks.

CO4: Understood How to apply for Research grants and Significance of Report Writing, Steps in Report Writing, Mechanics and Precautions of Report Writing, Layout of Research Report.
CO5: Got the knowledge of How to write scientific paper & Research Proposal - Structure of a conference and journal paper, how (and How Not) to write a Good Systems Paper:

Lab 1: Thermal Software Lab (PLCME103)

List of Experiments:

Lab 2: Advanced Thermal Engineering Lab-I (PLCME104)

List of Experiments:

Audit-1

[To be decided by the Department]: Refer Appendix-I

Semester-2

Core 3: Advanced Fluid Mechanics (ME) (PPCME205)

Module I
Concept of continuum, Body and surface forces, stress tensor, Scalar and vector fields, Eulerian and Lagrangian description of flow. Motion of fluid element - translation, rotation and vorticity; strain rate tensor, continuity equation, Stream function and vorticity equation.

Module II
Reynolds Transport theorems and its applications, constitutive equations, Stokes hypothesis and its use in the derivation of Navier Stokes equations for incompressible flow from. Exact solutions of Navier Stokes equations: plane Poiseuille flow and Couette flow, Hagen-Poiseuille flow, flow between two concentric rotating cylinders, Stoke's first and second problem, Hiemenz flow, flow near a rotating disk, Slow viscous flow: Stokes and Oseen's approximation, Theory of hydro dynamic lubrication.
Computer simulation of simple exact solutions of the N.S. equations

Module III
Boundary layer: Concept of Boundary layer development, Prandtl’s Boundary layer Equation for incompressible flow, Similarity solution methodology for Blasius, Falkner Skan equations using finite difference method (computer program in suitable any suitable language is desired). Approximate methods for boundary layer equations such as integral method. Boundary layer separation. Computer simulation of the boundary layer problems (Blasius and Falker Skan equations) through similarity solution
Turbulence: Description of turbulent flow, velocity correlations, RANS Equations, Reynolds stresses, Prandtl's Mixing Length Theory, Karman's velocity defect law, universal velocity distribution.

Books:

1. Viscous Fluid flow by F. M. White, Tata Mcgraw Hill
2. An Introduction to Fluid Dynamics by G. K. Batchelor, Cambridge University Press
3. Advanced Engineering Fluid Mechanics By Muralidhara and Biswas, Narosa Publishing house
4. Incompressible Flow by R. L. Panton Willy Publisher
5. Boundary layer Theory by Schlitching
6. Advanced Fluid Mechanics, Som and Biswas, Tata McGraw Hill Fluid Mechanics,
7. Introduction to Fluid Mechanics, Shaughnessy, Oxford University Press
8. Finite Difference computing with PDEs: A modern software approach by Hans Petter Langtangen, Svein Linge
9. Engineering Equation Solver: Application to Engineering and Thermal Engineering Problems by Sukanta K. Dash Narosa Publishing House

Core 4: Convective Heat and Mass Transfer (PPCME206)

Module I

Fundamentals of Convection, Physical Mechanism of Convection, Classification of Fluid Flows, Velocity Boundary Layer, Thermal Boundary Layer, Laminar and Turbulent Flows, Heat and Momentum Transfer in Turbulent Flow, Derivation of Convection Equations for a Flat Plate, Solutions of Convection Equations for a Flat Plate, Non dimensionalized Convection Equations and Similarity, Functional Forms of Friction and Convection Coefficients, Analogies between Momentum and Heat Transfer

External Forced Convection, Drag and Heat Transfer in External Flow, Parallel Flow over Flat Plates, Flow Across Cylinders and Spheres, Flow Across Tube Banks

Internal Forced Convection, Average Velocity and Temperature, The Entrance Region, General Thermal Analysis, Laminar Flow in Tubes, Turbulent Flow in Tube

Module II

Natural Convection, Physical Mechanism of Natural Convection, Equation of Motion and the Grashof Number, Natural Convection over Surfaces, Natural Convection from Finned Surfaces and PCB, Natural Convection into Enclosures, Combined Natural and Forced Convection, combined forced and free convection combined convection

Boiling and Condensation: Boiling – Pool and flow boiling, correlations. Condensation – modes and mechanisms – correlations and problems.

