Biju Patnaik University of Technology, Orissa
Rourkela

M.Tech Syllabus in Thermal Engg. / Heat Power Engg.

Recommended Course Structure for M.Tech Programs in BPUT

Semester I

Professional core :	3 subjects	12 credits	(4 credits each)
Elective:	2 subjects	6 credits	(3 credits each)
Sessionals/ Laboratory :	1 or 2 nos.	4 credits	
Pre-thesis work and seminar		2 credits	
	Total	**24 credits**	

Semester II

Professional core :	2 subjects	8 credits	(4 credits each)
Elective:	3 subjects	9 credits	(3 credits each)
Sessionals/ Laboratory :	1 or 2 nos.	4 credits	
Pre-thesis work and seminar		2 credits	
Comprehensive viva voce I		2 credits	
	Total	**25 credits**	

Semester III

Thesis part I		14 credits
Open elective		3 credits
	Total	**17 credits**

Semester IV

Thesis part II		20 credits
Seminar		2 credits
Comprehensive viva voce II		2 credits
	Total	**24 credits**

Total 90 credits

M.Tech in Thermal Engineering / Heat Power Engineering (Modified)

Course Structure

Semester 1

Sl. No.	Subject	Contact Hours L – T – P	Credits
Professional Core			
1.	Advanced Fluid Mechanics	3 – 1 – 0	4
2.	Advanced Heat Transfer – I (Conduction and Radiation)	3 – 1 – 0	4
3	Advanced Refrigeration Engineering	3 – 1 – 0	4
Electives			
4.	Elective – I	3 – 0 – 0	3
5	Elective – II	3 – 0 – 0	3
Sessionals			
6.	Engineering Software Laboratory	0 – 0 – 3	2
7.	Thermal Engineering Laboratory	0 – 0 – 3	2
8.	Pre-thesis work and seminar		2
		Total credit	24

Elective – I (*Any One*):

Internal Combustion Engines

Energy Conservation and Management

Gas Dynamics

Hydel Power and Wind Energy

Elective – II(*Any One*):

Solar Energy Technology

Thermal and Nuclear Power Plants

Renewable Energy Systems

Design of Thermal Systems

Semester 2

Sl. No.	Subject	Contact Hours L – T – P	Credits
Professional Core			
1.	Advanced Engineering Thermodynamics	3 – 1 – 0	4
2.	Advanced Heat Transfer – II (Convective Heat and Mass Transfer)	3 – 1 – 0	4
Electives			
3.	Elective – III	3 – 0 – 0	3
4.	Elective-IV	3 – 0 – 0	3
5.	Elective - V	3 – 0 – 0	3
Sessionals			
	Advanced Thermal Engg and Measurement Laboratory	0 – 0 – 3	2
6.	Elective Laboratory	0 – 0 – 3	2
8.	Pre-thesis work and seminar		2
9.	Comprehensive Viva-Voce I		2
		Total credit	25

Elective – III(*Any One*):
Computational Fluid Dynamics
Computational Methods in Thermal Engineering
Experimental Methods in Thermal Engineering
Heat Exchanger Analysis and Design

Elective – IV (*Any One*):

Theory of Combustion and Emission

Air Conditioning and Ventilation Systems

Gas Turbine and Jet Propulsion

Boiling, Condensation and Two-phase Flow

Elective – V (*Any One*):

Cryogenic Technology

Aircraft and Rocket Propulsion

Power Plant Practice and Control

Finite Element Methods in Thermal Engineering

Semester 3

Sl. No.	Subject	Contact Hours L – T – P	Credits
1.	Open Elective	3 – 0 – 0	3
1.	Thesis Part I		14
			17

Open Elective (Any one)

Research Methodology

Design of Experiments

Project Management and Costing

Quality System Design

Soft Computing

Semester 4

Sl. No.	Subject	Contact Hours L – T – P	Credits
1.	Thesis Part II (Presentation and Evaluation)		20
2.	Seminar		2
3	Comprehensive Viva-Voce II		2
			24

Total Credits: 90

Syllabus (First Semester)

Professional Core

Advanced Fluid Mechanics

Module I

Concept of continuum and definition of a fluid. 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 velocity potential.

