COURSE STRUCTURE AND CURRICULUM

for

M. Tech Course

in

Mechanical Engineering

SPECIALIZATION: **HEAT POWER ENGINEERING**

(Approved by AICTE & Affiliated to
the West Bengal University of Technology,
Kolkata)

Departments of Mechanical Engineering,

Contents

PG COURSE (HEAT POWER)

FIRST YEAR FIRST SEMESTER

Sl.No.	Code	Theory	Contact Periods/Week				Credit
			L	T	P	Total	
1	M(MME)-101	Advanced Numerical Methods & Operation Research	3	1	0	4	4
2	MHPE-101	Advanced Thermodynamics	4	0	0	4	4
3	MHPE-102	Heat and Mass Transfer	4	0	0	4	4
4	MHPE-103	Advanced Internal Combustion Engine	4	0	0	4	4
5	Elective (Any one subject from following)						
	MHPE-104	a. Turbo-machinery	4	-	0	4	4
	MHPE-105	b. Advanced Power Plant Engineering					
	MHPE-106	C. Heat Exchangers System Design & Performance					
		Total Theory	19	1	0	20	20

Sl. No.	Code	Practical	Contact Periods/Week				Credit
			L	T	P	Total	
1	MHPE-191	Thermal Engineering Laboratory-I (Experiment on IC Engine, Fuel properties & Solar energy)	-	-	4	4	2
2	MHPE-192	Thermal Engineering Laboratory-II (Experiment on Heat transfer & Refrigeration)	-	-	4	4	2
3	MHPE-181	Seminar-I	-	2	-	2	1
		Total laboratory/practical				10	5
		Total Semester				30	25

FIRST YEAR SECOND SEMESTER

Sl. No.	Code	Theory		Contact periods/week			Credit
			L	T	P	Total	
1	MHPE-201	Computational Fluid Dynamics	4	-	-	4	4
2	MHPE-202	Renewable Energy	4	-	-	4	4
3	MHPE-203	Advanced Refrigeration and Air Conditioning	4	-	-	4	4
4	**Elective(Any two from following subjects)**						
	MHPE-204	Design of Thermal Power Plant Equipments	4+4	-	-	8	4+4
	MHPE-205	b. Nuclear Power Engineering					
	MHPE-206	c. Cryogenic Engineering					
	MHPE-207	a. Energy conservation & Management					
	MHPE-208	b. Solid & Hazardous Waste Management					
	MHPE-209	c. Design and Optimization of Energy systems					
Total Theory			20	-	-	20	20

Sl. No.	Code	Practical	Contact periods/week				Credit
			L	T	P	Total	
1	MHPE-291	Thermal Engineering Laboratory-III (CFD)	0	0	4	4	2
2	MHPE-281	Seminar- II	0	2	0	2	1
3	MHPE-282	Comprehensive viva-voce	0	0	0	0	4
		Total laboratory/practical				06	07
		Total				26	27

SECOND YEAR FIRST SEMESTER

Sl. No.	Code	Course of Study	Contact periods/week				Credit
			L	T	P	Total	
1	MHPE-381	Pre-submission Defense of Dissertation	-	-	-	-	4
2	MHPE-382	Dissertation (Progress)	-	-	-	24	18
		Total	-	-	-	24	22

SECOND YEAR SECOND SEMESTER

Sl. No.	Code	Course of Study	Contact periods/week				Credit
			L	T	P	Total	
1	MHPE-481	Dissertation (Completion)	-	-	-	24	18
2	MHPE-482	Post Submission Defense of Dissertation	-	-	-	-	6
		Total	-	-	-	24	24

Detailed Syllabus

FIRST YEAR FIRST SEMESTER

M (MME) – 101 : Advanced Numerical Methods & Operation Research

Contacts: 3L + 1T
Total Contact Hrs: 52
Internal Assessment: 30
Lecture: 39
Examinations: 70
Tutorial: 13
Total Marks: 100

Module	Topics & Content	Hours
	Section-A: Operation research	
1	**Linear Programming :** Lines and hyperplanes, convex sets, convex hull and their properties -Formulation of a Linear Programming Problem - Theorems dealing with vertices of feasible regions and optimality - Graphical solution - Simplex method (including Big M method); infeasible and unbounded LPP's, alternate optima - Dual problem and duality theorems - Dual simplex method and its application in post optimality analysis - Revised simplex method .	14
2	**Transportation problem:** Introduction - Basic feasible solution by north-west corner rule, Row minima and column minima methods, Vogel's approximation method - degeneracy - MODI method (including the theory).	3
3	**Assignment problem** : Hungarian method for solving assignment problems - travelling salesman problem.	2
4	**Integer Programming :** Gomory's cutting plane method for an integer linear programming problem and a mixed integer linear programming problem.	3
5	**Theory of Games:** Introduction – Minimax (maximin) – Criterion and	4

	optimal strategy – Solution of games with saddle points – Rectangular games without saddle points – 2 X 2 games – dominance principle – m X 2 & 2 X n games –graphical method.	

Module	Topics & Content	Hours
Section-B: ADVANCED NUMERICAL METHODS		
6	Review of solution of system of linear simultaneous equation-Gauss-Seidel Iteration Method, Relaxation Method. Solution of tridiagonal system, III conditioned system and iterative method to improve accuracy of an ill conditioned system. Evaluation of double integrals by numerical methods and its application, solution of nonlinear simultaneous equations by Newton-Raphson's Method, Central difference interpolation - Gauss, Stirling and Bessel's interpolation formula; Spline interpolation-cubic spline, Numerical solution of partial differential equations- Laplace and Poisson's equation; heat conductive and wave equations by finite difference method.	26

REFERENCES:

1. S.S. Sastry-'Introductory Methods of Numerical Analysis', PHI
2. B.S. Grewal and J.S. Grewal-'Numerical Methods in Engineering and Science', Khanna Publishers, Delhi
3. H.A.Taha-'An Introduction to Operations Research', PHI
4. Kanti Swarup et. al.-'Operations Research', Sultan Chand and Co.
5. J.B. Scarborough-'Numerical Mathematical Analysis', Oxford & IBH Publishing Co., New Delhi
6. M.K.Jain, S.R.K. Iyengar, R.K.Jain-'Numerical Methods for Scientific and Engineering Computation', New Age International (P) Ltd., Publishers
7. G. Shanker Rao-'Numerical Analysis', New Age International (P) Ltd., Publishers
8. E. Balagurusamy-'Numerical Methods', Tata Mc. Graw Hill Publishing Company Limited, New Delhi

