Mahatma Education Society's

Pillai College of Engineering

(Autonomous)

Affiliated to University of Mumbai

Dr. K. M. Vasudevan Pillai's Campus , Sector 16, New Panvel – 410 206.

Department of Mechanical Engineering

Syllabus
of

M.Tech. in Mechanical Engineering

for
The Admission Batch of AY 2022-23

First Year - Effective from Academic Year **2022-23**

Second Year - Effective from Academic Year **2023-24**

as per

Choice Based Credit and Grading System

Mahatma Education Society's

Pillai College of Engineering

Vision

Pillai College of Engineering (PCE) will admit, educate and train a diverse population of students who are academically prepared to benefit from the Institute's infrastructure and faculty experience, to become responsible professionals or entrepreneurs in a technical arena. It will further attract, develop and retain, dedicated, excellent teachers, scholars and professionals from diverse backgrounds whose work gives them knowledge beyond the classroom and who are committed to making a significant difference in the lives of their students and the community.

Mission

To develop professional engineers with respect for the environment and make them responsible citizens in technological development both from an Indian and global perspective. This objective is fulfilled through quality education, practical training and interaction with industries and social organizations.

Dr. K. M. Vasudevan Pillai's Campus , Sector - 16, New Panvel – 410 206

Department of Mechanical Engineering

Vision

To develop a world class programme with excellence in teaching, learning and research that would lead to growth, innovation and recognition.

Mission

The mission of the Mechanical Engineering Program is to benefit the society at large by providing technical education to interested and capable students. These technocrats should be able to apply basic and contemporary science, engineering and research skills to identify problems in the industry and academia and be able to develop practical solutions to them.

Program Structure for
Master of Technology in (Mechanical) Thermal Engineering

Semester I

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract	Theory	Practical	Total
ME550T	Computer Programming Paradigms	03	--	03	--	03
ME551T	Business Communication and Intellectual Property	03	--	03	--	03
ME5xxT	Department Level Optional Course-I	03	--	03	--	03
ME5xxT	Department Level Optional Course-II	03	--	03	--	03
ME5xxT	Department Level Optional Course-III	03	--	03	--	03
ME565L	Renewable Energy Lab	--	02	--	01	01
ME566L	Dissertation-I	--	02	--	01	01
TOTAL		**15**	**04**	**15**	**02**	**17**

Course Code	Course Name	Examination Scheme							
		Theory							
		Internal Assessment			End Sem Exam	Exam Duration (Hrs)	Term Work	Oral/ Practs	Total
		IA 1	IA 2	Avg					
ME550T	Computer Programming Paradigms	40	40	40	60	3	-	-	100
ME551T	Business Communication and Intellectual Property	40	40	40	60	3	-	-	100
ME5xxT	Department Level Optional Course-I	40	40	40	60	3	-	-	100
ME5xxT	Department Level Optional Course-II	40	40	40	60	3	-	-	100
ME5xxT	Department Level Optional Course-III	40	40	40	60	3	-	-	100
ME565L	Renewable Energy Lab	--	--	--	--	--	25	25	50
ME566L	Dissertation-I	--	--	--	--	--	25	25	50
TOTAL		**200**	**200**	**200**	**300**	**15**	**50**	**50**	**600**

Department Level Optional Course:

Course Code	Course Name
DLOC-I	
ME552T	Numerical Methods and Computational Techniques
ME553T	Advanced Fluid Mechanics
ME554T	Experimental Methods for Thermal & Fluid Systems
DLOC-II	
ME555T	Solar Energy Engineering
ME556T	Cryogenics
ME557T	Energy Audit & Management
DLOC-III	
ME558T	Refrigeration and Air conditioning System Design
ME559T	Wind Energy and Conversion Systems

Program Structure for
Master of Technology in (Mechanical) Thermal Engineering

Semester II

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract	Theory	Pract	Total
ME567T	Modeling and Analysis of Thermal System	03	--	03	--	03
ME568T	Advanced Heat Transfer	03	--	03	--	03
ME5xxT	Department Level Optional Course-IV	03	--	03	--	03
ME5xxT	Department Level Optional Course-V	03	--	03	--	03
ME5xxT	Department Level Optional Course-VI	03	--	03	--	03
ME582L	Computational Fluid Dynamics Lab	--	02	--	01	01
ME583L	Dissertation-II	--	02	--	01	01
TOTAL		**15**	**04**	**15**	**02**	**17**

Course Code	Course Name	Examination Scheme							
		Theory							
		Internal Assessment			End Sem Exam	Exam Duration (Hrs)	Term Work	Pract/ Oral	Total
		IA 1	IA 2	Avg					
ME567T	Modeling and Analysis of Thermal System	40	40	40	60	3	--	--	100
ME568T	Advanced Heat Transfer	40	40	40	60	3	--	--	100
ME5xxT	Department Level Optional Course-IV	40	40	40	60	3	--	--	100
ME5xxT	Department Level Optional Course-V	40	40	40	60	3	--	--	100
ME5xxT	Department Level Optional Course-VI	40	40	40	60	3	--	--	100
ME582L	Computational Fluid Dynamics Lab	--	--	--	--	--	25	25	50
ME583L	Dissertation-II	--	--	--	--	--	25	25	50
TOTAL		**200**	**200**	**200**	**300**	**15**	**50**	**50**	**600**

Department Level Optional Course:

Course Code	Course Name
DLOC-IV	
ME569T	Computational Fluid Dynamics
ME570T	Thermal Design of Electronic Equipment
DLOC-V	
ME571T	Heat Exchanger Design and Performance
ME572T	Advanced Turbo Machinery
DLOC-VI	
ME573T	Thermal Energy Storage Systems and Applications
ME574T	Sustainable/Zero Energy Buildings

Program Structure for
Master of Technology in (Mechanical) Thermal Engineering

Semester III

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract	Theory	Pract	Total
ME650LC	Internship / Relevant Certification	-	-	-	03	03
ME651LC	Dissertation-III	-	-	-	12	12
TOTAL		-	-	-	15	**15**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (Hrs)			
		IA 1	IA 2	Avg					
ME650LC	Internship / Relevant Certification	-	-	-	-	-	50	50	100
ME651LC	Dissertation-III	-	-	-	-	-	100	-	100
TOTAL		-	-	-	-	-	150	50	200

Program Structure for
Master of Technology in (Mechanical) Thermal Engineering

Semester IV

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract	Theory	Pract	Total
ME653LC	Dissertation-IV	-	30	-	15	15
		-	30	-	15	**15**

Course Code	Course Name	Examination Scheme							
		Theory							
		Internal Assessment			End Sem Exam	Exam Duration (Hrs)	Term Work	Pract/ Oral	Total
		Test 1	Test 2	Avg					
ME653LC	Dissertation-IV	-	-	-	-	-	100	100	200
TOTAL		-	-	-	-	-	100	100	200

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME550T	Computer Programming Paradigms	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME550T	Computer Programming Paradigms	40	40	40	60	-	-	-	100

Course Objectives:

1. To Introduce students to functional, logic and concurrent programming paradigms.
2. To Enable students to formulate newer abstractions in the above paradigms.
3. To Familiarize students with writing functional and Object oriented programs.
4. To Prepare students to solve real-world problems using appropriate programming paradigms

Course Outcomes:

On successful completion of course learner/student will be able to:

1. Understand and apply the concepts that form the basis of functional, logic and object oriented programming paradigms.
2. Formulate abstractions with procedures and data in different programming paradigms.
3. Write programs in different programming paradigms especially functional, logic and object oriented paradigms.
4. Formulate, implement and solve a given problem scenario using appropriate programming paradigm

Detailed Theory Syllabus:

Sr. No.	Module	Detailed Content	Hours
1	**Introduction**	**Overview of different programming paradigms –** Imperative,logical, functional and object-oriented Programming.	2
2	**Java Programming**	**Introduction:** Principles of OOP, Classes, Objects, Abstraction, Encapsulation, Inheritance, Polymorphism, Message passing Features of Java Language , Data Types, Operators. **Control Statements:** If-Statement, If-else, Nested-if, Switch Statement, break, continue. **Iteration Statements:** for-loop, while-loop, and do-while-loop.	8
3	**Python Programming**	**Introduction:** Features, Identifiers, Keywords, Indention, Variables and Comments, Basic data types: Numeric, Boolean, Compound. **Operators:** Arithmetic, comparison, relational, assignment, logical, bitwise, membership, identity operators, operator	8

		precedence. **Control flow statements:** Conditional statements (if, if…else, nested if. Looping in Python: while-loop, for-loop, nested-loops, Loop manipulation using continue, pass, break. **Functions:** Introduction to Functions, Decorators, Iterators and Generators.	
4	**R Programing**	**Introduction:** Basic functionalities of R , data types and operations: numbers, characters and composites, Numeric variables, strings and factors,R packages. **Data structures:** vectors, matrices, lists and data frames.Grouping, loops and conditional execution, Functions. **Exploratory data analysis:** Range, summary, mean, variance, median, standard deviation, histogram, box plot, scatterplot, Graphics and tables , Visualizations and interpretation of results.	8
5	**Matlab programming**	**Introduction:** Features, Interface, File Types, Array, Matrix Operation. Arithmetic Operator Logical, Relational. **Branch and Loop:** If-statement, If-else statement, Else-if statement Pause, Break, Continue, Switch-case, try-catch, Return Statement, For Loop,While Loop. Types of Function, Return Types. **Interface and Graphics:** Plotting, Multiple Plot, 2-D Plot, Introduction to Graphical User Interface, GUI Function, Property, GUI Component Design.	8
6	**Metaverse Technology**	History, Features, Metaverse value chain, Technologies Involved in the Metaverse. Blockchain Adoption in Metaverse, AR, VR, MR in Metaverse, NFT (non-fungible token) for Metaverse. Financial and Economics of Metaverse, Benefits of Metaverse, Use-cases.	5

