

UNIVERSITY OF MUMBAI



Revised Syllabus for the M. E. Program
Program: M. E. (Mechanical Engineering)
THERMAL ENGINEERING

(As per Credit Based Semester and Grading System with
effect from the academic year 2012–2013)

**Program Structure for
ME Mechanical Engineering (Thermal Engineering)
Mumbai University
(With Effect from 2012-2013)
Semester I**

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned						
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total			
TEC101	Advanced Thermodynamics & Heat Transfer ^{&}	04	--	--	04	--	--	04			
TEC102	Experimental Techniques and Instrumentation in Thermal & Fluids Engineering	04	--	--	04	--	--	04			
TEC103	Numerical Methods and Computational Techniques	04	--	--	04	--	--	04			
TEE101X	Elective I	04	--	--	04	--	--	04			
TEE102X	Elective II	04	--	--	04	--	--	04			
TEL101	Laboratory I - Simulation of Thermal Systems	--	02	--	--	01	--	01			
TEL102	Laboratory II - Renewable Energy Lab	--	02	--	--	01	--	01			
Total		20	04	--	20	02	--	22			
Subject Code	Subject Name	Examination Scheme									
		Theory					End Sem.E xam.	Exam. Duration (in Hrs)	Term Work	Pract. /oral	Total
		Internal Assessment			Avg.						
		Test 1	Test 2	Avg.							
TEC101	Advanced Thermodynamics & Heat Transfer ^{&}	20	20	03	80	03	--	--	100		
TEC102	Experimental Techniques and Instrumentation in Thermal & Fluids Engineering	20	20	03	80	03	--	--	100		
TEC103	Numerical Methods and Computational Techniques	20	20	03	80	03	--	--	100		
TEE101X	Elective I	20	20	03	80	03	--	--	100		
TEE102X	Elective II	20	20	03	80	03	--	--	100		
TEL101	Laboratory I - Simulation of Thermal Systems	--	--	--	--	--	25	25	50		
TEL102	Laboratory II - Renewable Energy Lab	--	--	--	--	--	25	25	50		
Total		--	--	100	400	--	50	50	600		

Subject Code	Elective I	Subject Code	Elective II
TEE1011	Refrigeration & Air Conditioning System Design	TEE1021	Utilization of Solar Energy
TEE1012	Uncertainty and Error Analysis	TEE1022	Power Generation Methodologies
TEE1013	Cogeneration and Waste Heat Recovery Systems	TEE1023	Energy Conservation, Management and Audit
TEE1014	Fluid Dynamics	TEE1024	Environmental Engineering & Pollution Control

&Common for Energy Engineering and Thermal Engineering

Semester II

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned				
		Theor y	Pract.	Tut.	Theory	Pract.	Tut.	Total	
TEC201	Modeling and Analysis in Thermal Engineering	04	--	--	04	--	--	04	
TEC202	Computational Fluid Dynamics	04	--	--	04	--	--	04	
TEC203	Fuels, Combustion and Emission Control	04	--	--	04	--	--	04	
TEE203X	Elective III	04	--	--	04	--	--	04	
TEE204X	Elective IV	04	--	--	04	--	--	04	
TEL203	Laboratory III - CFD Lab	--	02	--	--	01	--	01	
TEL204	Laboratory IV - Measurement & Virtual Instrumentation [§]	--	02	--	--	01	--	01	
Total		20	04	--	20	02	--	22	
Subject Code	Subject Name	Examination Scheme							
		Theory					Term Work	Pract. /oral	Total
		Internal Assessment			End Sem.E xam.	Exam. Duration (in Hrs)			
		Test1	Test 2	Avg.					
TEC201	Modeling and Analysis in Thermal Engineering	20	20	20	80	03	--	--	100
TEC202	Computational Fluid Dynamics	20	20	20	80	03	--	--	100
TEC203	Fuels, Combustion and Emission Control	20	20	20	80	03	--	--	100
TEE203X	Elective III	20	20	20	80	03	--	--	100
TEE204X	Elective IV	20	20	20	80	03	--	--	100
TEL203	Laboratory III - CFD Lab	--	--	--	--	--	25	25	50
TEL204	Laboratory IV - Measurement & Virtual Instrumentation [§]	--	--	--	--	--	25	25	50
Total		--	--	100	400	--	50	50	600

Subject Code	Elective III	Subject Code	Elective IV
TEE2031	Cryogenic Engineering	TEE2041	Speciality Engines
TEE2032	Internal Combustion Engine Design	TEE2042	Convective Heat Transfer
TEE2033	Heat Exchanger Design ^{&}	TEE2043	Non Conventional Power Plants
TEE2034	Steam and Gas Turbine	TEE2044	Advanced Turbo Machinery

[&] Common for Energy Engineering and Thermal Engineering

[§] Common for Machine Design, Automobile Engineering and Thermal Engineering

Semester III

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned				
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total	
TES301	Seminar	--	06	--	--	03	--	03	
TED301	Dissertation I	--	24	--	--	12	--	12	
Total		--	30	--	--	15	--	15	
Subject Code	Subject Name	Examination Scheme							
		Theory					Term Work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.				
		Test1	Test 2	Avg.					
TES301	Seminar	--	--	--	--	50	50	100	
TED301	Dissertation I	--	--	--	--	100	--	100	
Total		--	--	--	--	150	50	200	

Semester IV

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned				
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total	
TED401	DissertationII	--	30	--	--	15	--	15	
Total		--	30	--	--	15	--	15	
Subject Code	Subject Name	Examination Scheme							
		Theory					Term Work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.				
		Test1	Test 2	Avg.					
TED401	DissertationII	--	--	--	--	100	100	200	
Total		--	--	--	--	100	100	200	

Note:

- In case of Seminar, 01 Hour / week / student should be considered for the calculation of load of a teacher
- In case of Dissertation I, 02 Hour / week / student should be considered for the calculation of load of a teacher
- In case of Dissertation II, 02 Hour / week / student should be considered for the calculation of load of a teacher

Subject Code	Subject Name	Credits
TEC101	Advanced Thermodynamics & Heat Transfer^{&}	04

Module	Detailed Contents	Hrs.
01	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, Phase change process of pure substances, PVT surface, P-v & P-T diagrams, Use of steam tables and charts in common use	10
02	2nd law Analysis for engineering systems, T-ds relations, entropy generation, thermo electricity, Onsager equation. Exergy analysis of thermal systems, Thermodynamic Property Relations, Partial Differentials, Maxwell relations, Clapeyron equation,	10
03	Statistical Thermodynamics- Fundamentals, equilibrium distribution, Significance of Lagrangian multipliers, Partition function, Calculations of macroscopic properties from partition function, partition function for an ideal monatomic gas, equipartition of energy, Maxwell-Boltzmann statistics, Bose Einstein statistics, Fermi-Dirac statistics	10
04	Three dimensional heat conduction equation, conduction with moving boundaries, porous media heat transfer, Analytical solutions for temperature distribution, Numerical methods for fin analysis. Transient Conduction: Lumped capacitance and its validity, General lumped capacitance analysis, spatial effects. Problems related with conventional geometries.	10
05	Radiation in gases and vapour, Principle of Fluid flow and Convective heat transfer, Dimensionless parameters & physical significance, Reynolds analogy, Chilton-Colburn analogy, Heat transfer enhancement, Passive, active and compound Techniques	10
06	Phase change heat transfer and heat exchanger: condensation with shear edge on bank of tubes, Boiling - pool and flow boiling, Heat exchanger, E-NTU approach and design procedure, compact heat exchangers.	10