Module III

Heat Exchanger and Mass Transfer-Heat exchanger: types–LMTD method and the effectiveness–NTU method. Analogy Between Heat and Mass Transfer, Mass Diffusion, Boundary Conditions, Steady Mass Diffusion through a Wall, Transient Mass Diffusion, Diffusion in a Moving Medium, Mass Convection, Simultaneous Heat and Mass Transfer. Fick‘s law of diffusion – mass diffusion equation, Equimolar counter diffusion – convective mass transfer. Evaporation of water into air.

Essential Readings:

1. J.P. Holman., ‘Heat and Mass Transfer’, Tata McGraw Hill, 8th Ed.,1989.
2. D.D. Kern, ‘Extended Surface Heat Transfer’, New Age International Ltd.,1985.

Supplementary Reading:

1. F.P. Incropera and D. P. Dewit, ‘Fundamentals of Heat and Mass Transfer’, 4th Ed., John
2. Wiley & Sons,1998.
3. C.P. Kothandaraman., _Fundamentals of Heat and Mass Transfer’, 2nd Ed., New Age International, 1997.
4. E.R.D Eckert and R.M. Drake, _Analysis of Heat and Mass Transfer’, McGraw Hill,1980.
5. Kays, W.M. and Crawford W., _Convective Heat and Mass Transfer’, McGraw Hill Inc.,1993.
6. Burmister L.C., ‘Convective Heat Transfer’, John Willey and Sons,1983.

PE 3: Air Conditioning & Ventilation Systems (PPEME208)

Module I

Psychometry: simple psychometrics processes, use of psychometrics chart.; Summer Air–conditioning, Winter Air-Conditioning, Comfort and industrial air conditioning; Design Conditions, ventilation loads, Comfort air-Conditioning, Physiological factors. Comfort index.

Module II

Load Estimation, Applied Psychrometrics Air conditioning systems: Spray systems, chilled water and DE Coils, absorption and adsorption systems. Humidifiers.; Principles of ventilation. Air filtration, Air conveying Fans, ducts and air diffusion equipment. Estimation of air conditioning load, determination of supply state.

Module III

Design and constructional details of Unitary air conditioning equipment.; Noise level and acoustic control. Automatic controls in air conditioning.

Note: Students are encouraged to use Cycle pad software which is an open source software.

Text book

1. W.F. Stoecker, and J.W. Jones, Refrigeration and Air Conditioning, 2nd Edition, Tata McGraw Hill, New Delhi1982.
2. ASHRAE Handbook-Fundamentals, American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc., Atlanta, USA,1997.
3. W.R Haines and C.L Wilson, HVAC Systems Design Handbook, McGraw Hill, 2nd Ed., New Delhi, 1994.
4. R.C Legg, Air Conditioning Systems-Design, Commissioning and maintenance, Batsford Ltd, London 1991.

PE 3: Gas Turbine & Jet Propulsion (PPEME209)

Module I

Introduction, application, shaft power gas dynamics – Compressibility effect, steady one dimensional compressible flow of a perfect gas in a duct, isentropic flow in a constant area duct with friction, normal shock waves, oblique shock wave, isentropic two dimensional, supersonic expansion and compression.;

Module II

Centrifugal fans Blowers and Compressors: Principle of operations, work done and pressure rise, slip factor, diffusers, compressibility effects, non-dimensional qualities for plotting compressor characteristics. Brayton cycle, regeneration and reheating cycle analysis; Axial flow fans and compressors: Elementary theory, degree of reaction, three dimensional flow, simple design methods, blade design, calculation of stage performance, overall performance, and compressibility effects. Performance characteristics.

Module III

Combustion system: Form of combustion, important factors affecting combustion chamber design, combustion processes, combustion chamber performance, practical problem. ; Axial flow turbines: elementary theory, vortex theory, choice of blade profile, pitch and chord ; estimation of stage performance, he cooled turbine. ; Prediction of performance of simple gas turbines: component characteristic, off design shaft gas turbine, equilibrium running gas generators, off design o free turbine and jet engine, methods of displacing the equilibrium, running line, incorporation of variable pressure losses, methods of improving part load performance, matching procedure for twins pool engines, behavior of gas turbine .Gas turbine rotors and stresses.