Theory Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Class Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Books and References:

A. Books:

1. Scott M L, Programming Language Pragmatics, 4th Edn., Morgan Kaufmann Publishers, 2015
2. E. Balaguruswamy, “Programming with Java A primer”, Fifth edition, Tata McGraw Hill Publication
3. Dr. R. Nageswara Rao, ”Core Python Programming” , Dreamtech Press, Wiley Publication
4. Metaverse: Introduction to The Virtual Reality, Augmented Reality,ISBN-13 : 978-1806030484
5. Beginning R: The Statistical Programming Language by Dr. Mark Gardener, Wiley Publications
6. Peter I. Kattan, MATLAB for Beginners: A Gentle Approach, 2008. ISBN: 9781438203096

B. References:

1. Programming Languages: Concepts and Constructs; 2nd Edition, Ravi Sethi, Pearson Education Asia, 1996.
2. Herbert Schildt, “Java-The Complete Reference”, Tenth Edition, Oracle Press, Tata McGraw Hill Education.
3. Navigating the Metaverse by Cathy Hackl, Dirk Lueth, Tommaso Di Bartolo, John Arkontaky, Yat Siu Released May 2022 Publisher(s): Wiley ISBN: 9781119898993
4. Hands-On Programming with R by Grolemund, O Reilly Publications
5. Stormy Attaway, "MATLAB: A Practical Introduction to Programming and Problem Solving," 2018, Butterworth-Heinemann, ISBN: 978-0128154793

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME551T	Business Communication and Intellectual property	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME551T	Business Communication and Intellectual Property Rights	40	40	40	60	-	-	-	100

Course Objectives:

1. To provide an outline to effective organisational communication
2. To enable learners to formulate professional documents in a structured manner that meets the corporate requirements.
3. To foster a comprehensive understanding of marketing strategies for establishing the brand of the business using digital technologies and aim at better customer experience
4. To develop creative and impactful presentation skills
5. To acquaint learners with the procedure of obtaining Patents, Copyrights, Trademarks and Industrial designs
6. To inculcate the ethical code of conduct and corporate etiquettes.

Course Outcomes:

1. Apply business communication strategies and principles to prepare effective communication for developing and presenting business messages
2. Acquire the writing skills necessary for professional documents to meet the corporate requirement.
3. Understand existing and emerging social media tools to execute a comprehensive communication plan
4. Able to illustrate effective presentation, research, organisational and creative skills necessary for lifelong learning.
5. Recognize the crucial role of IP in organisations of different industrial sectors for the purposes of product and technology development
6. Able to determine the importance of ethics and etiquettes in social and professional situations

Prerequisite: Basic language skills

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
I	Business Communication	1.1 Role of communication in business organisation 1.2 Relevance of communication 1.3 Types- Verbal Non-verbal 1.4 Channels- Vertical, Horizontal and Lateral	2	CO1
II	Business Writing	2.1 Business Proposals (SWOT analysis) 2.2 Grant / Research Proposals 2.3 1.2 Memos 2.4 1.3 Press Releases 2.5 1.4 Business Plans	8	CO2
III	Digital Social Media	3.1 Communicating via Social Media 3.2 Social Media and Public Relations, Social Media strategy and Planning 3.3. Content Strategy. Web Content, Organisation and Distribution 3.4 Social Networking Sites (LinkedIn, Twitter), Photo sharing Sites (Instagram, Snapchat, Pinterest 3.5 News Writing and Community Management 3.6. Facebook and business 3.7. You Tube and Livestreaming	6	CO3
IV	Speaking Skills	4.1 Speaking on Panels, Moderating Panels, Speaking as keynote or Individual Talk 4.2 Introducing speakers, Summarising speeches and Meeting conference content 4.3 Presentation Skills- a) Visually present relationship between two or more data sets b) Data Presentation Methods- Line graph, Column chart, Vertical bar, scatter plot c) Presentation style- Audience analysis, Care and concern for the audience, effective use of transitions and animations, slide design and content	7	CO4
V	Intellectual Property for Business	5.1. Meaning, Relevance, Business Impact, Protection of Intellectual Property 5.2. Types of Intellectual Property **Copyrights –** Introduction, Nature of copyright, Indian copyright law, copyright works, Author and ownership of copyright,	8	CO5

		Licensing of copyrights, Infringement of copyrights, Remedies and actions, Copyright for digital media, Software/ Internet **Patents**- Concept of patent, Product/Process Patents, Patent Law, Patentable subject matter, Patentability criteria, Duration of patent, Procedure for filing Patent Application, Types of Applications, Procedure of Opposition, Revocation of Patents, Ownership and Maintenance of Patents, Compulsory licensing, Qualification and registration Procedure **Trademarks**- Introduction, Rationale of protection of trademark as (a) an aspect of commercial and (b) of consumer rights, Kinds of marks (brand names, logos, signatures, symbols, well known marks, certification marks and service marks), Indian Trademarks Law, Procedure for Registration of Trademarks, Non Registrable Trademarks, Infringement of Trademarks and Right of Goodwill, Offences and Penalties **Trade secrets** **Designs**- Need for Protection of Industrial designs, Procedure and Infringement **Geographical Indications** – Concept, Procedure of Registration, duration of protection, Infringement, Penalties and Remedies		
VI	Ethics And Ethical Code of Conduct	6.1 Writing Resume and statement of purpose 6.2 Business and corporate activities(special emphasis on business meetings, emails, blogs and webpages) 6.3 Personal ethics, conflicting values, choosing a moral response, the process of making ethical decisions.	4	CO6

Sr. No.	Details of Assignments	Details of Activities	Hours	CO Mapping
I	Written assignment on summarising a research proposal 4 page grant proposal (to be included as part of term work)	Example of summarising techniques to be demonstrated.	4	CO1, CO2
II	Written assignment on blog posts, web content	NA	4	CO1, CO3, CO4
III	Presentation skills	Mock Presentation	6	CO1, CO4
IV	Written Assignment on Resume writing/Statement of Purpose.	NA	2	CO2, CO6
V	Written Assignment on Intellectual Property	NA	4	CO5

Text Books/References:

1. Raman Meenakshi & Singh Prakash, Business Communication Second edition, Oxford University Press, Paperback, 2012
2. Jeremy Harris Lipschultz, Social Media Communication: Concepts, Practices, Data, Law and Ethics Third edition, Paperback, 2020
3. V. K. Ahuja, Intellectual Property Rights In India, Hardcover, 2015

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME552T	Numerical Methods and Computational Techniques	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME552T	Numerical Methods and Computational Techniques	40	40	40	60	-	-	-	100

Course Objectives:

1. To impart knowledge on numerical methods that will come in handy to solve the problems that arise in Thermal Engineering.
2. To study and apply numerical solution techniques for the ordinary and partial differential equations governing the Thermal engineering problems.
3. To study the mathematical structure which could be used to describe the behaviour and results of most numerical methods commonly used in Thermal Engineering problems.
4. To write code for some real-lifeThermal Engineering problems.

Course Outcomes: Upon successful completion of this course, the learner will be able to

1. Solve governing equations in thermal Engineering using numerical methods.
2. Identify live Initial value problems and boundary value problems arise in thermal engineering
3. and use suitable numerical methods to solve them.
4. Write codes for thermal engineering problems in MATLAB, C, C++ and also to solve thermal
5. engineering problems.

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	**High speed computation:** Introduction, Errors and Analysis- Accuracy of Numbers, Types of errors, Machine Computation, Brief introduction of computer software which can be used in solving the problems numerically.	02
02	**Root finding for polynomial and transcendental equation:** Bisection method, Iteration Method-Successive Approximation, Iteration method for system of non-linear equations,Secant method, Regula-Falsi method, Newton-Raphson methodMethods for multiple roots, Muller's method, Methods for complex roots,Bairstow method, Rate of convergence, Merits, and demerits of methods	07
03	**Solution of simultaneous Linear Algebraic Equations:** Direct Methods-Gauss elimination, Pitfalls of Gauss Elimination method, LU factorizationCholeski Decomposition method, Iterative methods-Jacobi method, Gauss-Seidel method	07

04	**Interpolation and Curve Fitting:** Lagrange and Newton interpolation,Finite difference operators, interpolating polynomials using finite differences, Hermite Interpolation, Bivariate Interpolation, Piecewise and Spline interpolation, Least-squares approximation, Fitting of non-linear curves, Polynomial functions, Multiple linear regression. Significance of interpolating polynomials in numerical differentiation and in numerical integration methods which are studied at the lower semesters.	10
05	**Numerical Solution of Ordinary Differential Equations:** Initial Value Problems- Single step methods and Multi step methods, Milne's Method, Runge-Kutta methods, Solution of simultaneous differential equations and higher order equations, Boundary Value Problems- Shooting method, Finite difference method, Finite difference representation of differential equations	07
06	**Numerical Solution of Partial Differential Equations:** Elliptic, Parabolic and Hyperbolic Partial Differential Equations and their solutions using finite difference schemes, Explicit and Implicit schemes. Stability, Applications of finite difference method to thermal engineering problems like temperature distribution in a rod etc.	08