&Common for Energy Engineering and Thermal Engineering

TEXT BOOKS:

1. Sonntag, R.E., and Van Wylen, G, Introduction to Thermodynamics, Classical and Statistical, John Wiley and Sons,
2. Cengel Y.A. & Boles M.A., Thermodynamics an Engineering Approach, TMH
3. Rao, Y.V.C., Postulational and Statistical Thermodynamics, Allied Publisher Limited, New Delhi
4. Kalyan Annamalai & Ishwar K Puri, Advanced Thermodynamics Engineering, CRC Press London
5. Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons
6. Patankar. S.V. Numerical heat Transfer and Fluid flow, Hemisphere Publishing Corporation

REFERENCES:

1. J.P. Holman- Heat transfer, McGraw Hill, Int.
2. S.P. Sukhatme, Heat transfer, University Press
3. Bejan A & Kraus A, Heat Transfer Handbook, John Wiley & Sons
4. Moran and Shapiro -- Fundamentals of Engineering Thermodynamics, John Wiley & Sons
5. Bejan A, Advanced engineering thermodynamics, John Wiley and Sons

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Subject Code	Subject Name	Credits
TEC102	Experimental Techniques and Instrumentation in Thermal & Fluids Engineering	04

Module	Detailed Contents	Hrs.
01	Description Planning of experiments: preliminary, intermediate and final stages in experimental investigations. Steady state and transient techniques. Selection of measuring devices based on static, dynamic characteristics and allowable uncertainties, basics of TAGUCHI method for design of experiments	13
02	Analysis of experimental data and determination of overall uncertainties in experimental investigation, Calibration of temperature measuring devices, uncertainties in measurement of temperature under various conditions	12
03	Optical and radiation methods of temperature measurement. Steady state and transient methods of measuring heat fluxes. Measurement of thermal radiation and associated parameters	10
04	Calibration of pressure and vacuum measuring devices. Estimation of uncertainties in measurements of pressure and vacuum, Calibration of flow and velocity measuring devices. Uncertainties in measurement under various conditions. Measurement of turbulence, hot wire/film anemometers, Measurement of thermophysical properties	12
06	Data logging and acquisition, intelligent instruments and their use, Basics of P, PI, PID controllers, pneumatic and hydraulic controllers, electronic controllers, applications to machine tools, furnaces, material handling etc	11

TEXT BOOKS:

1. Prebrashensky V, Measurements and Instrumentation in Heat Engineering, Vol. 1 and 2, MIR Publishers, 1980
2. Raman C S, Sharma G R, Mani V S N, Instrumentation Devices and Systems, TMH, New Delhi, 1983

REFERENCES:

1. E.O. Doebelin "Measurement systems, Application and Design", McGraw-Hill 1990
2. J.P. Holman "Experimental Methods for Engineers", McGraw-Hill, 1994
3. E.R.G. Eckert and Goldsteen "Measurement Techniques in Heat Transfer", Technovision, 1970

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Subject Code	Subject Name	Credits
TEC103	Numerical Methods and Computational Techniques	04

Module	Detailed Contents	Hrs.
01	Algebraic and transcendental equation: Bisection method, Fixed point, Regula-Falsi method, Muller's method, Newton-Raphson method, Rate of convergence, Merits and demerits of methods	08
02	Simultaneous Linear Equations: Motivation, Gauss elimination, Pivoting, Factoring, Solution accuracy, Iterative methods, Jacobi method, Gauss-Siedel method, Relaxation method.	10
03	Interpolation and Curve Fitting: Motivation, Polynomial forms, Linear interpolation, Lagrangean interpolation, Newton interpolation, Spline interpolation, Chebyshev Interpolation, Regression analysis, Fitting linear equations, Least-square method, Fitting transcendental equations, Polynomial functions, Multiple linear regression.	12
04	Numerical integration and differentiation: Maxima and Minima, Trapezoidal rule, Simpson's 1/3 and 3/8 rule, Weddle's rule, Euler-Maclaurin's formula, Gaussian Quadrature formula	10
05	Numerical solution of ordinary differential equation: Picard's Method of successive approximation, Euler's Method, Modified Euler's Method, Runge-Kutta Methods	10
06	Boundary-value and Eigen-value Problem: Motivation, Shooting method, Finite difference method, Finite volume method, Polynomial method, Power method, Elliptic, Parabolic and Hyperbolic Partial Differential Equations.	10

Students have to develop a programme to cater to a real life thermal engineering problem based on any of the numerical method mentioned in the syllabus as a part of Test

TEXT BOOKS:

1. Computer Based Numerical and Statistical Techniques, Manish Goyal, Laxmi Publications (P) Ltd, New Delhi
2. Introductory Methods of Numerical Analysis, S. S. Sastry, Prentice-Hall of India (P) Ltd, New Delhi

REFERENCES:

1. Numerical Methods in Engineering, Salvadori M G, Baron M L, Prentice-Hall
2. Numerical Methods for Engineers, Chapra S C, Candel R P, 2nd Ed, McGraw-Hill, New York
3. Applied Numerical Analysis, Gerald CF, Wheatley PO, 6th edition, Pearson Education, 1999
4. Numerical Mathematics and Computing, Cheney W., Kincaid D., 5th edition, Thomson / Brooks/Cole, 2004.
5. Numerical Methods for Partial Differential Equations, William F. Ames, 2nd Edition, Academic Press, 1977

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Subject Code	Subject Name	Credits
TEE1011	Refrigeration & Air Conditioning System Design	04

Module	Detailed Contents	Hrs.
01	REFRIGERATION CYCLES: Analysis, Multi-pressure Systems, REFRIGERANTS: Classification of Refrigerants, Refrigerant Properties, Oil Compatibility, Blends, System Design Criteria for New Refrigerants, Phaseout Schedule, Natural Refrigerants	11
02	SYSTEM COMPONENTS : Refrigeration Compressors, Different Types, Performance, Capacity Control, Evaporators, Evaporator Circuitry, Applications and Different Types, Condensers, Types, Evaporative Condensers, Optimum Cooling Water Rate and Velocity, Cooling Towers, Range and Approach	11
03	VAPOUR ABSORPTION SYSTEMS: LiBr& Aqua Ammonia Systems. Double Effect Chillers. Solar Energy operated m/c's PSYCHROMETRICS: Introduction, Properties of air and water vapour mixture. Psychrometric chart and its use in air conditioning. ASHRAE Comfort Chart	11
04	DESIGN OF EQUIPMENTS: Analysis of air conditioning load, load calculation. Equipment selection and balancing. AIR CONDITIONING SYSTEMS: Window Type, Package Type, Split Type, Central Units – direct and indirect. Construction details. Evaporative cooling system.	11
05	AIR DISTRIBUTION: Air Distribution Devices – Air Circuits – Design of Air Supply System. Noise consideration	06
06	SPECIAL APPLICATIONS : Air Conditioning in Automobiles, Railway Coaches, Marine Vessels, Aircraft and other Commercial Applications, Applications of nano technology in HVACR. CONTROLS: Electrical components & controls, starting and running circuits, relay types and controls, Temperature, Pressure, Oil Flow controls, Compressor Motor-Protection Devices.	10

