ANNA UNIVERSITY, CHENNAI
NON- AUTONOMOUS COLLEGES
AFFILIATED TO ANNA UNIVERSITY
M.E. THERMAL ENGINEERING
REGULATIONS 2025

PROGRAMME OUTCOMES (POs):

PO	Programme Outcomes
PO1	An ability to independently carry out research /investigation and development work to solve practical problems
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PROGRAMME SPECIFIC OUTCOMES (PSOS)

PSO	Programme Specific Outcomes
PSO1	Design, develop, and analyze advanced thermal and energy systems for improved efficiency, sustainability, and performance in real-world applications.
PSO2	Develop sustainable and efficient energy solutions by applying emerging technologies with ethical and environmental responsibility.

ANNA UNIVERSITY, CHENNAI

POSTGRADUATE CURRICULUM (NON-AUTONOMOUS AFFILIATED INSTITUTIONS)

Programme: M.E., Thermal Engineering **Regulations:** 2025

Abbreviations:

BS –Basic Science (Mathematics)

ES – Engineering Science (General (**G**), Programme Core (**PC**), Programme Elective (**PE**))

SD – Skill Development

TCP –Total Contact Period(s)

L –Laboratory Course

T – Theory

LIT –Laboratory Integrated Theory

PW – Project Work

Semester I

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	MA25C06	Applied Mathematical and Statistical Modelling	T	3	1	0	4	4	BS
2.	TE25C01	Advanced Thermodynamics	LIT	3	0	2	5	4	ES (PC)
3.	TE25C02	Advanced Fluid Mechanics and Heat Transfer	LIT	3	0	2	5	4	ES (PC)
4.	TE25C03	Instrumentation and Control for Thermal Systems	T	3	0	0	3	3	ES (PC)
5.	TE25C04	Fuels and Combustion	LIT	3	0	2	5	4	ES (PC)
6.	TE25C05	Technical Seminar	-	0	0	2	2	1	SD
						TOTAL	**24**	**20**	

Semester II

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	TE25C06	Computational Fluid Dynamics	LIT	3	0	2	5	4	ES (PC)
2.	TE25C07	Modelling and Analysis of Thermal Systems	T	3	0	0	3	3	ES (PC)
3.	TE25201	Design of Heat Exchangers	T	3	0	0	3	3	ES (PC)
4.		Industry Oriented Course I	-	1	0	0	1	1	SD
5.		Programme Elective - I	T	3	0	0	3	3	ES (PE)
6.		Programme Elective - II	T	3	0	0	3	3	ES (PE)
7.		Self-Learning Course	-	-	-	-	-	1	-
						TOTAL	**18**	**18**	

Semester III

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	EY25C02	Artificial Intelligence and Machine Learning in Energy Systems	T	3	0	0	3	3	ES (PC)
2.		Programme Elective-III	T	3	0	0	3	3	ES (PE)
3.		Programme Elective-IV	T	3	0	0	3	3	ES (PE)
4.		Programme Elective-V	T	3	0	0	3	3	ES (PE)
5.		Industry Oriented Course II	-	1	0	0	1	1	SD
6.	TE25301	Project Work I	-	0	0	12	12	6	SD
7.	TE25302	Industrial Training	-	-	-	-	-	2	SD
						TOTAL	**25**	**21**	

Semester IV

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	TE25401	Project Work II	---	0	0	24	24	12	SD
						TOTAL	**24**	**12**	

PROGRAMME ELECTIVE COURSES (PE)

S. No.	Course Code	Course Title	Periods Per Week			Total Contact Periods	Credits
			L	T	P		
1.	EY25C03	Modern Power Plants	3	0	0	3	3
2.	TE25001	Turbomachines	3	0	0	3	3
3.	EY25C04	Waste to Energy	3	0	0	3	3
4.	EY25C05	Polygeneration Systems	3	0	0	3	3
5.	TE25C08	Thermal Management in Electronics and Batteries	3	0	0	3	3
6.	EY25C06	Hydrogen Energy and Fuel Cell Technology	3	0	0	3	3
7.	TE25002	Hybrid and Electric Vehicles	3	0	0	3	3
8.	TE25003	Machine Learning in IC Engines	3	0	0	3	3
9.	TE25004	Energy Storage Technologies	3	0	0	3	3
10.	TE25005	Solar Photovoltaic Technology and Systems	3	0	0	3	3
11.	TE25C09	Carbon Sequestration and Utilisation	3	0	0	3	3
12.	TE25010	Refrigeration Systems	3	0	0	3	3
13.	TE25011	Air-Conditioning Systems	3	0	0	3	3
14.	TE25012	Energy Audit in Thermal and Electrical Utilities	3	0	0	3	3
15.	EY25C07	Sustainability in Buildings	3	0	0	3	3
16.	TE25013	Air and Chilled Water Systems for HVAC Applications	3	0	0	3	3
17.	TE25014	Low Temperature Refrigeration Systems	3	0	0	3	3
18.	TE25015	Gas Dynamics and Space Propulsion	3	0	0	3	3
19.	TE25016	Renewable Energy Technology	3	0	0	3	3

Semester I

MA25C06	Applied Mathematical and Statistical Modelling	L	T	P	C
		3	1	0	4

Course Objectives:

- To equip students with advanced mathematical techniques, specifically Fourier Transforms, for formulating and solving partial differential equations that model fundamental mechanical engineering phenomena such as heat transfer, vibrations, and fluid flow.
- To provide a strong foundation in statistical inference, enabling students to estimate population parameters (like material properties and process capabilities) from experimental data and assess the quality and reliability of these estimators.
- To enable students to design efficient, structured experiments and apply appropriate statistical tests to make valid, data-driven decisions for comparing processes, optimizing designs, and solving complex engineering problems.

Fourier Transform: Definitions, Properties, Transform of elementary functions, Dirac delta function, Convolution theorem, Parseval's identity, Solutions to partial differential equations: Heat equation, Wave equation, Laplace and Poison's equations.

Estimation Theory: Unbiasedness, Consistency, Efficiency and sufficiency, Maximum likelihood estimation, Method of moments.

Testing of Hypothesis: Sampling distributions, small and large samples, Tests based on Normal, t, Chi square, and F distributions for testing of means, variance and proportions, Analysis of r x c tables, Goodness of fit, independent of attributes.

Design of Experiments: Analysis of variance, One way and two-way classifications, Completely randomized design, Randomized block design, Latin square design, 2^2 Factorial design.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%.

References:

1. Andrews, L. C., & Shivamoggi, B. K. (2003). Integral transforms for engineers. Prentice Hall of India.
2. Devore, J. L. (2014). Probability and statistics for engineering and the sciences, Cengage Learning.
3. Johnson, R. A., Miller, I., & Freund, J. (2015). Miller and Freund's probability and statistics for engineers, Pearson Education Asia.

E-resources:

1. https://www.edx.org/learn/probability-and-statistics/massachusetts-institute-of-technology-probability-the-science-of-uncertainty-and-data
2. https://www.itl.nist.gov/div898/handbook/
3. https://ocw.mit.edu/courses/2-830j-control-of-manufacturing-processes-sma-6303-spring-2008

TE25C01	Advanced Thermodynamics	L	T	P	C
		3	0	2	4

Course Objectives:

To develop the ability to apply thermodynamic principles for analyzing energy systems and cycles using theoretical, experimental, and simulation approaches.

Thermodynamic Laws and Systems: Thermodynamics Laws and processes, Closed & Open Systems, Steady-state operations, Second Law efficiency.

Practical: Verification of First Law using Calorimeter, Experiment on Heat Work Interaction in Closed System (P-V diagram plotting)

Availability: Available Work: Non-flow and steady flow processes, Entropy Generation Mechanisms, Entropy Minimization Techniques, Exergy of fuels, Combustion Process and Exergy, Exergy Analysis in Heat exchangers, Boilers, Heat pumps, Turbomachines, Internal combustion Engines.

Practical: Entropy Generation in Flow through Pipe (Friction Loss Measurement), Exergy Analysis of a Heat Exchanger (Shell & Tube setup), Fuel Combustion Calorific Value Analysis using Bomb Calorimeter, Software Simulation: Exergy analysis using Software.

Ideal & Real Gas Mixtures: Van der Waals Equation of state, Virial Equations, Maxwell Relations, Joule–Thomson Coefficient, Thermodynamic Relations, Real gas mixtures

Practical: Virtual demonstration of Joule-Thomson Expansion Experiment (Throttle Valve Setup.

Thermodynamic Cycles: Rankine, Kalina, Supercritical and Gas Cycles, Refrigeration & Heat Pump Cycles, Combined Cycle and Cogeneration Systems.

Practical: Performance Test on a Vapour Compression Refrigeration Unit, Virtual simulation of mini powerplant and associated thermal cycles.

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

References:

1. Bejan, A. (2016). Advanced engineering thermodynamics. John Wiley & Sons.
2. Annamalai, K., Puri, I. K., & Jog, M. A. (2011). Advanced thermodynamics engineering. CRC Press.
3. Kuo, K. K. (2005). Principles of combustion. John Wiley & Sons.
4. Wark, K., Jr. (1995). Advanced thermodynamics for engineers. McGraw-Hill.
5. Borel, L., &Favrat, D. (2010). Thermodynamics and energy systems analysis: From energy to exergy. CRC Press.

E-Resources:
https://ocw.mit.edu/courses/mechanical-engineering/2-05-thermodynamics-fall-2003/
https://www.youtube.com/@LearnEngineering
https://nptel.ac.in/courses/112/105/112105275
https://ocw.tudelft.nl/courses/thermodynamics/
https://nptel.ac.in/courses/112/103/112103231
https://www.coursera.org/learn/energy-systems
https://dwsim.org/

	Description of CO	Mapped POs	PSO1	PSO2
CO1	Describe the Advanced Concepts of thermodynamics for design and analysis of thermal systems	PO3 (3)	3	–
CO2	Evaluate entropy generation, exergy, and availability in energy systems and combustion processes.	PO1 (3), PO3 (3)	3	3
CO3	Analyze real gas behavior at various conditions.	PO1 (2), PO2 (3), PO3 (3)	3	–
CO4	Simulate the performance of advanced thermodynamic cycles and energy conversion systems using software and interpret data.	PO1 (3), PO2 (3), PO3 (3)	3	3

TE25C02	Advanced Fluid Mechanics Heat Transfer	L	T	P	C
		3	0	2	4

Course Objectives:
To provide knowledge and skills to analyze and apply principles of fluid mechanics and heat transfer, Including conduction, convection, phase change, and advanced applications, through theoretical study, experimental investigation, and computational techniques.

Fluid Kinematics and Boundary Layer Theory: 3D Governing Equations: Mass, momentum and applications, Rotational & irrotational flows, stream & potential functions, Vorticity, flow visualization concepts, Velocity Boundary layer theory: displacement, momentum & energy thickness,Laminar and turbulent boundary layers (flat plate & circular pipe)

Practical: Measurement of boundary layer thickness over a flat plate in a wind tunnel, Determination of velocity profile for laminar/turbulent flow using Pitot tube.

Fluid Flow Analysis: Laminar flow: parallel plates and circular pipes, Friction factor, smooth vs rough pipes, Moody diagram, Minor and major losses, pipes in series/parallel, Power transmission through pipes,1D compressible flow in variable area ducts,Nozzles and diffusers, choking and flow regimes

Practical: Flow rate measurement in pipes using venturi/mass flow meters, Determination of friction factor using Moody's chart, Losses in pipe systems (major & minor losses), experimental setup

Conduction: Boundary Conditions, Thermal Conductivity, Conduction equation, Fin Design, analytical solutions, Multi-dimensional steady state heat conduction, Transient Heat conduction, Lumped Capacitance Method, Semi-Infinite Media Method

Practical:
Thermal conductivity of solids & liquids and effect of temperature, Thermal analysis of fins, Lumped heat method for analysis of different geometries

Convection: Energy & Momentum equations, Laminar & Turbulent Boundary Layers, Entry length, Reynolds-Colburn Analogy, Heat transfer coefficient for flow over a flat surface, circular & non-circular ducts

Practical:
Thermal & hydraulic boundary layer development through fluid, Free & Forced convective heat transfer coefficient studies.

Two-Phase Heat Transfer

Pool & Convective boiling, critical heat flux, Dropwise & filmwise condensation, Melting & Solidification, Heat transfer enhancement methods.

Practical:
Plotting of boiling & condensation curves, T-t plots during melting & solidification

Thrust Areas: Thermoregulation, Laser Generated Heat Transfer, Tissue Thermal Properties and Perfusion, Thermal Damage and Rate Processes in Biologic Tissues, Thermal Injury, Mathematical models of bio-heat transfer

Machine Learning in Heat Transfer, Linear regression and Neural networks, Practical considerations & Applications.