Module II

Transport theorems, constitutive equations, derivation of Navier Stokes equations for compressible flow. 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, flow in convergent- divergent channels. Slow viscous flow : Stokes and Oseen's approximation,

Module III

Theory of hydrodynamic lubrication. Boundary layer : derivation, exact solutions, Blasius, Falkner Skan, series solution and numerical solutions. Approximate methods. Momentum integral method. Two dimensional and axisymmetric jets. Description of turbulent flow, velocity correlations, Reynold's stresses, Prandtl's Mixing Length Theory, Karman's velocity defect law, universal velocity distribution.

Books:

Advanced Fluid Mechanics, Som and Biswas, Tata McGraw Hill

Fluid Mechanics, A.K.Mohanty

Fundamentals of Fluid Mechanics, Schlitching

Introduction to Fluid Mechanics, Shaughnessy, Oxford University Press

Advanced Heat Transfer – I (Conduction and Radiation)

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 lap- lace 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. Radiant energy transfer through absorbing, emitting and scattering media. Combined conduction and radiation systems: fins, Introduction to solar radiation in earth‘s atmosphere.

Books

V.S Arpaci – *Conduction Heat Transfer*
E.M Sparrow, R.D Cess – *Radiation Heat Transf*
R.Siegal and J.R Howell-*Thermal radiation heat transfer*.
Y.A.Sengel, Heat Transfer, Tata McGrawHill
Krith, Fundamentals of Heat Transfer
Ozisik, Heat Transfer, John Wiley

Advanced Refrigeration Engineering

Module I

Analysis of refrigeration cycle, principles of psychrometry properties and processes, Air washer, Cooling towers, dehumidifiers, wet bulb and dew point temperatures. Multistage cycle and their optimization.

Module II

Thermodynamic Properties of pure and mixed refrigerants. Eco-friendly Refrigerants, vapour absorption cycle and its components. Ejector Refrigeration System, Vortex Tubes, Principle of liquefaction of gases, Dry ice manufacture, Magnetic Refrigeration Sysem

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

Refrigeration and Air Conditioning, C.P.Arora, Tata McGraw Hill

Refrigeration and Air Conditioning, Stoecker and Zones, McGraw Hill

Refrigeration and Air Conditioning, Domkundwar and Arora, Dhanpat Rai and Sons

Refrigeration and Air Conditioning, Manohar Prasad, East West Press

Refrigeration and Air Conditioning, P.L.Balaney

Elective I

Internal Combustion Engines

Module I

Thermodynamic Analysis of I.C.Engine Cycles. Effect of design and operating parameters on 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.

Module II

Fuels and combustion in S.I. engines, knocking and fuel rating. Energy balance, volumetric efficiency, measurement of indicated and brake power. Advanced theory of carburetion. Fuel Injection Systems for S.I. and C.I. Engines. Cooling of engine and governing of engine. Ignition system : conventional and electronic.

Module III

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.

Books

Fundamentals of I.C. Engines by H.B.Heywood, McGraw Hill
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

Energy Conservation and Management

Module I

Significance and Scope of Energy conservation and Management, Basic principles and total energy concept, First law optimization, availability. Exergy analysis. Second law optimization of thermal systems.

Module II

Energy audits and conservation programme, elements of energy accounting. Plant energy studies : concepts, resources, procedures and implementation. Energy accounting indices, energy budget and variance analysis- statistical and engineering models. Economic aspects, payback. Waste Heat recovery; high, medium and low temperature applications, Methods of energy conservation in domestic and industrial sectors; case studies

Module III

Energy sources, Classification and characterization of fuels (fossil and bio-fuel), conversion and utilization, environmental and economic issues, optimum use of energy resources, Thermodynamic cycles, Principles of thermal energy conversion in boilers, internal combustion engines and gas turbines, cogeneration and combined cycle power generation, fuel cells and MHD technology, solar, wind and nuclear power, utilization of industrial heat, Energy management in industry, Environmental and economic evaluation advanced pollution control technology.