REFERENCES:

1. Dossat, R.J., "Principles of Refrigeration", John Wiley & Sons, 1989.
2. W.F. Stoecker, Refrigeration and Air Conditioning, McGraw Hill Book Company, 1985.
3. Jordan and Priester, Refrigeration and Air Conditioning, 1985.
4. Althouse, A.D., &Turnquist, C.H. "Modern Refrigeration and Air Conditioning". Good Heart – Wilcox Co.
5. Hains, J.B. "Automatic Control of Heating & Air Conditioning", McGraw Hill, 1981.
6. ASHRAE Handbook (Fundamentals & Equipments)
7. P N Ananthanarayanan , "Modern Refrigeration & Air Conditioning" McGraw Hill.
8. Shan K Wang, "Handbook of Refrigeration & Air Conditioning".
9. Threlkeld J L, Thermal Environmental Engineering, Prentice-Hall, 1962
10. Gosney W B, Principles of Refrigeration,Cambridge University Press, 1982

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Subject Code	Subject Name	Credits
TEE1012	Uncertainty and Error Analysis	04

Module	Detailed Contents	Hrs.
01	Basics on Uncertainties General Characteristics of Uncertainties, Definitions, Uncertainty of Data Depending on One Variable, Multiple Uncertainty Components (Quadratic Sum), Uncertainty Evaluations (Error Analysis), Experimental Uncertainty	11
02	Frequency and Probability Distributions , Frequency Distribution (Spectrum), Probability Distributions, Statistical Confidence, Dealing with Probabilities, Inductive Approach to Uncertainty, Deductive Approach to Uncertainty,	10
03	Correlation , Introduction, Correlated (Systematic) Uncertainties, Differentiation from “Systematic Errors” , Correlation in Cases of Linear Regression, Consistency among Data Sets, Target Shooting as a Model for Uncertainties	10
04	Dealing with Internal Uncertainties , Calculations with Both Types of Uncertainties, Total Uncertainty, Using Internal Uncertainties for Diagnosis	08
05	Presentation and Estimation of Uncertainties , Graphic Presentation of Uncertainties, Correct Presentation of Uncertainties, Finding the Size of Internal Uncertainties, Estimating the Size of Uncertainties	10
06	Feedback of Uncertainties on Experiment Design , Optimizing Experiments, Optimizing Background Measurements, Optimizing with Respect to Dead Time, Optimizing in View of the Mathematical Presentation, Achieving the Smallest Overall Uncertainty	11

Students have to apply concepts/ carry out error analysis to a real life thermal engineering problem

TEXT BOOKS:

1. Manfred Drogg, Dealing with Uncertainties A Guide to Error Analysis, Springer, 2007
2. Stephanie Bell, A Beginner’s Guide to Uncertainty of Measurement, , National Physical Laboratory, UK, 1999
3. Taylor J R, Introduction to Error Analysis, University Press, Oxford, 1982

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End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Subject Code	Subject Name	Credits
TEE1013	Cogeneration and Waste Heat Recovery Systems	04

Module	Detailed Contents	Hrs.
01	COGENERATION: Introduction - Principles of Thermodynamics - Combined Cycles-Topping -Bottoming - Organic Rankine Cycles - Advantages of Cogeneration Technology	10
02	APPLICATION & TECHNO ECONOMICS OF COGENERATION: Cogeneration Application in various process industries. Sizing of waste heat boilers - Performance calculations, Part load characteristics selection of Cogeneration Technologies – Financial considerations - Operating and Investments - Costs of Cogeneration	16
03	WASTE HEAT RECOVERY: Introduction - Principles of Thermodynamics and Second Law - sources of Waste Heat recovery - Diesel engines and Power Plant etc.	09
04	WASTE HEAT RECOVERY SYSTEMS: Recuperators - Regenerators - economizers - Plate Heat Exchangers - Waste Heat Boilers-Classification, Location, Service Conditions, Design Considerations, Unfired combined Cycle - supplementary fired combined cycle - fired combined cycle - fluidised bed heat exchangers - heat pipe exchangers - heat pumps - thermic fluid heaters	10
05	APPLICATIONS & TECHNO ECONOMICS of Waste Heat Recovery Systems: Applications in industries, selection of waste heat recovery technologies - financial considerations - operations and investment costs of waste heat recovery	09
06	Introduction to tri-generation and quad-generation	06

REFERENCES:

1. Charles H.Butler, Cogeneration, McGraw Hill Book Co., 1984.
2. Horlock JH, Cogeneration-Heat and Power, Thermodynamics and Economics, Oxford, 1987.
3. Institute of Fuel, London, Waste Heat Recovery, Chapman & Hall Publishers, London, 1963.
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.
6. I. Pilatowsky, R.J. Romero, C.A. Isaza, S.A. Gamboa, P.J. Sebastian, W. Rivera, Cogeneration Fuel Cell-Sorption Air Conditioning Systems (Green Energy and Technology), Springer

Assessment:

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End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Subject Code	Subject Name	Credits
TEE1014	Fluid Dynamics	04

Module	Detailed Contents	Hrs.
01	Mass, Momentum and Energy Conservation & Governing Laws: Statistical & continuum methods, Eulerian&Lagrangian coordinates, material derivatives, control volumes, Reynolds transport theorem (RTT), conservation of mass, momentum and energy, constitutive equations, Navier-Stokes equations-differential &intergral approach, energy equations, governing equations for Newtonian fluids, boundary conditions.	11
02	Potential Flows: Stokes stream functions, solution of potential equation, flow in a sector, flow around a sharp edge, flow near a blunt nose force and moment on a circular cylinder and sphere, conformal transformations, Joukowski transformations, Elements of airfoil and wing theory.	11
03	Viscous Incompressible Flows: Exact solutions for Couette flow, Poiseuille flow, flow between rotating cylinders, Stokes first problem, Stokes second problem, pulsating flow between parallel surfaces, stagnation-point flow, flow over porous wall. Stokes approximation,	11
04	Boundary Layer Theory: Review of boundary layers: laminar and turbulent boundary layers; transition; separation, Blasius' solution for boundary layer	09
05	Introduction to turbulence: Transition of flows, Origin of turbulence- its consequences; Physics of turbulent motion- concept of Reynolds stress, mean flow equations, Turbulence models RANS, LES. DNS- Kolmogorov scales. Isotropic and homogeneous turbulence.	10
06	Introduction to Compressible Flow: Velocity of sound and its importance, physical difference between incompressible, subsonic and supersonic flows, Mach no. Application to subsonic, transonic and supersonic flow around a two-dimensional aerofoil.	08