Text books

1. J.E Lee, Theory and design of stream and gas turbine

2. Cohen & Rogers, Gas Turbines
3. Design and Analysis of Gas-turbines, Cumsty

PE 3: Theory of Combustion and Emission (PPEME210)

Module I
Cycle Analysis; Gas, steam and combined power cycles, refrigeration and air conditioning cycles, second law analysis.
Combustion Theory; Fuels and types, combustion process, combustion mechanism, adiabatic flame temperature, flame propagation, stability, kinetics, combustion, aerodynamics, gaseous detonations, flame ignition and extinction and condensed phase combustion, combustion in SI and CI engines, ignition and burning rate analysis.

Module II
Combustion Systems; Solid burning equipments, strokers, pulverized coal burning systems, cyclone combustors, emissions, types of fluidized beds, fluidized bed combustion, fundamentals bubbling bed, gas and liquid burners types, gas turbine combustion systems, combustion modeling. Design of Advanced Combustion Systems; Design of combustion systems for boilers furnaces, gas turbines and internal combustion engines, different combustion chamber performance.

Module III
Types, theory of combustion, energy balance calculations, Emissions from combustion: constituents and types of emission, mechanisms of hydrocarbon and particulate emissions, theories of soot and NOx formation. Control of emissions, modeling of emissions.

Books

1. C. R. Ferguson and A.T. Krik Patrick, - Internal Combustion Engine, John Wiley & Sons. Inc. 2001.
2. Stephen R Turns, - Introduction to Combustion: Concepts and Applications, McGraw Hill,2000.

3. G.L. Borman and K.N. Ragland, - Combustion Engineering, McGraw Hill,1998.
4. D. Winterbone, - Advanced Thermodynamics for Engineers, Elsevier,1996

PE 4: Computational Methods in Thermal Engineering (PPEME220)

Module I

Introduction: Introduction to computational methods in science and engineering, Numerical interpolation, integration, Numerical solution of Boundary and initial value (BVP/IVP) problems, introduction to finite difference method and its implementation to express different derivatives. Different Finite difference (FDM) schemes consistency, stability analysis and convergence of numerical schemes. Various finite difference and finite element methods and their applications to fundamental partial differential equations in engineering and applied sciences. Case studies selected from fluid mechanics and heat transfer with computer program. Computer programs on numerical interpolation, integration and BVP/IVPs

Module II

Finite Difference Method: Types of boundary conditions, different difference schemes for uniform and non-uniform Grids, Grid Independence Test. Basic finite difference schemes. Boundary treatments. Fourth order RK methods and Predictor – corrector methods and Nachsheim-Swigert iteration with applications to flow and heat transfer. Parabolic and hyperbolic problems. Problem solving through FDM using some appropriate computer software.

Module III

Model problems and stability estimates. Examples of the methods of lines. The Lax-Richtmyer equivalence theorem. Stability analysis. Discrete Fourier series. Von- Neumann stability analysis. Consistency, convergence and error estimates. Keller Box and Smith‘s method with applications to thermal boundary layers.; Convection dominated problems: The failure of standard discretization, Upwinding and Higher order methods.

Books:

1. S. V. Patankar, "Numerical heat transfer fluid flow", Hemisphere Publishing Co,1980.
2. C. A. J. Fletcher, "Computational Techniques for Fluid Dynamics", Fundamental and General Techniques, Springer-Verlag,1987.
3. K. Muralidhar and T. Sundararajan, "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi1995
4. S. K. Dash, Engineering Equation Solver, "Applications to Engineering and Thermal Engineering Problems", Narosa Publishing House, India
5. D. A. Anderson, I. I. Tannehill, and R. H. Pletcher, "Computational Fluid Mechanics and Heat Transfer", Hemisphere Publishing Corporation, New York, USA,1984.
6. P. S., Ghosh dasdidar, "Computer Simulation of flow and heat transfer" TMH Ltd.,1998.
7. T. K. Bose, "Numerical Fluid Dynamics" Narosa Publishing House,1997

Recommended Computer software:
C, C++, Fortran, Matlab, EES, Python (any one of these)

PE 4: Computational Fluid Dynamics (ME) (PPEME221)

Module I
Introduction: Basic tools of CFD, Numerical Vs experimental tools.; Mathematical Behavior of PDEs: Parabolic, Hyperbolic and Elliptic PDEs.; Methodology of CFDHT: Discrete representation of flow and heat transfer domain: Grid generation, Governing equations and boundary conditions based on FVM/FDM, Solution of resulting set of linear algebraic equations, Graphical representation and analysis of qualitative results,

Module II
Error analysis in discretization using FVM/FDM, Solution of 1-D/2-D steady/unsteady: Diffusion problems, Convection problems, Convection-diffusion problems, source term linearization; Explicit and Implicit Approach: Explicit and implicit formulation of unsteady problems, Von Numann Stability analysis.