9. Steven C. Chapra, Raymond P. Canale-'Numerical Methods for Engineers', Tata Mc. Graw Hill Publishing Company Limited, New Delhi
10. Wagner, H.M. - 'Principles of Operations Research', Printice-Hall of India, New Delhi
11. S.D.Sharma-'Operations Research', Kedarnath
12. J.K.Sharma-'Operation Research', MacMil

MHPE-101, Advanced Thermodynamics

Contacts: 4L

Total Contact Hrs:

Internal Assessment: 30

Examinations: 70

Module	Topics & Content	Hours
1	**Equation of State** State postulate for Simple System and equation of state, Ideal gas equation, Deviation from ideal gas, Equation of state for real gases, generalized Compressibility chart, Law of corresponding states	4
2	**Properties of Pure Substances** Phase change process of pure substances, PVT surface, P-v &P- T diagrams, Use of steam tables and charts in common use	4
3	**Laws of thermodynamics:** 2nd law Analysis for Engg. Systems, Entropy flow & entropy generation, Increase of entropy principle, entropy change of pure sub, T-ds relations, entropy generation, Exergy analysis of thermal systems, decrease of Exergy principle and Exergy destruction.	12
4	**Thermodynamic Property Relations** Partial Differentials, Maxwell relations, Clapeyron equation, general relations for du, dh, ds, and C_v and C_p, Joule Thomson Coefficient, _h, _u, _s of real gases.	10

5	**Chemical Thermodynamics** Chemical reaction - Fuels and combustion, Enthalpy of formation and enthalpy of combustion, First law analysis of reacting systems, adiabatic flame temperature, Chemical and Phase equilibrium - Criterion for chemical equilibrium, equilibrium constant for ideal gas mixtures, some remarks about Kp of Ideal-gas mixtures, fugacity and activity, Simultaneous relations, Variation of Kp with Temperature, Phase equilibrium, Gibb's phase rule, Third law of thermodynamics, Nerst heat theorem and heat death of universe.	12
Module	**Topics & Content**	**Hours**
6	**Gas Mixtures** Mass & mole fractions, Dalton's law of partial pressure, Amagat's law, Kay's rule.	4
7	**Introduction to Classical irreversible thermodynamics**. Conjugate Fluxes and Forces, Entropy Production, Onsager's Reciprocity relations, Thermo-electric phenomena, formulations, Power Generation, Refrigeration.	6

REFERENCES

1. Michael Boles**,** Yunus Cengel,,-" Thermodynamics: An Engineering Approach (SI Units)**"**, Tata mcgraw hill education private limited.
2. Gordon, Rogers **,-"**Engineering Thermodynamics", 4/e, pearson Publication
3. Signe Kjelstrup, Dick Bedeaux**, -**Elements of Irreversible Thermodynamics for Engineers, Eivind Johanness, tapir academic press
4. Axel Kleidon, Ralph D. Lorenz, -"Non-Equilibrium Thermodynamics and the Production of Entropy**"** Springer
5. Michael J. Moran, Howard N. Shapiro**, -"**Fundamentals Of Engineering Thermodynamics", Appendices, 6th Edition , john wiley & sons.
6. Howell, Dedcius, -" Fundamentals of engineering Thermodynamics" , McGraw Hill, Inc, USA
7. Van Wylen , Sontag:,-"Thermodynamics "John Wiley & Sons, Inc.,USA
8. P.K Nag, -"Basic & Applied Thermodynamics " TMH, New Delhi.
9. Adrian Bejan ,- "Advanced Engineering Thermodynamics" John Wiley and Sons, 1988**.**

MHPE-102, Heat & Mass Transfer

Contacts: 4L **Internal Assessment: 30**

Total Contact Hrs: **Examinations: 70**

Module	Topics & Content	Hours
1	Conduction: Fourier law of heat conduction; Governing equation and boundary conditions for different coordinate systems; One dimensional steady state conduction with and without heat sources; Fins of constant and variable cross sectional area; Multidimensional steady state heat conduction problems with and without heat sources; Heat conduction in anisotropic media	10
2	Introduction, Lumped Heat Capacity system, Transient heat flow in a semi-finite solid, Convection Boundary Conditions, Multi Dimensional system, Transient numerical method, Thermal resistance and capacity formulation, Graphical Analysis - Applicability of Heisler charts	6
3	Convection: Reynolds transport theorem and transport equations; One dimensional problems–Couette flow, Poisuille flow, Stefan flow etc.; Forced convection in thermally developed and developing flows; Derivation of boundary layer equations by order of magnitude analysis; Solution of boundary layer equations by similarity variable and integral	12

	methods; , Empirical relations for pipe and tube flow, Flow across cylinders, spheres, Tube bank Introduction to natural convection; Natural convection in boundary layers; Integral method, scaling analysis	
4	Condensation and Boiling: Introduction, condensation heat transfer phenomena, the condensation number, Film condensation on inclined plates, vertical and horizontal tubes, sphere, tube banks. Condensation and Boiling enhancement Technique, Boiling Heat, Transfer, Bubble dynamics and their heat transfer correlations for pool and flow boiling.	6
Module	**Topics & Content**	**Hours**
5	Radiation: Basic definitions, surface properties, view factors; Radiation exchange in black and grey enclosure; Radiosity matrix; Interaction of surface radiation with other mode of heat transfer. Radiant energy transfer through absorbing, emitting and scattering media. Combined conduction and radiation systems: fins, Introduction to solar radiation in earth‘s atmosphere.	12
6	Mass Transfer: Basic definitions; Fick’s law of diffusion; Species conservation equation; Solution of one dimensional mass transfer problem	6

REFERENCES:

1. Saddik Kakac: Heat Conduction, McGraw-Hill Pub.
2. S.P.Sukhatme: Heat Transfer, Universities press.
3. J.P. Holman, Heat Transfer, McGraw-Hill Pub.
4. A.J. Chapman: Heat Transfer, Macmillan Publishing Co. New York.
5. W.M.Kays and Crawford: Convective Heat and Mass transfer, McGraw-Hill Co.
6. Eckert and Drake: Analysis of Heat Transfer, McGraw-Hill Co.
7. Naylor: Introduction to Convective Heat Transfer Analysis,
8. Burmister: Convective Heat Transfer,
9. IncroperaDewitt: Fundamentals of Heat and Mass Transfer, Wiley India Pvt Ltd (2010)