Practical:
Irradiation studies & heat generation from lasers

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

References:

1. Çengel, Y. A., & Cimbala, J. M. (2018). *Fluid mechanics: Fundamentals and applications*. McGraw-Hill.
2. White, F. M. (2016). *Fluid mechanics*. McGraw-Hill Education.
3. Lienhard, J. H., IV, & Lienhard, J. H., V. (2020). *A heat transfer textbook*. Phlogiston Press.
4. Holman, J. P. (2002). *Heat transfer*. Tata McGraw-Hill.
5. Çengel, Y. A. (2020). *Heat and mass transfer: Fundamentals and applications*. McGraw-Hill.
6. Incropera, F. P., & DeWitt, D. P. (2002). *Fundamentals of heat and mass transfer*. John Wiley & Sons.

E-Resources:

https://nptel.ac.in/courses/112105269?utm_
https://www.youtube.com/playlist?list=PLbMVogVj5nJTZJHsH6uLCO00I-ffGyBEm&utm
https://onlinecourses.nptel.ac.in/noc25_me171/preview?utm
https://onlinecourses.nptel.ac.in/noc23_ch32/preview?utm

	Description of CO	Mapped POs	PSO1	PSO2
CO1	Describe the principles of fluid mechanics to analyze flow behavior, boundary layers, and pressure/velocity variations in internal and external flows.	PO3 (3)	3	–
CO2	Evaluate fluid flow parameters, frictional losses, and compressible flow behavior in ducts, nozzles, and diffusers through theoretical and experimental studies.	PO1 (2), PO3 (3)	3	–
CO3	Analyze heat transfer by conduction, convection, and phase change, and validate models using experimental investigations.	PO1 (3), PO2 (2), PO3 (3)	3	3
CO4	Utilize computational and modern techniques, including machine learning, to simulate advanced heat transfer and bio-heat transfer processes for sustainable applications.	PO1 (3), PO2 (3), PO3 (3)	3	3

TE25C03	Instrumentation and Control for Thermal Systems	L	T	P	C
		3	0	0	3

Course Objectives:

To provide knowledge and skills in experimental methods, measurement systems, and industrial automation for accurate data acquisition, analysis, and process control.

Experimental Methods: Statistical and regression analysis, uncertainty and data reduction, experimental design, basics of data analytics and machine learning.

Activities: Mini-project on regression and uncertainty analysis using software, Design of Experiments (DoE) simulation using Taguchi method, Introduction to Python/R for basic data analytics.

Sensors, Transducers and Calibration: LVDT, strain gauge, capacitive, piezoelectric, optical and magnetic transducers; thermocouple, RTD, thermistor; calibration of sensors; electronic, fibre-optic and pneumatic transmitters; telemetry.

Activities: Lab experiments using LVDT, strain gauge, and thermocouples, Sensor signal acquisition and visualization via DAQ systems, Calibration experiments with standard temperature and pressure instruments

Measurements in Thermal Systems: Temperature, pressure, and flow measurements, Measurement of: Thermal conductivity, Specific heat, Viscosity, Rheological analysis of Newtonian and non-Newtonian fluids, Humidity, Solar irradiation, Differential Scanning Calorimetry, Calorific values of fuels (solid, liquid, gas)

Activities: Measurement of temperature, pressure, flow using industrial instruments, Determination of thermal conductivity and specific heat in the lab, Analysis using Differential Scanning Calorimetry (DSC)

Control Systems and Industrial Automation: Open/closed loop systems, transfer functions, feedback, signal conditioning, DAQ, PID and PLC controllers, regulators, thermostats, drives, SCADA, DCS, IIoT, and system optimisation.

Activities: Simulation of PID control using software, PLC programming using ladder logic (e.g., Siemens, Allen-Bradley), Hands-on with SCADA/DCS platforms (demo setups or software simulators), Virtual labs on IIoT and remote monitoring systems

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

References:

1. Holman, J. P. (2011). Experimental methods for engineers. Tata McGraw-Hill.
2. Doebelin, E. O. (2004). Measurement systems: Application and design. McGraw-Hill.
3. Kirkup, L. (2019). Experimental methods for science and engineering students. Cambridge University Press.
4. Morris, A. S., &Langari, R. (2015). Measurement and instrumentation: Theory and application. Elsevier.
5. Anderson, N. A. (2017). Instrumentation for process measurement and control.

CRC Press.
6. Datta, A., & Goel, P. (2023). Practical guide to instrumentation, automation and robotics. Elsevier.
7. Lipták, B. G. (Ed.). (2018). Instrument engineers' handbook: Process measurement and analysis. CRC Press.

E-resources and Other Resources:

https://nptel.ac.in/courses/106/106/106106179/
https://nptel.ac.in/courses/108/105/108105062/
https://nptel.ac.in/courses/112/104/112104906/
https://nptel.ac.in/courses/108/101/108101037/
https://nptel.ac.in/courses/108/105/108105062/

	Description of CO	Mapped POs	PSO1	PSO2
CO1	Describe the experimental methods, statistical analysis, and data analytics for accurate investigation of thermal systems.	PO1 (3), PO2 (2)	3	–
CO2	Demonstrate the use of sensors, transducers, and advanced measurement systems for thermal parameters.	PO3 (3)	3	–
CO3	Design and implement control and automation\strategies (PID, PLC, SCADA, IIoT) for efficient and sustainable thermal system operations.	PO1 (3), PO2 (3), PO3 (3)	3	3

TE25C04	Fuels and Combustion	L	T	P	C
		3	0	2	4

Course Objective

To introduce the principles of combustion, stoichiometry, flame behavior, and thermodynamics across solid, liquid, and gaseous fuels and to emphasize the analysis of combustion systems, emissions, and safety, with a focus on modern fuel technologies and sustainable energy application

Combustion Fundamentals and Stoichiometry: Combustion types and mechanisms, stoichiometry and flame characteristics, ignition, flame stabilization and combustion kinetics, flue gas analysis

Practical: Estimation of calorific value using bomb calorimeter, orsat gas analysis for flue gases, determination of air-fuel ratio for a given fuel.

Solid Fuels: Solid fuel types, properties and analysis, carbonization, gasification, and liquefaction, advanced biomass processing and hybrid fuels

Practical: Proximate and ultimate analysis of coal/biomass, study of fixed bed gasifier setup, fuel handling and briquetting of biomass

Liquid and Gaseous Fuels: Refining and testing of liquid fuels, synthetic fuels, bio, and alternative fuels, gaseous fuels: properties, production, and applications

Practical: Flash point and fire point testing (Pensky-Martens apparatus),Kinematic viscosity testing using redwood viscometer, measurement of octane and cetane numbers (engine method/demo)

Combustion Devices: Burners for fuels, pulverized fuel, furnaces and fluidized beds, low-NOx and smart burner technologies.

Practical: Performance testing of bunsen/industrial burner, design of a simple liquid/gas fuel burner, combustion efficiency measurement, flame visualization using high-speed camera/schlieren methods (demo or project)

Emissions and Combustion Safety: Emission sources, measurements and control, sensors, safety in fuel storage and combustion systems.

Practical: Measurement of NOx, SOx, CO, and particulate matter, study of fire extinguishing systems and combustion safety protocols

Combustion Sustainability: Green Fuels**:** hydrogen, ammonia, bio-fuels, and carbon-neutral fuels, AI/IoT in combustion optimization, emission reduction strategies, carbon capture in combustion systems, lean premixed combustion.

Practical: Performance evaluation of engine on biodiesel, Combustion of hydrogen or ammonia (simulation or demo setup), IoT-enabled emission monitoring, life cycle assessment (LCA) of biofuels, simulation of oxy-fuel combustion in software.

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

References:

1. Sarkar, S. (2009). Fuels and combustion. Orient Longman Pvt. Ltd.
2. Philips, H. J. (2008). Fuels – solids, liquids, and gases: Their analysis and valuation. Biobliolife Publisher.
3. Turns, S. R. (2012). An introduction to combustion: Concepts and applications . Tata McGraw-Hill.
4. Mishra, D. P. (2010). Fundamentals of combustion. University Press.
5. Sharma, S. P., & Mohan, C. (1984). Fuels and combustion. Tata McGraw-Hill.
6. Mukhopadhyay, R., & Datta, S. (2007). Engineering chemistry. New Age International Pvt. Ltd.

E-Resources:

https://nptel.ac.in/courses/112106184
https://ocw.mit.edu/courses/2-61-internal-combustion-engines-spring-2017/
https://www.coursera.org/learn/energy-production
https://www3.nd.edu/~powers/ame.60636/notes.pdf
https://www.ieabioenergy.com/

Other Resources:

Interactive simulation platforms:
https://vlabs.iitkgp.ac.in/heat/
https://learncheme.com/simulations/thermodynamics/adiabatic-flame-temperature/
https://learncheme.com/quiz-yourself/interactive-self-study-modules/combustion-reactions/
https://www.nist.gov/services-resources/software/fire-dynamics-simulator-fds

	Description of CO	**Mapped POs**	**PSO1**	**PSO2**
CO1	Describe the combustion fundamentals, stoichiometry, and flame behavior concepts to analyze different fuel types.	PO1 (3), PO3 (2)	3	–
CO2	Evaluate properties, testing methods, and performance of solid, liquid, and gaseous fuels including biofuels.	PO1 (3), PO2 (2), PO3(2)	3	–
CO3	Design and analyze combustion devices, emission control techniques, and safety protocols for fuel systems.	PO1 (3), PO2 (3)	3	2
CO4	Assess sustainable and advanced combustion practices for clean energy applications.	PO1 (3), PO3 (3)	–	3

Semester II

TE25C06	Computational Fluid Dynamics	L	T	P	C
		3	0	2	4

Course Objectives:

To impart the fundamentals of computational fluid dynamics and provide hands-on training, while introducing advanced CFD tools for analyzing complex systems.

Governing Differential Equations

Finite Volume approach – Scalar, Vector, Tensor, Governing equations for conservation of mass, momentum and energy – Classification of partial differential equations – Types of Boundary Conditions, Initial and Boundary value problems, Taylor's Series, Stoke's law, Vorticity, Diffusion, Divergence theorem, Types of Errors

Practicals:

Determination of approximate solutions for Navier-Stokes equation using computer software

Grid Generation

Types of Meshes – Structured, Body-Fitted & Unstructured Mesh, Coordinate Transformations, Topology, Refinement, Overlapping, Adaptive Mesh, Moving Mesh, Mesh Quality & Mesh Design, Coarse & Fine Mesh, Grid Independence Test.

Practicals:

Mesh Generation for various geometries

Diffusion

Multidimensional diffusion problems, Discretisation of steady & unsteady diffusion equations – Explicit, Implicit and Crank-Nicholson's schemes, Stability of schemes, Numerical Solutions.

Practicals:

Simulation of steady & transient diffusion problem using CFD Tool with results and reports.

Convection-Diffusion

1D convection – diffusion problem, Discretisation using Central difference scheme, upwind scheme, QUICK scheme.
Phase Change – Mathematical Formulation, Discretisation, Enthalpy method, Problems

Practicals:

Discretisation of governing equation using software, Simulation of phase-change problems using CFD Tool.

Flow Modelling

Pressure-velocity coupling algorithms – SIMPLE, SIMPLEC, PISO, Turbulence Models – Governing equation for turbulent kinetic energy & dissipation (k-ε model), Large Eddy Simulation

Practicals:

Simulation of internal and external flows and execution of CFD Project with results and reports.

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology and weightage:

Assessment Exams (50%), Assignment/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions (10%)

References:

1. Versteeg and Malalasekera, N, "An Introduction to computational Fluid Dynamics, Finite Volume Method," Pearson Education, Ltd., Second Edition, 2014.
2. Subas and V. Patankar "Numerical heat transfer fluid flow", CRC Press, 2018.
3. Jiyuan Tu, Gaun-Heng Yeoh, Chaoqun Liu, Computational Fluid Dynamics: A practical approach, Elsevier, 2018.
4. Chung T.J, Computational Fluid Dynamics, Cambridge University Press, 2014.
5. Randall J. LeVeque, Finite Volume Methods for Hyperbolic Problems, Cambridge University Press, 2004.
6. Vladimir D. Liseikin, Grid Generation Methods, Springer, 2017.
7. Moukalled F, Mangani L, Darwish M, The Finite Volume Method in Computational Fluid Dynamics, Springer, 2016.
8. Hirsch Ch, Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics, Elsevier, 2007.

   Oleg Zikanov, Essential Computational Fluid Dynamics, Wiley, 2019.

E-resources:

https://nptel.ac.in/courses/112/105/112105045/
https://ocw.mit.edu/courses/mechanical-engineering/2-29-numerical-fluid-mechanics-spring-2015/
https://www.grc.nasa.gov/www/cfd/
https://www.ansys.com/training-center
https://www.journals.elsevier.com/journal-of-computational-physics

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain governing equations, boundary conditions, discretization methods, and numerical errors in CFD	PO1 (3), PO3 (2)	3	2
CO2	Apply finite volume methods, mesh generation, and numerical schemes to solve fluid flow and heat transfer problems	PO1 (3), PO2 (3)	3	3
CO3	Estimate stability, convergence, and accuracy of CFD solutions and grid independence	PO1 (3), PO3 (3)	3	3
CO4	Analyze CFD results, turbulence models, and flow simulations for problem-solving and optimization	PO3 (3)	3	3

TE25C07	Modelling and Analysis of Thermal Systems	L	T	P	C
		3	0	0	3

Course Objectives:

To understand energy conversion principles, develop and model thermal systems using numerical and flow analysis techniques, apply optimization and AI-based methods to solve energy-related problems, and integrate economic models for effective energy system analysis.