Students must understand the practical applications of Numerical methods by writing codes for 1-d and 2-d steady and unsteady thermal problem in MATLAB, C, C++ as part of assignments in Term Work:

Assessment:
Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 marks
2. Continuous evaluation: Test/Assignments /Quiz/Case studies/Seminar presentation of 50 Marks

End Semester Examination: 60 Marks
Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Text/Reference Books:

1. Computer Based Numerical and Statistical Techniques, Manish Goyal, Laxmi Publications (P) Ltd, New Delhi
2. Numerical Methods for Engineers, Chapra S C, Candle R P, 2nd Ed, NcGraw-Hill, New York
3. Applied Numerical Analysis, Gerald CF, Wheatley PO, 6thedition, Pearson Education, 1999
4. Numerical Mathematics and Computing, Cheney W., Kincaid D., 5thedition, Thomson / BrooksCole, 2004.
5. Numerical Methods for Partial Differential Equations, William F. Ames, 2nd Edition, Academic Press, 1977
6. Numerical Methods for Scientific and Engineering Computation, M.K. Jain, S.R.K. Iyengar, R.K.Lain, New Age International (P) Limited.
7. Numerical Methods in Engineering, Salvadori M G, Baron M L, Prentice-Hall

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME553T	Advanced Fluid Mechanics	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME553T	Advanced Fluid Mechanics	40	40	40	60	-	-	-	100

Objectives:

1. To study application of mass, momentum and energy equations in fluid flow.
2. To study different types of turbulent model
3. To study incompressible and compressible fluid flow
4. To familiarize with dimensional analysis of Thermal and Fluid systems.

Outcomes: Upon successful completion of this course, the learner will be able to

1. Formulate and solve equations of the control volume for fluid flow systems
2. Calculate resistance to flow of incompressible fluids through closed conduits and over surfaces.
3. Select suitable turbulent model for fluid flow problem
4. Apply fundamentals of compressible fluid flows to relevant systems
5. Illustrate understanding of dimensional analysis of Fluid systems.

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	Eulerian & Lagrangian coordinates, Definition and equations for source, sink, irrotational vortex, circulation concept of circulation. Navier-Stokes equations-differential & integral approach, energy equations, governing equations for Newtonian fluids, boundary conditions Momentum of fluid in motion: impulse momentum relationship and its applications for determination of thrust for pipe bend	08
02	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,	06
03	Introduction to dimensional analysis of thermal and fluid systems, Methods of dimensional analysis - Buckingham π Theorem and Rayleigh's Method (Only derivations, no numerical) Boundary Layer Theory: Review of boundary layers: laminar and turbulent boundary layers; transition; separation, Blasius' solution for boundary layer	06

04	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.	06
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	06
06	Compressible Fluid flow: Propagation of sound waves through compressible fluids, Sonic velocity and Mach number; Stagnation properties, Application of continuity, momentum and energy equations for steady-state conditions; Steady flow through the nozzle, Isentropic flow through ducts of varying cross-sectional area, Effect of varying back pressure on nozzle performance, Critical pressure ratio.. Application to subsonic, transonic and supersonic flow around a two-dimensional aerofoil.	07

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 marks
2. Continuous evaluation: Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Text/ReferenceBooks:

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

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME554T	Experimental Methods for Thermal & Fluid Systems	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME554T	Experimental Methods for Thermal & Fluid Systems	40	40	40	60	-	-	-	100

Objectives:

1. To convince the importance of experimentation
2. To familiarize the various instruments
3. To enable the students to design the experiments
4. To develop the instrument selection skill.

Outcomes:

Upon successful completion of this course, the learner will be able to

1. Plan and execute the experiment.
2. Learn the different strategies of experiments.
3. Select the electrical measurements and sensing devices.
4. Select and measure the flow, pressure and thermal conductivity.
5. Calibrate the instruments.
6. Measure the heat flux.

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	Experiment versus simulation, need of experimentation, Experimental planning and analysis of results:Importance of experiments in engineering and science, stages of typical experiment, Experimental planning, literature survey and equipment identification, test section design, fabrication and instrumentation, test facility calibration and measurements, Analysis of Results: and Data reduction,Using Excel to present and analyse data, spreadsheets for data analysis.	06
02	Design of experiments: Strategy of experimentation, Typical applications of experimental design, Types of experiments, guidelines for designing experiments, experiment design factors & protocol and examples.Analysis of Experimental Data, Causes and Types of Experimental Errors, Error Analysis on a Commonsense Basis, Uncertainty Analysis and Propagation of Uncertainty Graphical Analysis and Curve Fitting, Choice of Graph Formats	07

03	Basic electrical measurements and sensing devices, basic analog & digital meters, power supplies, signal conditioning, digital voltmeter, output recorders, counters-time and frequency measurements, difference between analog and digital instruments. Temporal response of probes and transducers: measurement system model, system response, amplitude response, frequency response, zeroth, first, and second order systems; examples of thermocouple response, anemometer. Probe compensation in the frequency domain.	06
04	Flow measurements: Positive displacement and flow obstruction methods, flow measurement by drag effects, magnetic flow meters, flow visualisation methods, the shadowgraph. Thermal conductivity measurements, thermal conductivity of liquids and gases, heat flux meters, detection of thermal radiation, detection of nuclear radiation.	06
05	Probes and transducers: Pressure transducers; noise measurement, Velocity - Pitot static tube (low as well as high speeds), 5-hole probe, Hotwire anemometer, CCA, CTA, Laser Doppler velocimetry, Particle image velocimetry. Temperature measurement: thermocouples, RTD, thermistor, infrared thermography, Heat flux measurement.	06
06	Calibration of measuring sensors and instruments Principles of calibration, control of calibration environment, calibration chain and traceability, calibration records,	06

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 marks
2. Continuous evaluation: Test/Assignments /Quiz/Case studies/Seminar presentation of 40 marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Text/Reference Books:

1. C. Tropea, A.L. Yarin, and J.F. Foss, Editors, Springer Handbook of Experimental Fluid Mechanics, 2007.
2. T.G. Beckwith and N.L. Buck, Mechanical Measurements, Addison-Wesley, MA (USA), 1969.
3. H.W. Coleman and W.G. Steele Jr., Experiments and Uncertainty Analysis for Engineers, Wiley & Sons, New York, 1989.
4. E.O. Doeblin, Measurement Systems, McGraw-Hill, New York, 1986.
5. R.J. Goldstein (Editor), Fluid Mechanics Measurements, Hemisphere Publishing Corporation, New York, 1983; second edition, 1996.
6. J. Hecht, The Laser Guidebook, McGraw-Hill, New York, 1986.
7. B.E. Jones, Instrumentation Measurement and Feedback, Tata McGraw-Hill, New Delhi, 2000.
8. M. Lehner and D. Mewes, Applied Optical Measurements, Springer-Verlag, Berlin, (1999).
9. F. Mayinger, Editor, Optical Measurements: Techniques and Applications, SpringerVerlag, Berlin, 1994.
10. D.C. Montgomery, Design and Analysis of Experiments, John Wiley, New York, 2001.
11. A.S. Morris, Principles of Measurement and Instrumentation, Prentice Hall of India, New Delhi, 1999.

12. F. Natterer, The Mathematics of Computerized Tomography, John Wiley & Sons, New York, 1986.
13. P.K. Rastogi, Ed., Photomechanics, Springer, Berlin, 2000.
14. M. Van Dyke, An Album of Fluid Motion, The Parabolic Press, California, 1982
15. Langari, R., Morris, A. S. (2015). Measurement and Instrumentation: Theory and Application. Netherlands: Elsevier Science.
16. Wright, L. M., Han, J. (2020). Experimental Methods in Heat Transfer and Fluid Mechanics. United States: CRC Press.
17. Kirkup, L. (2019). Experimental Methods for Science and Engineering Students: An Introduction to the Analysis and Presentation of Data. United Kingdom: Cambridge University Press.

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME555T	Solar Energy Engineering	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME555T	Solar Energy Engineering	40	40	40	60	-	-	-	100

Objectives:

1. To learn the basics of the solar energy spectrum.
2. To learn about types of Solar cells and their ratings.
3. To learn the solar thermal system; an energy efficient approach.
4. To learn about solar power plants.

Outcomes: Upon successful completion of this course, the learner will be able to

1. Get knowledge of the competing demands and requirements of the various solar operated
2. electrical power network.
3. Understand how renewable generation and distributed storage interacts with and is integrated
4. into the power network.
5. Understand Solar energy measurement techniques.
6. Understand Need of solar cooling system to reduce dependency on the mains grid.