REFERENCES:

1. Foundations of Fluid Mechanics, S.W. Yuan, Prentice-Hall India Pvt. Ltd, New Delhi.
2. Advanced Fluid Mechanics, K. Muralidhar & G. Biswas, Narosa Publishing, 2005.
3. Boundary Layer Theory, H. Schlichting, 6th Edition, McGraw-Hill Inc., 1986.
4. Turbulent Flow, R. J. Garde, 2nd Edition, New Age International Publishers.
5. Modern Compressible Flow with Historical Perspective, John D. Anderson, McGraw Hill.
6. Fundamentals of Aerodynamics (2nd ed), J. D. Anderson, McGraw Hill.
7. Fundamentals of Fluid Mechanics, B.R. Munson, D.F. Young & T.H. Okiishi, 2nd Ed., John Wiley.
8. Introduction to Fluid Mechanics, R.W. Fox & A.T. McDonald, 5th Edition, John Wiley, 2001.
9. Viscous Fluid Flow, F. M. White, 2nd Edition, McGraw-Hill, 1991.

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Subject Code	Subject Name	Credits
TEE1021	Utilization of Solar Energy	04

Module	Detailed Contents	Hrs.
01	Description Solar Radiation, availability, measurement and estimation; Isotropic and anisotropic models; empirical relations	10
02	flat plate collector, concentrating collector, thermal energy storage: steady state and dynamic analysis, process economics	10
03	Solar water heating: active and passive, building heating and cooling, solar drying, solar distillation	11
04	Industrial process heating, solar ponds: evaporative processes	09
05	Simulation in solar process design, limitations of simulation, design of active systems by f-chart, utilizability method	08
06	Solar photovoltaic systems, PV generators: characteristics and models, load characteristics and direct coupled systems, maximum power point trackers, applications, design procedure , applications of nano materials/technology in solar energy	12

References:

1. S. P. Sukhatme, Solar Energy - Principles of thermal collection and storage, third edition, Tata McGraw-Hill, New Delhi.
2. J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, second edition, John Wiley, New York, 1991.
3. D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia, 2000.
4. M. S. Sodha, N. K. Bansal, P. K. Bansal, A. Kumar and M. A. S. Malik, Solar Passive Building: science and design, Pergamon Press, New York, 1986.
5. M. A. S. Malik, G. N. Tiwari, A. Kumar and M.S. Sodha, Solar Distillation. Pergamon Press, New York, 1982.

Assessment:

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Subject Code	Subject Name	Credits
TEE1022	Power Generation Methodologies	04

Module	Detailed Contents	Hrs.
01	Energy Resources, Primary, secondary, renewable, non renewable energy sources. Major energy resources in use for power generation: Fossil fuel, nuclear fuel, hydel, solar, wind and geothermal resources.	12
02	Advanced features of various types of power plants, e.g., thermal, hydro, nuclear, solar, wind, tidal, bio-gas, geothermal, fuel cell, thermo photovoltaic, etc	11
03	Non conventional Emerging renewable power generation technologies: Solar thermal energy Updraft tower, power tower, solar furnace, wave power,	11
04	Non Conventional Experimental power generation technologies: Atmospheric Cold Megawatts (ACM), Blue energy/ Reverse electro dialysis, thermoelectric power	10
05	Utilizing Waste Materials as a Source of Alternative Energy: Benefits and Challenges	09
06	Techno-Economic feasibility study of power generation	07

References:

1. Energy and power generation handbook : established and emerging technologies / editor K.R. Rao, ASME Press, 2011
2. Power Generation Technologies, Paul Breeze, Elsevier, 2005

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Subject Code	Subject Name	Credits
TEE1023	Energy Conservation, Management and Audit	04

Module	Detailed Contents	Hrs.
01	Introduction: Energy Scenario, Importance of energy Conservation, Need of Energy Management, Energy audit: Types of Energy Audit, Methodology, Onsite measurements, Instruments, analysis of Energy Consumption pattern, Material and Energy Balance	09
02	Energy Efficiency in Thermal Systems: Steam systems, Fuels and Combustion, Boiler Efficiency, Steam distribution, Thermal Insulation, Furnaces, Waste heat recovery, Cogeneration	11
03	Energy Efficiency in Electrical Systems: Power factor, Motor drives, Motor Loading and efficiency, Speed control of Motors, Lighting, Energy efficient windows	10
04	Energy Efficiency in utility systems: Energy conservation in Pumps, Fans, Compressed Air Systems, Refrigeration & air conditioning systems, recuperators, heat wheels, heat pipes, heat pumps.	10
05	System Approach: Motor Pump system, Motor Compressor system, etc. Case Study	09
06	Demand side management: Load curve analysis, peak shifting/scheduling Economic Analysis: Calculating Energy savings, Payback period, Life Cycle costing, Internal Rate of return	11

References:

1. L.C.Witte, P.S.Schmidt, D.R.Brown, Industrial Energy Management and Utilisation, Hemisphere, Washington, 1988.
2. Industrial Energy Conservation Manuals, MIT Press, Mass, 1982.
3. I.G.C.Dryden, Butterworths, The Efficient Use of Energy, London, 1982
4. W.C.Turner, Wiley, Energy Management Handbook, New York, 1982.
5. Technology Menu for Efficient energy use- Motor drive systems, Prepared by National Productivity Council and Centre for & Environmental Studies- Princeton Univ, 1993.

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Subject Code	Subject Name	Credits
TEE1024	Environmental Engineering & Pollution Control	04

Module	Detailed Contents	Hrs.
01	Air Pollution Natural and anthropogenic sources of pollution, Primary and Secondary pollutants, Transport and diffusion of pollutants, Gas laws governing the behavior of pollutants in the atmosphere, air sampling methods, Methods of monitoring and control of air pollutants SO ₂ NO ₂ , CO, SPM	11
02	Effects of pollutants on human beings, plants, animals, materials and on climate, Acid Rain, Ambient Air Quality Standards, Air pollution control methods and equipment.	10
03	Water Pollution Types, sources and consequences of water pollution, Physico-chemical and Bacteriological sampling and analysis of water quality, Standards. sewage and waste water treatment and recycling ASP/STP, Water quality standard, treatment, utilization and disposal of sludge, Government norms	09
04	Land Pollution Sources and classification of land pollutants, Industrial waste effluents and heavy metals, their interactions with soil components, degradation of different insecticides, fungicides and weedicides in soil. Solid waste management, Process and equipments for energy recovery from municipal solid waste and industrial waste, MSW Act 2000.	10
05	Other sources of pollution Noise: Sources of noise pollution, measurement of noise and Indices, exposure levels and standards, Noise control and abatement measures. Impact of noise on human health. Marine : Sources and nature of pollutants, oil pollution, metallic pollutants, status of coastal and estuarine pollution in India, Chemicals and drugs from oceans, sea level rise, cause, effect and control Radiation: Introduction, types of radiation and radioactivity, sources and effects.	10
06	Pollution from power generation Pollutants from power generation points-thermal power plant, Control measures to Reduce them. Environmental considerations in cogeneration and waste heat recovery	10