10. Cengel: Heat Transfer Practical Approach, McGraw Hills Co.

11. P.K.Nag: Heat Transfer, TATA McGraw-Hill Co.

12. Bejan: Convective Heat and Mass transfer, wiley india pvt ltd

MHPE-103, Advanced I.C. Engines

Contacts: 4L

Internal Assessment: 30

Total Contact Hrs: 52

Examinations: 70

Module	Topics & Content	Hours
1	**Introduction** Review of basic air standard, fuel air and actual cycles, Effect of design and operating parameters on cycle efficiency. Modified fuel-air cycle considering heat losses and valve timing.	2
2	**Reactive systems**: Combustion, Equivalence ratio, Enthalpy of formation, Enthalpy of combustion, Internal Energy of combustion and heating values, Adiabatic combustion Temperature, Dissociation and chemical equilibrium.	3
3	**Fuel-air cycles:** Factors affecting fuel-air cycles, Equilibrium charts, Unburned and burned mixture charts, Relation between the above. Alternative Fuels	4

4	Combustion in SI and CI Engines, Combustion chamber Design Principles	3
5	**Carburetor and Fuel Injection Systems** Advanced theory of carburetion, Calculation of the air-fuel ratio for a simple and modern carburetor. CI Engine Fuel Injection Systems: Review of fuel injection systems, Electronically controlled unit fuel injection systems, CI Engine Governors, Spray characteristics, penetration, Dispersion, Rate of fuel injection in CI Engines, fuel line hydraulics and pressure waves in fuel lines. EFI system, MPFI system,	10
Module	**Topics & Content**	Hours
6	**Ignition systems:** Review of conventional ignition systems, Electronic Ignition systems, TAC, TCI and CDI systems, Spark advance mechanism. Engine Friction and Lubrication: Review, Lubrication principles, hydrodynamic lubrication, boundary lubrication and mixed-film lubrication systems, bearing lubrication, Rotating Journal bearings, Properties of lubricants, SAE Viscosity number, Different lubrication systems.	7
7	**Heat Transfer in Engines and cooling systems** Review of basic concept, Heat transfer considerations, conduction, convection and radiation, Heat transfer in combustion chambers, Heat transfer in exhaust systems, Piston and valve cooling, Different types of cooling systems.	5
8	Supercharger and Turbo charger, variable compression Ratio Engines and Wankel Rotary Engines. Testing and Performance on the engines.	4
9	**Exhaust Emissions**: Review, Measurement of exhaust emission, NDIR, FID, CLA systems, Oxygen analyzer, Measurement of particulates, Measurement of exhaust smoke, Gas chromatography, catalytic converter, Thermal reactors. ; Engine instrumentation-Types of pollutants-Euro and Bharat norms-Emission control	10

	methods in SI and CI engines-catalytic converters-EGR-Modern evaporative emission control system ; Lean Burn Engines – Stratified charge Engines – homogeneous charge compression ignition engines – Plasma Ignition – Zero Emission Vehicles, Engines for special applications – Mining, Defence, Engine Simulation: Mathematical modeling, implementation of CFD concept in engine simulation.	
10	**Off-highway** Tractor, Bulldozer etc. Submarines, Race car Engine systems, Flexible fuel systems. Surface ignition,	4

REFERENCES:

1. C.F.Taylor, -"The Internal-combustion Engine in" International Textbook Co., 1961.
2. J.B.Heywood, - "Internal Combustion Engine Fundamentals" Mcraw-Hill, 1988
3. H.N.Gupta -, "Fundamentals of I.C. Engines" PHI Learning Pvt. Ltd., 01-Jun-2006
4. M. L. Mathur, R. P. Sharma –" A Course In IC Engine" Dhanpat Rai, 1981
5. V.Ganeshan , – 'I.C.Engines" Tata McGrawHill
6. K.K. Ramalingam,- " Internal Combustion Engine Fundamentals". , Scitech Publications

MHPE-104, Turbo machinery (Elective)

Contacts: 4L

Total Contact Hrs: 52

Credit:4

Internal Assessment: 30

Examinations: 70

Total Marks: 100

MODULE	Topics & Content	HOURS
1.	**Classification and Constructional features :** Radial, Axial and Mixed–Flow pumps, Fans and Compressors and turbines; Single–stage and Multi–stage machines; components – impeller, runner, inlet guide vanes, inducers, outlet guide vanes, vaneless and vaned diffuser, scroll casing, nozzles, diffuser, etc.	5
2.	**Two–dimensional flow analysis for a turbo machine:** Conservation principle of mass, angular momentum and energy in inertial	15

	and non–inertial frame of reference; Application of these principles in radial flow machines and in cascade analysis of axial–flow turbo machines; Velocity diagram; Concept of total head, total pressure, rotor work, stagnation enthalpy and modified relative stagnation enthalpy; slip; Incidence and deviation of Flow; constant rule; Degree of reaction; Multistage compressor and turbine. Volumetric, mechanical, hydraulic, manometric and overall efficiencies; Diffuser, Nozzle and Blade efficiency; Mollier diagram for expansion and compression processes in turbine, compressor, diffuser and nozzle; Total–to–total and Total–to–static efficiency; Polytropic efficiency; cavitation, stall, surge and choking.	
MODULE	CONTENT	HOURS
3.	**Dimensional Analysis and Machine Performance :** Dimensional analysis for incompressible and compressible flow turbo machines; Work, head and power coefficients; Mach number. Reynold's Number, Specific Speed and Cavitation parameter; Overall characteristics curves for pump, fan, compressor and turbine; Similarity concept; Model study and scale effects.	10
4.	**Propulsion :** Turbojet and Ramjet Components – Diffuser and air intake, Compressor, Combustion chamber, gas turbine and nozzle; Equation of motion of a rocket; Specific impulse; Matching of Compressor and Turbine. Three Dimensional Flows	10
5.	**Analysis Through Turbomachines :** Radial Equilibrium Theory; Free, Forced and Combined Vortex design of blades; Actuator Disc Approach; Blade row interaction effects; Design of stationary and moving blades**.**	6
6.	**Design and Performance Analysis of Turbo machines:** Radial flow pumps, fans, compressors and turbines; axial flow pumps, fans, compressors and turbines; Wind turbines, Steam turbine and Gas turbines**.**	6

