MRK INSTITUTE OF TECHNOLOGY

AN AUTONOMOUS INSTITUTION

(Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai)

KATTUMANNARKOIL- 608 301, CUDDALORE DISTRICT, TAMILNADU, INDIA

CHOICE BASED CREDIT SYSTEM

Programme: M.E – Thermal Engineering **Regulations:** 2026

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.

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PRINCIPAL
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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.	26MA102	Applied Mathematical and Statistical Modeling	T	3	1	0	4	4	BS
2.	26TE101	Advanced Thermodynamics	LIT	3	0	2	5	4	ES (PC)
3.	26TE102	Advanced Fluid Mechanics and Heat Transfer	LIT	3	0	2	5	4	ES (PC)
4.	26TE103	Instrumentation and Control for Thermal Systems	T	3	0	0	3	3	ES (PC)
5.	26TE104	Fuels and Combustion	LIT	3	0	2	5	4	ES (PC)
6.	26TE105	Technical Seminar - I	-	0	0	2	2	1	SD
						TOTAL	**24**	**20**	

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Semester II

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	26TE201	Computational Fluid Dynamics	LIT	3	0	2	5	4	ES (PC)
2.	26TE202	Modeling and Analysis of Thermal Systems	T	3	0	0	3	3	ES (PC)
3.	26TE203	Design of Heat Exchangers	T	3	0	0	3	3	ES (PC)
4.		Programme Elective - I	T	3	0	0	3	3	ES (PE)
5.		Programme Elective - II	T	3	0	0	3	3	ES (PE)
6.		Self-Learning Course	-	-	-	-	-	1	-
7.	26TE204	Technical Seminar - II	-	0	0	2	2	1	SD
						TOTAL	**19**	**18**	

Semester III

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	26TE301	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.	26TE302	Project Work I	-	0	0	16	16	8	SD
6.	26TE303	Industrial Training	-	-	-	-	-	2	SD
						TOTAL	**28**	**22**	

Semester IV

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	26TE401	Project Work II	---	0	0	24	24	12	SD
						TOTAL	**24**	**12**	

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PROGRAMME ELECTIVE COURSES (PE)

S. No.	Course Code	Course Title	Periods Per Week			Total Contact Periods	Credits
			L	T	P		
1.	26TE001	Modern Power Plants	3	0	0	3	3
2.	26TE002	Turbo machines	3	0	0	3	3
3.	26TE003	Waste to Energy	3	0	0	3	3
4.	26TE004	Polygeneration Systems	3	0	0	3	3
5.	26TE005	Thermal Management in Electronics and Batteries	3	0	0	3	3
6.	26TE006	Hydrogen Energy and Fuel Cell Technology	3	0	0	3	3
7.	26TE007	Hybrid and Electric Vehicles	3	0	0	3	3
8.	26TE008	Machine Learning in IC Engines	3	0	0	3	3
9.	26TE009	Energy Storage Technologies	3	0	0	3	3
10.	26TE010	Solar Photovoltaic Technology and Systems	3	0	0	3	3
11.	26TE011	Carbon Sequestration and Utilization	3	0	0	3	3
12.	26TE012	Refrigeration Systems	3	0	0	3	3
13.	26TE013	Air-Conditioning Systems	3	0	0	3	3
14.	26TE014	Energy Audit in Thermal and Electrical Utilities	3	0	0	3	3
15.	26TE015	Sustainability in Buildings	3	0	0	3	3
16.	26TE016	Air and Chilled Water Systems for HVAC Applications	3	0	0	3	3
17.	26TE017	Low Temperature Refrigeration Systems	3	0	0	3	3
18.	26TE018	Gas Dynamics and Space Propulsion	3	0	0	3	3
19.	26TE019	Renewable Energy Technology	3	0	0	3	3

Semester I

26MA102	Applied Mathematical and Statistical Modeling	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.