Text Books:

1. Rao&Rao, Air Pollution
2. C J Rao, Environmental engineering, New Age Publishers

References:

1. G. Masters, Introduction to Environmental Engg&Science, Prentice Hall
2. H S Peavy, D R Rowe, G Tchobanoglous, Environmental Engg, McGraw Hill
3. DeNevers Noel, Air Pollution control Engg, McGraw Hill
4. Metcalf & Eddy, Waste Water Engg:treatment& reuse, McGraw Hill

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Subject Code	Subject Name	Credits
TEL101	Simulation of Thermal Systems	01

Simulation study using mathematical simulation software (or any programming language) on any six

1. Performance test on Spark Ignition engines using Alternate fuels such as ethanol and LPG.
2. Simulation studies of Vapour Absorption System.
3. Simulation studies of Petrol and Diesel engine cycles.
4. Simulation of Gas Turbine Cycles.
5. Simulation of Adiabatic flame temperature in constant volume heat addition process.
6. Simulation of Adiabatic flame temperature in constant pressure heat addition process
7. Calibration of a cryogenic temperature-measuring instrument.
8. Trial / Design of Sterling cycle refrigerator.
9. Trial / Design of Pulse tube refrigerator.

Visit to gas liquefaction plant.

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
TEL102	Renewable Energy Lab	01

1. Measurement of solar radiation and sunshine hours,
2. Measurement of albedo, UV & IR radiation,
3. Measurement of emissivity, reflectivity, transmittivity,
4. Performance testing of solar flat plate water heater (forced flow &thermosyphon systems)
5. Performance testing solar air heater & dryer & desalination unit,
6. Performance testing of solar thermal concentrators,
7. Characteristics of photovoltaic devices & testing of solar PV operated pump,
8. Energy consumption & lumen measurement of lights & ballasts.
9. Properties of fuel oils & biomass,
10. Testing of Gasifier orWind machines orFuel cell

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
TEC201	Modeling and Analysis in Thermal Engineering	04

Module	Detailed Contents	Hrs.
01	Introduction, Design versus analysis, need for optimization, basic characteristics of thermal systems, analysis, types and examples: energy systems, cooling systems for electronic equipment, environmental and safety systems, air-conditioning, refrigeration and heating systems, heat transfer equipment	11
02	Modeling of thermal systems, basic considerations in design, importance of modeling in design, types of models, mathematical modeling, physical modeling and dimensional analysis	08
03	Numerical modeling and simulation, development of a numerical model, solution procedure, merging of different models, accuracy and validation, system simulation, methods of numerical simulation, numerical simulation versus real systems	11
04	Economic considerations, calculation of interest, worth of money as a function of time, raising capital, economic factors in design, application to thermal systems	10
05	Problem formulation for optimization, basic concepts, optimization methods, optimization of thermal systems, practical aspects in optimal design	10
06	Knowledge based design and additional considerations, knowledge based systems, additional constraints, sources of information	10

Text Books:

1. YogeshJaluria, Design and Optimization of Thermal Systems, McGraw-Hill international editions, 1998

References:

1. Eckert E R G and Drake R M – Analysis of Heat and Mass Transfer, McGraw-Hill, New York, 1972
2. Szucs E – Similitude and Modeling, Elsevier, New York, 1977
3. Wellstead P E – Introduction to Physical System Modeling, Academic Press, New York, 1979
4. Chapra S C and Canale R P – Numerical Methods for Engineers, McGraw-Hill, New York, 1988
5. Atkinson K – An Introduction to Numerical Analysis, Wiley, New York, 1978

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Subject Code	Subject Name	Credits
TEC202	Computational Fluid Dynamics	04

Module	Detailed Contents	Hrs.
01	Definition and overview of CFD, Advantages and applications, CFD methodology	06
02	GOVERNING DIFFERENTIAL EQUATIONS: Governing equations for mass, momentum and energy; Navier-Stokes equations; Mathematical behavior of PDE's viz. parabolic, elliptic and hyperbolic, Initial and boundary conditions, Initial and Boundary value problems.	10
03	DISCRETIZATION TECHNIQUES: Introduction to Finite difference Method, Finite Volume method and Finite Element method Finite difference methods; Finite difference representation of PDE's; Solutions to Finite Difference Equations; Implicit, semi-implicit and explicit methods; Errors and stability criteria	13
04	FINITE VOLUME METHODS: FVM solutions to steady one, two and three dimensional diffusion problems and unsteady one and two dimensional diffusion problems, FVM solutions to convection-diffusion problems - one and two dimensional, steady and unsteady; Advection schemes; Pressure velocity coupling; SIMPLE family of algorithms	14
05	GRID GENERATION : Structured and Unstructured Grids; General transformations of the equations; body fitted coordinate systems; Algebraic and Elliptic Methods; multi block structured grids; adaptive grids	08
06	TURBULENCE MODELING: Effect of turbulence on governing equations; RANS, LES and DNS Models	09

References:

1. Muralidhar, K., Sundararajan, T., "Computational fluid flow and heat transfer", Narosa Publishing House, New Delhi 1995
2. Ghoshdasdar, P.S., "Computer simulation of flow and heat transfer" Tata McGraw-Hill Publishing company Ltd., 1998.
3. Subas, V. Patankar, "Numerical heat transfer fluid flow", Hemisphere publishing Corporation.
4. Taylor, C and Hughes J.B., Finite Element Programming of the Navier Stokes Equation, Pineridge Press Ltd., U.K , 1981.
5. Anderson, D.A., Tannehill , I.I., and Pletcher, R.H., Computational fluid Mechanics and Heat Transfer, Hemisphere Publishing Corporation, New York , USA, 1984.
6. Fletcher, C.A.J., "Computational Techniques for Fluid Dynamics 1" Fundamental and General Techniques, Springer- Verlag , 1987

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Subject Code	Subject Name	Credits
TEC203	Fuels, Combustion and Emission Control	04

Module	Detailed Contents	Hrs.
01	Introduction to fuels, types of fuels, commercial and non commercial fuels. Solid Fuels: Different types of solid fuels, Family of coal, origin of coal, composition of coal, analysis and properties of coal, action of heat on coal, oxidation of coal, hydrogenation of coal, classification of Indian coal, Storage of coal, carbonization, gasification and liquefaction and pulverization of solid fuels.	11
02	Liquid Fuels: Introduction to Petroleum, origin of petroleum, petroleum production, composition and classification, processing of petroleum, Important petroleum products, properties of petroleum products, liquid fuels from sources other than petroleum, storage and handling of liquid fuels, gasification of liquid fuels, petroleum refining in India.	10
03	Gaseous Fuels: Classification of gaseous fuels based on mode of occurrence and method of production, cleaning and purification of gaseous fuels. Hydrogen as energy carrier	10
04	COMBUSTION Combustion stoichiometry, Nature of combustion process, types of combustion process, Mechanism of combustion reaction, Spontaneous ignition temperature, velocity of flame propagation, limits of inflammability, flame structure, stability and diffusion of flames.	11
05	Kinetics of liquid and solid fuel combustion. Combustion appliances: Oil and gas burners, coal burning equipments.	11
06	EMISSION CONTROL Introduction, atmosphere, Emission control methods. Quantification of emissions	07

Text Books:

1. Fundamentals of Combustion by D P Mishra, PHI Publications.
2. Fuels and combustion by S P Sharma, Tata McGraw Hill Publications, 1984.