Energy Systems: Energy conversion methods and system development, Characteristics of workable and optimum systems, Concept selection and creativity, Energy balance for closed and control volume systems, Solving Governing equations: parabolic, elliptic, hyperbolic, Finite element and finite volume methods.

Activities: Perform lab experiments (e.g., on a heat exchanger or boiler setup) on energy balance, develop simple system models using MATLAB/Excel, Apply least squares method for curve fitting.

Modeling and Simulation: Modelling: steps and levels, Basics of mathematical modelling, Exponential forms and least squares method, Modeling of heat exchangers, Effectiveness-NTU method, pressure drop, pumping power, Simulation types: sequential/simultaneous, Flow diagrams, Newton-Raphson method, Optimization basics and problem formulation

Activities: Simulate heat exchangers using Effectiveness-NTU method, calculate pressure drop and pumping power in a piping system using experimental or simulated data, solve nonlinear equations using Newton-Raphson.

Optimization Techniques: Dynamic and geometric programming, Lagrange multipliers and constrained optimization, Linear regression, thermodynamic property relations, Advanced techniques: genetic algorithms, simulated annealing.

Activities: Solve optimization problems using Excel/MATLAB, conduct linear regression on thermodynamic data, implement genetic algorithms in Python/MATLAB, Apply simulated annealing to design problems.

Energy-Economy Analysis: Energy-economy modeling: multiplier analysis, Energy and environmental input/output analysis, Econometric energy demand models, Search techniques, univariate/multivariate analysis.

Activities: Build econometric energy demand models, Solve PDEs (e.g., heat conduction) using MATLAB/Python, Run FEM/FVM simulations with COMSOL/ANSYS/Open FOAM to solve thermal or fluid problems.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology and weightage:

Assessment Exams (50%), Assignment/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions (10%)

References:

1. B.K.Hodge: “Analysis and Design of Thermal Systems”, Prentice Hall Inc., 1990.

2. Bejan, A, Tsatsaronis, G and Moran, M., “Thermal Design and Optimization”, John Wiley & Sons, 1996
3. J. Nagrath & M.Gopal: “Systems Modelling and Analysis”, Tata McGraw Hill, 2007
4. D.J. Wide: “Globally Optimal Design”, Wiley- Interscience, 1978.
5. Mark E. Davis, “Numerical Methods and Modelling for Chemical Engineers”, John Wiley & Sons, 1984.
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E-Resources:

https://nptel.ac.in/courses/112/101/112101097/
https://nptel.ac.in/courses/112/106/112106133/
https://nptel.ac.in/courses/112/105/112105182/
https://nptel.ac.in/courses/112/101/112101097/
https://ocw.mit.edu/courses/mechanical-engineering/2-14-analysis-and-design-of-feedback-control-systems-spring-2014/

CO	CO Description	PO	PSO1	PSO2
CO1	Explain the fundamentals of energy conversion, thermal system development, and governing equations	PO1 (3), PO3 (2)	3	2
CO2	Apply numerical methods, modeling, and simulation techniques (MATLAB, Excel, COMSOL/ANSYS) to thermal systems	PO2 (3), PO3 (2)	3	2
CO3	Estimate system performance, pressure drop, pumping power, and effectiveness of thermal devices	PO2 (3), PO3 (2)	3	2
CO4	Analyze and optimize thermal systems using AI techniques, optimization methods, and energy-economy models	PO3 (3), PO5 (2)	3	3

TE25201	Design of Heat Exchangers	L	T	P	C
		3	0	0	3

Course Objectives:

To understand heat exchanger types and design methods including LMTD, NTU, TEMA classifications, shell-side analysis, special configurations, and the design of condensers and evaporators including multi-effect systems.

Design Parameters: Classification, Heat Exchanger variables, Thermal circuit, LMTD & NTU methods, Double-pipe and concentric tube design, Heat transfer, pressure drop, thermal stress, Temperature distribution, materials, and sizing.

Activities: Solve numerical problems using LMTD and NTU methods for various flow configurations, Mini-project: Design a basic concentric tube heat exchanger with thermal and sizing calculations, Lab demo or simulation: Analyze temperature distribution using software.

Shell-and-Tube Heat Exchangers: TEMA classification and construction, Mechanical and thermal design, Fluid allocation, Shell-side heat transfer and pressure drop: Kern, Bell-Delaware, and stream analysis methods

Activities: Use TEMA standards to create mechanical drawings of a shell-and-tube heat exchanger, shell-side performance analysis using Kern and Bell-Delaware methods

Compact Exchangers: Plate exchangers: types, flow pattern, design considerations, Spiral and helical: construction & design, applications.

Activities: CAD modeling of a compact heat exchanger with header and flow channel design, Design compact heat exchanger layout for a given application (HVAC, electronics, etc.),

Extended Surface Exchangers: Concept of Constructal heat exchangers, Fin-and-tube heat exchangers: Heat Transfer and Friction Characteristics, Periodic Flow Types, Core Pressure Drop, flow distribution, headers design, fins, sizing of heat exchanger,

Activities: Calculate fin efficiency and effectiveness for different fin geometries, Comparative analysis of pressure drop and flow distribution in plate vs. finned exchangers

Condensers: Condenser types, heat transfer coefficient, operational aspects, Water-cooled, Air-cooled & Evaporative Types, Wilson plot.

Activities: Plot and interpret Wilson plots using test data or simulated values, Evaluate and compare condenser types for HVAC and power plant applications

Evaporators: Types, Flow Patterns, heat load, multi-effect systems and testing standards.

Activities: Lab observation or virtual demo: Flow visualization in micro-channel evaporators

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology and weightage:

Assessment Exams (50%), Assignment/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions (10%)

References:

1. Sadik Kakaç, Hongtan Liu, Anchasa Pramuanjaroenkij, Heat Exchangers: Selection, Rating, and Thermal Design, CRC Press, 2020.
2. Kays W. M, London A. L, Compact Heat Exchangers, Scientific International, 2018.
3. Manfred Nitsche, Raji Olayiwola Gbadamosi, Heat Exchanger Design Guide, Elsevier Science, 2015.
4. Robert W. Serth, Thomas Lestina, Process Heat Transfer: Principles, Applications and Rules of Thumb, Elsevier Science, 2014.
5. Arthur P. Fraas, Heat Exchanger Design, Wiley, 2000.
6. Ann Marie Flynn, Toshihiro Akashige, Louis Theodore, Kern's Process Heat Transfer, Wiley, 2019.
7. Hesselgreaves J.E, Compact Heat Exchangers: Selection, Design and Operation, Elsevier Science, 2001.
8. Geoffrey Hewitt, Heat Exchanger Design Handbook, Begell House, 2008.
9. TEMA Standards, 10th Edition, 2019.

E-resources:

https://nptel.ac.in/courses/112/105/112105182/

https://nptel.ac.in/courses/103107125

https://nptel.ac.in/courses/112/105/112105129/

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain LMTD and NTU methods for basic heat exchanger design	PO1 (3), PO3 (2)	3	2
CO2	Apply shell-and-tube exchanger analysis using TEMA and shell-side methods	PO2 (3), PO3 (2)	3	2
CO3	Estimate design parameters for compact exchangers like plate, spiral, and helical types	PO3 (3), PO4 (2)	3	3
CO4	Analyze extended surface exchangers, fin performance, and condenser types using heat transfer methods	PO3 (3), PO5 (2)	3	3

Semester III

EY25C02	Artificial Intelligence and Machine Learning in Energy Systems	L	T	P	C
		3	0	0	3

Course Objectives:

To introduce AI and Machine Learning techniques for modern energy systems with a focus on data-driven modeling, optimization, and their applications in renewable energy forecasting, smart grids, energy management, and predictive maintenance.

AI in Energy Systems

Basics of Artificial Intelligence (AI), Machine Learning, Role of AI in modern energy systems, data acquisition from energy devices and sensors (IoT), case studies.

Activities

Simulate a simple AI-based decision system for energy efficiency using software, Collect sample IoT sensor data (temperature, voltage, current) and visualize trends.

Forecasting and Optimization in Energy Systems

Time-series forecasting of solar irradiance, wind speed, and load demand, ML models: linear regression, decision trees, random forest, SVM, optimization techniques: genetic algorithms, particle swarm optimization, ant colony optimization, energy demand prediction and scheduling, battery storage and microgrid optimization using AI.

Activities

Build a solar irradiance forecasting model using time-series data, Compare ML models (Linear Regression vs. Random Forest vs. SVM) for load prediction, Implement a simple Genetic Algorithm or Particle Swarm Optimization for battery scheduling.

Intelligent Control and Fault Detection

AI in HVAC systems and building energy management, smart controllers using ANN and fuzzy logic, fault detection and diagnostics in PV, turbines, and motors, predictive maintenance using ML and DL, classification techniques: KNN, naïve bayes, CNN for anomaly detection

Activities

Design a fuzzy logic controller for HVAC temperature control, Implement ANN-based predictive maintenance model for motor vibration data, Train a CNN to detect anomalies in PV panel output patterns.

Smart Grids and Energy Analytics

AI in smart grid management and demand-side response, load disaggregation and consumption pattern analysis, AI in grid stability, outage detection, and cyber-physical systems, big data and cloud platforms (e.g., TensorFlow, AWS IoT) for energy analytics, case studies on AI-powered utilities and smart meters**.**

Activities
Apply AI algorithms for outage detection from grid event logs, perform load disaggregation using machine learning on household energy data, deploy a simple AI-based demand response simulation using AWS IoT or Google Cloud AI tools.
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%
Assessment Methodology and weightage: Assessment Exams (50%), Assignments/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions(10%)
References: 1. Siano, Pierluigi, Artificial Intelligence Techniques for Renewable Energy Systems, Springer, 2021 2. James Smith, AI and Machine Learning for Energy Engineers, Wiley, 2022. 3. Mohamed E. El-Hawary, Artificial Intelligence Applications in Power Systems, IEEE Press, 2020. 4. Sebastian Raschka, Python Machine Learning, Packt Publishing, 2020 5. Research articles from IEEE Xplore, ScienceDirect, and SpringerLink
E-Resources: https://nptel.ac.in/courses/106102220 https://nptel.ac.in/courses/112106298 https://www.coursera.org/learn/ai-for-everyone https://www.coursera.org/specializations/data-science-python https://www.edx.org/course/artificial-intelligence-ai https://www.udemy.com/course/ai-for-renewable-energy/

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain AI and ML concepts, data acquisition from energy devices, and applications in modern energy systems.	PO1 (3), PO3 (2)	3	2
CO2	Apply ML models and optimization techniques (linear regression, decision trees, random forest, SVM, GA, PSO) for energy forecasting, scheduling, and battery/microgrid optimization.	PO1 (3), PO2 (3)	3	3
CO3	Estimate performance of intelligent control systems, predictive maintenance models, and fault detection in PV panels, turbines, and motors.	PO1 (3), PO3 (3)	3	3
CO4	Analyze AI-enabled smart grid operations, load disaggregation, demand-side management, and energy analytics for optimized energy management.	PO3 (3)	3	3

TE25301	Project Work I	L	T	P	C
		0	0	12	6

Course Objectives:

- The main learning objective of this course is to prepare the students for identifying a specific problem for the current need of the society and or industry, through detailed review of relevant literature, developing an efficient methodology to solve the identified specific problem.

  Note: A project topic must be selected by the students in consultation with their guides. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.

TE25302	Industrial Training	L	T	P	C
		0	0	0	2

Course Objectives:

- To gain hands-on experience in industries for understanding various real-time processes and work environment in industrial setup.

DURATION

The students have to undergo practical industrial training for four weeks (During summer vacation in first year of the course) in recognized industrial establishments.

I. At the end of the training, they have to submit a report with following information:

1. Profile of the Industry,
2. Product range,
3. Organization structure,
4. Plant layout,
5. Processes/Machines/Equipment/devices,
6. Personnel welfare schemes,
7. Details of the training undergone,
8. Projects undertaken during the training, if any
9. Learning points.

II. End Semester examination will be a Viva-Voce Examination type which will be evaluated by a committee consisting of Programme Incharge, Professor and Course Coordinator during Third Semester.

Semester IV

TE25401	**Project Work II**	L	T	P	C
		0	0	24	12

Course Objectives:

- The main learning objective of this course is to prepare the students for solving the specific problem for the current need of the society and or industry, through the formulated efficient methodology, and to develop necessary skills to critically analyse and discuss in detail regarding the project results and making relevant conclusions.

Note: A project topic must be selected by the students in consultation with their guides. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.

PROGRAMME ELECTIVE COURSES

EY25C03	Modern Power Plants	L	T	P	C
		3	0	0	3

Course Objectives:

To understand and analyze conventional and advanced power generation systems including coal-based, diesel, gas turbine, cogeneration, combined, hydro, and nuclear plants with focusing on efficiency, components, safety, load parameters, cost, and environmental impact.