Unit I	**Fourier Transform**	**12**
Definitions, Properties, Transform of elementary functions, Dirac delta function, Convolution theorem, Parseval's identity.		
Unit II	**Estimation Theory**	**12**
Unbiasedness, Consistency, Efficiency and sufficiency, Maximum likelihood estimation, Method of moments.		
Unit III	**Testing of Hypothesis**	**12**
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.		
Unit IV	**Analysis of Variance and Experimental Design**	**12**
Analysis of variance, One way and two-way classifications, Completely randomized design, Randomized block design, Latin square design, 2^2 Factorial design.		
Unit V	**Solutions to Partial Differential Equations**	**12**
Heat equation, Wave equation, Laplace and Poisson's equations.		
		TOTAL : 60 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 11th Edition, John Wiley & Sons, 2025.
2. Leif Ellingson and Anna Panorska, Probability and Statistics for Engineering and the Sciences, 10th Edition, Cengage, 2026.

References:

1. Larry C. Andrews and Bhimsen K. Shivamoggi, Integral Transforms for Engineers, Prentice Hall of India, 2003.
2. Jay L. Devore, Probability and Statistics for Engineering and the Sciences, 9th Edition, Cengage Learning, 2016.
3. Richard A. Johnson, Irwin Miller and John E. Freund, Miller & Freund's Probability and Statistics for Engineers, 9th Edition, Pearson, 2023.
4. Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, 7th Edition, Wiley, 2018.
5. Dennis Wackerly, John Chen and Adam Loy, Mathematical Statistics with Applications, 8th Edition, Cengage Learning, 2026..

E-resources:

https://www.edx.org/learn/probability-and-statistics/massachusetts-institute-of-technology-probability-the-science-of-uncertainty-and-data

https://www.itl.nist.gov/div898/handbook/https://ocw.mit.edu/courses/2-830j-control-of-manufacturing-processes-sma-6303-spring-2008

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the concepts of Fourier transforms, integral transforms, probability distributions, and mathematical functions for solving engineering problems.	PO3 (3)	3	–
CO2	Apply estimation theory and statistical inference techniques to analyze engineering data and estimate unknown parameters.	PO1 (3), PO3 (3)	3	–
CO3	Analyze hypothesis testing methods, probability distributions, and statistical tests for engineering decision-making and data interpretation.	PO1 (3), PO2 (3), PO3 (3)	3	2
CO4	Design and evaluate experiments using analysis of variance (ANOVA), design of experiments (DOE), and statistical modeling techniques.	PO1 (3), PO2 (3), PO3 (3)	3	2
CO5	Solve engineering problems involving heat, wave, Laplace, and Poisson differential equations using advanced mathematical modeling techniques.	PO1 (3), PO2 (3), PO3 (3)	3	2

(1) = Low; (2) = Medium; (3) = High

26TE101	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.

Unit I	Thermodynamic Laws And Systems	9

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

Unit II	Availability and Exergy Analysis	9

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, Turbo machines, Internal combustion Engines.

Unit III	Ideal and Real Gas Mixtures	9

Ideal & Real Gas Mixtures: Vander Waals Equation of state, Virial Equations, Maxwell Relations, Joule-Thomson Coefficient, Thermodynamic Relations, Real gas mixtures.

Unit IV	Thermodynamic Cycles	9

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

Unit V	Thermal Cycle Simulation and Performance Analysis	9

Thermal Cycle Modelling and Simulation: Modelling of Rankine, Brayton, Combined, Refrigeration and Heat Pump Cycles; selection of operating parameters; simulation techniques; performance prediction; energy and exergy analysis; parametric analysis; comparison of cycle performance under different operating conditions; optimization of thermal cycle parameters.