Module III
Solution of Navier-Stokes Equations for Incompressible Flows: Staggered and collocated grid system, SIMPLE and SIMPLER algorithms.; Special Topics in CFDHT: Numerical Methodology for Complex Geometry, Multi-block structured grid system, Solution of phase change Problems. Particle dispersion technique and its tracking by ultrasonic dispersion method.

Books
1. S.V. Patankar, Numerical Heat Transfer and Fluid Flow, Taylor and Francis, ISBN-10: 089116522

Supplementary Reading:

1. H. K. Versteeg and W. Malalasekra, Introduction to Computational Fluid Dynamics: The Finite Volume Method, Prentice Hall (2nd Edition), ISBN-10:0131274988.
2. Jr. D. A. Anderson, Computational Fluid Mechanics and Heat Transfer by McGraw-Hill Education
3. M. N. Ozisik, Finite Difference Method, CRC (1stEdition).

PE 4: Turbulent Flow (PPEME222)

Module I

Introduction: Nature of turbulent flows, irregularity, diffusivity, three-dimensional motions, dissipation, wide spectrum, origin of turbulence, eddy motions and length scales. Statistical Description of Turbulence: Random nature of turbulence, distribution function, probability density, moments, correlations, Taylor's hypothesis, integral micro scales, homogeneous and isotropic turbulence, Kolmogorov hypothesis, scales of turbulence, energy cascade, turbulence spectra.

Module II

Turbulent Transport of Moment and Heat: Reynolds decomposition, turbulent stresses, vortex stretching, Reynolds equations, mixing-length model, Reynolds' analogy, dynamics of turbulence, Free Shear Flows, Mixing Layer, Turbulent Wakes and Jets, Grid Turbulence.

Module III

Wall-Bounded Turbulent Flows: Channel and pipe flows, Reynolds stresses, turbulent boundary layer equations, logarithmic-law of walls, turbulent structures. Turbulence Modelling: Introduction, eddy- viscosity hypothesis, algebraic model, k-ε and k-ω model, Reynolds-stress model, near-wall treatment (Logarithmic law, Enhanced wall Treatment, RNG wall function), LES and DNS (only brief introduction). Experimental Methods:
Introduction, hot wire anemometry, uncertainty analysis (Kline method of computing the uncertainty analysis) and laser doppler anemometry.

Books:

1. Turbulent Flows, Stephen B. Pope, Cambridge University Press

2. A First Course in Turbulence, H. Tennekes and J. L. Lumley, MIT Press
3. Turbulence modelling, D. C. Wilcox
4. Turbulent Flows, P. A. Davidson

PE 4: Two-phase flow (PPEME223)

Module I

Introduction: Introduction to phase change flow and heat transfer technology, Various industrial applications, Revision of Basic thermodynamics and heat transfer.
Interfacial Phenomena & Phase Transitions: Interfacial tension, wetting phenomenon and contact angles, Phase stability and nucleation.

Module-II

Boiling and Condensation Heat Transfer: Boiling Fundamentals, Homogeneous and heterogeneous nucleation, Pool Boiling and Convective Flow Boiling, Heat Transfer and CFH mechanisms, Enhancement techniques External and Internal condensation, Film condensation theory, Dropwise Condensation theory, Enhancement techniques.

Two Phase Flows: Introduction to two-phase flows, Flow Patterns, Flow pattern Maps, Development of Homogeneous, Separated Flow and Drift Flux Models, Two-phase flow instabilities.

Module III

Measurement Techniques in Boiling and Condensation: Void Fraction measurement techniques, Visualization techniques, Contact angle/Surface tension measurement, Conventional thermometry, Data reduction, Applications.