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	Introduction to solar energy, World and Indian energy scenario, Solar spectrum,Solar constant, Solar Energy & Environment, Energy scenario and sustainable development through solar energy.	04
02	Solar energy measurement: Estimation of solar energy on earth's surface, characteristics of solar radiation, Sun –earth geometry and its effect on solar energy reaching on earth's surface, Depletion of solar radiation - Absorption, scattering, Solar day length – Sun path diagram – Shadow determination. Estimation of Sunshine hours, Calculation of total solar radiation on horizontal and tilted surfaces.	07
03	Solar Photovoltaic system : Solar Cell, PV Module and Solar arrays:- Parameters of solar cell, Effect of conversion efficiency, change in amount of input light, change in solar cell area, change in angle of light falling on PV Panel, Change in solar cell operating temperature, I-V characteristics of solar cell PV Module parameters, Measuring PV Module parameters, Series connection of PV Modules, Parallel connection of PV Modules, Mixed Combination of connections	07

04	Solar thermal system: Flat Plate Collector, Hot Air Collector, Evacuated Tube Collector, Parabolic, Compound Parabolic and Fresnel Solar Concentrators, Central Receiver System, Performance and Thermal Analysis of Solar Collectors, Solar Water Heating Systems (Active & Passive), Solar Dryers & Desalination Systems	07
05	Electrical energy conversion from solar energy: Solar Power plant, Estimating power and energy demand, site selection, land requirements, choice of modules, economic comparison, off grid systems, grid interface, economic analysis.	07
06	Solar Cooling: Potential and scope of solar cooling. Types of solar cooling systems, Solar refrigeration and air conditioning. Solar desiccant cooling system. Solar cooling alternatives. Advanced solar cooling systems. Solar thermoelectric refrigeration and airconditioning. Economics of solar cooling.	07

Assessment:
Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 marks

End Semester Examination: 60 Marks
Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Text/Reference Books:

1. Foster .R, Ghassemi M., Cota A., “Solar Energy”, CRC Press, 2010.
2. Duffie .J.A, Beckman W.A. “Solar Engineering of Thermal Processes”, 3rd ed., Wiley, 2006.
3. De Vos .A, “Thermodynamics of Solar Energy Conversion”, Wiley-VCH, 2008.
4. Garg .H.P, Prakash .J, “Solar Energy Fundamentals and Applications”, Tata McGraw-Hill, 2005.
5. Kalogirou .S, “Solar Energy Engineering”, Processes and Systems, Elsevier, 2009.
6. Petela .R, “Engineering Thermodynamics of Thermal Radiation for Solar Power”, McGraw-Hill Co., 2010.
7. Yogi Goswami .D, Frank Kreith, Jan F. Kreider, “Principles of Solar Engineering”, Second Edition, Taylor & Francis, 2003.
8. Andrews .J, Jelley .N, “Energy Science”, Oxford University Press, 2010.
9. Renewable Energy: Power for a Sustainable Future, Edited by Godfrey Boyle, 3rd Edition, Oxford University Press
10. Solar Energy: Principles of Thermal Collection and Storage by SP Sukhatme and J K Nayak, TMH
11. Solar Energy: Fundamentals and Applications by H.P. Garg& Jai Prakash, Tata McGraw Hill.
12. Solar Photovoltaic’s: Fundamentals, Technologies and Applications, C S Solanki, 2ndEdition, PHI Learning
13. Renewable Energy Technologies: A Practical Guide For Beginners, PHI Learning
14. Solar Energy: The Physics and Engineering of Photovoltaic Conversion, Technologies
15. By ArnoSmets, Klaus Jäger Olindo Isabella René van Swaaij , UIT Cambridge LTD
16. Solar Photovoltaic Technology And Systems - A Manual For Technicians,Trainers And Engineers, PHI Learning

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME556T	Cryogenics	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME556T	Cryogenics	40	40	40	60	-	-	-	100

Objectives:

1. To impact knowledge on cryogenic systems
2. To learn about different process involved for liquefaction and cryocoolers
3. To get the knowledge on the properties of both matter and fluid for better design of the process equipment in cryogenics application
4. To understand the gas liquefaction and refrigeration system
5. Instrumentation in cryogenic system is essential for measuring properties at low temperature
6. Safety in cryogenics is highly important for handling liquids or cryogens environments.

Outcomes: Learners will be able to

1. The knowledge on the properties of both matter and fluid for better design of the process equipment in cryogenics application.
2. Understand about operation and maintenance of cryogenic plants.
3. Analyze the existing systems and creation of new systems.

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	Properties of engineering materials at cryogenic temperatures, mechanical properties, thermal properties, electric & magnetic properties, superconducting materials, thermoelectric materials, composite materials, properties of cryogenic fluids, super fluidity of He3 & He4.	06
02	Measurement systems for low temperatures: Temperature measurements, pressure measurements, flow measurements, liquid level measurements, fluid quality measurements.	06
03	Cryogenic insulation: Various types such as expanded foams, gas filled & fibrous insulation, vacuum insulation, evacuated powder & fibrous insulation, opacified powder insulation, multi-layer insulation, comparison of performance of various insulations.	08
04	Minimum work for liquefaction: Methods to protect low temperature. Liquefaction systems for gases other than Neon. Hydrogen and Helium. Liquefaction Systems for Neon, Hydrogen and Helium: Components of Liquefaction systems. Heat	08

	exchangers. Compressors and expanders. Expansion valve.	
05	Applications of cryogenic systems, Super conductive devices such as bearings, motors, cryotrons, magnets, D.C. transformers, tunnel diodes, space technology, space simulation, cryogenics in biology and medicine, food preservation and industrial applications	06
06	Hazards: Physical hazards, Chemical hazards, Physiological hazards, combustion hazards, oxygen hazards, accidents in cryogenic plants & prevention.	05

Assessment:

Internal Assessment for 40 marks:

1. Consisting of One Compulsory Class Tests of 40 marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Cryogenic fundamentals-Haselden, Academic press New York
2. Cryogenic technology –Vance
3. Advance cryogenic –bailey, plenum press
4. Cryogenic engineering –Scott
5. Cryogenic systems-Baron, McGraw-Hill book
6. Cryogenic Systems/ R.F. Barren/ Oxford University Press
7. Cryogenic Engineering- Thomas Flynn- CRC Press-2nd Edition
8. Cryogenic Research and Applications: Marshal Sitting/ Von Nostrand/ Inc. New Jersey
9. Cryogenic Heat Transfer/ R.F.Baron
10. Cryogenic Engineering Edit / B.A. Hands/ Academic Press, 1986
11. Cryogenic Engineering/ R.B. Scott Van Nostrand/ Inc. New Jersey, 1959
12. Experimental Techniques in Low Temperature Physics- O.K. White, Oxford Press, 1968
13. Cryogenic Process Engineering/ K. D. Timmerhaus& T M Flynn/ Plenum Press, 1998
14. HandBook of Cryogenic Engineering – J.G. Weisend –II, Taylor and Francis, 1998

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME557T	Energy Audit And Management	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME557T	Energy Audit And Management	40	40	40	60	-	-	-	100

Objectives:

1. To impart basic knowledge to the students about current energy scenario, energy conservation, audit and management.
2. To inculcate among the students systematic knowledge and skill about assessing the energy efficiency, energy auditing and energy management.
3. To introduce performance evaluation criteria of various electrical and thermal installations to facilitate the energy management
4. To relate the data collected during performance evaluation of systems for identification of energy saving opportunities.

Outcomes: Learner will be able to....

1. To identify and describe the present state of energy security and its importance.
2. To identify and describe the basic principles and methodologies adopted in energy audit of an utility
3. To describe the energy performance evaluation of some common electrical installations and identify the energy saving opportunities.
4. To describe the energy performance evaluation of some common thermal installations and identify the energy saving opportunities.
5. To analyze the data collected during performance evaluation and recommend energy saving measures

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	**Energy Scenario:** Energy needs of growing economy, Long term energy scenario, Energy pricing, Energy sector reforms, Energy and environment: Air pollution, Climate change, Energy security, Energy conservation and its importance, Energy strategy for the future, Energy conservation Act-2001 and its features.	04
02	**Energy Management and Audit:** Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance,	10

	Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instrument. **Material and Energy balance:** Facility as an energy system, Methods for preparing process flow, Material and energy balance diagrams. **Financial Management:** Investment-need, Appraisal and criteria, Financial analysis techniques- Simple payback period, Return on investment, Net present value, Internal rate of return, Cash flows, Risk and sensitivity analysis, Financing options, Energy performance contracts and role of ESCOs.	
03	**Energy Management and Energy Conservation in Electrical System:** Electricity billing, Electrical load management and maximum demand Control; Power factor improvement, Energy efficient equipment and appliances, star ratings. Energy efficiency measures in lighting system, Lighting control: Occupancy sensors, daylight integration, and use of intelligent controllers. Energy conservation opportunities in: water pumps, industrial drives, induction motors, motor retrofitting, soft starters, variable speed drives.	10
04	**Energy Management and Energy Conservation in Thermal Systems:** Review of different thermal loads; Energy conservation opportunities in: Steam distribution system, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system. General fuel economy measures in Boilers and furnaces, Waste heat recovery, use of insulation-types and application. HVAC system: Coefficient of performance, Capacity, factors affecting Refrigeration and Air Conditioning system performance and savings opportunities.	09
05	**Energy Performance Assessment:** On site Performance evaluation techniques, Case studies based on: Motors and variable speed drive, pumps, HVAC system calculations; Lighting System: Installed Load Efficacy Ratio (ILER) method, Financial Analysis.	03
06	**Energy conservation in Buildings:** Energy Conservation Building Codes (ECBC): Green Build Building, LEED rating, Application of Non-Conventional and Renewable Energy Sources	03

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Handbook of Electrical Installation Practice, Geofry Stokes, Blackwell Science
2. Designing with light: Lighting Handbook, By Anil Valia, Lighting System
3. Energy Management Handbook, By W.C. Turner, John Wiley and Sons

4. Handbook on Energy Audits and Management, edited by A. K. Tyagi, Tata Energy Research Institute (TERI).
5. Energy Management Principles, C.B.Smith, Pergamon Press
6. Energy Conservation Guidebook, Dale R. Patrick, S. Fardo, Ray E. Richardson, Fairmont Press
7. Handbook of Energy Audits, Albert Thumann, W. J. Younger, T. Niehus, CRC Press.