TOTAL(Theory) : 45 PERIODS

Lab Experiments

1. Verification of the First Law of Thermodynamics using a Calorimeter.
2. Experimental Determination of Heat–Work Interaction in a Closed System.
3. P–V Diagram Plotting and Analysis for a Closed System.
4. Experimental Determination of Pressure Loss and Energy Loss in Flow through Pipes.
5. Exergy Analysis of a Shell-and-Tube Heat Exchanger.
6. Determination of Fuel Calorific Value using a Bomb Calorimeter and Combustion Analysis.
7. Experimental Demonstration of Throttling Process using a Throttle Valve Setup.
8. Experimental Determination of Joule–Thomson Effect for a Real Gas.
9. Performance Testing of a Vapour Compression Refrigeration System.
10. Determination of COP and Refrigeration Capacity of a Vapour Compression Refrigeration System.
11. Virtual Simulation and Performance Analysis of Rankine and Brayton Cycles.
12. Virtual Simulation and Parametric Performance Analysis of Combined, Refrigeration and Heat Pump Cycles.

Total (Lab) : 30 HOURS
Total (45+30):75 HOURS

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

Assessment Methodology: Quiz (10%), Assignment (10%), Flipped Class (10%), Practical (20%), Competitive Examinations (10%), Internal Examinations (40%).

Text Books:

1. Yunus A. Çengel, Michael A. Boles and Mehmet Kanoglu, Thermodynamics: An Engineering Approach, 10th Edition, McGraw Hill, 2025.
2. P. K. Nag and Sudipta De, Engineering Thermodynamics, 7th Edition, McGraw Hill, 2025.

References:

1. Bejan, A. (2016). Advanced Engineering Thermodynamics, 4th Edition, John Wiley & Sons.
2. Annamalai, K., Puri, I. K., & Jog, M. A. (2011). Advanced Thermodynamics Engineering, 2nd Edition, CRC Press.
3. Kirkpatrick, A. T., & Kuo, K. K. (2024). Principles of Combustion, 3rd Edition, John Wiley & Sons.
4. Winterbone, D., & Turan, A. (2015). Advanced Thermodynamics for Engineers, 2nd Edition, Elsevier.
5. Borel, L., & Favrat, D. (2010). Thermodynamics and Energy Systems Analysis: From Energy to Exergy, EPFL Press.

E-resources:

https://ocw.mit.edu/courses/mechanical-engineering/2-05-thermodynamics-fall-2003/
https://www.youtube.com/@LearnEngineering 3.https://nptel.ac.in/courses/112/105/112105275
https://ocw.tudelft.nl/courses/thermodynamics/ 5.https://nptel.ac.in/courses/112/103/112103231
https://www.coursera.org/learn/energy-systems

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the fundamental concepts of thermodynamic systems, laws, properties, and exergy analysis for engineering applications.	PO3 (3)	3	-
CO2	Analyze availability, exergy destruction, entropy generation, combustion processes, and energy systems Using advanced thermodynamic principles.	PO1 (3), PO3 (3)	3	3
CO3	Apply Maxwell relations, Joule–Thomson effect, real gas equations, gas mixtures, and thermodynamic relations to solve engineering problems.	PO1 (2), PO2 (3), PO3 (3)	3	-
CO4	Evaluate the performance of refrigeration systems, heat pumps, combined cycles, and cogeneration systems Using thermodynamic analysis.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Simulate thermal cycles using engineering software and interpret the performance of power plant and thermal energy systems.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) = Low; (2) = Medium; (3) = High

26TE102	Advanced Fluid Mechanics and 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.

Unit I	Fluid Kinematics and Boundary Layer Theory	9

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).

Unit II	Fluid Flow Analysis	9

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.

Unit III	Conduction	9

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.

Unit IV	Convection	9

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.

Unit V	Advanced Phase-Change Heat Transfer and Thermal Systems	9

Pool boiling – nucleate, transition and film boiling – boiling curve and critical heat flux – condensation: film wise and drop wise condensation – heat transfer with phase change – heat exchanger effectiveness – NTU method – compact and extended-surface heat exchangers – thermal performance and design considerations – heat transfer enhancement techniques – thermal management of electronic and high-heat-flux systems – applications in energy and thermal systems.