REFERENCES:

1. S.M. Yahya, Turbine, Compressors and Fans.

2. Fluid Mechanics and Thermodynamics of Turbomachinery 6th Edition by S. L. Dixon, Cesare A. Hall Elsevier, Publisher.

3. Fundamentals of Turbomachinery by B. K. Venkanna, PHI Learning Publisher.

4.Turbomachinery Rotordynamics: Phenomena, Modeling, and Analysis by Childs, Dara Childs Wiley-Interscience Publisher

5.Thermodynamics and Fluid Mechanics of Turbomachinery: Volumes I and II illustrated edition Edition Springer Publisher

6. A.T. Sayers, Hydraulic and Compressible Flow Turbomachines.

7. G. FGopalakrishnan, A Treatise on Turbo Machines, Scitech Publication.

8. Karassic, Kulzsch, Fraser and Messina, Pump Handbook.

MHPE-105, Advanced Power Plant Engineering

Contacts: 4L **Internal Assessment: 30**

Total Contact Hrs: **Examinations: 70**

Module	Topics & Content	Hours
1	**Introduction** Energy reserves and Energy utilization the world– Electrical Power Generation &Consumption in India. Types of Power Plants Merits and Demerits – Criteria for Selection of Power Plants.	5
2	**Steam power plant** Layout – Super Heaters, Reheaters, Condensers Economizers and Feed Water heaters -Operation and performance – Rankine cycle with Super Heat, Reheat and Regeneration –Fluidized Bed combustion boiler – Advantages – waste heat Recovery boilers – Co –generation Power Plant - Emissions and their controls	12
3	**Nuclear power plant** Overview of Nuclear Power Plant – Nuclear physics Radio activity – fission process, Reaction Rates – diffusion theory – Critical heat flux –Nuclear Power Reactors– different types – advantages and limitations – Materials used for Reactors. Hazards in Nuclear Power Plant – Remedial Measures - Safety	10

	precautions – Methods of Waste disposal Different form of Waste from Power Plant	
4	**GAS TURBINE AND MHD POWER PLANT** Layout of Gas Turbine - Basic Gas turbine cycle – cycle improvements – Intercoolers, Reheaters and regenerators, Thermodynamic analysis of Gas turbine –Operations and performance of Gas Turbine Layout of MHD Power Plant – Principles of Working –Function and Importants of Individual Component - salient features.	13

Module	Topics & Content	Hours
5	**COMBINED CYCLE POWER PLANT:-** Binary vapour cycles – Coupled cycles – Combined Power cycle Plants – Advantages and Limitations, Gas turbine – Steam turbine Power Plant And MHD – Steam Power Plant.	12

REFERENCES

1. P, K, Nag, - 'Power Plant Engineering", TataMc Grraw Hill
2. M.M. Wakil,-"Power Plant Engineering Technology", Tata Mc Graw Hill
3. Everett B. Woodruff Lammers, Thomas F. Lamme, - " Steam Plant operation" ,McGraw Hill
4. Thomas C. Elliott, Kao,- "Standard Hand Book of Power Plant Engineering"
5. Rolf Kehlhofer,-"Combined-cycle Gas and Steam Turbine Power Plants".

MHPE-106, Heat Exchangers System Design & Performance

Contacts: 4L

Internal Assessment: 30

Total Contact Hrs:

Examinations: 70

Module	Topics & Content	Hours
1	Introduction to Heat Exchangers: Classification of Heat Exchangers, Direct transfer type, Storage type, Direct contact type, Tubular, Plate and Extended surface H.Es.	3
2	Basic Thermal and Hydraulic Relations in Heat Exchangers Design: Basic Principles of Thermal Design, The effectiveness-NTU Method, Thermal Hydraulic correlations for H.E Design, Shell side flow correlation, The tube side correlations,	5
3	Thermal Design of Shell and Tube H.Es: Ideal tube banks, Kern's Method, Tinker Model, Divided Flow Method, Design considerations, Effects of fouling.	8
Module	**Topics & Content**	**Hours**
4	Design of Condensers: Types of surface condensers, Choice of a condenser, Operational problems in condensers, Heat Transfer coefficient calculations for condensing vapors, Pressure drop calculations, Design procedure	8
5	Thermal Design of Compact Heat Exchangers: Flow arrangements and Surface Geometries, Heat Transfer and Friction factor data, Calculation Procedure of Compact H.E.	5
6	Special Type of Heat Exchangers: Heat pipe heat exchangers, application areas, Design criteria, Rod Baffle H.E, New Tube Bundle Baffling Concept, Regenerators	5
7	Optimization of Heat Exchangers: Different parameters under designer's control, Minimization of annualized total cost, minimization of only fixed cost, placement of fluids, tube length, tube O.D, and pitch, baffle spacing, number of shell passes, number of tube passes and General Strategy.	7
8	Mechanical Design of Heat Exchangers: Scope of TEMA, Type of Exchangers, Mechanical Design, Components of heat exchangers, weir plate, conventional type impingement plate, dome type impingement plate, vapor belt, Design aspects, Design of components of H.E, Main shell, channel shell and channel dish, Flanges, Tube sheet etc.	7
9	Heat Exchanger Control Systems: Feedback temperature control, feed forward control of heat exchanger	4

REFERENCES:

1. Fraas, A.P.and M.N.Ozisik ,-"Heat exchanger Design", Wiley New York.
2. Kays, –"Compact Heat Exchanger", W.M., Mc-Graw- Hill, New York.
3. Kern, D.Q, -"Process Heat Transfer", Mc-Graw- Hill, New York.
4. Kern, D.Q., -"Extended Surface Heat Exchangers "Mc-Graw- Hill, New York.
5. Walker, G ,-'Industrial Heat Exchangers-A Basic Guide", Mc-Graw- Hill, New York.
6. Shinakey, F.G, -"Process control systems" Mc-Graw- Hill, New York.
7. Tubular exchange manufacturers' Association, TEMA standards, 1982.
8. R. Shah, A. Kraus, D. Metzger,- "Compact Heat Exchangers" Hemsisphere Publishing Corporation.
9. S. Kakac, A. , Bergles, F. Mayinger,-" Heat Exchangers Thermal Hydraulic Fundamentals and Design " McGraw-Hill Book Company.