Coal-Based: Supercritical, Pulverized fuel, AFBC/PFBC boilers, Superheat, Reheat, Regenerative Rankine Cycles, Turbines, Condensers and Cooling Towers.

Activities: Rankine Cycle simulation using software, Case study on supercritical and PF boilers in Indian power stations

Diesel and Gas Turbine: Diesel Engine, cycle, plant layout, performance, cooling and lubrication systems, Gas turbines, Brayton cycle, advantages, limitations with intercooling, reheating, regeneration – analysis and improvement.

Activities: Layout drawing of a diesel power plant with cooling/lubrication systems, Performance evaluation of turbocharged vs non-turbocharged engines, Lab demo or video on gas turbine start-up and operation

Cogeneration and MHD Systems: Cogeneration types, heat-to-power ratio, performance, Combined Heat and Power, Binary and Polygeneration cycles, MHD: Open/Closed cycles, Hybrid MHD-steam systems.

Activities: Comparison chart of different cogeneration systems (steam, gas, IC engine-based), Simulation or animation-based learning of MHD generation principles, Mini-project: Analyze a real-world CHP system (e.g., sugar or cement plant)

Hydroelectric and Nuclear Power Plants: Hydro: types, components, pumped storage, micro/mini plants, Nuclear fuels, fertile fuels, moderators, coolants, reactor types, safety measures and environmental concerns.

Activities: Create a scaled diagram of a hydroelectric system including pumped storage, Poster presentation on nuclear reactor types with pros and cons, Safety and environmental review of historical nuclear incidents

Economics and Environmental Issues: Load parameters and load curve analysis, site selection, capital and operating cost, power tariffs, pollution control, and waste disposal from power plant.

Activities: Plot load curves using real or simulated daily power demand data, Cost comparison assignment for different power plant types (CAPEX/OPEX)

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology and weightage:

Assessment Exams (50%), Assignment/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions (10%)

References:

1. Nag, P.K., “Power Plant Engineering”, Tata McGraw Hill Publishing Co Ltd, New Delhi, 2002.
2. Haywood, R.W., “Analysis of Engineering Cycles”, Pergamon Press Oxford, 4th Edition, 2012
3. Wood, A.J., Wollenberg, B.F., “Power Generation, operation and control”, John Wiley, New York,1991
4. Gill, A.B., “Power Plant Performance”, Butterworths, 1984.
5. Lamarsh, J.R., “Introduction to Nuclear Engineering”, Addison-Wesley, 2nd edition, 1983.
6. Arora and S. Domkundwar, “A Course in Power Plant Engineering”, Dhanpat Rai Publications, 6th edition, 2016

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain principles, components, and cycles of conventional and advanced power plants	PO1 (3), PO3 (2)	3	2
CO2	Apply simulation and analysis techniques to evaluate power plant performance	PO1 (3), PO2 (3)	3	3
CO3	Estimate efficiency, cost, and environmental impact of different power generation systems	PO1 (3), PO3 (3)	3	3
CO4	Analyze operational performance, optimization, and integration of power plant systems	PO3 (3)	3	3

TE25001	Turbomachines	L	T	P	C
		3	0	0	3

Course Objectives:

To understand turbomachinery fundamentals, analyze and design centrifugal and axial flow devices, and apply compressor selection for HVAC and industrial applications.

Turbo Machine Energy Interactions

Energy transfer in fluids and rotor interaction, Velocity triangles and Euler's equation for turbo machines, Degree of reaction and various efficiencies (isentropic, mechanical, thermal, overall, polytropic), Fan laws, dimensionless parameters, specific speed, Cordier diagram and performance characterization

Activities: Draw and analyze velocity triangles for different turbo machines, Use software to plot fan laws and dimensionless parameters, Case study or group discussion on Cordier diagram and its practical relevance.

Fans and Blowers

Centrifugal Blowers: Velocity triangles, characteristic curves, Impeller casing, inlet, volute, diffusers, Losses (leakage, mechanical), multi-vane impellers, cross-flow fans, Selection for duct flow, Axial Flow Fans: Rotor design (airfoil and vortex theory), Cascade effects, blade twist, stage design, Surge, stall, stator, casing, Mixed flow impellers, selection for duct flow

Activities: Create a model or CAD simulation of a centrifugal blower showing impeller, volute, and diffuser, Analyze axial fan blade profiles using vortex and airfoil theory, Virtual lab or software simulation of airflow through axial/centrifugal fans.

Compressors

Centrifugal, velocity triangles, performance, Part load operation, Capacity control, Selection for different applications, axial flow compressors.

Activities: Disassemble and identify components of reciprocating and centrifugal compressors, Experiment or simulation to study performance under part-load conditions.

Design & Applications

Special designs for HVAC, cooling towers, ventilation, boosters, turbochargers. Fan arrangements (series/parallel), airflow and pressure losses in ventilation, roof/tunnel/mines ventilation, air distribution in various HVAC capacities.

Activities: Design a ventilation layout for a tunnel or mine with fan selection and pressure loss estimation., Mini project: Air distribution system design for a small/medium HVAC setup, Visit/report on real-world applications (HVAC plant, cooling tower, or ventilation system).

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology and weightage:

Assessment Exams (50%), Assignment/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions (10%)

References:

1. S. L. Dixon, C. A. Hall, Fluid Mechanics and Thermodynamics of Turbomachinery, B&H, 2014.
2. WTW Bill Cory, Fans & Ventilation: A Practical Guide, Elsevier, 2010.
3. Erik Dick, Fundamentals of Turbomachines, Springer, 2015.
4. R. I. Lewis, Turbomachinery Performance analysis, Elsevier, 1996.
5. Frank P. Bleier, Fan Handbook: Selection, Application and Design, Mc-Graw Hill, 1998.
6. Royce N. Brown, Compressors: Selection & Sizing, Elsevier, 2011.
7. Fans & Ventilation A practical guide (Bill) cory WTW, Elsevier, 2005.

E-resources:

https://nptel.ac.in/courses/112102105

https://nptel.ac.in/courses/112107290

https://nptel.ac.in/courses/112107208

https://nptel.ac.in/courses/112107289

https://www.youtube.com/c/TheEngineeringMindset

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the fundamentals of energy transfer, velocity triangles, efficiencies, and performance parameters in turbomachinery	PO1 (3), PO3 (2)	3	2
CO2	Apply the working principles, design features, and selection criteria of centrifugal and axial flow devices	PO2 (3), PO3 (2)	3	2
CO3	Estimate the construction, performance characteristics, and control methods of compressors for various applications	PO3 (3), PO4 (2)	3	3
CO4	Analyze fan/blower design and selection for real-world HVAC, ventilation, and industrial systems	PO3 (3), PO5 (2)	3	3

EY25C04	Waste to Energy	L	T	P	C
		3	0	0	3

Course Objectives:

To provide knowledge of technologies that convert waste into usable energy forms like heat, electricity, biofuels and provides application of advanced tools for optimizing and evaluating waste-to-energy systems.

Energy from Waste & Waste Characterization

Introduction to energy from waste: Definition, scope, and need, Classification and characterization of waste, Waste as fuel, Overview of conversion technologies, Circular economy and zero-waste concepts in energy systems, Introduction to Life Cycle Assessment (LCA) of waste-to-energy systems

Applications: Applied in urban waste management systems (e.g., Chennai, Pune, Indore) to classify organic, plastic, and inert waste for energy use, Used in converting agro-industrial residues like bagasse and rice husk into bioenergy in sugar mills and food processing units.

Combustion & Thermal Conversion Technologies

Combustion processes: Theory and principles, Densification of biomass and waste solids, Biomass stoves and Fixed bed combustors, Inclined grate combustors and fluidized bed combustors ,Energy and efficiency analysis of combustion systems, Waste-to-energy from plastics and refuse-derived fuel (RDF), Emission control and pollutant capture in combustion-based WTE

Applications: Applied in pyrolysis and RDF-based cement kilns to reduce landfill burden and recover heat, Community heating using biomass stoves and fixed-bed combustors in rural Himalayan areas.

Gasification and Pyrolysis Technologies

Gasification systems: Fixed bed, fluidized bed, Syngas generation and thermal applications, Engine-generator integration and electrical power generation from syngas, Pyrolysis: Types, process parameters, charcoal production, Pyrolytic oils and gases: Yield optimization, applications, Co-gasification of biomass and plastic waste

Applications: Decentralized Biomass Gasifiers are used in off-grid rural electrification projects (e.g., Husk Power Systems in Bihar) to supply power from rice husk, Syngas Production is applied in small-scale industries for thermal applications or as a fuel in IC engines, Biochar and Pyrolysis Oil Production is used in agriculture for soil amendment and in research on alternative fuels.

Biological & Emerging Waste-to-Energy Technologies

Anaerobic digestion: Process fundamentals, biogas production, Fermentation processes: Ethanol, butanol, hydrogen production, Transesterification of waste oils to biodiesel, Microbial Fuel Cells (MFCs): Principles and design, Algal biomass cultivation from wastewater, energy extraction from algae, Integration of biorefineries and carbon capture.

Applications: Cow dung, kitchen, and food waste are used in community biogas plants (e.g., Pune, Bengaluru) for cooking gas and electricity, Microbial Fuel Cells (MFCs) in emerging application in wastewater treatment plants to simultaneously treat water and generate electricity. Algae-Based Wastewater Treatment and Biofuel Production is applied in experimental setups in urban STPs to convert nutrient-rich waste into algal biomass for bioenergy.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Poster presentation (10%), Quiz (10%), Assignment (20%), Field visit/Case study report (20%), Internal Examinations (40%)

References:

1. Sjaak van Loo, Jaap Koppejan, “The Handbook of Biomass Combustion and co-firing”,Routledge, First Edition, 2008.
2. David C. Dayton, Thomas D. Foust, “Analytical Methods for Biomass haracterization and Conversion”, Elsevier, 2019 (ebook).
3. D.D. Hall and R.P. Grover, “Biomass Regenerable Energy”, John Wiley, First Edition, 1987.
4. Chakraverthy A, “Biotechnology and Alternative Technologies for Utilization of Biomass or Agricultural Wastes”, Oxford & IBG publishing Co. Ltd., First Edition, 1989.
5. Samir K. Khanal, “Bioenergy and Biofuel from Biowastes and Biomass”, ASCE, 2010

E-Resources:

https://nptel.ac.in/courses/103106214
https://www.coursera.org/learn/renewable-energy-entrepreneurship
https://www.edx.org/course/energy-principles
https://cpcb.nic.in/municipal-solid-waste/
https://mnre.gov.in/biomass-powercogen
https://www.eia.gov/energyexplained/biomass/
https://www.irena.org/
https://www.journals.elsevier.com/waste-management
https://www.tatapower.com/businesses/waste-to-energy.aspx
https://www.unep.org/resources/report/state-waste-energy-sector

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain waste-to-energy concepts, waste characterization, and LCA	PO1 (3), PO3 (2)	3	2
CO2	Apply thermal, biological, and emerging WTE technologies for energy generation	PO1 (3), PO2 (3)	3	3
CO3	Estimate energy output, efficiency, and emissions from different WTE systems	PO1 (3), PO3 (3)	3	3
CO4	Analyze performance, optimization, and integration of WTE processes and biorefineries	PO3 (3)	3	3

EY25C05	Polygeneration Systems	L	T	P	C
		3	0	0	3

Course Objectives:

To provide knowledge of design, integration, and operation of polygeneration systems for producing multiple energy outputs efficiently with application of advanced technologies like AI, digital twins, and smart control for sustainable energy management.

Fundamentals of Polygeneration and Energy System Integration

Overview of polygeneration systems and their multi-output capabilities (power, heat, cooling, fuels),Classification based on fuel type (fossil, renewable, hybrid) and application (CHP, CCHP, etc.),Concepts of energy system integration and coupling of thermal, electrical, and chemical streams.