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME558T	Refrigeration and Air conditioning System Design	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME558T	Refrigeration and Air conditioning System Design	40	40	40	60	-	-	-	100

Objectives:

1. To understand industrial refrigeration and air conditioning systems and their analysis
2. Impart knowledge of psychrometry and its application in air conditioning system design
3. Know how about controls in refrigeration and air conditioning

Outcomes: Learner will be able to

1. Analyse performance of various refrigeration cycles and air conditioning systems
2. Identify suitable refrigeration system and propose design of the same
3. Design conventional or non-conventional air conditioning system for specific application

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	Refrigeration: Cycles: Analysis, Multi-pressure Systems, Refrigerants: Classification of Refrigerants, Refrigerant Properties, Oil Compatibility, Blends, System Design Criteria for New Refrigerants, Phase-out Schedule, Natural Refrigerants.	06
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, Expansion valve.	06
03	Vapour Absorption Systems: LiBr & Aqua Ammonia Systems. Double Effect Chillers. Solar Energy operated m/c's Industrial Refrigeration: Cold Stores, Ammonia Refrigeration Systems, Safety requirement for refrigeration systems.	08
04	Psychrometrics: Introduction, Properties of air and water vapour mixture. Psychrometric chart and its use in air conditioning. ASHRAE Comfort Chart Design of Equipments: Analysis of air conditioning load, load calculation.Equipment selection and balancing.	07
05	Air Conditioning Systems: Window Type, Package Type, Split Type, Central Units – direct and indirect. Construction details. Evaporative cooling system. Air	06

	Distribution: Air Distribution Devices – Air Circuits – Design of Air Supply System.	
06	Controls: Electrical components & controls, starting and running circuits, relay types and controls, Temperature, Pressure, Oil Flow controls, Compressor Motor-Protection Devices, Refrigeration valves.	05

Assessment:

Internal Assessment: 40 marks

3. Consisting of One Compulsory Class Tests of 40 marks
4. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Dossat, R.J., Principles of Refrigeration, John Wiley & Sons, 1989.
2. Stoecker W.F., Refrigeration and Air Conditioning, McGraw Hill Book Company, 1985.
3. Jordan and Priester, Refrigeration and Air Conditioning, 1985.
4. Althouse, A.D. and Turnquist, C.H., Modern Refrigeration and Air Conditioning, Good Heart – Wilcox Co.
5. Hains, J.B., Automatic Control of Heating and Air Conditioning, McGraw Hill, 1981.
6. ASHRAE Handbooks (Fundamentals, Equipments and Systems)
7. Ananthanarayanan P N, Modern Refrigeration and 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
11. Stoecker W. F., Industrial refrigeration, Business News Publishing Company

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME559T	Wind Energy and Conversion Systems	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME559T	Wind Energy and Conversion Systems	40	40	40	60	-	-	-	100

Objectives:

1. Understand the technologies that are used to harness the power of the wind.
2. Develop an intuitive understanding of wind turbine design criterion and its conversion system.
3. Discuss the positive and negative aspects of wind energy in relation to natural and human aspects of the environment.

Outcomes: Learner will be able to

1. Explain the existing wind energy potential..
2. Analyze the various aerodynamic loads and its design criterion on wind turbine systems.
3. Describe the existing Wind Energy Conversion System.
4. Analyze the control mechanism of wind turbines.
5. Understand the application of wind energy with case studies and its environmental impacts.

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	**Basics Of Wind Energy Technology** Wind statistics- Measurements and data Presentation, Historical developments, latest developments, state of art of wind energy technology, turbine rating, economic analysis of wind turbine, Indian scenario and worldwide developments, present status and future trends. Wind turbine aerodynamics.	08
02	**Characteristics Of Wind Energy** Nature of atmospheric winds- Wind resource characteristics and assessment– Anemometry, speed frequency distribution, effect of height, wind rose, Weibull distribution, atmospheric turbulence, gust wind speed, effect of topography. Effect of Reynolds's number, actuator disc, Betz coefficient, design of wind turbine blade, effect of stall and blade tip speed ratio and coefficient of torque.	08
03	**Wind Energy Conversion System (WECS)** Rotor Selection, Annual Energy Output, HAWT, VAWT, Rotor Design Considerations-Number of Blades, Blade Profile -2/3 Blades and Teetering, Coning- Upwind/Downwind, Power Regulation, Yaw System- Tower,	10

	Synchronous and Asynchronous Generators and Loads, Integration of Wind Energy Converters to Electrical Networks, Inverters- Testing of WECS, WECS Control System - Requirements and Strategies.	
04	**Control Mechanisms** Pitch control, yaw control, Electrical and Mechanical aerodynamic braking, teeter mechanism. Wind turbine dynamics with DC and AC generators: induction and synchronous generators, variable speed operation, effect of wind turbulence. Case study of design of wind mill.	07
05	**Wind Energy Application** Wind pumps - Performance analysis, design concept and testing, Principle of WEG- Stand alone, grid connected and hybrid applications of WECS, Economics of wind energy utilization, Wind energy in India.	06

Assessment:
Internal Assessment: 40 marks
Consisting of One Compulsory Class Tests of 40 Marks
Continuous evaluation: Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Books/References:

1. Spera D.A., Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering, ASME Press, NY 1994.
2. Martin OL Hansen: Aerodynamics of Wind Turbines, 2nd ed. Earthscan, London.
3. B.H.Khan: Non Conventional Energy Sources, Tata McGraw-Hill Education, 2006.
4. Johnson, G.L., Wind Energy Systems, Prentice Hall, 1985.
5. Martin OL Hansen: Aerodynamics of Wind Turbines, 2nd ed. Earthscan, London.
6. L. L. Freris, Wind Energy Conversion systems, Prentice Hall, UK, 1990.
7. Steve Parker, “Wind power”, Gareth Stevens Publishing, 2004.

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME565L	Renewable Energy Lab	Contact Hours	2	-	-	2
		Credits	1	-	-	1

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME565L	Renewable Energy Lab	-	-	-	-	25	25	-	50

Course Objectives:

1. To understand the potential & energy extraction through renewable energy sources.
2. To understand challenges in energy generation through renewable sources.
3. To understand the importance of energy security, improve access to energy.

Course Outcomes: Upon successful completion of this course, the learner will be able to

1. Understand the sun earth geometry associated with Solar energy and evaluate the amount of solar flux received on earth's surface.
2. Understand the working of Wind machines as a part of renewable energy source.
3. Evaluate the performance of solar thermal concentrators

The laboratory will focus on the following:

1. Measurement of solar radiation and sunshine hours.
2. Measurement of albedo, UV & IR radiation.
3. Measurement of emissivity, reflectivity, transmissivity.
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 pumps.
8. Energy consumption & lumen measurement of lights & ballasts.
9. Properties of fuel oils & biomass.
10. Testing of Gasifier or Wind machines or Fuel cell

Laboratory Assessment

Internal Assessment

Term Work Marks	: 25 Marks
Laboratory Work (Journal Completion)	: 20 Marks
Attendance	: 5 Marks

End Semester Practical/Oral Examination:

Pair of Internal and External Examiners should conduct practical/viva based on contents.
Distribution of marks for practical/viva examination shall be as follows:
Oral Examination: 25 Marks

Text/Reference Books:

1. Non-conventional energy sources by G.D. Rai, Khanna Publishers
2. Renewable Energy:Power for a Sustainable Future, Edited by Godfrey Boyle, 3rd Edition, Oxford University Press
3. Solar Energy: Principles of Thermal Collection and Storage by SP Sukhatme and J K Nayak, TMH
4. Solar Energy: Fundamentals and Applications by H.P. Garg& Jai Prakash, Tata McGraw Hill.
5. Wind Power Technology, Joshua Earnest, PHI Learning, 2014
6. Renewable Energy Sources, J W Twidell& Anthony D. Weir. ELBS Pub.
7. Energy Conversion Systems, R D Begamudre, New Age International (P) Ltd., Publishers, New Delhi, 2000.
8. Solar Photovoltaics: Fundamentals, Technologies and Applications, C S Solanki, 2ndEdition, PHI Learning

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME566L	Dissertation-I	Contact Hours	2	-	-	2
		Credits	1	-	-	1

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME566L	Dissertation-I	-	-	-	-	25	-	25	50

Guidelines for Dissertation-I

Students should do literature survey and identify the problem for Dissertation and finalize in consultation with the Guide/Supervisor. Students should use multiple literatures and understand the problem. Students should attempt to solve 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 Problem definition and Feasibility of problem solution
- Relevance to the specialization
- Clarity of objective and scope
- Quality of Written and Oral Presentation

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.