MHPE-191, THERMAL ENGINEERING LABORATORY-I (Experiment on IC Engine, Fuel properties & Solar energy)

Contact :4P
Total contact Hrs:52 **Fullmarks:100**
Credit:2

Experiments on
1. Performance test on Spark Ignition engines.
2. Emission measurement in Spark Ignition and Compression Ignition Engines.
3. Properties of fuel oils.
4. Solar radiation measurement
5. Performance study in a solar water heater

MHPE-192, THERMAL ENGINEERING LABORATORY-II (Experiment on Heat transfer & Refrigeration)

Contact :4P
Total contact Hrs:52 **Fullmarks:100**
Credit:2

Experiments on

1. Performance study in a cooling tower
2. Performance study in a refrigeration and heat pump systems.
3. Performance of Heat Exchangers- concentric tube, shell & Tube & cross flow heat exchanger

4. Boiling Heat transfer
5. Drop wise & Film wise condensation
6. Heat transfer Augmentation

MHPE-181, Seminar-I

Contact: 2T
Total Contachrs:26 **Fullmarks:100**
Credit:1

It would be based on literature review on some emerging areas related to this course. Seminar presentation would be made byan individual student & a term paper would have to be submitted by each student separately

First Year Second Semester

MHPE-201, Computational Fluid Dynamics

Contacts: 4L **Internal Assessment: 30**

Total Contact Hrs: **Examinations: 70**

Module	Topics & Content	Hours
1	Introduction: Conservation equation; mass; momentum and energy equations; convective forms of the equations and general description.	4
2	Classification and Overview of Numerical Methods: Classification into various types of equation; parabolic elliptic and hyperbolic; boundary and initial conditions; over view of numerical methods.	5
3	Finite Difference Technique: Finite difference methods; different means for formulating finite difference equation; Taylor series expansion, integration over element, local function method; treatment of boundary conditions; boundary layer treatment; variable property; interface and free surface treatment; accuracy of f.d. method.	6
4	Finite Volume Technique: Finite volume methods; different types of finite volume grids; approximation of surface and volume integrals; interpolation methods; central, upwind and hybrid formulations and comparison for	6

	convection-diffusion problem.	
5	Finite Element Methods: Finite element methods; Rayleigh-Ritz, Galerkin and Least square methods; interpolation functions; one and two dimensional elements; applications.	5
6	Methods of Solution: Solution of finite difference equations; iterative methods; matrix inversion methods; ADI method; operator splitting; fast Fourier transform.	5
7	Time integration Methods: Single and multilevel methods; predictorcorrector methods; stability analysis; Applications to transient conduction and advection-diffusion problems.	5
Module	**Topics & Content**	**Hours**
8.	Numerical Grid Generation: Numerical grid generation; basic ideas; transformation and mapping.	4
9	Navier-Stokes Equations: Explicit and implicit methods; SIMPLE type methods; fractional step methods.	6
10	Turbulence modeling: Reynolds averaged Navier-Stokes equations, RANS modeling, DNS and LES.	6

REFERENCES:

1. 1. S. V. Patankar, -"Numerical Heat Transfer and Fluid Flow", McGraw-Hill.
2. T. J. Chung,- "Computational Fluid Dynamics", Cambridge University Press.
3. H. K. Versteeg & W. Malalasekera,-" An Introduction to Computational Fluid Dynamics", Longman Scientific & Technical.
4. J. H. Ferziger and M. Peric, -"Computational Methods for Fluid Dynamics", Springer.
5. John C. Tannehill, Dale A. Anderson and Richard H. Pletcher, -"Computational Fluid Mechanics and Heat Transfer", Taylor &Francis.
6. John D. Anderson Jr,-"Computational Fluid Dynamics", McGraw Hill Book Company.

MHPE-202, Renewable Energy

Contacts: 4L *Internal Assessment: 30*

Total Contact Hrs: *Examination: 70*

Module	Topics & Content	Hours
1	**Introduction** Fossil fuel based systems, Impact of fossil fuel based systems, Non conventional energy–seasonal variations and availability, Renewable energy – sources and feature. Hybrid energy system ,Distributed energy systems and dispersed generation (DG)	3
2	.**Solar thermal systems** Solar radiation spectrum, Radiation measurement Technologies, Applications: Heating, Cooling, Drying, Distillation, Power generation	7
3	**Solar Photovoltaic systems** Operating principle, Photovoltaic cell concepts Cell, module, array, Series and parallel connections, Maximum power point tracking, Applications, Battery charging, Pumping, Lighting, Peltier cooling	7
4	**Micro-hydel** Operating principle, Components of a micro-hydel power plant Types and characteristic of turbines, Selection and modification, Load balancing	5
5	**Wind**	5

	Wind patterns and wind data, Site selection Types of wind mills, Maximum efficiency & power, Characteristics of wind generators, Load matching	
6	**Biomass** Learning objectives, Operating principle, Combustion and fermentation, Anaerobic digester, Wood gasifier, Pyrolysis, Applications: Bio gas, Wood stoves, Bio diesel, Combustion engine	5
7	**Fuel Cell** Introduction and overview of fuel cells technology: low and high temperature fuel Cells. Fuel cell thermodynamics., Hydrogen production and storage, Safety issues and cost expectation life	8
Module	**Topics & Content**	**Hours**
8	**Costing** Life cycle costing (LCC), Solar thermal system LCC, Solar PV system LCC, Microhydel LCC, Fuel cells Wind system LCC, Biomass system LCC	8
9	**Hybrid Systems** Need for Hybrid Systems, Range and type of Hybrid systems, Case studies of Diesel-PV, Wind-PV, Microhydel-PV, Biomass-Diesel systems, electric and hybrid electric vehicles	4

REFERENCES:

1. S.P.Sukhatme, _Solar Energy Principle of Thermal Collection and Storage', Tata McGraw Hill, 1990.
2. G.L. Johnson, Wind energy systems, Prentice Hall Inc. New Jersey.
3. J.M.Kriender, _Principles of Solar Engineering', McGraw Hill, 1987.