References:

1. Fuels and combustion by Samir Sarkar, Universities Press (India) Pvt Ltd, Third Edition 2009.
2. An Introduction to Combustion: Concepts and Applications, Stephen Turns, McGraw Hill Publications.
3. Principles of combustion by K K Kuo, 2nd Edition, John Wiley & Sons, New Jersey, 2005
4. Gupta, R B., "Hydrogen fuel: Production, transport and storage", Boca Raton : CRC Press, 2008.
5. Vishwanathan B., and Scibioh M A., "Fuel Cells", Hyderabad: Universities Press, 2006.

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Subject Code	Subject Name	Credits
TEE2031	Cryogenic Engineering	04

Module	Detailed Contents	Hrs.
01	Introduction: Basic thermodynamics applied to liquification and refrigeration process, isothermal, adiabatic and Joule Thompson expansion process, adiabatic demagnetization, low temperature properties of engineering material, properties of cryogenic fluids	10
02	Liquification cycles: Carnot liquification cycle, Figure of Merit and yield of liquification cycles. Inversion curve, Joule Thompson effect	10
03	LindeHampson cycle, Precooled LindeHampson cycle, Claudes cycle, Dual cycle	09
04	Gas Liquification Systems: Helium refrigerated hydrogen liquification systems. Critical components in liquification systems, Binary mixtures, T-C and H-C diagrams, Principle of rectification, Rectification column analysis, McCabe Thiele method, Adsorption system for purification	11
05	Cryogenic Refrigerators: J T cryocoolers, Stirling cycle refrigerators, G M Cryocoolers, Pulse Tube Refrigerators, Regenerators used in cryogenic refrigerators, Magnetic refrigerators, Cryogenic Dewar construction and design, Cryogenic Transfer Lines, Insulations used in Cryogenic systems	10
06	Measurement and Application of Cryogenics: Different types of vacuum pumps, Instrumentation to measure flow, level and temperature. Applications of cryogenics in space programs, Superconductivity, Cryo Metallurgy, Medical and biological applications	10

References:

1. Klaus D. Timmerhause and Thomas M Flynn, Cryogenic Process Engineering, Plenum Press, New York, 1989
2. Randall F Barron, Cryogenic Systems, McGraw Hill, 1985
3. Scott R B, Cryogenic Engineering, Van Nostrand and Co., 1962
4. Herald Weinstock, Cryogenic Technology, 1969

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Subject Code	Subject Name	Credits
TEE2032	Internal Combustion Engine Design	04

Module	Detailed Contents	Hrs.
01	General Considerations in Engine Design: Principle of similitude, choice of cycle, speed, fuel, bore and stroke, cylinder arrangement, choice of material, stress and fatigue considerations, design for manufacture	10
02	Design of Major Components: Piston system, connecting rod assembly, crankshaft system, valve gearing ,stress analysis	10
03	Design of Other Components: Inlet and exhaust manifolds, cylinder block, cylinder liner, cylinder head, gaskets, crankcase, Engine foundations and mountings, bearings, flywheel. Turbocharger, supercharger, computer controlled fuel injection system	12
04	Design of Two-Stroke Engines: Arrangement and sizing of ports, piston assembly, intake and exhaust system, scavenging, application to automotive gasoline and marine diesel engines	10
05	Optimization of Engine Components, Preparation of working drawings of designed components	11
06	Multi-fuel engines, Effect of change in fuel on engine design and performance	07

References:

1. Maleev V L, Internal Combustion Engines; Theory and Design, 2nd Intl. Ed., McGraw-Hill, New York, 1973
2. Gordon P.Blair, Basic design of Two-stroke Engines, S.A.E., 1992.
3. Gordon P.Blair, Advanced Concepts of Two-stroke Engines, S.A.E., 1990.
4. Pounder, C.C., Marine Diesel Engines, Butterworths, 1981.
5. A.Kolchin and V.Demidov, Design of Automotive Engines, Mir Publishers, Moscow, 1984.
6. Gordon P.Blair, Design and Simulation of Four-Stroke Engines, Society of Automotive Engineers, Inc.,USA, 1999.
7. D.E. Winterbone and R.J.Pearson, Design Techniques for Engine Manifolds, Wave action methods for I.C Engines, Professional Engineering Publishing Ltd., UK, 2000

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Subject Code	Subject Name	Credits
TEE2033	Heat Exchanger Design^{&}	04

Module	Detailed Contents	Hrs.
01	Constructional Details and Heat Transfer: Types - Shell and Tube Heat Exchangers - Regenerators and Recuperators - Industrial Applications Temperature Distribution and its Implications - LMTD – Effectiveness	10
02	Flow Distribution and Stress Analysis: Effect of Turbulence - Friction Factor - Pressure Loss - Channel Divergence Stresses in Tubes - Heater sheets and Pressure Vessels - Thermal Stresses - Shear Stresses - Types of Failures	10
03	Design Aspects: Heat Transfer and Pressure Loss - Flow Configuration - Effect of Baffles - Effect of Deviations from Ideality - Design of Typical Liquid - Gas-Gas-Liquid Heat Exchangers	10
04	Condensers and Evaporators Design: Design of Surface and Evaporative Condensers - Design of Shell and Tube - Plate Type Evaporators	10
05	Cooling Towers: Packing - Spray Design - Selection of Pumps - Fans and Pipes - Testing and Maintenance, Compact cooling towers	10
06	Design of Special Purpose Heat Exchangers: corrosive environment. Marine/space applications, compact heat exchanger	10

&Common for Energy Engineering and Thermal Engineering

Text Books:

1. Shah R K, Sekulic D P, Fundamentals of Heat Exchanger Design, John Wiley, 2003
2. KakacSadik, Liu Hongtan, Heat exchangers : selection, rating and thermal design , 2nded, CRC Press, 2002

References:

1. T. Taborek, G.F. Hewitt and N.Afgan, Heat Exchangers, Theory and Practice, McGraw Hill Book Co., 1980
2. Walker, Industrial Heat Exchangers - A Basic Guide, McGraw Hill Book Co., 1980
3. Nicholas Cheremisiwoff, Cooling Tower, Ann Arbor Science Pub 1981
4. Arthur P. Fraas, Heat Exchanger Design, John Wiley & Sons, 1988

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Subject Code	Subject Name	Credits
TEE2034	Steam and Gas Turbine	04