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME567T	Modeling and Analysis of Thermal System	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME567T	Modeling and Analysis of Thermal System	40	40	40	60	-	-	-	100

Course Objectives:

1. Differentiate design and analysis
2. Understand problem formulation and various modeling and simulation methods to optimize the solution

Course Outcomes: Learner will be able to…

1. Identify design parameters of basic thermal systems
2. Formulate the problem and propose the solution

DETAILED SYLLABUS:

Module No.	Detailed Content	Hours	CO Mapping
I	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	08	CO1
II	Modeling of thermal systems, basic considerations in design, the importance of modeling in design, types of models, mathematical modeling, physical modeling, and dimensional analysis	07	CO2
III	Numerical modeling and simulation, development of a numerical model, solution procedure, merging of different models, accuracy and validation, system simulation, methods of numerical simulation, and numerical simulation versus real systems.	06	CO2
IV	Economic considerations, calculation of interest, worth of money as a function of time, raising capital, economic factors in design, application to thermal systems	06	CO1
V	Problem formulation for optimization, basic concepts, optimization methods, optimization of thermal systems,	06	CO2

	practical aspects in optimal design		
VI	Knowledge-based design and additional considerations, knowledge-based systems, additional constraints, sources of information	06	CO1

Theory Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Class Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

References:

1. Yogesh Jaluria, Design and Optimization of Thermal Systems, McGraw-Hill international editions, 1998
2. Stoecker W F, Design of Thermal Systems, 3rd Ed. McGraw Hill, 2011
3. Eckert E R G and Drake R M, Analysis of Heat and Mass Transfer, McGraw-Hill, New York, 1972
4. Szucs E, Similitude and Modeling, Elsevier, New York, 1977
5. Wellstead P E, Introduction to Physical System Modeling, Academic Press, New York, 1979
6. Chapra S C and Canale R P, Numerical Methods for Engineers, McGraw-Hill, New York, 1988
7. Atkinson K, An Introduction to Numerical Analysis, Wiley, New York, 1978

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME568T	Advanced Heat Transfer	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME568T	Advanced Heat Transfer	40	40	40	60	-	-	-	100

Course Objectives

1. Impart the advanced knowledge of heat transfer.
2. Get analytical solutions for Dimensional steady and transient heat conduction problems.
3. Deep understanding on the governing equations for convection heat transfer and its application.
4. Understand the boiling and condensation mechanism.

Course Outcomes: Learner will be able to

1. Able to estimate the thermal contact resistance. .
2. Able to apply lumped system analysis for the solution of transient heat conduction problem..
3. Able to calculate the heat transfer coefficient for the enclosures.
4. Able to apply empirical correlations for the force convection problem.
5. Able to explain the flow patterns in condensation heat transfer.
6. Able to compute the radiation heat transfer in case of gas radiation.

Module	Detailed Contents	Hrs.
01	Introduction to basic laws and general heat conduction equations, boundary and initial conditions. Multidimensional heat transfer. Concept of variable thermal conductivity in plane walls. Thermal contact resistance. Three dimensional heat conduction. Heat transfer enhancement techniques. Active and passive techniques.	07
02	Heat transfer in common configurations, concept of conduction shape factor. Conduction in porous media. Transient heat conduction: Lumped system analysis. Introduction to transient heat conduction in large plane walls and cylinders with spatial effects.	06
03	Natural Convection heat transfer: Solution of convection equation for flat plate. Grashof number. Natural convection over vertical plate, horizontal plate, vertical and horizontal cylinder, spheres. Natural convection cooling of finned surfaces, vertical PCBs. Natural convection inside vertical and horizontal rectangular enclosures, concentric cylinders.	07
04	Forced Convection: Laminar forced convection in long tube, correlations for laminar forced convection. Correlations for coiled tubes, Empirical	06

	correlations for turbulent forced convection for circular ducts and tubes	
05	Introduction to flow boiling, flow patterns in vertical and horizontal tubes, Correlations, post dry-out heat transfer. Condensation: heat transfer correlation for condensation heat transfer for vertical plate. Film condensation inside horizontal tubes and horizontal tubes.	06
06	Gas Radiation, radiation network for an absorbing and transmitting medium, radiation properties of the environment, effect of radiation on temperature measurement, radiation heat transfer coefficient,	06

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks.

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Books/References:

1. Yunus A Cengel and Afgin J Ghajar, Heat and Mass Transfer: Fundamentals and Applications, 5thEd., McGraw-Hill Education
2. Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons
3. S.P. Sukhatme, Heat Transfer, University Press
4. Patankar. S.V.,Numerical heat Transfer and Fluid flow, Hemisphere Publishing Corporation
5. J P Holman, Heat Transfer, 9th Ed., McGraw Hill, Int.
6. Frank Kreith& John S Bohn, Principles of Heat Transfer, Cengage Learning India Pvt Ltd.
7. C P Kothandaraman, Fundamentals of Heat and Mass Transfer, New Age International Publishers.
8. Bejan A and Kraus A, Heat Transfer Handbook, John Wiley & Sons
9. Bejan A, Convective Heat Transfer, Wiley, Third edition, 2004

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME569T	Computational Fluid Dynamics	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME569T	Computational Fluid Dynamics	40	40	40	60	-	-	-	100

Objectives:

1. Understand the laws of fluid flow for ideal and viscous fluids.
2. Develop finite difference and finite volume discredited forms of the CFD equations.
3. Formulate explicit & implicit algorithms for solving the Euler Equation & Navier Stokes Equation.

Outcomes:

Upon successful completion of this course, the learner will be able to

1. Explain the fundamental principles of fluid motion and their application to the analysis and solution of problems in fluid flow engineering.
2. Solve Fluid dynamic & Heat transfer problem using computational fluid dynamics.

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	**Introduction:** Definition and overview of CFD, Advantages and disadvantages, applications, CFD methodology, Working of Commercial CFD Softwares	05
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. Selection criteria for BC	08
03	**Grid Generation:** Structured and unstructured Grids: O-type, H-type, C-type of Structured Grid Generation,General transformations of the equations; body fitted coordinate systems; Algebraic and Elliptic Methods; adaptive grids	05
04	**Discretization Techniques:** Introduction to Finite difference Method, Finite Volume method and Finite Element method Finite difference methods; Finite difference representation of	08

	PDE's; Solutions to Finite Difference Equations; Implicit, semi-implicit and explicit methods; Errors and stability criteria	
05	**Turbulence Modeling:** Introduction to Turbulence, Modeling Effect of turbulence on governing equations; RANS, LES and DNS Models	06
06	**Finite Difference & Finite Volume Methods:** FDM & FVM solutions to steady and unsteady one-, two- and three-dimensional problems and, FVM solution to steady & unsteady one- and two-dimensional diffusion, convection-diffusion (no numerical); Advection schemes; Pressure velocity coupling; SIMPLE family of algorithms.	07

Theory Assessment:
Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Text/Reference Books:

1. Modern Compressible Flow with Historical Perspective, John D. Anderson, McGraw Hill.
2. Fundamentals of Aerodynamics, J. D. Anderson, 2nd Ed, McGraw Hill.
3. An introduction to computational fluid dynamics-The finite volume method, Versteeg.H.K. ,Malalasekera.W., Prentice Hall
4. Computational Fluid Mechanics and Heat Transfer, Anderson, D.A., Tannehill, I.I., and Pletcher, R.H., Hemishphere Publishing Corporation, New York, USA, 1984.
5. Introduction to Computational Fluid Dynamics, Niyogi P. ,Laha M.K., Chakrabarty S.K., Pearson Education, India.
6. Computational Fluid Flow and Heat Transfer, Muralidhar, K., and Sundararajan,T., Narosa Publishing House ,New Delhi1995.
7. Computer Simulation of flow and heat transfer, Ghoshdasdidar, P. S., Tata McGrawHill Publishing Company Ltd., 1998.
8. Finite Element Programming of the Navier Stock Equation, Taylor, C and Hughes J.B., Pineridge Press Ltd.U.K.1981.
9. Computational Techniques for Fluid Dynamics: Fundamental and General Techniques, Fletcher, C.A.J., Springer-Verlag, 1987.
10. Numerical Fluid Dynamics, Bose, T. K., Narosa Publishing House, 1997
11. Turbulent Flow, R. J. Garde, 2ndEd., New Age International Publishers.

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME570T	Thermal Design of Electronic Equipment	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME570T	Thermal Design of Electronic Equipment	40	40	40	60	-	-	-	100

Objectives:

1. To teach students about modes of heat transfer in electronic devices.

Outcomes: Upon successful completion of this course, the learner will be able to

1. Gain in depth knowledge of designing cooling systems for electronic equipment.
2. Design a system that withstands high pressure.
3. Understand fluid dynamics in electronic equipment design.
4. Understand the effect of various modes of heat transfer on designing a system.