Applications: Integrated Energy Parks combining solar, wind, and biomass for rural electrification, Industrial energy hubs that supply power, steam, and heating to industrial clusters. Urban energy systems providing electricity, hot water, and space cooling, Community-based polygeneration for remote/off-grid villages using hybrid energy sources

Components and Conversion Processes in Polygeneration

Processes: Internal combustion engines, steam cycles, gas turbines, Organic Rankine Cycles (ORC), combined cycles, fuel cells, Refrigeration: Electric and thermally-driven systems, Solar, wind, and biomass-based conversion systems, Energy storage: Batteries, hydrogen storage, thermal storage

Applications: CHP systems in textile, paper, and chemical industries, Use of Organic Rankine Cycle (ORC) in waste heat recovery of cement and steel plants, Microgrid systems using gas turbines and fuel cells in commercial buildings, Solar-biomass hybrid plants in agro-processing and dairy farms

Performance and Thermoeconomic Evaluation of Polygeneration

Evaluation of natural gas, solar, and biomass-based systems, First law and exergy-based performance metrics, Environmental and emission benefits of integrated systems, Optimal design strategies for maximum resource utilization, Thermoeconomic analysis and multi-objective optimization

Applications: Exergy and cost optimization in refineries and petrochemical plants, Energy-efficiency audits and thermoeconomic modeling in integrated power plants, Life cycle cost analysis of solar + diesel + battery hybrid systems, AI-driven operational optimization in smart cities and net-zero campuses

Applications in Buildings and Industries

Building energy systems :heating, cooling, and electrical loads, Solar and IC engine-based polygeneration for net-zero buildings,Case studies on building-scale polygeneration (BIPV + heat pumps + hydrogen),Industrial applications: low-grade

heat recovery, coal-renewable hybrids, Polygeneration in process industries and agro-processing units, Demand-side forecasting and load prediction using neural networks, Integration with smart grids and demand response systems
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%
Assessment Methodology: Poster presentation (10%), Quiz (10%), Assignment (20%), Field visit/Case study report (20%), Internal Examinations (40%)

References:

1. Ibrahim Dincer and Yusulf bicer, "Integrated Energy Systems for multigeneration", Elesvier Ltd, 2020
2. Franceso Calise, Maasimo Daccadia, Laura Vanoli and Maria Vicidomini, "Polygeneration systems – Deign, Process and echnlogies", Academic Press, 2022.
3. Majid Amidpour, Mohammad Hasan Khoshgoftar Manesh, "Cogeneration and Polygeneration Systems", Elesevier Science, 2020
4. Yang Chen, "Optimal Design and Operation of Energy Polygeneration Systems", MIT Press, 2013
5. Cristina Gil de Moya, Carl-Johan Fogelholm, "Technoeconomic Assessment of Polygeneration Systems", Universitat Politècnica de Catalunya. Escola Tècnica Superior d' Enginyeria Industrial de Barcelona, 2008

E-Resources:

https://nptel.ac.in/courses/112101015
https://nptel.ac.in/courses/112105231
https://ocw.mit.edu/courses/energy-systems/
https://www.iea.org/topics/renewables/cogeneration
https://www.irena.org

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain fundamentals of polygeneration systems, classifications, energy integration concepts, and multi-output capabilities	PO1 (3), PO3 (2)	3	2
CO2	Apply knowledge of components and conversion processes, including engines, turbines, fuel cells, ORC, storage, and renewable integration in polygeneration systems	PO1 (3), PO2 (3)	3	3
CO3	Estimate performance metrics, exergy efficiency, environmental impact, and cost-effectiveness of polygeneration systems using thermoeconomic analysis	PO1 (3), PO3 (3)	3	3
CO4	Analyze polygeneration applications in buildings and industries, including smart-grid integration, AI-driven optimization, and net-zero energy solutions	PO3 (3)	3	3

TE25C08	Thermal Management in Electronics and Batteries	L	T	P	C
		3	0	0	3

Course Objectives:

To Understand chilled water systems, chiller types, and selection criteria. To Explore advanced cooling methods and assess their effectiveness in electronics. To Analyse thermal management in real-world electronic systems across industries. To Learn battery thermal behavior and design effective thermal management systems.

Thermal Fundamentals in Electronics

Heat transfer modes, electronics packaging, material properties, contact/spreading resistance, heat sinks, thermal interface materials, JEDEC standards.

Activities: Simulate heat sink design (ANSYS/SolidWorks), Analyze material thermal properties, Case study using JEDEC standards

Applications: Design of efficient electronic packaging, Optimizing heat sinks and thermal interfaces in processors, Ensuring device reliability via proper thermal resistance control, Standard-compliant electronics cooling (JEDEC).

Cooling Technologies

Microchannels, fluid selection, jet impingement, immersion cooling, heat pipes, vapor chambers, thermoelectric coolers, MEMS/NEMS cooling, recent trends.

Activities: CFD simulation of microchannel/jet cooling, Prototype immersion or heat pipe system, Use thermoelectric cooler in experiment

Applications: High-performance cooling in CPUs/GPUs and power electronics, Thermal control in compact devices (e.g., smartphones, VR headsets), Emerging tech: MEMS/NEMS cooling in miniaturized systems

Applications

Thermal management in automobiles, trains, ships, avionics, data centers, laptops, Mobile phones, IoT devices, TVs, RADAR, satellites, LEDs, and LASERs.

Activities: Case study: automotive or avionics cooling, Thermal profiling of laptops/smartphones, LED/LASER cooling analysis

Applications: Thermal solutions in transport systems (cars, trains, aircraft), Mobile/IoT device heat management, Thermal design in consumer electronics (LEDs, TVs, RADAR, LASERs)

Battery Systems and Thermal Management

Battery types, energy balance, electrochemical modeling, duty cycle, thermal behavior, runaway, BTMS design (air, liquid, PCM), and recent advances.

Activities: Battery thermal modeling (MATLAB), Heat generation and energy balance study, Design air/liquid/PCM BTMS, Review on latest BTMS advancements

Applications: Battery pack design for EVs and hybrid vehicles, Thermal safety in energy storage systems, Preventing battery aging and thermal runaway, Efficient BTMS in drones, power tools, and portable devices

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Poster presentation (10%), Quiz (10%), Assignment (20%), Field visit/Case study report (20%), Internal Examinations (40%)

References:

1. Younes Shabany, Heat Transfer: Thermal Management of Electronics, CRC Press Inc, 2010.
2. L.T. Yeh, Thermal Management of Microelectronic Equipment, ASME, 2016.
3. Arman Vassighi, Manoj Sachdev, Thermal and power management of integrated circuits, Springer, 2006.
4. Marc A Rosen, Aida Farsi, Battery Technology: From Fundamentals to Thermal Behaviour and Management, Elsevier, 2023.
5. Shriram Santhanagopalan, Kandler Smith, Gi-Heon Kim, Jeremy Neubauer, Ahmad A. Pesaran, Matthew Keyers, Design and Analysis of Large Lithium-Ion Battery Systems, Artech House Publishers, 2014.
6. Jerry E. Sergent, Al Krum, Thermal Management Handbook: For Electronic Assemblies, McGraw-Hill, 1998.
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CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain heat transfer fundamentals, electronics packaging, cooling technologies, application domains, and battery thermal behavior including BTMS concepts	PO1 (3), PO2 (2)	3	2
CO2	Apply thermal principles, CFD/simulation tools, and cooling techniques to design thermal management systems for electronics and batteries	PO1 (3), PO3 (3)	3	3
CO3	Estimate heat generation, thermal resistance, cooling performance, and battery thermal characteristics under varying operating conditions	PO1 (3), PO2 (3)	3	3
CO4	Analyze thermal performance, reliability, safety issues, and effectiveness of cooling systems and BTMS in real-world applications	PO3 (3)	3	3

EY25C06	Hydrogen Energy and Fuel Cell Technology	L	T	P	C
		3	0	0	3

Course Objectives:

To provide an integrated understanding of hydrogen as a clean energy carrier, its generation, storage, and utilization, along with the design, working, and application of fuel cell technologies for sustainable energy systems.

Hydrogen Energy – Fundamentals, Properties, and Policies

Salient characteristics of hydrogen as an energy carrier, Global and Indian hydrogen policy landscape, Hydrogen economy and net-zero commitments, Hydrogen colour codes: Grey, Blue, Green, Pink, etc., Physical and chemical properties of hydrogen, Hazards, types, safety codes, regulations, and standards

Applications: National Green Hydrogen Mission (India) – driving hydrogen demand in steel, refining, and fertilizer sectors., Hydrogen Handling and Safety Codes: Used by industries such as Linde, Air Liquide, BOC India, which deal with compressed hydrogen and cryogenic systems, Oil & Gas Industry (e.g., Reliance, IOCL) requiring compliance with global hydrogen safety standards (ISO, NFPA).

Hydrogen Generation and Storage Technologies

Hydrogen production methods: Steam reforming, partial oxidation,Coal gasification and biomass conversion, Electrolysis (Alkaline, PEM, SOE), Photocatalytic and biological methods, Hydrogen storage techniques: Physical:Compressed gas, liquefied hydrogen, Chemical: Metal hydrides, chemical carriers, novel adsorbents, Safety and management of hydrogen storage, Comparison of methods and challenges in scale-up

Application: Steam methane reforming in large-scale industries like BPCL, HPCL, Green hydrogen production via electrolysis – pilot projects by NTPC, Adani, Indian Oil-L&T ReNew Power JV, Used in waste-to-hydrogen projects by Indian Oil R&D Centre, Thermax, and CSIR labs, Cryogenic storage systems in industrial gas suppliers (e.g., INOX Air Products),

Fuel Cell Technology – Fundamentals, Classification, and Performance

Basics of fuel cell operation and components, Fuel cells vs. batteries: comparative overview, Classification based on temperature/electrolyte: Working principles, materials, and fabrication methods, Thermodynamic and electrochemical theory, Fuel cell losses: Polarization and power density curves, Efficiency and performance improvement techniques

Application: PEMFC in backup power for telecom towers (e.g., by Ballard Power Systems, H2e Power Systems),SOFC and MCFC in industrial CHP and microgrids, Labs at ARCI Hyderabad, IISc Bangalore, BHEL R&D, and DRDO, Pilot fuel cell buses: Tata Motors in collaboration with IOCL and NTPC,

Applications, Integration, and Future Directions

Applications of hydrogen and fuel cells in: Domestic, industrial, commercial, transportation, and grid-scale sectors, Use of hydrogen in ICEs, sensors, and hydrogen refueling infrastructure, Environmental and economic aspects: Cost, LCA, emissions, Fuel cell-powered vehicles and infrastructure (Indian pilot projects: NTPC, IOCL, TATA), Future trends: Hydrogen corridors, green hydrogen hubs, ammonia economy, Policy, funding mechanisms (e.g., India's National Green Hydrogen Mission)

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Poster presentation (10%), Quiz (10%), Assignment (20%), Field visit/Case study report (20%), Internal Examinations (40%)

References:

1. Gupta, R. B., "Hydrogen Fuel: Production, Transport and Storage", Taylor and Francis, 2009.
2. Agata Godula Jopek, "Hydrogen Production by Electrolysis", Wiley-VCH, 2015
3. Michael Hirscher, "Handbook of Hydrogen Storage", Wiley-VCH, 2010.
4. James Larminie and Andrew Dicks, "Fuel cell systems Explained", Wiley publications, 2003.
5. Ryan O. H., Suk Won C. and Whiteny C., "Fuel Cell Fundamentals", John Wiley & Sons, 2016
6. Christopher M A Brett, "Electrochemistry – Principles, Methods and Applications", Oxford University, 2004

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CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain hydrogen fundamentals, properties, policies, and safety standards	PO1 (3), PO3 (2)	3	2
CO2	Apply hydrogen generation, storage, and handling methods in practical scenarios	PO1 (3), PO2 (3)	3	3
CO3	Estimate performance, efficiency, and losses in fuel cells and hydrogen systems	PO1 (3), PO3 (3)	3	3
CO4	Analyze applications, integration, and future trends of hydrogen energy and fuel cells	PO3 (3)	3	3

TE25002	Hybrid and Electric Vehicles	L	T	P	C
		3	0	0	3

Course Objectives:

To understand the performance, power sources, and architecture of HEVs/EVs, includi electric drives, motor control, and energy storage and management systems.

Introduction to Hybrid & Electric Vehicles

Vehicle performance basics, Power sources and transmission, History and impact of HEVs/EVs, Environmental and energy aspects

Activities: Compare Vehicle Specs – Analyze performance data (torque, power, range) of ICE vs. EV vs. HEV, Case Study – Study Tesla, Toyota Prius, or Tata Nexon EV: performance, technology, and impact, Group Debate – “Are electric vehicles truly green?” Evaluate energy lifecycle, Timeline Activity – Prepare a history timeline of hybrid and electric vehicle evolution.

Hybrid Electric Drive Trains

Hybrid traction concepts and topologies, Electric traction and configurations, Power flow and fuel efficiency

Activities: Drivetrain Topology Mapping – Draw and analyze parallel, series, and series-paral hybrid systems, Power Flow Simulation – Use software to simulate hybrid and electric power flows, Fuel Efficiency Comparison – Evaluate hybrid vs. electric drivetrain fuel economy in various drive cycles.

Electric Drives & Control

Key electric components in HEVs/EVs, Control of Motor Drives: DC, induction, Permanent Magnet (PM), and Switch Reluctance Motor (SRM) drives, Drive system efficiency

Activities: Motor Drive Demo – Set up or simulate DC, induction, and PM motor control (using MATLAB/LTspice), Efficiency Analysis – Calculate drive system efficiency under different loading and control modes, Control Algorithm Design – Implement a simple speed control loop in Simulink for a motor.

Energy Storage & Management

Energy Storage Requirements in Hybrid and Electric Vehicles, Battery, fuel cell, and supercapacitor systems, Drive sizing and energy management strategies, classification and comparison of energy management strategies, implementation issues.