Module	Detailed Contents	Hrs.
01	Classification of steam turbines, combination of turbines, overview of turbines, Flow of steam through impulse turbine blades / impulse and reaction turbine blades, Energy losses in steam turbines, governing and performance of steam turbines	12
02	Steam turbine auxiliary systems: turbine protective devices, tripping devices, unloading gears, lubricating systems, glands and sealing systems	11
03	Construction, Operation and Maintenance of Steam Turbines	07
04	Gas Turbine-shaft power cycles, velocity diagram and work done by gas turbine, turbine blade cooling, blade materials, blade manufacture, matching of turbine components,	11
05	Combustion chambers, requirements, types, factor affecting performance of CC, performance of turbines	08
06	GT auxiliary systems, operation and maintenance, starting and ignition systems, lubrication systems, Fuel system and controls, operation, maintenance and trouble shooting	11

Text Books:

1. R Yadav, Steam and Gas Turbines and Power Plant Engineering, Central Publishing House, Allahabad, 2004
2. Ganesan, V., Gas Turbines, Tata McGraw-Hill Pub.Co.Ltd., New Delhi, 1999.

References:

1. Lee J F, Theory and Design of Steam and Gas Turbines, McGraw-Hill, New York
2. Gas Turbine Engineering Handbook, Meherwan P Boyce, Gulf Publishing Company.
3. Cohen, H., Rogers, G.E.C., and Saravanamuttoo, H.I.H., Gas Turbine Theory, Longman Group Ltd, 1989
4. Gordon C, Dates, Aero-thermodynamics of Gas Turbine and Rocket Propulsion AIAA Education Series, NY, 1984.

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Subject Code	Subject Name	Credits
TEE2041	Speciality Engines	04

Module	Detailed Contents	Hrs.
01	Introduction: The design features of Automotive, Locomotive, Marine, Stationary and Generator - set engines	12
02	S I Engine Systems: Spark ignition engine system variants – Stoichiometry, Lean-burn, port injected/direct injected, carbureted, Air assisted fuel injection engines, Hybrid Electric Vehicle systems, Rotary Piston Engines, Dedicated fueled engine systems - CNG, LPG, H2, Alcohols	12
03	C I Engine Systems: Compression ignition engines system variants - Low, Medium and High speed system characteristics, High pressure fuel injection systems, Homogeneous Charge Compression Ignition systems, Dual and dedicated fueled engine systems, producer gas fueled engine systems, cogeneration system	12
04	Special Purpose Engine Systems: Engines for special applications – Mining, Defense, Off-highway -Tractor, Bulldozer etc. Submarines, Race car engine systems, Flexible fueled systems, Conventional and Alternative Fuels of Special purpose engines	12
05	Life Cycle Analysis of Engine Systems: Endurance Tests - Continuous and Intermittent Tests - Full and Part Throttle Testing of Engines - Simulation of life cycle Analysis	12

References:

1. The Wankel Engine - Design, Development, Application, Jan P.Norbye, Chilton Book Company, USA,1971.
2. Introduction to Internal Combustion Engines, Richard Stone, Third Edition , Society of AutomotiveEngineers Inc, USA, 1999.
3. Diesel Engine References Book, Bernard Challen and RodicaBaranescu (Editors) 2nd Edition, R - 183,SAE International, 1999.
4. Some Unusual Engines, L.J.K.Setright, Mechanical Engineering Publication Ltd., UK, 1975.
5. The Wankel R C Engine, R.F.Ansdale, A.S.Barnes& Co., USA, 1969.
6. Bosch Technical Instruction Booklets,Robert Bosch Gmbh, Germany, 1985.

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Subject Code	Subject Name	Credits
TEE2042	Convective Heat Transfer	04

Module	Detailed Contents	Hrs.
01	Introduction to heat transfer by convection, a review of viscous flow, conservation of mass and momentum equations and Navier Stokes equation, energy equation, derivation of energy equation	07
02	Boundary Layer Theory: Boundary layer equation, Momentum integral methods, laminar boundary layer over a flat plate, boundary layer separation, , energy equation in non dimensional form, derivation of thermal boundary layer equation, Boundary Layer approximations, Laminar and Turbulent External Boundary layers with effects of Pressure Gradient, Wall thermal conditions, Viscous dissipation	10
03	Free convection: boundary layer over vertical flat plate and cylinder- series and similarity solution. Free convection inside curved bodies and between parallel plates. Free convection over heated horizontal plate	10
04	External Flows: Thermal boundary layer, low Prandtl and high Prandtl number approximations. Thermal boundary layer over isothermal and adiabatic flat plate and wedge. Heat transfer from curved surfaces.	09
05	Internal Flows: Heat transfer in a parallel flow over a flat surface, analogy between momentum and heat transfer in turbulent flow, heat transfer in parallel flow and cross flow over a cylinder, heat transfer in parallel flow over a sphere, heat transfer for impinging jets, forced convection in internal flows, concept of entrance length and fully developed flow, heat transfer in high speed flow. Steady forced convection in Couette flow, Poiseuille , plane Poiseuille flow and Leveque solution, Graetz problem	14
06	Turbulent Flow: Turbulent Flows, laminar-turbulent transition, Universal law-of-the Wall for smooth and rough surfaces, mixing-length theory and 2-equation models, Turbulence Modelling, Convective heat transfer thorough porous media	10

References:

1. Kays W M and Crawford M E, "Convective Heat and Mass Transfer", McGraw Hill Int Edition, 3rd edition, 1993.
2. Spalding D B, "Introduction to Convective Mass Transfer", McGraw Hill, 1963.
3. Bird R. B., Stewart W. E. and Lightfoot E. N., " Transport Phenomena ", John Wiley and sons, Inc., 1960.
4. Schlichting H., " Boundary Layer Theory ", Sixth edition, McGraw Hill , 1968.
5. Bejan, Convective Heat Transfer, Wiley, Third edition, 2004
6. Patrick H. Oosthuizen, David Naylor, "Convective Heat Transfer Analysis", Mcgraw Hill. Inc.[1999]

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Subject Code	Subject Name	Credits
TEE2043	Non Conventional Power Plants	04

Module	Detailed Contents	Hrs.
01	Potential of renewable energy sources, renewable electricity and key elements, Global climate change, CO ₂ reduction potential of renewable energy.	10
02	Solar thermal power plants (Concentrators, solar chimney etc.), Solar thermal conversion devices, Economics and social considerations, Design considerations of component selection. Solar photovoltaic power plants, photovoltaic technology, Design of a photovoltaic system, economics and costing, Application as a distributed power supply strategy	10
03	Wind energy: Wind energy potential measurement, wind electric generator component design, economics and demand side management, energy wheeling, and energy banking concepts.	10
04	Biogas: properties of biogas (Calorific value and composition), biogas plant technology and status	10
05	Other plants: Fuel cell based power plants, tidal and wave energy plant design, OTEC power plants. Geothermal energy: hot springs and steam ejection site selection, power plants, and economics.	10
06	Environmental impacts, Economic and social considerations, Financing mechanisms, Carbon credits, clean development mechanisms	10

References:

1. S.P.Sukhatme, Solar Energy – Principles of thermal collection and storage, II edition, Tata McGraw Hill, New Delhi, 1996.
2. J.A.Duffie and W.A.Beckman, Solar engineering of Thermal processes, II edition, John Wiley, New York, 1991.
3. D.Y.Goswami, F.Kreith and J.F.Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia, 2000.
4. D.D.Hall and R.P.Grover, Biomass Regenerable Energy, John Wiley, New York, 1987.
5. Mukund R Patel, Wind and Solar Power Systems, CRC Press, 1999.
6. J F Manwell, J.C.McGowan, A.L.Rogers, Wind Energy Explained: Theory, Design and Application, John Wiley and Sons, May 2002.
7. R D Begamudre, Energy Conversion Systems, New Age International (P) Ltd., Publishers, New Delhi ,2000.