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	**Introduction:**Introduction to modes of heat transfer in electronic equipment conduction, convection and radiation. Theoretical power dissipation in active devices like CMOS device, Junction FET, Power MOSFET. Theoretical power dissipation in passive devices like Interconnect , resistor, capacitor	07
02	**Steady state conduction:** Conduction in simple geometry like plain wall without heat generation, conduction through cylinder and spheres without heat generation. Conduction in complex geometries like multidimensional analytic method, multidimensional graphical method. **Conduction:** Transient-lumped capacitance method. **Thermal Contact Resistance in Electronic Equipment Interfaces:** Simplified contact resistance model, geometry of contacting surface.	06
03	**Fluid dynamics for electronic equipments:** Introduction. **Hydrodynamics properties of fluid:** compressibility, viscosity and surface tension. **Fluid statistics:** Relationship between pressure and density. **Fluid dynamics:** streamline & flow fields, One and two dimensional flow. **Incompressible fluid flow:** One dimensional flow-Euler and Bernoulli's equation. **Incompressible fluid flow:** laminar and turbulent flow. **Electronic chassis flow**	06

04	**Convection heat transfer in electronic equipment:** boundary layer theory, Forced convection laminar flow, forced convection in turbulent flow:- circular and non circular tubes. **Forced convection external flow:** Laminar and forced convection flow over flat plate. **Forced convection flow along populated circuit boards.** **Natural convection:** flat plate, vertical fins, horizontal and vertical cylinder, spheres	07
05	**Radiation heat transfer in electronic equipment:** Introduction, radiation equations, surface characteristics like absorptance, emittance and reflectance. Calculation of view factors, Environmental effects:- solar radiation and atmospheric radiation.	06
06	**Heat transfer with phase change and combined mode of heat transfer & Experimental verification:** **Introduction:** dimensionless parameters in boiling and condensation, modes of boiling liquids, evaporation.Conduction in series and parallel, conduction and convection in series, radiation and convection in parallel, Overall heat transfer coefficient. **Experimental verifications:** The use of measurement and testing in verification, measurements and verification ,Surface temperature: Selection of verification objects, choice of measurement timings, Exterior surface temperature of device,surface temperature of interior parts of the device. **Measurement of sir flow:** Principle of flow measurement, factors affecting selection of flow measurement methods, Flow measurement techniques.	07

Assessment:
Internal Assessment: 40 marks
Consisting of One Compulsory Class Tests of 40 Marks
Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks
Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. YounesShabany, Heat Transfer: Thermal Management of Electronics, CRC Press Inc, 2010.
2. Ravi Kandasamy and Arun S. Mujumdar, Thermal Management of Electronic Components, Lambert Academic Publishing, 2010.
3. Dave S. Steinberg, Cooling Techniques for Electronic Equipment, Wiley, 1991.
4. Sung Jin Kim, Sang Woo Lee, Air Cooling Technology for Electronic Equipment, Taylor & Francis, 1996.
5. Rao R. Tummala, Fundamentals of Microsystems Packaging, McGraw-Hill, 2001.
6. Yunus A. Cengel, Heat Transfer: A Practical Approach. McGraw-Hill, 2003.
7. Thermal Design of Electronic Equipment by Ralph Remsburg , CRC Press
8. Richard K. Ulrich & William D. Brown Advanced Electronic Packaging - 2nd Edition : IEEE Press, 1995.

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME571T	Heat Exchanger Design and Performance	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME571T	Heat Exchanger Design and Performance	40	40	40	60	-	-	-	100

Course Objectives:

1. Impart knowledge of sizing and designing of various heat exchangers using various methods
2. Learn performance analysis and maintenance aspects of heat exchanging equipments

Course Outcomes: Learner will be able to

1. Customize sizing and/or designing of heat exchangers
2. Identify efficacy of conventional or compact heat exchangers for specific purpose

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	**Constructional Details and Heat Transfer:** Types - Shell and Tube Heat Exchangers - Regenerators and Recuperators - Industrial Applications, Methodology, Design consideration, Temperature Distribution and its Implications - LMTD –Effectiveness	08
02	**Flow Distribution and Stress Analysis:** Effect of Turbulence –Effect of Fouling Friction Factor - Pressure Loss - Channel Divergence Stresses in Tubes Types of Failures	06
03	**Design Aspects:** TEMA standard, FlowConfiguration - Effect of Baffles - Effect of Deviations from Ideality - Design of Typical Liquid - Gas-Gas-Liquid Heat Exchangers	08
04	**Condensers and Evaporators Design:** Design of Surface and Evaporative Condensers - Design of Shell and Tube - Plate Type Evaporators	07
05	**Cooling Towers:** Types- Spray Design - Selection of Fans- Testing and Maintenance of cooling towers, Compact cooling towers, cooling tower performance variable	06
06	**Design of Special Purpose Heat Exchangers:** Corrosive environment. Marine/space applications, compact heat exchanger	04

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Books/References:

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, 2nd ed, CRC Press, 2002
3. D Q Kern, Precess Heat Transfer, McGraw Hill
4. W. M. Kays and A. L. London,Compact heat exchanger, 3 Sub Edition, Krieger Pub Co
5. MojtabaSabet,Cooling tower fundamentals and best design practices, Outskirts Press, 2014
6. T. Taborek, G.F. Hewitt and N.Afgan, Heat Exchangers, Theory and Practice, McGraw Hill Book Co., 1980
7. Walker, Industrial Heat Exchangers - A Basic Guide, McGraw Hill Book Co., 1980
8. Nicholas Cheremisioff, Cooling Tower, Ann Arbor Science Pub 1981
9. Arthur P. Fraas, Heat Exchanger Design, John Wiley & Sons, 1988

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME572T	Advanced Turbo Machinery	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME572T	Advanced Turbo Machinery	40	40	40	60	-	-	-	100

Course Objectives

1. Study basic concepts and principles of turbomachinery
2. Learn performance analysis of centrifugal as well as axial machines like fans, blowers and compressors

Course Outcomes: Learner will be able to

1. Read and understand performance characteristic curves of various turbo machines
2. Design blowers and fans for specified applications
3. Identify suitable control and testing methods for blowers and fans

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	**Basic concepts of turbo machines:** Definition of Turbo machine, classification; Euler's pump equation and Euler's turbine equation, dimensional analysis applied to hydraulic machines and compressible flow machines.	07
02	**Principles of turbomachinery:** Transfer of energy to fluids, Performance Characteristics, fan laws, selection of centrifugal, axial, mixed flow, Axial flowMachines	06
03	**Analysis of centrifugal Machines:** Centrifugal Compressors and Blowers:Theoretical characteristic curves, Euler's characteristics and Euler's velocity triangles, losses and hydraulic efficiency, flow through inlet nozzle, impeller,diffusers, casing	07
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	07
05	**Design and applications of blowers and Fans:**	07

	Special design and applications of blower induced and forced draft fans for air-conditioning plants and cooling towers,ventilation systems	
06	**Testing and control of Blowers and Fans:** Performance testing, noise control,speed control, throttling control at discharge and inlet	05

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Books/References:

1. Stepanoff A.J. Turboblowers, John Wiley & sons, 1970.
2. Brunoeck, Fans, Pergamon Press, 1973.
3. Austin H. Chruch, Centrifugal pumps and blowers, John wiley and Sons, 1980.
4. Dixon, Fluid Mechanics, Thermodynamics of turbomachinery, Pergamon Press, 1984.
5. Dixo,Worked examples in turbomachinery, Pergamon Press, 1984.
6. BudugurLakshminarayana, 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

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME573T	Thermal Energy Storage Systems and Applications	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME573T	Thermal Energy Storage Systems and Applications	40	40	40	60	-	-	-	100

Course Objectives:

1. Learn various thermal energy storage methods.
2. To understand the impact of various energy storage on the environment.
3. To learn mathematical modelling of thermal storage systems

Course Outcomes:

Upon successful completion of this course, the learner will be able to

1. Choose the best suited method from available methods of energy storage to reduce impact on the environment.
2. Carry out Energy and Exergy Analysis of Thermal Energy Storage Systems.
3. Understand recent advancements in energy storage technologies.

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	**Energy storage systems:** Introduction, Energy Demand, Energy Storage, Energy Storage Methods, Comparison of Energy Storage Technologies.	05
02	**Thermal Energy Storage (TES) Methods and Environmental Impact:** Introduction to Thermal Energy Storage, Solar Energy and TES Methods, Cold Thermal Energy Storage (CTES), Seasonal TES. Thermal Energy Storage and Environmental Impact: Introduction, Major Environmental Problems, Environmental Impact on TES Systems, Potential Solutions to Environmental Problems.	07
03	**Thermal Energy Storage and Energy Savings:** TES and Energy Savings , Additional Energy Savings Considerations for TES , Energy Conservation with TES: Planning and Implementation , Some Limitations on Increased Efficiency , Energy Savings for Cold TES	05
04	**Energy and Exergy Analyses of Thermal Energy Storage Systems:** Energy and Exergy Analyses, Thermodynamic Considerations in TES Evaluation, Exergy Evaluation of a Closed TES System, Measures for Closed TES Systems, Importance of Temperature in Performance Evaluations for Sensible TES	07

	Systems, Exergy Analysis of Aquifer TES Systems, Thermally Stratified Storages, Cold TES Systems and Solar Ponds.	
05	**Numerical Modeling and Simulation of Thermal Energy Storage Systems:** Approaches and Methods, Selected Applications, Numerical Modeling, Simulation, and Analysis of Sensible TES Systems and Latent TES Systems, Illustrative Application for a Complex System: Numerical Assessment of Encapsulated Ice TES with Variable Heat Transfer Coefficients.	07
06	**Recent Advances in TES Methods, Technologies, and Applications:** Recent developments in TES Types and Performance , Micro- and Macro-Level Advances in TES Systems and Applications, Performance Enhancement Techniques, Innovative Applications of TES Systems, Advanced Applications of Exergy Methods.	08

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Test/Assignments /Quiz/Case studies/Seminar presentation of 40 marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Text/Reference Books:

1. Thermal Energy Storage: Systems and Applications, 2nd Edition, Ibrahim Dincer, Marc A. Rosen , John Wiley & Sons
2. Exergy Method: Technical and Ecological Applications: No.18 (Developments in Heat Transfer) by J. Szargut , WIT Press
3. Thermal Design and Optimization 1st Edition, by Adrian Bejan, George Tsatsaronis, Michael J. MoranJohn Wiley & Sons, Inc
4. Advances in Thermal Energy Storage Systems , Methods and Applications by Luisa F. Cabeza, Woodhead Publishing,
5. Thermal Energy Storage Technologies for Sustainability: Systems Design, Assessment and Applications by S. KalaiselvamDr. (Author), R. Parameshwaran, Academic Press
6. Thermal Energy Storage Analyses and Designs by Pei-Wen Li (Author), Cho Lik Chan Academic Press.
7. Latent Heat-Based Thermal Energy Storage Systems: Materials, Applications, and the Energy Market, by AmritanshuShukla (Editor), Atul Sharma (Editor), Pascal Henry Biwolé , CRC Press
8. Thermal, Mechanical, and Hybrid Chemical Energy Storage Systems 1st Edition, by Klaus Brun, Timothy C. Allison, Richard Dennis, Academic Press
9. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002.
10. Schmidt.F.W and Willmott.A.J, Thermal Storage and Regeneration, Hemisphere Publishing Corporation, 1981.
11. Lunardini.V.J, Heat Transfer in Cold Climates, John Wiley and Sons 1981.