Activities: Battery Sizing Activity – Calculate required battery size for a given EV range, Storage System Comparison – Compare batteries, fuel cells, and supercapacitors in terms of energy density, cost, and life, Energy Management Strategy Simulation – Use MATLAB to test rule-based vs. fuzzy logic EMS

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology:

Assessment Exams (50%), Assignment/Case Study (10%), Quiz/Problem (10%), Virtual

demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions (10%)

References:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003
3. MehrdadEhsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
4. Rand D.A.J, Woods, R & Dell RM Batteries for Electric vehicles, John Wiley & Sons, 1998

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CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the fundamentals and societal impact of hybrid and electric vehicles	PO1 (3), PO3 (2)	3	2
CO2	Analyze hybrid and electric drivetrain topologies and their efficiency	PO2 (3), PO3 (2)	3	2
CO3	Describe electric motor types and control methods used in HEVs/EVs	PO2 (3), PO4 (2)	3	2
CO4	Evaluate energy storage technologies and apply energy management strategies	PO3 (3), PO5 (2)	3	3

TE25003	Machine Learning in IC Engines	L	T	P	C
		3	0	0	3

Course Objectives:

- To understand machine learning fundamentals and apply supervised, unsupervised, and reinforcement learning techniques, including probabilistic models, for diagnostics, control, and optimization of internal combustion engines.

ML Introduction & Mathematical Foundations

Need, history, and applications of ML, Types of ML and challenges, Basics of linear algebra, Analytical geometry, probability, statistics, Bayesian conditional probability

Activities: Math Toolkit Workshop: Solve basic problems on linear algebra, probability, and statistics relevant to ML, Group Discussion: Explore real-world applications and challenges of ML in engineering.

Supervised Learning Techniques

Regression: Linear, Lasso, logistic, Overfitting, underfitting, cross-validation, Support vector machines (SVM), kernel methods, K-nearest neighbours, Decision trees (ID3, CART), Ensemble methods: Random Forest

Activities: Hands-on Lab (Python/Scikit-learn): Implement linear regression, logistic regression, and decision trees on engine datasets, Algorithm Comparison Activity: Compare SVM, k-NN, and Random Forest for emission prediction, Mini Project: Build a simple ML model to predict engine fuel consumption.

Unsupervised & Reinforcement Learning

Clustering: K-means, hierarchical, cluster validity, Dimensionality reduction: Principal Component Analysis (PCA), EM algorithm, recommender systems, Reinforcement learning: Elements, model-based, temporal difference

Activities: Clustering Exercise: Apply K-means to cluster engine data (e.g., temperature, RPM, torque), Reinforcement Learning Demo: Simulate a basic environment using Q-learning or temporal difference learning, Case Study: Analyze how RL is used in adaptive cruise control or throttle control systems.

Probabilistic Methods & ML for IC Engines

Probabilistic learning: Naïve Bayes, Maximum Likelihood, Maximum Apriori , Bayesian belief networks and inference, Sequence models: Markov models, Hidden Markov Models (HMM), ML in IC engine modeling, optimization, calibration, diagnostics, and control, Decision trees and data needs for ML in ICE, ML for combustion stability and component fault diagnostics

Activities: Bayesian Modeling Workshop: Build a Naïve Bayes model to classify engine faults, Sequence Modeling Lab: Implement HMM to predict future engine states using time-series data, Decision Tree Flowchart Design: Create a rule-based decision tree for engine diagnostics and control actions.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology:

Assessment Exams (50%), Assignment/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions (10%)

References:

1. Stephen Marsland, "Machine Learning: An Algorithmic Perspective", Chapman & Hall/CRC, 2nd Edition, 2014.
2. Kevin Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012
3. Tom M Mitchell, "Machine Learning", McGraw Hill Education, 2013.
4. Hal Daumé III, "A Course in Machine Learning", 2017 (freely Downloadable online)

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https://course.fast.ai/
https://nptel.ac.in/courses/106106140

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain machine learning concepts and foundational mathematics	PO1 (3), PO3 (2)	3	2
CO2	Apply supervised learning models for classification and regression	PO2 (3), PO3 (2)	3	2
CO3	Utilize unsupervised and reinforcement learning in pattern discovery and decision making	PO2 (3), PO4 (2)	3	2
CO4	Implement probabilistic models and ML solutions for ICE modeling and diagnostics	PO3 (3), PO5 (2)	3	3

TE25004	Energy Storage Technologies	L	T	P	C
		3	0	0	3

Course Objectives:

To provide foundational knowledge of various energy storage methods thermal, electrical, chemical, and mechanical and analyse the performance of modern systems like batteries and hydrogen storage, explores emerging technologies, safety challenges

Overview of Energy Storage Systems

Classification, key performance parameters, comparison of technologies, energy storage prediction and system optimization using softwares.

Activities:

Compare two different energy storage technologies based on cost, efficiency, and application suitability, to model and optimize an energy storage system by using software, Analyze performance data of existing storage projects and identify optimization opportunities.

Thermal Energy Storage

Sensible heat storage systems, latent heat storage systems, Phase Change Materials (PCMs) and packed bed units, thermochemical storage systems, modern developments: solid-solid PCM and compact thermal storage systems.

Activities:

Create a small-scale packed bed sensible heat storage system using common materials, Use simulation software to model heat transfer in a TES system, Observe a thermal storage installation in an HVAC or solar thermal power plant.

Electrochemical and Electrical Storage

Lead-acid, NiCd, NiMH, Li-ion, zinc-air batteries, battery performance and safety, supercapacitors, ultracapacitors, SMES, emerging technologies: solid-state batteries, fast charging systems,Vehicle to Grid(V2G) technology,AI applications in battery health monitoring and predictive diagnostics.

Activities:

Measure charge/discharge curves, efficiency, and cycle life of different battery types, develop a simple AI model (using Python) to predict battery health based on dataset inputs, Demonstrate safe handling, charging, and disposal procedures for batteries.

Hydrogen Energy Storage

Challenges in hydrogen storage, storage methods, storage protocols, hybrid storage systems.

Activities:

Evaluate compressed gas, liquid hydrogen, and metal hydride storage systems, Propose a conceptual hybrid storage system integrating hydrogen with another storage type.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology and weightage:

Assessment Exams (50%),Assignments/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions(10%)

References:

1. Ibrahim Dincer and Mark A. Rosen, "Thermal Energy Storage Systems and Applications", John Wiley & Sons 2002.
2. James Larminie and Andrew Dicks, "Fuel cell systems Explained", Wiley publications,2003.
3. Luisa F. Cabeza, "Advances in Thermal Energy Storage Systems: Methods and Applications", Elsevier Woodhead Publishing, 2015.
4. Robert Huggins, "Energy Storage: Fundamentals, Materials and Applications", 2nd edition, Springer, 2015.
5. Ru-shiliu, Leizhang, Xueliang sun, "Electrochemical technologies for energy storage and conversion", Wiley publications, 2012.

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https://nptel.ac.in/courses/112107291
https://www.edx.org/course/energy-storage
https://www.coursera.org/learn/batteries
https://www.homerenergy.com

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the need for energy storage and compare various storage technologies based on technical and economic parameters	PO1 (3), PO3 (2)	3	2
CO2	Analyze the working principles and thermal characteristics of sensible and latent heat storage systems	PO2 (3), PO3 (2)	3	2
CO3	Evaluate the performance and application of electrochemical and electrical storage systems	PO3 (3), PO5 (2)	3	3
CO4	Examine hydrogen storage techniques and fuel cells for clean energy applications	PO3 (3), PO4 (2)	3	3

TE25005	Solar Photovoltaic Technology and Systems	L	T	P	C
		3	0	0	3

Course Objectives:

To understand PV module types and grid codes, and to design, analyze, and model standalone, grid-tied, and hybrid PV systems with MPPT, metering, and compliance considerations.

PV Modules: PV module structure, types, and electrical behavior, PV cell interconnection and fabrication, De-rating factors, mounting structures, and recycling, Grid code basics: voltage, frequency, harmonics

Activities: Lab activity: Measure I-V characteristics of different PV modules, Simulation: Analyze effects of temperature and irradiance on PV performance, Mini research: Study on solar panel recycling and sustainability

Standalone PV Systems: Standalone PV system components and schematics, Maximum power point tracking (MPPT) algorithms, load and battery interfacing, Modeling, simulation, and applications of off-grid systems

Activities: Hands-on setup: Build a small standalone PV system with battery and load, Simulation: MPPT algorithm performance using software, Design task: Sizing and layout of an off-grid PV system for a rural house

Grid-Connected PV Systems: Grid-tied PV components, interface, and inverter operation, Net/gross metering, real power injection, floating PV, Modeling and simulation.

Activities: Simulation: Net metering setup and grid feed-in using system modeling tools, Case study: Floating PV installations in India, Seminar: IEEE 2800 standards and compliance

Hybrid Systems: Hybrid system types and need, Case studies: Diesel-PV, Wind-PV, Micro hydel-PV, PV-Hydrogen, Electric and hybrid Vehicles, Modeling and simulation of hybrid systems

Activities: Simulation: Hybrid energy system design using software, Project: Energy flow analysis of electric and hybrid electric vehicles, Group activity: Compare and select a suitable hybrid system for a given location.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology and weightage:

Assessment Exams (50%), Assignment/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions (10%)

References:

1. A. Goetzberger, V. U. Hoffmann, Volker Uwe, “Photovoltaic Solar Energy Generation”, Springer, 2005.
2. Jenny Nelson, “The Physics of Solar Cells”, Imperial College Press, 2003.
3. Chetan Singh Solanki, “Solar Photovoltaics: Fundamentals, Technologies and Applications”, PHI Learning Pvt. Ltd. 2005.

4. T. Markvart, “Solar Electricity”, John Wiley & Sons, 2000.
5. R. A. Messenger and Amir Abtahi, “Photovoltaic Systems Engineering”, CRC Press, 2017.

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https://www.homerenergy.com/

https://nptel.ac.in/courses/112/107/112107289/

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the structure, types, electrical characteristics of PV modules, and basic grid code requirements	PO1 (3), PO3 (2)	3	2
CO2	Design and analyze standalone PV systems with MPPT, battery, and load integration	PO2 (3), PO3 (2)	3	2
CO3	Evaluate grid-connected PV systems, inverter operations, and apply relevant technical standards	PO3 (3), PO5 (2)	3	3
CO4	Assess and compare hybrid energy systems for various applications through case studies and simulations	PO3 (3), PO4 (2)	3	3

TE25C09	Carbon Sequestration and Utilisation	L	T	P	C
		3	0	0	3

Course Objectives:

To provide students with a thorough understanding of the science, engineering, policy, and economics of carbon capture, utilization, and storage technologies in the context of climate mitigation, with emphasis on Indian and global perspectives.

Introduction to CCUS and Climate Context

Climate change science and GHG emissions, Role of carbon capture, utilization, and storage (CCUS) in carbon neutrality and net-zero goals, Sources of CO_2 emissions: Power, industry, transportation, Types of CCUS: Post-combustion, pre-combustion, oxyfuel combustion, Global CCUS status and initiatives (IEA, IPCC, UNFCCC),Indian initiatives: NCAP, NDCs, National Hydrogen Mission, Long-term Low Emissions Development Strategy

CO_2 Capture and Compression Technologies

CO_2 capture principles – absorption, adsorption, membranes, cryogenic, Solvent-based (amine), solid sorbents, advanced materials (MOFs, zeolites),CO_2 compression and dehydration systems, Energy penalty, efficiency losses, and cost implications, Case studies: NTPC CCUS pilot plant, Indian coal-based capture trials

CO_2 Transport, Utilization, and Geological Storage

Transport modes: Pipelines, ships, road, CO_2 utilization: Enhanced Oil Recovery (EOR), urea manufacturing, mineralization, algae cultivation, concrete curing, Geological storage: Saline aquifers, depleted oil and gas fields, Site selection, reservoir modeling, monitoring, and verification (MMV),Environmental and safety risks – leakage, induced seismicity.

Economics, Policies, and Regulatory Frameworks

CCUS project cost components and economic modelling, Carbon pricing, carbon credits, ETS, and carbon trading mechanisms, CCUS in India: Policy status, draft roadmaps, stakeholder roles, International frameworks: EU Green Deal, U.S. Inflation Reduction Act (IRA), Article 6 of the Paris Agreement, Social acceptance, legal liability, financing mechanisms (Green Climate Fund, MDBs).

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Poster presentation (10%), Quiz (10%), Assignment (20%), Field visit/Case study report (20%), Internal Examinations (40%)

References:

1. M. M. Maroto-Valer, Carbon Capture and Storage, Elsevier, 2010,1st Edition.
2. Ian Havercroft, Richard Macrory, Stefan Schwarze, Carbon Capture and Storage: Emerging Legal and Regulatory Issues, Hart Publishing,2018,2nd Edition.
3. B. Sudhakara Reddy, Energy and Climate Change: India's Clean Energy Pathways, Routledge,2022,1st Edition.
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Indian, Initiatives,TERI Press,2021,1st Edition. 5. IPCC Special Report Carbon Dioxide Capture and Storage, Cambridge University Press, (for IPCC),2005,1st Edition.
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CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain climate change, CCUS technologies, and regulatory frameworks	PO1 (3), PO3 (2)	3	2
CO2	Apply CO_2 capture, transport, utilization, and storage methods	PO1 (3), PO2 (3)	3	3
CO3	Estimate economic, energy, and environmental parameters of CCUS projects	PO1 (3), PO3 (3)	3	3
CO4	Analyze CCUS performance, monitoring, and optimization strategies	PO3 (3)	3	3

TE25010	Refrigeration Systems	L	T	P	C
		3	0	0	3

Course Objectives:

To study refrigeration cycles, refrigerants and components, assess environmental impacts, estimate cooling loads, and explore advanced refrigeration systems.