Book

R. Gold Stick and A. Thumann, Principles of Waste Heat Recovery, PHI, 1986.

D. Y. Goswami, F. Kreith, Energy Conversion- CRC Press, 2007

V. Kadambi, and M. Prasad, Introduction to energy conversion turbo machinery: Energy conversion cycle- Wiley Eastern, New Delhi, 1974,

Gas Dynamics

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 shock waves; 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

L. D. Landau and E. M. Lifshitz, Fluid Mechanics. 2nd ed., Butterworth-Heinemann, 1995.

H. W. Liepmann, and A. Roshko, Elements of Gas Dynamics, Dover Pub, 2001.

References

P. H. Oosthuizen and W. E. Carscallen. Compressible Fluid Flow. NY, McGraw-Hill, 1997.

M. A. Saad, Compressible Fluid Flow. 2nd ed. Upper Saddle River, NJ: Prentice-Hall, 1993.

F. M. White, Viscous Fluid Flow. 2nd ed. New York: McGraw-Hill, 1991.

A. H. Shapiro, Compressible Fluid Flow 1 and 2. Hoboken NJ: John Wiley.

Hydel Power and Wind Energy

Module I:
Elements of hydropower scheme, hydropower development in India. Power house structures and Layout. Hydropower plants classification: Surface and underground power stations, Low- medium-high head plants-layout and components, pumped storage plants. Load and power studies: load curve, load factor, load duration curve, firm capacity, reservoir capacity, capacity factor

Module II:
Hydraulic turbines and types and classification, constructional features, selection, characteristic curves, governing of turbine, drafts tubes-types, hydraulic principles. Gates and valves types. Penstock and surge tanks.
Wind machine types, classification, parameters. Wind measurements, data presentation, power in the wind. Wind turbine aerodynamics, momentum theories, basic aerodynamics, airfoils and their characteristics

Module III:
Horizontal Axis Wind Turbine (HAWT) - Blade Element Theory, wake analysis, Vertical Axis Wind Turbine (VAWT) aerodynamics.
HAWT rotor design considerations, number of blades, blade profile, 2/3 blades and teetering, coning, power regulation, yaw system, tower.
Wind turbine loads, aerodynamic loads in steady operation, wind turbulence, static - dynamic - fatigue analysis, yawed operation and tower shadow, WECS control system, requirements and strategies.
Wind Energy Conversion System (WECS) siting, rotor selection, Annual Energy Output (AEO).
Synchronous and asynchronous generators and loads, integration of wind energy converters to electrical networks, inverters. Testing of WECS.

Text Books

Water Power Engineering: M.M.Desmukh, Dhanpat rai and Sons
Wind Energy Conversion Systems, Freris L.L., Prentice Hall 1990.

Reference Books

Water power Development : Mosonyi
Hydroelectric hand book: Creagar, W.P. and Justin, J.D., John Wiley & Sons,New York.
Davis' Handbook of applied hydraulics : Zipparro, V. J. and Hasen H., Mc-GrawHill, Inc.,
Hydropower structures : R.S.Varshiray, Nem Chand and Bros. Roorkee
Water Power Engineering: M.M.Dandekar and K.N.Sharma, Vikas Pub
Spera D.A., Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering, ASME Press, NY 1994.
Johnson, G.L., Wind Energy Systems, Prentice Hall, 1985.

Elective II:

Solar Energy Technology

Module I

Current alternate energy sources-thermodynamic view point and conversion methods. Components of solar energy systems, collector performance. Radiation and meteorological data processing, long term conversion factors. System configurations and system performance prediction.

Module II

Simulations, design methods. System design and optimizations. Solar thermal systems applications to power generation, heating and cooling.

Module III

Solar passive devices solar stills, ponds, greenhouse, dryers. Trombe wall, overhangs and winged walls. Wind energy conversion systems. Economics of solar and wind energy systems.