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME574T	Sustainable/Zero Energy Buildings	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME574T	Sustainable/Zero Energy Buildings	40	40	40	60	-	-	-	100

Course Objectives:

1. To study fundamental concepts of solar building design and energy systems.
2. To study the process involved in site selection of green buildings.
3. To study various energy efficient materials for green building construction.
4. To study various ASHRAE and IGBC standards.

Course Outcomes: Upon successful completion of this course, the learner will be able to

1. Understand the benefits of green building.
2. Understand various heat transfer processes that increase cooling load in a building.
3. Understand various methods adopted for Occupant Comfort and Wellbeing.

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	**Introduction to Green Buildings:** Definition of green buildings and sustainable development, typical features of green buildings, benefits of green buildings towards sustainable development. Green building rating systems – GRIHA, IGBC and LEED, overview of the criteria as per these rating systems.	05
02	**Site selection and planning:** Criteria for site selection, preservation of landscape, soil erosion control, minimizing urban heat island effect, maximizing comfort by proper orientation of building facades, day lighting, ventilation, etc. Water conservation and efficiency: Rainwater harvesting methods for roof & non-roof, reducing landscape, water demand by proper irrigation systems, water efficient plumbing systems, water metering, wastewater treatment	05
03	**Energy Efficiency:** Environmental impact of building constructions, Concepts of embodied energy, operational energy and life cycle energy. Methods to reduce operational energy: Energy efficient building envelopes, efficient lighting technologies, energy efficient appliances for heating and air-conditioning systems in buildings, zero	08

	ozone depleting potential (ODP) materials, wind and solar energy harvesting, energy metering and monitoring, concept of net zero buildings.	
04	**Heat transfer processes in buildings:** Thermal conductivity, resistance, transmittance, surface characteristics, surface coefficient, heat capacity, insulation. Calculation of principle building energy gains and losses. Estimation of building energy performance for heating and cooling for different climatic contexts. Importance of energy to human development, conventional and renewable energy sources – supply, uses and environmental impact. Assessment future growth in energy demand, availability, potential for sustainable development. Sustainable issues of planning, design and development.	08
05	**Building materials:** Methods to reduce embodied energy in building materials: A. Use of local building materials B. Use of natural and renewable materials like bamboo, timber, rammed earth, stabilized mud blocks, C. use of materials with recycled content such as blended cements, pozzolana cements, fly ash bricks, vitrified tiles, materials from agro and industrial waste. D. Reuse of waste and salvaged materials.Waste Management: Handling of construction waste materials, separation of household waste.	08
06	**Indoor Environmental Quality for Occupant Comfort and Wellbeing:** Day-lighting, air ventilation, exhaust systems, low VOC paints, materials & adhesives, building acoustics. Codes related to green buildings: NBC, ECBC, ASHRAE, UPC etc, Energy Conservation Act 2001	05

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 marks
2. Continuous evaluation: Test/Assignments /Quiz/Case studies/Seminar presentation of 40 marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

Text/Reference Books:

1. IGBC Green Homes Rating System, Version 2.0., Abridged reference guide, 2013, Indian GreenBuilding Council Publishers.
2. GRIHA version 2015, GRIHA rating system, Green Rating for Integrated Habitat Assessment.
3. Alternative building materials and technologies by K.S. Jagadish, B.V. Venkatarama Reddy and K.S. NanjundaRao.
4. Non-Conventional Energy Resources by G. D. Rai, Khanna Publishers.
5. Sustainable Building Design Manual, Vol.1 and 2, TERI, New Delhi 2004.
6. Mike Montoya, Green Building Fundamentals, Pearson, USA, 2010.
7. Charles J. Kibert, Sustainable Construction – Green Building Design and Delivery, John Wiley &Sons, New York, 2008.
8. Regina Leffers, Sustainable Construction and Design, Pearson / Prentice Hall, USA, 2009.

9. Faber, Oscar and Kell, J.R. Heating and air-conditioning of buildings. 2002.
10. Thomas, Randall & Fordham Max Sustainable urban design:an environmental approach" 2003.
11. Edwards, Brian and Hyett, Paul Rough guide to sustainability
12. Langston, Craig A. and Ding, Grace Sustainable practices in the built environment 2001.
13. GivoniBaruch,"Passive and Low Energy Cooling of Buildings",VNR, New YorK, 1994.
14. Martin J Gainsborough, Radford and Helen Bennets, T J Williamson, "Understanding Sustainable architecture", Spon Press, London, 2003.

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME582L	Computational Fluid Dynamics Lab	Contact Hours	2	-	-	2
		Credits	1	-	-	1

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME582L	Computational Fluid Dynamics Lab	-	-	-	-	25	25	-	50

Course Objectives:

1. Understand the laws of fluid flow for ideal and viscous fluids.
2. Develop finite difference and finite volume discredited forms of the CFD equations.
3. Formulate explicit & implicit algorithms for solving the Euler Equation & Navier Stokes Equation.

Course Outcomes: Upon successful completion of this course, the learner will be able to

1. Explain the fundamental principles of fluid motion and their application to the analysis and solution of problems in fluid flow engineering.
2. Solve Fluid dynamic & Heat transfer problem using computational fluid dynamics.

Lab Syllabus:

Sr. No.	Details	Hrs.
1	Simulate and solve 1D steady and unsteady flows problem using any commercial CFD package like Ansys-FLUENT, STAR CCM, FLUIDYNE, Ansys-CFX, etc. or write simple codes in MATLAB, C, C++ etc	2
2	Simulate and solve 2D steady and unsteady flows problem using any commercial CFD package like Ansys-FLUENT, STAR CCM, FLUIDYNE, Ansys-CFX, etc. or write simple codes in MATLAB, C, C++ etc	2
3	Simulate and solve 3D steady and unsteady flows problem using any commercial CFD package like Ansys-FLUENT, STAR CCM, FLUIDYNE, Ansys-CFX, etc. or write simple codes in MATLAB, C, C++ etc	2
4	Simulate and solve 1D steady and unsteady heat transfer problem using any commercial CFD package like Ansys-FLUENT, STAR CCM, FLUIDYNE, Ansys-CFX, etc. or write simple codes in MATLAB, C, C++ etc	2
5	Simulate and solve 2D steady and unsteady heat transfer problem using any commercial CFD package like Ansys-FLUENT, STAR CCM, FLUIDYNE, Ansys-CFX, etc. or write simple codes in MATLAB, C, C++ etc	2
6	Simulate and solve 3D steady and unsteady heat transfer problem using any ommercial CFD package like Ansys-FLUENT, STAR CCM, FLUIDYNE, Ansys-CFX, etc. or write simple codes in MATLAB, C, C++ etc	2

Laboratory Assessment:

Term Work

Laboratory Work (Journal Completion)	: 25 Marks
Laboratory work (Experiments)	: 20 Marks
Attendance	: 5 Marks

End Semester Practical/Oral Examination:

Pair of Internal and External Examiners should conduct viva based on contents.
Distribution of marks for viva examination shall be as follows:
Oral and practical Examination: 25 Marks

Text/Reference Books:

1. Modern Compressible Flow with Historical Perspective, John D. Anderson, McGraw Hill.
2. Fundamentals of Aerodynamics, J. D. Anderson, 2nd Ed, McGraw Hill.
3. An introduction to computational fluid dynamics-The finite volume method, Versteeg.H.K., Malalasekera.W., Prentice Hall
4. Computational Fluid Mechanics and Heat Transfer, Anderson, D.A., Tannehill, I.I., and Pletcher, R.H., Hemishphere Publishing Corporation, New York, USA, 1984.
5. Introduction to Computational Fluid Dynamics, Niyogi P. ,Laha M.K., Chakrabarty S.K., Pearson Education, India.
6. Computational Fluid Flow and Heat Transfer, Muralidhar, K., and Sundararajan,T., Narosa Publishing House ,New Delhi1995.
7. Computer Simulation of flow and heat transfer, Ghoshdasdidar, P. S., Tata McGrawHill Publishing Company Ltd., 1998.
8. Finite Element Programming of the Navier Stock Equation, Taylor, C and Hughes J.B., Pineridge Press Ltd.U.K.1981.
9. Computational Techniques for Fluid Dynamics: Fundamental and General Techniques, Fletcher, C.A.J., Springer-V
10. Numerical Fluid Dynamics, Bose, T. K., Narosa Publishing House, 1997
11. Turbulent Flow, R. J. Garde, 2ndEd., New Age International Publishers.