Supplementary Reading:

4. V.S. Mangal, _Solar Engineering', Tata McGraw Hill, 1992.
5. N.K.Bansal, _Renewable Energy Source and Conversion Technology', Tata McGraw Hill, 1989.
6. P.J. Lunde., _Solar Thermal Engineering', John Willey & Sons, New York, 1988.
7. J.A. Duffie, and W.A. Beckman, _Solar Engineering
8. O'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, Fuel Cell Fundamentals, Wiley, NY (2006).

9. Bard, A. J. , L. R., Faulkner, Electrochemical Methods, Wiley, N.Y. (2004) Ref Book.
10. Basu, S. (Ed) Fuel Cell Science and Technology, Springer, N.Y. (2007).

MHPE-203, Advanced Refrigeration & air conditioning

Contacts: 4L

Internal Assessment: 30

Total Contact Hrs:

Examinations: 70

Module	Topics & Content	Hours
1	Air cycle refrigeration systems, Vapour Compression Refrigeration Systems, vapour Compression Refrigeration Systems: Performance Aspects And Cycle Modifications	4
2	Multi-Stage Vapour Compression Refrigeration Systems, Multi-Evaporator and Cascade Systems	4
3	Vapour Absorption Refrigeration Systems, Vapour Absorption Refrigeration Systems Based On Water-Lithium Bromide Pair, vapour Absorption Refrigeration Systems Based On Ammonia-Water Pair	4
4	Refrigeration System Components: Compressors, Performance of Reciprocating Compressors, Rotary, Positive Displacement Type Compressors, Centrifugal Compressors, Condensers & Evaporators, Expansion Devices	10
5	Refrigerants	2
6	Psychrometry, Psychrometric Processes, Inside And Outside Design Conditions, Psychrometry of Air Conditioning Systems, Evaporative, Winter	10

	and All Year Air Conditioning Systems.	
7	Cooling and Heating Load Calculations - Estimation of Solar Radiation, Cooling and Heating Load Calculations -Solar Radiation Through Fenestration - Ventilation and Infiltration, Cooling and Heating Load Calculations - Heat Transfer Through Buildings - Fabric Heat Gain/Loss	10
7	Selection of Air Conditioning Systems, Transmission of Air in Air Conditioning Ducts, Design of Air Conditioning Ducts, Space Air Distribution, Ventilation for Cooling	8

REFERENCES:

1. Refrigeration and Air-conditioning Data - Stocker W.F. and Jones J.W, McGraw Hill, 1985
2. Refrigeration and Air Conditioning- Manohar Prasad, Willey Eastern Ltd., 1990
3. Refrigeration and Air conditioning- Jordan and Priester, Prentice Hall of India, 1974
4. Refrigeration and Air-Conditioning- Arora, C.P.
5. Refrigeration and Air-Conditioning- Arora, C.P, Tata McGraw Hill
6. Refrigeration and Air-Conditioning- Domkundwar and Arora
7. Cryogenic Technology- Herald Weinstock,1969
8. Refrigeration and Air Conditioning- Stoecker W.F., and Jones, J.W.

MHPE-204, Design of thermal Power plant equipments (Elective)

Internal Assessment: 30

Contacts: 4L

Total Contact Hrs: Examinations: 70

Module	Topics & Content	Hours
1	Heat transfer in furnaces – Furnace heat balance – Design of furnaces – Blast furnace –Electric furnace – Fluidized bed combustion furnace. Circulation – Positive and Natural circulation – Circulation ratio.	8
2	Types of Condensers – Design of condensers – Surface area calculation – Air leakage and its effects – Methods of removal of air leakage – condenser water cooling systems – Air pump – Wet and Dry capacity and dimensions of air pumps	8
Module	**Topics & Content**	**Hours**
3	Types of Super heaters – Location – Performance – Radiation and Convection, characteristics – Design of super heater – Super heater temperature control.	7
4	Types of Evaporators – Details of submerged types of evaporator – Single effect and Double effect evaporators – Steam requirements.	6
5	Advantages – Disadvantages – Recuperative and Regenerative air preheaters – Design Considerations – High temperature and Low temperature limitations	7
6	Power required for draught fan – Pressure losses – Diameter and Height of the Chimney – Chimney design.Mechanical carry over – Silica carry over –Gravity separator – ESP, Cyclone separator.	6
7	Economizer arrangement – Design of an economizer suitable for a power plant	6
8	Dust cleaning equipment – Selection criteria – Design, operation and maintenance of electro static precipitators, Bag filters.	4

REFERENCS:

1. AroraS.C. and Domkundwar, S, Power Plant Engineering, Dhanpat Rai & Co., New Delhi, 2002.

2. Vopat and Skrotzhi, Power Plant Engineering, Tata McGraw Hill Book Co., New Delhi, 1972.

3. Oliver Lyle, the efficient use of steam, Her Majestry's Stationery Office, London,1962.

4. Potter, Power Plant Theory and Design, the Ronald Press Co., New Delhi, 1972

Module	Sub-Module	Topic	No. of Lect.
1	a	Introduction: Nuclear Power – Indian and Global perspective. Indian Nuclear Power Programme.	1
	b	Nuclear reactions: Radioactive decay and half life; Neutron Reaction, elastic and inelastic scattering, cross section of neutron reactions, thermal and fast neutrons; mechanism of nuclear fission, fission rate and reactor power, fission yield, prompt and delayed neutron	5
2.	a	Diffusion and slowing down of neutrons: Neutron diffusion theory, the diffusion equation, diffusion length, diffusion of one-speed neutrons from a point source,	3
	b	Infinite plane source and a medium of finite thickness; Infinite and effective multiplication factors, geometric and material buckling;	2
	c	Elastic scattering, logarithmic energy decrement, slowing down in infinite media. Reflected reactors, four factor formula, Radiation shielding.	4
3		Nuclear reactor Thermal- Hydraulics, Dynamics and control, passive cooling systems.	6
4	a	Element of Nuclear Power Stations, Type of power reactors	1
	b	BWR-core and reactor vessels, steam generating system, safely features	2
	c	PWR - core and reactor vessels, coolant recirculation system. safely constraints	3
	d	PHWR – Design concepts, Coolant System, fuel type, special features, safe.	7
	e	FBR – Global and Indian Perspective Design features, fuel type, Coolant System, safely features, Breeding, Doubling.	5

	f	AHWR – Reactor system, fuel type, advance features, coolant system, safely parameters, status of development.	
5		Nuclear Reactor Accidents, Loss of Coolant Accident (LOCA cooling system.	
6		Reprocessing and Waste Management	
7		Nuclear Instrumentation, Health Physics	3