Text Books

S. P. Sukhatme, Solar Energy - Principles of thermal collection and storage, second edition, Tata McGraw-Hill, New Delhi, 1996

J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, second edition, John Wiley, New York, 1991

References

D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia, 2000

D. D. Hall and R. P. Grover, Biomass Regenerable Energy, John Wiley, New York, 1987.

J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, 1986.

Thermal and Nuclear Power Plants

Module I :
Energy scenario. Overview of steam power plant. Analysis of steam cycles. Feedwater heaters. Deaerator and drain cooler. Optimization of cycle parameters, reheat and regeneration. Analysis of multi-fluid coupled cycles. Cogeneration of powerand process heat. Combined cycle power generation. Fuels. Combustion mechanisms. Draft systems. Combustion control. Furnaces for burning coal in fluidized beds and in pulverized form. Coal handling installation.

Moddule II :
Different types of boilers and their specific uses. Boiler mountings and accessories. Feedwater treatment. Boiler maintenance. Circulation theory. Downcomers and risers. Drum and its internals. Economiser. Convective and radiant super heaters. Superheat temperature control. Recuperative and regenerative air preheaters. Dust and ash removal systems. Environmental aspects of power generation

Module III :
Basic concepts of reactor physics, radioactivity. Neutron Scattering. Thermal and fast reactors. Nuclear cross-sections. Neutron flux and reaction rates. Moderator criteria. Reactor core design. Conversion and breeding. Types of reactors. Characteristics of boiling water, pressurized water, pressurized heavy water, gas cooled and liquid metal cooled reactors. Future trends in reactor design and operation. Thermal-hydraulics of reactors. Heavy water management. Containment system for nuclear reactor. Reactor safety radiation shields. Waste management. Indian nuclear power programme.

Text Book:

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.

S. Sarg et al., ‗*Physics of Nuclear Reactors'*, Tata McGraw Hill Publishing Company Ltd., 1985.

T. J. Connoly., ‗*Fundamentals of Nuclear Energy'*, John Wiley, 1978.

Renewable Energy Systems

Module I

Energy scenario and renewable energy sources : global and Indian situation. Potential of non-conventional energy sources, economics. Solar Radiation: Solar thermal process, heat transfer devices, solar radiation measurement, estimation of average solar radiation. Solar energy storage: stratified storage, well mixed storage, comparison.

Module II

Hot water system, practical consideration, solar ponds, Non-convective solar pond, extraction of thermal energy and application of solar ponds. Wind energy: The nature of wind. Wind energy resources and modeling. Geothermal energy: Origin and types of geothermal energy and utilization.

Module III

OTEC: Ocean temperature differences. OTEC systems. Recent OTEC developments. Wave energy: Fundamentals. Availability Wave-energy conversion systems. Tidal energy: Fundamentals. Availability Tidal-energy conversion systems. ; Energy from biomass: Photosynthesis; Biomass resource; Utilisation of biomass.

Books

S.P.Sukhatme, ‗Solar Energy Principle of Thermal Collection and Storage', Tata McGraw Hill, 1990.

G.L. Johnson, Wind energy systems, Prentice Hall Inc. New Jersey.

J.M.Kriender, ‗Principles of Solar Engineering', McGraw Hill, 1987.

Reference

V.S. Mangal, ‗Solar Engineering', Tata McGraw Hill, 1992.

N.K.Bansal, ‗Renewable Energy Source and Conversion Technology', Tata McGraw Hill, 1989.

P.J. Lunde., ‗Solar Thermal Engineering', John Willey & Sons, New York, 1988.

J.A. Duffie, and W.A. Beckman, ‗Solar Engineering of Thermal Processes', Wiley & Sons, 1990.

Design of Thermal Systems

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

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

References

Y. Jaluria, Design and Optimization of Thermal Systems –CRC Press, 2007.

Bejan, G. Tsatsaronis, M.J. Moran, Thermal Design and Optimization - Wiley, 1996.

R. F. Boehm, Developments in the Design of Thermal Systems - Cambridge University Press, 1997.

N.V. Suryanarayana, Design & Simulation of Thermal Systems - MGH, 2002.