Refrigeration Cycles

Reversed Brayton & Carnot VCR cycles, Practical VCR cycle, Sub-cooling, superheating, LSHX, Performance factors, Multi-pressure & Cascade cycles

Activities

Simulation of VCR and cascade cycles using software, Performance comparison of ideal vs practical cycles

Refrigerants & Lubricants

History & designation of refrigerants, Environmental protocols (Montreal/Kyoto), Eco-friendly & sustainable refrigerants, Refrigerant-oil compatibility, Safety standards & energy efficiency

Activities

Case study on eco-friendly refrigerants (R-134a vs R-290, etc.), Group discussion on Montreal and Kyoto protocols, Chart preparation on refrigerant properties and oil compatibility

System Components

Classification and Performance aspects of Compressors, condensers, evaporators, expansion devices, Receivers, driers, accumulators, suction line risers

Activities

Virtual/physical demonstration of compressors, condensers, etc. Performance comparison using manufacturer catalogs.

Load Analysis & Advanced Systems

Cooling load estimation, Cold/Cool storages, System balancing & capacity control, Not-in-kind systems (CO_2, absorption, vortex, Thermoelectric, Steam-Jet, magnetic, etc.), Electrical components: drives, relays, Electric Circuits for domestic and commercial appliances

Activities

Cooling load estimation of a small room or cold storage, Electrical circuit diagram preparation for refrigeration units

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology and weightage:

Assessment Exams (50%),Assignments/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions(10%)

References:

1. Arora, C.P., Refrigeration and Air conditioning, McGraw Hill, 3rd Ed., 2010.

2. Dossat R.J., Principles of refrigeration, John Wiley, S.I. Version, 2001.
3. Ibrahim Dincer, Refrigeration Systems and Applications, John Wiley & Sons, 2017.
4. Jordan and Priester, Refrigeration and Air conditioning 1985.
5. Langley, Billy C., ‘Solid state electronic controls for HVACR’ Prentice-Hall 1986.
6. Stoecker W.F., Refrigeration and Air conditioning, McGraw-Hill Book Company, 1989
7. Rex Milter, Mark R.Miller., Air conditioning and Refrigeration, McGraw Hill, 2006.

E-Resources:

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CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain refrigeration cycles, system components, and refrigerant types, including environmental impacts	PO1 (3), PO3 (2)	3	2
CO2	Apply refrigeration principles to simulate VCR, cascade cycles, and system performance	PO2 (3), PO3 (2)	3	2
CO3	Estimate cooling loads for rooms, cold storage, and evaluate system capacity requirements	PO3 (3), PO5 (2)	3	3
CO4	Analyze advanced refrigeration systems, component selection, and energy efficiency strategies	PO3 (3), PO4 (2)	3	3

TE25011	Air-Conditioning Systems	L	T	P	C
		3	0	0	3

Course Objectives:

To understand air conditioning fundamentals, psychrometry, comfort and IAQ parameters, estimate cooling loads, apply sustainable cooling techniques, analyze duct and fan-coil systems, and study modern AC system operations.

Air Conditioning Principles & Comfort Design

Air conditioning basics, psychrometry of air conditioning processes, air washers, evaporative cooling, ventilation, Psychrometric analysis of Summer and Winter air conditioning, Selection of design conditions Thermal Comfort models, IAQ, and clean room concepts.

Activities

Plot air processes on psychrometric charts, Build/demo a simple air washer or cooler, IAQ survey in classroom/lab

Load Analysis & Sustainability

Heat transmission through building envelope, Solar radiation, Infiltration & ventilation loads, cooling/heating load calculations, passive cooling, ECBC norms, green buildings, and sustainable cooling solutions.

Activities

Estimate cooling load for a room, Analyze solar gain and wall heat transfer, Evaluate ECBC/green building compliance

Air Distribution Systems

Flow through Ducts, Static and Dynamic Losses, duct design and balancing, diffusers, fan-duct interactions, and fan coil units.

Activities

Build a simple duct model with airflow test, Use software/virtual lab for duct layout

Operation of Different Systems

Room, packaged, and centralized AC systems, radiant cooling, DCV, VAV, UFAD, hydronic, air handling, and MAC systems.

Activities

Compare types of AC systems in a chart, Conduct a mini energy audit, Demo basic controls using Arduino or relays

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology:

Assessment Exams (50%),Assignments/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions(10%)

References:

1. Arora C.P., Refrigeration and Air Conditioning, Tata McGraw Hill Pub. Company,
2. ASHRAE, Fundamentals and equipment , 4 volumes-ASHRAE Inc. 2021.
3. Ali Vedavarz, Sunil Kumar, Mohammed Iqbal, Hussain Handbook of Heating, Ventilation and Air conditioning for Design Implementation, Industrial pressInc,2017.
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E-Resources:

https://nptel.ac.in/courses/112105129
https://comfort.cbe.berkeley.edu/
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CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the operation and features of various air conditioning systems and their applications	PO1 (3), PO3 (2)	3	2
CO2	Apply psychrometric principles to analyze air conditioning processes and comfort conditions	PO2 (3), PO3 (2)	3	2
CO3	Estimate heating and cooling loads and recommend sustainable solutions for buildings	PO3 (3), PO5 (2)	3	3
CO4	Analyze and design air distribution systems including ductwork, fans, and airflow optimization	PO3 (3), PO4 (2)	3	3

TE25012	Energy Audit in Thermal and Electrical Utilities	L	T	P	C
		3	0	0	3

Course Objectives:

To understand energy audit types, procedures, and utility patterns, and to analyze electrical, HVAC, and building systems using instruments, case studies, and modern tools like ML and carbon tracking.

Energy Auditing: Types and procedures of energy audits, energy utility rates, conventional and renewable sources, energy use graphs and analysis.

Activities: Analyze sample audit reports, Plot and interpret energy use graphs, Calculate electricity bills using utility rates

Electrical Motor & Lighting Audit: Electrical distribution systems, power factor and quality, audit of motors and lighting (Compact Fluorescent Lamps, Compact Halogen Lamps, LED, halogen), lighting controls, appliances.

Activities: Measure power factor and load with meters, Prepare audit checklist for motors/appliances, Survey and classify electrical loads

HVAC and Building Audits:

Audit procedures for commercial and residential buildings, Electricity usage pattern, HVAC load calculation, building envelope analysis, energy consumption history, Energy audit forms. General forms and report preparation based on case studies

Activities: Evaluate building envelope and insulation, Calculate heating/cooling loads, Fill sample audit forms

Energy Audit Instruments

Electrical Measuring Instruments: multimeter, power analyzer, thermometer, hygrometer, Flow – Pitot, Ultrasonic, Coriolis. Speed – Tachometer, RADAR Gas Leak Detectors, Lux Meters, Distance Meter, IAQ meter, flue gas analyzer, fuel efficiency monitor.

Activities: Measure IAQ, lighting, and gas leak levels, Present case studies with carbon footprint, Simulate ML-based energy forecasting, Case studies: Apartments, schools, hotels, IT parks, etc., carbon footprint, ML in energy management.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology and weightage:

Assessment Exams (50%),Assignments/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions(10%)

References:

1. Moncef Krarti, Energy Audit of Building Systems, CRC Press, 2020.
2. Herbert C. Wendes, HVAC Procedures & Forms Manual, River Publishers, 2020.
3. Steve Doty, Commercial Energy Auditing Reference Handbook, Fairmont Press, 2011.
4. Tarik Al-Shemmeri, Energy Audits: A Workbook for Energy Management in Buildings, Wiley, 2011.
5. Chandan Kumar Shiva, Mohan Rao Ungarala, Shriram S. Rangarajan, Vedik

Basetti, Artificial Intelligence and Machine Learning in Smart City Planning, Elsevier, 2003.
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CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain types of energy audits, utility rates, and energy use patterns	PO1 (3), PO3 (2)	3	2
CO2	Apply procedures to perform electrical energy audits on distribution systems, motors, and lighting	PO2 (3), PO3 (2)	3	2
CO3	Estimate HVAC and building energy performance through audits including thermal load and envelope analysis	PO3 (3), PO5 (2)	3	3
CO4	Analyze energy audit instrument readings and interpret results for real-world applications and carbon impact	PO3 (3), PO4 (2)	3	3

EY25C07	Sustainability in Buildings	L	T	P	C
		3	0	0	3

Course Objectives:

To provide a comprehensive understanding of sustainable building design principles and climate-responsive architecture and exposure to passive design strategies, energy-efficient materials, and integration of renewable energy systems in buildings.To apply simulation tools for optimizing building performance and achieving environmental certification standards.

Foundations of Sustainable Building Design

Relationship between climate and building design: thermal zones, climatic data analysis, Historical evolution of green building concepts, Key aspects of sustainable buildings, Indoor environmental quality (IEQ), Building performance standards: ECBC, GRIHA, LEED, WELL and IGBC, Sustainable building life cycle and carbon footprint basics., Integration of sustainability goals in building codes and smart cities

Applications: LEED, GRIHA, WELL standards in real estate and institutional buildings, Selection of sustainable sites based on orientation, terrain, and microclimate, Use of low-embodied energy and recycled materials in construction, Integration of sustainable design principles in urban master plans

Sustainable Landscaping and Building Envelopes

Energy-efficient landscaping: microclimate modification, xeriscaping, shading devices, arbors, green roofs, Role of vegetation in passive design, Building envelope design: thermal comfort, psychrometry, comfort indices, Thermal properties of materials, insulation strategies, reflective materials, Use of Energy Plus or Design Builder in façade retrofits and new construction

Applications: Use of xeriscaping, green roofs, and shade trees in housing societies, IT parks, Passive insulation and thermal lag management in schools, hospitals, and government offices, Applied in urban heat island mitigation projects

Passive Strategies and Climate-Responsive Architecture

Introduction to HVAC and limitations in sustainable design, Passive heating techniques: sun path diagrams, direct gain, indirect gain, isolated systems, Passive cooling techniques: natural ventilation, evaporative cooling, radiative cooling, earth-air tunnels, Daylighting design: principles, visual comfort, shading strategies, Bioclimatic building design and thermal zoning, AI and parametric tools for daylight and thermal optimization

Applications: Maximizing daylight while minimizing glare and heat gain, Stack effect and cross ventilation used in hostels, community centers, and dormitories, Earth-Air Tunnels and Radiative Cooling Implemented in resorts, eco-homes, and public pavilions in hot regions, Bioclimatic Architecture in Remote or Rural Housing

Building Performance, Renewable Integration & Simulation

Heat gain/loss through fenestration, infiltration, Overall Thermal Transmittance (U-value) calculations, Building thermal load estimation, Thermal storage systems in buildings, Integration of renewable energy, Simulation tools for sustainable building design: eQuest, Energy Plus, IES-VE, Techno-economic analysis of renewable integration and Net Zero Energy Buildings (NZEBs)

Applications: Rooftop Solar PV and BIPV Systems Used in smart homes, airports, railway stations, and SEZs, Thermal Load Calculations for HVAC Optimization are critical in malls, data centers, and hospitals,Tools like IES-VE, eQuest used for green building compliance.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Poster presentation (10%), Quiz (10%), Assignment (20%), Field visit/Case study report (20%), Internal Examinations (40%)

References:

1. Baruch Givoni: “Climate considerations in building and Urban Design”, John Wiley & Sons, 1996.
2. Jakhar O P, “Energy Conservation in Buildings”, Khanna Publishers, 1st Edition, 2020.
3. Jan F. Kreider, Peter S. Curtiss, Ari Rabl, “Heating and Cooling of buildings: Design for Efficiency”, CRC Press, Second Edition, 2010.
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https://onlinecourses.nptel.ac.in/noc22-ar06/preview
https://www.usgbc.org/leed
https://www.grihaindia.org/
https://energyplus.net/

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain climate-responsive building design, sustainable materials, green certification systems (LEED, GRIHA, ECBC, WELL, IGBC), and life-cycle sustainability concepts.	PO1 (3)	3	2
CO2	Apply sustainable landscaping, passive design strategies, thermal comfort analysis, and building envelope optimization using simulation tools.	PO1 (3), PO3 (3)	3	3
CO3	Estimate building thermal loads, U-values, energy consumption, daylight performance, and renewable energy generation potential.	PO2 (3), PO4 (3)	3	3
CO4	Analyze building performance, HVAC efficiency, renewable integration, and techno-economic feasibility toward Net Zero Energy Buildings (NZEBs).	PO3 (3), PO4 (3)	3	3

TE25013	Air and Chilled Water Systems for HVAC Applications	L	T	P	C
		3	0	0	3

Course Objectives:

To understand thermal and material aspects of electronic cooling, design HVAC systems including piping, ducts, and ventilation, and apply smart controls for energy-efficient and IAQ-compliant building environments.