Internal Assessment: 30

Examination: 70

MHPE205, Nuclear Power Engineering (Elective)

Contacts: 4L

Total Contact Hrs:

REFERENCES:

1. Lamarsh, J.R. and Baratta, A.J., "Introduction to Nuclear Engineering", 3rd Edition, Prentice Hall, 2001.
2. Duderstadt, J.J. and Hamilton, L.J., "Nuclear Reactor Analysis", John Wiley and Sons, 1976.
3. Glasstone, S. and Sesonske, A, "Nuclear Reactor Engineering Vol-1: Reactor Design Basics", 4th Edition, Elsevier, 1996.
4. Glasstone, S. and Sesonske, A, "Nuclear Reactor Engineering Vol-2: Reactor System Engineering", 4th Edition, Elsevier, 1996.
5. M.M.EI. Wakil., 'Nuclear Power Engineering', McGraw Hill Book Company, New York, 1987.

Supplementary Reading:

a. Loftness, 'Nuclear Power Plants', D. Van Nostrand Company Inc, Princeton, 1964.
b. S. Sarg et al., 'Physics of Nuclear Reactors', Tata McGraw Hill Publishing Company Ltd., 1985.

c. T. J. Connoly., 'Fundamentals of Nuclear Energy', John Wiley, 1978.mary heat removal systems, control and safety features; FBR-general features and coolant systems.

MHPE-206, *Cryogenic Engineering*

Contacts: 4L ***Internal Assessment: 30***

Total Contact Hrs: ***Examinations: 70***

Module	Topics & Content	Hours
1	**Introduction** Insight on cryogenics, Properties of cryogenic fluids, Material properties at cryogenic Temperatures. Properties of cryogenic fluids.	6
2	**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, Helium refrigerated Hydrogen liquefaction Systems. Critical components in liquefaction Systems.	10

3	**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.	8
4	**Cryogenic refrigerators** J.T.Cryocoolers, Stirling Cycle Refrigerators, G.M.Cryocoolers, Pulse Tube Refrigerators, Regenerators used in Cryogenic Refrigerators, Magnetic Refrigerators.	8
5	**Handling of cryogenic** Cryogenic Dewar Construction and design, Cryogenic transfer lines. Insulations used in Cryogenic systems, Different types of vacuum pumps, instrumentation to measure flow, level and temperature.	8
6	Cryostat design, Dilution Refrigerator and Adiabatic Demagnetization, Safety in Cryogenics.	7

Module	Topics & Content	Hours
7	**Applications** Applications of Cryogenics in Space Programmes, Superconductivity, Cryo Metallurgy, Medical applications	5

REFERENCES:

1. Randall F. Barron, "Cryogenics Systems", Second Edition Oxford Univesity Press New York, Clarendon Press, Oxford, 1985.
2. Timmerhaus, Flynn, "Cryogenics Process Engineering", Plenum Press, New York.
3. Pipkov, "Fundamentals of Vacuum Engineering", Meer Publication.
4. G.M Walker. "Cryocooler-Part 1 Fundamentals" Plenum Press, New York and London.
5. G.M Walker. "Cryocooler-Part 2" Plenum Press, New York and London.

MHPE-207, ***Energy Conservation & Management (Elective)***

Contacts: 4L

Internal Assessment: 30

Total Contact Hrs: 52

Module	Topics & Content	Hours
1	**Energy Scenario** Principles and Imperatives of Energy Conservation - Energy Consumption Pattern – Resource Availability - Role of Energy Managers in Industries.	3
2	**Thermal Energy auditing** Energy Audit-purpose, methodology with respect to process Industries - Power plants, Boilers etc., -characteristic method employed in certain energy intensive industries - Various energy conservation measures in Steam System - Losses in Boiler, Methodology of upgrading Boiler performance ,Energy conservation in pumps, fans & compressors, Air conditioning and refrigeration systems, Steam traps-types, function, necessity	9
Module	**Topics & Content**	**Hours**
3	**Role of Instrumentation in Energy conservation** Total energy systems - Concept of Total energy - Advantages & limitations - Total energy system & Application - Various possible schemes employing steam turbines movers used in Total energy systems ,Potential & economics of Total energy systems	8
4	**Energy Economics** Economic analysis of investments, Present value criterion, Discount rate, simple payback period, return on investment, net present value(NPV), internal rate of return, life cycle costing, energy performance contracts and role of ESCOs, Energy Management Information Systems.	8
5	**Economics of Power Generation** Factors affecting the cost of generation – Load factor, Diversity factor, Plant capacity factor, Plant use factor, Load curves, Load duration curves, Reduction of costs by Interconnection of Stations, Choice of size & number of generator units, Tariffs : types and significance.	8

6	**Co-generation & Tri-generation** Definition, need, application, advantages, classification, saving Potential. Waste Heat Recovery: Concept of conversion efficiency, energy waste, waste heat recovery classification, advantages and applications, commercially viable waste heat recovery devices.	8
7	International Energy Policies of G-8 Countries, G-20 Countries, OPEC Countries, EU Countries. International Energy Treaties (Rio, Montreal, Kyoto), INDO-US Nuclear Deal. Future Energy Options: Sustainable Development, Energy Crisis: Transition from carbon rich and nuclear to carbon free technologies, parameters of transition. Concept of carbon capture	8

REFERENCES:

1. CB Smith, Enegy Management Principles, Pergamon Press, NewYork, 1981

2. Hamies, Energy Auditing and Conservation; Methods, Measurements, Management & Case study,Hemisphere, Washington, 1980

3. Trivedi, PR, Jolka KR, Energy Managemnent, Commonwealth Publication, NewDelhi, 1997

4. Witte, Larry C, Industrial Energy Management & Utilization, Hemisphere Publishers, Washington,1988

5. Diamant, RME, Total Energy, Pergamon, Oxford, 1970.

6. International Energy Outlook' -EIA annual Publication

MHPE-208, Solid & Hazardous Waste Management (Elective) **Internal Assessment: 30**