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Subject Code	Subject Name	Credits
TEE 2044	Advanced Turbo Machinery	04

Module	Detailed Contents	Hrs.
01	Basic concepts of turbomachines: Definition of Turbomachine, classification; Euler's pump equation and Euler's turbine equation, dimensional analysis applied to hydraulic machines and compressible flow machines.	07
02	Principles of turbo machinery: Transfer of energy to fluids, Performance characteristics, fan laws, selection of centrifugal, axial, mixed flow, Axial flow machines	06
03	Analysis of centrifugal Machines: Centrifugal Compressors and Blowers: Theoretical characteristic curves, Eulers characteristics and Eulers velocity triangles, losses and hydraulic efficiency, flow through inlet nozzle, impeller, diffusers, casing, leakage, disc friction, mechanical losses, cross flow fans	10
04	Analysis of axial flow Machines: Axial flow fans and compressors: Rotor design airfoil theory, vortex theory, cascade effects, degree of reaction, blade twist, stage design, surge, choking and stall, stator and casing, mixed flow impellers. Design considerations for supersonic flow	12
05	Design and applications of blowers and Fans: Special design and applications of blower induced and forced draft fans for air-conditioning plants, cooling towers, ventilation systems, booster systems.	07
06	Testing and control of Blowers and Fans: Performance testing, noise control, speed control, throttling control at discharge and inlet.	06

References:

1. Stepanoff A.J. Turboblenders, John Wiley & sons, 1970.
2. Brunoek, Fans, Pergamon Press, 1973.
3. Austin H. Chrch, Centrifugal pumps and blowers, John wiley and Sons, 1980.
4. Dixon, Fluid Mechanics, Thermodynamics of turbomachinery, Pergamon Press, 1984.
5. Dixon. Worked examples in turbomachinery, Pergamon Press, 1984.
6. Budugur Lakshminarayana, Fluid Dynamics and heat Transfer of Turbomachinery, John Wiley and Sons, Inc
7. Handbook of Turbomachinery, Edited by Earl Logan Jr, Ramendra Roy; Second Edition , Marcel Dekker, Inc, New York
8. Rama S.R.Gorla, Aijaz Khan, Turbomachinery Design and Theory, Marcel Dekker, Inc, New York

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Subject Code	Subject Name	Credits
TEL203	CFD Lab	01

The laboratory will focus on the following:

1. Give adequate exposure to commercially available analysis packages
2. Train students to write simple codes in MATLAB, C, C++ for control volume analysis
3. Give students an understanding of the working of a complete code through exercises on simple flows

The laboratory assignments should be based on the following:

1. Simulate and solve 2-d and 3-d steady and unsteady flows using any commercial CFD package like Ansys-FLUENT, STAR CCM, FLUIDYNE, Ansys-CFX, etc.
2. Write codes for 1-d and 2-d steady conduction with and without source and do the post processing to verify with analytical results
3. Write codes for steady, 2-d conduction-advection problems and do the post processing to verify with analytical results

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
TEL204	Measurement & Virtual Instrumentation[§]	01

Topic	Laboratory Sessions (each of 02 Hrs)
I. Study of sensor characteristics, selection, calibration and measurement of minimum 05 mechanical parameters such as flow, load, pressure, speed and temperature	05
II. Virtual Instrumentation a. Simulation of any system with Virtual Instrumentation (VI) environment using any suitable software b. Interfacing of sensors used for measuring above mentioned parameters in I with VI software and measurement of these parameters on any laboratory model or actual working system	08
III. Demonstration of interfacing of VI software with suitable generic hardware	02

§Common for Machine Design, Automobile Engineering and Thermal Engineering

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
TES 301	Seminar	03

Guidelines for Seminar

- Seminar should be based on thrust areas in Mechanical Engineering
- Students should do literature survey and identify the topic of seminar and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the topic and compile the report in standard format and present in front of Panel of Examiners(pair of Internal and External examiners appointed by the University of Mumbai).
- Seminar should be assessed based on following points
 - Quality of Literature survey and Novelty in the topic
 - Relevance to the specialization
 - Understanding of the topic
 - Quality of Written and Oral Presentation

NOTE :

1. Assessment of Seminar will be carried out by a pair of Internal and External examiner. The external examiner should be selected from approved panel of examiners for Seminar by University of Mumbai, OR faculty from Premier Educational Institutions /Research Organizations such as IIT, NIT, BARC, TIFR, DRDO, etc. OR a person having minimum Post-Graduate qualification with at least five years' experience in Industries.
2. Literature survey in case of seminar is based on the broader area of interest in recent developments and for dissertation it should be focused mainly on identified problem.
3. At least 4-5 hours of course on Research Methodology should be conducted which includes literature survey, identification of problems, analysis and interpretation of results and technical paper writing in the beginning of 3rd semester.

Subject Code	Subject Name	Credits
TED 301 / TED 401	Dissertation (I and II)	12 + 15

Guidelines for Dissertation

- Students should do literature survey and identify the problem for Dissertation and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the problem. Students should attempt solution to the problem by analytical/simulation/experimental methods. The solution to be validated with proper justification and compile the report in standard format.

Guidelines for Assessment of Dissertation I

- Dissertation I should be assessed based on following points
 - Quality of Literature survey and Novelty in the problem
 - Clarity of Problemdefinition and Feasibility of problem solution
 - Relevance to the specialization
 - Clarity of objective and scope
- Dissertation I should be assessed through a presentation by a panel of internal examiners appointed by the Head of the Department/Institute of respective Programme.

Guidelines for Assessment of Dissertation II

- Dissertation II should be assessed based on following points
 - Quality of Literature survey and Novelty in the problem
 - Clarity of Problemdefinition and Feasibility of problem solution
 - Relevance to the specialization or current Research / Industrial trends
 - Clarity of objective and scope
 - Quality of work attempted
 - Validation of results
 - Quality of Written and Oral Presentation
- Dissertation II should be assessed through a presentation jointly by Internal and External Examiners appointed by the University of Mumbai

Students should publish at least one paper based on the work in reputed International / National Conference (desirably in Refereed Journal)