Water Chillers – Fundamentals & Configurations

Chilled water in HVAC applications, Chiller types and system configurations, Load profiles, efficiency, and part-load performance, Mixed energy source chillers

Activities: Analyze chiller configurations (single/multi)**,** Case study on chiller selection**,** simulate chiller systems using HVAC software

Chiller Design & System Components

Chiller selection and installation, Pumping and piping design, Control strategies and performance, Thermal energy storage and special considerations

Activities: Design piping and pump layouts, Mini project on thermal energy storage, Site/virtual visit to observe chiller setup

Air Handling Units & Duct Design

Psychrometrics and AHU types, AHU components and selection, Economizer, single/multi-zone systems, Duct design methods: regain, friction, T-method

Activities: Use psychrometric chart for air analysis, Duct design using regain/friction methods, Measure airflow and pressure in ducts

Air Distribution Systems

Constant/variable volume systems, Sub-zone heating, draw-through cooling, Reheat, double/triple duct, fan coil, induction systems, Hydronic Heat pumps, heat recovery, economizers, Energy-saving strategies and retrofits

Activities: Compare CAV vs VAV systems, Audit for HVAC energy retrofit, Design multi-zone air system

Ventilation, Filtration & Air Quality Control

Ventilation and exhaust systems, Air filters: types, ratings, and testing, IAQ, outside air needs, thermal comfort, Demand control ventilation

Activities: Measure indoor air quality, Design ventilation for different spaces, Simulate IAQ scenarios

Air System Controls & Smart Systems

Thermostats, dampers, damper motors, automatic valves, Direct digital control (DDC), Smart systems using fuzzy logic and neural networks, Integration of control systems for optimized HVAC performance

Activities: Develop basic smart HVAC control, Simulate automation using BMS tools, Test thermostats, dampers, actuators

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology and weightage:

Assessment Exams (50%), Assignment/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions (10%)

References:

1. Herbert W. Stanford III, HVAC Water Chillers and Cooling Towers Fundamentals, Application, and Operation, Second Edition, CRC PressTaylor & Francis Group Boca Raton London New York, 2011
2. Tseng-Yao Sun Air Handling Systems Design, McGraw-Hill Professional; 1st edition, 1994
3. Allan T. Kirkpatrick & James S. Elleson, cold air distributionsystem design guide, ASHEAC - 1996 USA.
4. John I. Levenhagen, Donald H. Spethmann, HVAC controls and systems, McGraw – Hill International Edition. NY – 1992.
5. Shan K.Wang, Handbook of Air-conditioning and Refrigeration, McGraw -Hill, 2001
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https://nptel.ac.in/courses/112106211
https://nptel.ac.in/courses/105/108/105108205/
https://www.epa.gov/indoor-air-quality-iaq
https://nptel.ac.in/courses/108104131

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain chilled water system concepts, chiller configurations, and air-handling unit selection	PO1 (3), PO3 (2)	3	2
CO2	Apply design principles to chilled water systems, including piping, pumps, duct layout, and thermal energy storage	PO2 (3), PO3 (2)	3	2
CO3	Estimate HVAC performance using psychrometrics, air distribution calculations, and ventilation strategies	PO2 (3), PO3 (2)	3	2
CO4	Analyze and apply control strategies, smart automation (DDC, fuzzy logic, neural networks), and IAQ standards	PO3 (3), PO5 (2)	3	3

TE25014	Low Temperature Refrigeration Systems	L	T	P	C
		3	0	0	3

Course Objectives:

To understand low-temperature principles, gas liquefaction, cryo-coolers, and cryogenic storage, transfer, and measurement systems for industrial and scientific applications.

Fundamentals & Applications of Low-Temperature Refrigeration

Temperature limits, material behaviour, and applications in industry, medicine, space, gas, superconductivity, and levitation.

Activities: Case study on cryogenic use in MRI or space applications, Material property comparison at cryogenic temperatures

Gas Liquefaction & Purification

Liquefaction cycles (Carnot, Linde Hampson, Claude), Inversion Curve-Joule-Thomson effect, ortho-para hydrogen conversion, Gas purification: rectification, Column Analysis-McCabe Thiele method and adsorption systems

Activities: Simulation of Linde and Claude cycles using software (e.g., EES/MATLAB), Group problem-solving on Joule-Thomson inversion curve, McCabe-Thiele rectification column analysis using Excel or plotting tools, Mini-project on designing a basic gas purification setup using adsorption

Cryo-Coolers

JT, GM cryo-coolers, Stirling, pulse tube, and magnetic refrigerators; regenerators used in cryogenic systems.

Activities: Comparative study or presentation on different cryo-cooler types, CFD simulation of regenerator performance, Literature review on pulse tube and magnetic refrigeration advancements

Storage, Transport & Instrumentation

Cryogenic Dewars design, transfer lines, insulation, vacuum pump types, and flow/level/temperature measurement instruments.

Activities: Design sketch of a cryogenic Dewar vessel, Visit/report on a cryogenic storage facility (e.g., hospital, gas plant), Hands-on session or video analysis of flow and temperature sensors used in cryogenics

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology and weightage:

Assessment Exams (50%), Assignment/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions (10%)

References:

1. Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering, Plenum Press NewYork, 1989.
2. Mukhopadhay Mamata, Fundamentals of cryogenic engineering, PHI learning, 2010
3. Pipkov, "Fundamentals of Vacuum Engineering", Meer Publication.
4. Randall F. Barron, "Cryogenics Systems", Second Edition Oxford University Press New York, Clarendon Press, Oxford, 1985.
5. Thomas Flynn, Cryogenic Engineering, Revised and Expanded, CRC Press, 2004.

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https://ocw.mit.edu/
https://www.cryomech.com/
https://www.mathworks.com/
https://www.cryogenicsociety.org/
https://vlab.co.in/

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain low-temperature refrigeration concepts, material behavior, and their applications	PO1 (3), PO3 (2)	3	2
CO2	Apply and analyze gas liquefaction cycles and purification methods	PO2 (3), PO3 (2)	3	2
CO3	Estimate and describe working principles, performance, and applications of various cryo-coolers	PO2 (3), PO3 (2)	3	2
CO4	Analyze cryogenic storage, transport systems, and measurement instrumentation	PO3 (3), PO5 (2)	3	3

TE25015	Gas Dynamics and Space Propulsion	L	T	P	C
		3	0	0	3

Course Objectives:

To provide fundamental and applied knowledge of wave motion, shock waves, air-breathing and rocket propulsion systems, enabling students to analyze, design, and evaluate propulsion technologies for aircraft and space applications.

Wave Motion & Shock Waves

Wave motion, Mach waves/cone, sound waves, normal & oblique shocks, property relations, deflection relations, Method of Characteristics, expansion waves.

Activities

Simulation of shock wave formation using computational tools (CFD), Laboratory demo of sound wave propagation and measurement.

Air-Breathing Engines

Aircraft propulsion theory, turboprop, turbojet, turbofan, turboshaft, ramjet, scramjet, thrust augmentation, thrust vector control, jet fuels.

Activities

Case study on different propulsion systems in commercial and military aircraft, Performance comparison of turbojet, turbofan, and ramjet using data charts.

Thermodynamics of Aircraft Engines

Engine–aircraft matching, inlet & nozzle design, performance of ramjet, turbojet, scramjet, turbofan engines, problem analysis.

Activities

Calculations on engine–aircraft matching for given mission profiles, Plotting performance curves for different engine types.

Rocket Propulsion

History, deflagration/detonation, solid & liquid propellant combustion, propellant types & injection, supersonic combustion, feed systems, RCS, heat transfer, electric propulsion types, ion & Hall thrusters.

Activities

Analysis of combustion chamber design for solid and liquid rockets, Simulation of electric propulsion thrust characteristics.

Rocket Staging & Performance

Rocket equation, escape/orbital velocity, multi-staging, space missions, performance parameters, losses, efficiencies, rocket design.

Activities

Multi-stage rocket design project for a target orbit, Mission planning for a specific satellite launch profile.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology and weightage: Assessment Exams (50%), Assignment/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions (10%)
References: 1. Philip G. Hill and Carl R. Peterson, Mechanics and Thermodynamics of Propulsion, Second Edition, Addition — Wesley Publishing Company, New York, 2009. 2. Cohen,H. Rogers, G.F.C. and Saravanamuttoo, H.I.H, Gas Turbine Theory Longman,1989 3. S.M.Yahya, Gas Dynamics & Jet Propulsion,3rd Edition, New Age International, 2010 4. George P. Sutton, Oscar Biblarz. Rocket Propulsion Elements, John Wiley & Sons, 8th Edition, 2010. 5. Ramamurthy, Rocket Propulsion, Pan Macmillan (India) Ltd, 2010 6. W.P.Gill, H.J.Smith& J.E. Ziurys, “Fundamentals of Internal Combustion Engines as applied to Reciprocating, Gas turbine & Jet Propulsion Power Plants”, Oxford & IBH Publishing Co., 1980
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CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the principles of wave motion, shock waves, and expansion waves in aerodynamic problems	PO1 (3), PO3 (2)	3	2
CO2	Apply thermodynamics to engine–aircraft matching, and assess thrust augmentation methods	PO2 (3), PO3 (2)	3	2
CO3	Estimate performance of inlets, nozzles, and air-breathing propulsion systems	PO2 (3), PO3 (2)	3	2
CO4	Analyze rocket propulsion systems, propellants, combustion processes, and electric propulsion	PO3 (3), PO5 (2)	3	3

TE25016	Renewable Energy Technology	L	T	P	C
		3	0	0	3

Course Objectives:

- To understand the role of renewable energy in the energy–environment context and the Indian energy scenario.
- To learn the principles, technologies, and applications of major renewable energy systems.

Energy And Environment

Indian energy scenario - Potential of various renewable energy sources - Greenhouse effect – Ozone depletion - Climate Change – UNFCCC - Energy Pricing – Fuel and Energy Substitution

Activities: Energy flow diagram of Indian energy scenario, Case study on greenhouse gas emissions, UNFCCC policy review and discussion

Solar Energy

Solar radiation – Measurements of solar radiation – Solar spectrum - Solar thermal collectors – Solar thermal applications – thermal energy storage – Fundamentals of solar photo voltaic conversion – Solar cells – Solar PV Systems – Solar PV applications.

Activities: Layout drawing of a solar thermal power plant, Performance comparison of solar PV vs solar thermal systems, Lab demo or video on solar PV module characteristics

Wind Energy

Wind data and energy estimation – Betz limit - Site selection for windfarms – characteristics - Wind resource assessment – Windmills – Accessories – Environmental issues - Applications.

Activities: Layout drawing of a wind power plant, Performance evaluation of wind turbines at different wind speeds, Lab demo or video on wind turbine operation and control

Bio-Energy

Bio resources – Thermochemical Conversion: combustion, gasification, pyrolysis and carbonisation – Biochemical conversion: Biomethanation, Fermentation – Physiochemical : Biodiesel, Briquetting and Pelletisation – Applications

Activities: Process flow diagram of a biogas/biodiesel plant, Performance comparison of biogas and biodiesel systems, Lab demo or video on biomass gasification or biodiesel production.

Hydro & Wave Energy Systems

Small hydro - Tidal energy – Wave energy

Activities: Layout drawing of a small hydro power plant, Performance estimation of hydro turbine types, Lab demo or video on tidal and wave energy conversion devices

Geothermal & Hybrid Energy Systems

Geothermal energy – Hybrid systems – Environmental impacts

Activities: Layout drawing of a geothermal power plant, Performance evaluation of hybrid renewable energy systems, Lab demo or video on hybrid system operation and integration

Weightage:

Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology and weight age:

Assessment Exams (50%), Assignment/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions (10%)

References:

1. Godfrey Boyle, "Renewable Energy, Power for a Sustainable Future", Oxford University Press, 2017, Fourth Edition.
2. Rai.G.D., "Non-Conventional Energy Sources", Khanna Publishers, 2014, Sixth Edition
3. S. P. Sukhatme, J K. Nayak, "Solar Energy", McGraw Hill, 2017, Fourth Edition.
4. B H Khan, "Non-Conventional Resources", McGraw Hill, 2016, Third Edition.
5. John Twidell, "Renewable Energy Resources", Routledge, 2022, Fourth Edtion .

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4. https://www.classcentral.com/course/swayam-renewable-energy-power-plants-503053 https://www.classcentral.com/course/swayam-renewable-energy-technologies-473693
5. https://www.coursera.org/learn/introduction-to-renewable-energy
6. https://online-learning.tudelft.nl/courses/sustainable-energy-design-a-renewable-future/ https://alison.com/course/renewable-energy-fundamentals
7. https://www.edx.org/learn/renewable-energy

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the role of renewable energy, environmental impacts, and Indian energy scenario	PO1 (3), PO3 (2)	3	2
CO2	Apply principles and technologies of solar, wind, bio, hydro, and geothermal energy systems	PO2 (3), PO3 (2)	3	2
CO3	Estimate energy potential, performance, and efficiency of renewable energy systems	PO2 (3), PO3 (2)	3	2
CO4	Analyze hybrid energy systems, environmental effects, and integration strategies	PO3 (3), PO5 (2)	3	3