Examination: 70

Contacts: 4L

Total Contact Hrs: 52

Credit:4

Module	Topics & Content	Hours
.1	Municipal solid waste (management and handling) rules, hazardous waste (management and handling) rules, biomedical waste handling rules, flyash rules, recycled plastics usage rules, batteries (management and handling) rules.	6
2.	Sources; composition; generation rates; collection of waste; separation, transfer and transport of waste; treatment and disposal options.	6
3.	Characterization of waste, compatibility and flammability of chemicals, fate and transport of chemicals, health effects.	4
4.	Sources, measures, health effects; nuclear power plants and fuel production; waste generation from nuclear power plants; disposal options.	6
Module	**Topics & Content**	**Hours**
5	Defining risk and environmental risk, methods of risk assessment, case studies.	6
6.	Chemical treatment processes for MSW (combustion, stabilization and solidification of hazardous wastes); physico-chemical processes for hazardous wastes (soil vapor extraction, air stripping, chemical oxidation); ground water contamination and remediation.	8
7.	Biochemistry of microbial metabolism; aerobic biodegradation of municipal solid waste: composting and vermi-composting; anaerobic biodegradation of municipal solid waste: waste to energy options, other methods; bioremediation - fundamentals.	8
8.	Landfills, concepts, design and construction and pollution potential.	8

REFERENCES:

1. Vesilind P.A., Worrell W. and Reinhart D.R., -"Solid Waste Engineering", Thomson Books.
2. Bhide A.D. and Sundaresan B.B., -"Solid Waste Management, Collection, Processing and Disposal", Nagpur.
3. Tchobanoglous G., Theisen H. and Vigil S.A.,- "Integrated Solid Waste Management", McGraw-Hill International editions.
4. "Manual on Municipal Solid Waste Management", CPHEEO, Ministry of Urban Development, Government of India.
5. Management and Handling Rules for: municipal solid waste, biomedical waste, hazardous waste and radioactive wastes, Government of India Publications.

MHPE-209, Design and Optimization of Energy systems

Contacts: 4L

Internal Assessment: 30

Total Contact Hrs: 52

Examinations: 70

Module	Topics & Content	Hours
1	**Introduction** • Introduction to design and specifically system design.	6

	• Morphology of design with a flow chart. • Very brief discussion on market analysis, profit, time value of money, an example of discounted cash flow technique. • Concept of workable design, practical example on workable system and optimal design.	
2	**System Simulation** • Classification. • Successive substitution method - examples. • Newton Raphson method - one unknown - examples. • Newton Raphson method - multiple unknowns - examples. • Gauss Seidel method - examples. • Rudiments of finite difference method for partial differential equations, with an example.	10
3	**Regression and Curve Fitting** • Need for regression in simulation and optimization. • Concept of best fit and exact fit. • Exact fit - Lagrange interpolation, Newton's divided difference - examples. • Least square regression - theory, examples from linear regression with one and more unknowns - examples. • Power law forms - examples. • Gauss Newton method for non-linear least squares regression examples.	10

Module	Topics & Content	Hours
4	**Optimization** • Introduction. • Formulation of optimization problems – examples. • Calculus techniques – Lagrange multiplier method – proof, examples. • Search methods – Concept of interval of uncertainty, reduction ratio, reduction ratios of simple search techniques like exhaustive search, dichotomous search, Fibonacci search and Golden section search – numerical examples. • Method of steepest ascent/ steepest descent, conjugate gradient method –	26

	examples. • Geometric programming – examples. • Dynamic programming – examples. • Linear programming – two variable problem –graphical solution. • New generation optimization techniques – Genetic algorithm and simulated annealing - examples. • Introduction to Bayesian framework for optimization- examples.	

REFERENCES

1. Prof. C. Balaji ,-"Essentials of Thermal System Design and Optimization", , Aue Books, New Delhi in India and CRC Press in the rest of the world.
2. Y.Jaluria, -"Design and optimization of thermal systems", Mc Graw Hill, 1998.
3. L.C.Burmeister ,-"Elements of thermal fluid system design", , Prentice Hall, 1998.
4. W.F.Stoecker ,-"Design of thermal systems," , Mc Graw Hill, 1989.
5. J.S.Arora, -"Introduction to optimum design", Mc Graw Hill, 1989.
6. K.Deb ,-"Optimization for engineering design" - algorithms and examples, , Prentice Hall, 1995.

MHPE-291, THERMAL ENGINEERING LABORATORY-III (CFD)

Contact :4P

Total contact Hrs:52 **Fullmarks:100**

Credit:2

Software: Fluent /Star CD/ ANSYS/CFX / user defined codes.

1. Steady State Conduction in Solid
2. Steady State Convection in Solid

3. Steady State Radiation in Solid
4. Combined conduction and convection
5. Unsteady state conduction and convection
6. Unsteady state conduction and radiation
7. Steady state conduction in Fluids
8. Steady state convection in Fluids
9. Two-phase flows
10. Condensation and boiling heat transfer.

. **MHPE-281, Seminar-II**
Contact: 2T
Total contact Hrs: 26 **Fullmarks: 100**
Credit: 1

Seminar would be based on literature review on some emerging areas related to this course. Seminar presentation would be made by an individual student, and a report would have to be submitted by each student separately.

SECOND YEAR FISRST SEMESTER

Course of Study

MHPE-381: Pre – submission Defense of Dissertation

Credit: 4

Full Marks: 300

Project work would be of two – semester duration and one project would be allotted to one student. The project work done up to the end of the third semester would be evaluated and the evaluation will be internal evaluation. The total credit will be divided in the following way:

- Synopsis – semester : 20 %
- Thesis : 40 %
- Viva : 40 %

MHPE- 382 Dissertations (Progress)…… Full Marks: 100

Credit: 18

Viva voce of the project will be based on the project thesis to be conducted at the end of the

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SECOND YEAR SECOND SEMESTER

Course of Study

M HPE– 481: Dissertation (Completion)

Credit: 18

Full marks: 300

Project work would be of two – semester duration and one project would be allotted to one student. The project work done up to the end of the fourth semester would be evaluated and the evaluation will be internal evaluation. The total credit will bedivided in the following way

- Synopsis – semester : 20 %
- Thesis : 40 %
- Viva : 40 %

MHPE – 482: Post - submission Defense of Dissertation

Credit: 6

Full marks: 100

Viva voce of the project will be based on the project thesis to be conducted at the end of the semester – IV.