Applications of Phase Change Technology: Boilers / Evaporators and Condensers for Nuclear / Power / RAC industry, Electronics thermal management, Gravity assisted thermos syphons / Vapor chambers, Conventional heat pipes

Micro heat pipes, Capillary pumped loops/ Loop heat pipes, Micro two-phase heat exchangers

Books

1. Liquid Vapor Phase Change Phenomena, by Van P. Carey (Taylor &Francis)
2. Heat Pipe Science and Technology, Amir Faghri (Taylor and Francis)
3. One Dimensional Two-Phase Flow, G. B. Wallis (McGraw Hill)
4. Heat Transfer Characteristics in Boiling and Condensation, Karl Stephan(Springer)
5. Convective Boiling and Condensation, Collier John (Oxford Engineering Science)
6. Two-phase Flow and Heat Transfer, P. B. Whalley (Oxford Engineering Science)
7. Heat Pipe Technology and Applications, J. P. Peterson (John Wiley &Sons)
8. Heat pipes, David Reay
9. Heat Transfer – A practical approach, Yunus Cengel (Tata McGraw Hill)
10. Heat Transfer – Incropera and Dewitt, John Wiley and Sons

Mini Project with Seminar (PPRME201)

[To be decided by the Department]

Lab 3: Advanced Thermal Lab-II (PLCME204)

List of Experiments:

Lab 4: Computational Techniques and Soft Computing Lab (PLCME202)

List of Experiments:

Audit-2

[To be decided by the Department]: Refer Appendix-II

Semester-3

PE 5: Renewable Energy Systems (PPEME309)

Module I
SOLAR ENERGY: Availability of solar energy, Measurement of sunshine, solar radiation data, estimation of average solar radiation, the black body, absorptance and emittance, Kirchoff's law. Reflection from surfaces, Solar energy selection, selective surfaces, Construction of solar flat plate and evacuated tube collectors, Performance of solar energy collectors, Solar heating and cooling. Wind mills and wind turbine systems, Classification of wind machines: Horizontal & Vertical axis configuration. High and low solidity rotors, Elements of wind mills and wind turbine systems, Aerodynamic models, Rankine Froud Actuator disc model, Betz limit, angular momentum wake rotation theory, Aerofoil sections and their characteristics, Estimation of power output and energy production.

Module II
OCEAN THERMAL ENERGY: Ocean thermal energy sources, Ocean thermal energy power plant development, Closed and open cycles. Advantages and operating difficulties. TIDAL & WAVE ENERGY Tidal power sources, Conventional and latest design of tidal power system, The ocean wave, Oscillating water column (Japanese) and the Dam, Atol design. GEOTHERMAL ENERGY: Earth as source of heat energy, stored heat and renewability of earth's heat, Nature and occurrence of geo thermal field, Classification of thermal fields, Model of Hyper thermal fields & Semi thermal fields, drilling hot water measurements. FUEL CELL ENERGY: Description, properties and operation of fuel cells, Major components & general characteristics of fuel cells, Indirect methanol fuel cell systems. Phosphoric acid fuel cell systems and molten carbonate fuel cell systems.

Module III

BIOMASS ENERGY: Types of conversion techniques for the production of solid, liquid and gaseous fuels by chemical and biochemical methods, and Biomass gasifiers- Selection of a model and size, Technical, Climatic, geographical and economic issues.

BOOKS:

1. Principles of Solar Engineering: F. Kreith & J. F. Krieder / McGraw Hill Book Co
2. Solar Energy: Sukhatme and Nayak
3. Wind Energy Conversion Systems: L. C. Freris, Prentice Hall, Inc.
4. Non-conventional Energy Sources: G.D. Rai
5. Energy Technology: S. Rao & B. B. Parulekar

PE 5: Nuclear Power Generation and Safety (PPEME310)

Module I

Introduction, Why Nuclear Power for Developing Countries, Atomic Nuclei, Atomic Number and Mass Number, Isotopes, Atomic Mass Unit, Radioactivity and Radioactive Change Rate of Radioactive Decay, Mass – Energy Equivalence, Binding Energy, Release of Energy by Nuclear Reaction, types of Nuclear Reactions, Initiation of Nuclear Reaction, Nuclear Cross – section, Nuclear Fission, The Fission Chain Reaction, moderation, Fertile Materials and Breeding.

Module II

Nuclear Reactors: Introduction, General Components of Nuclear Reactor, General Problems of Reactor Operation, Different Types of Reactors, Pressurised Water Reactors (PWR), Boiling Water Reactors (BWR), Heavy Water – cooled and Moderated CANDU (Canadian Deuterium Uranium) Type Reactors, Gas-cooled Reactors, Breeder Reactors, Reactor Containment Design, Location of Nuclear Power Plant, Nuclear Power Station in India, India's 3-stage Programme for Nuclear Power Development, Comparison Nuclear Plants with Thermal Plants.

Nuclear Materials: Introduction, Fuels, Cladding and Structural Materials Coolants, Moderating and Reflecting Materials, Control Rod Materials, Shielding Materials.

Module III

Nuclear Waste & Its Disposal: Introduction, Unit of Nuclear Radiation, Types of Nuclear Waste, Effects of Nuclear Radiation, Radioactive Waste Disposal System, Gas Disposal System.

Safety Rules: Personal Monitoring, Radiation Protection (Radiation Workers, Non-Radiation Workers, Public at large), Radiation Dose (Early effect, Late effect hereditary effect)

Text books

1. M. M. EI. Wakil., ‗Nuclear Power Engineering', McGraw Hill Book Company, New York, 1987.
2. S. Glasstone and A. Setonske., Nuclear Reactors, Engineering, 3rd Ed., CBS Publishers and Distributors, 1992. Reference Loftness, Nuclear Power Plants, D. Van Nostrand Company Inc, Princeton, 1964.
3. P. K. Nag "Power Plant Engineering", Tata McGraw Hill

PE 5: Energy Economics and Auditing (PPEME311)

Module I

Engineering Economics – Nature and scope, General concepts on micro & macroeconomics. The Theory of demand, Demand function, Law of demand and its exceptions, Elasticity of demand, Law of supply and elasticity of supply. Determination of equilibrium price under perfect competition (Simple numerical problems to be solved). Theory of production, Law of variable proportion, Law of returns to scale.

Time value of money – Simple and compound interest, Cash flow diagram, Principle of economic equivalence. Evaluation of engineering projects – Present worth method, Future worth method, Annual worth method, internal rate of return method, Cost-benefit analysis in public projects. Depreciation policy, Depreciation of capital assets, causes of depreciation, Straight line method and declining balance method.

Module II

Cost concepts, Elements of costs, Preparation of cost sheet, Segregation of costs into fixed and variable costs. Break-even Analysis-Linear approach. (Simple numerical problems to be solved) Banking: Meaning and functions of commercial banks; functions of Reserve Bank of India. Overview of Indian Financial system.

Mauditing & targeting – Economics of various Energy Conservation schemes. Total Energy Systems Energy Audit -various Energy Conservation Measures in Steam -Losses in Boiler.

Module III

Energy Conservation in Steam Systems -Case studies. Energy conservation in Centrifugal pumps, Fans &Blowers, Air compressor – energy consumption & energy saving potentials – Design consideration. Refrigeration & Air conditioning - Heat load estimation -Energy conservation in cooling towers & spray ponds – Case studies Electrical Energy -Energy Efficiency in Lighting. Organizational background desired for energy management motivation, detailed process of M&T-Thermostats, Boiler controls- proportional, differential and integral control, optimizers; compensators.

Books:

1. Riggs, Bedworth and Randhwa, "Engineering Economics", McGraw Hill Education India.
2. D.M. Mithani, Principles of Economics. Himalaya Publishing House
3. Eastop T.D & Croft D.R, Energy Efficiency for Engineers and Technologists, Logman Scientific & Technical, ISBN-0-582-03184, 1990.
4. Reay D.A, Industrial Energy Conservation, 1stedition, Pergamon Press, 1977.

PE 5: Waste Heat Recovery (PPEME312)

Module I

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

Module II

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.
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.

Module III

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. R. Gold Stick and A. Thumann, Principles of Waste Heat Recovery, PHI, 1986.
2. D. Y. Goswami, F. Kreith, Energy Conversion- CRC Press, 2007
3. EDUCOGEN – The European Educational tool for cogeneration, Second Edition, 2001
4. SenguptaSubrata, Lee SS EDS, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.
5. De Nevers, Noel, Air Pollution Control Engineering, McGrawHill, New York, 1995.

Open Elective

[To be decided by the Department]: Refer Appendix-III

Project 1: (PPRME301)

[To be decided by the Department]: Dissertation (Phase-I)

Semester-4

Project 2: (PPRME401)

[To be decided by the Department]: Dissertation (Phase-II)