TOTAL : 45 PERIODS

Lab Experiments

1. Measurement of Boundary Layer Thickness over a Flat Plate in a Wind Tunnel.
2. Determination of Velocity Profile for Laminar and Turbulent Flow using a Pitot Tube.
3. Flow Rate Measurement in Pipes using Venturimeter, Orifice Meter and Rotameter.
4. Determination of Friction Factor in Smooth and Rough Pipes using Moody's Chart.
5. Experimental Determination of Major and Minor Losses in Pipe Flow.
6. Determination of Thermal Conductivity of Solids and Liquids and Study of the Effect of Temperature.
7. Thermal Analysis of Fins and Determination of Fin Performance.
8. Experimental Analysis of Lumped Heat Transfer for Different Geometries.
9. Experimental Study of Thermal and Hydraulic Boundary Layer Development in Fluid Flow.
10. Determination of Free and Forced Convective Heat Transfer Coefficients.
11. Experimental Study of Boiling and Condensation Curves with T–T Plots during Melting and Solidification.
12. Study of Laser-Generated Heat Transfer and Irradiation Studies of Heat Generation from Lasers.

Total (Lab) : 30 HOURS

Total (45+30):75 HOURS

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

Assessment Methodology: Quiz (10%), Assignment (10%), Flipped Class (10%), Practical (20%), Competitive Examinations (10%), Internal Examinations (40%).

Text Books:

1. Yunus A. Çengel and John M. Cimbala, Fluid Mechanics: Fundamentals and Applications, 5th Edition, McGraw-Hill, 2026.
2. Yunus A. Çengel and Afshin J. Ghajar, Heat and Mass Transfer: Fundamentals and Applications, 7th Edition, McGraw-Hill, 2026.

References:

1. Çengel, Y. A., & Cimbala, J. M. (2026). Fluid Mechanics: Fundamentals and Applications, 5th Edition, McGraw-Hill Education.
2. White, F. M., & Xue, H. (2022). Fluid Mechanics, 9th Edition, McGraw-Hill Education.
3. Lienhard, J. H., IV, & Lienhard, J. H., V. (2024). A Heat Transfer Textbook, 6th Edition, Phlogiston Press.

4. Holman, J. P. (2009). Heat Transfer, 10th Edition, McGraw-Hill.
5. Çengel, Y. A., & Ghajar, A. J. (2021). Heat and Mass Transfer: Fundamentals and Applications, 6th Edition, McGraw-Hill Education.

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

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the governing equations of fluid flow, boundary layer theory, and flow visualization techniques for engineering applications.	PO3 (3)	3	–
CO2	Analyze fluid flow through pipes, friction losses, flow measurement techniques, and compressible flow using advanced fluid mechanics principles.	PO1 (3), PO3 (3)	3	3
CO3	Apply heat conduction principles to solve steady-state and transient heat transfer problems using analytical and numerical methods.	PO1 (3), PO2 (3), PO3 (3)	3	–
CO4	Evaluate convective heat transfer, boundary layer behavior, free and forced convection, and heat transfer enhancement techniques.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Analyze phase change heat transfer, radiation, mass transfer, and advanced heat transfer applications using computational and modern engineering techniques.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) = Low; (2) = Medium; (3) = High

26TE103	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.

Unit I	Experimental Methods and Data Analytics	9

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

Unit II	Sensors, Transducers and Calibration	9

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

Unit III	Thermal Measurements	9

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

Unit IV	Control Systems	9

Control Systems and Industrial Automation: Open/closed loop systems, transfer functions, feedback, signal conditioning, DAQ, PID and PLC controllers, regulators, thermostats, drives, SCADA, DCS.
Activity: Simulation of PID control using software.

Unit V	Industrial Automation and IIOT	9

IIoT and system optimization.
Activity: 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.

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. J. P. Holman, Experimental Methods for Engineers, 8th Edition, McGraw-Hill Education, 2012.
2. William Bolton, Instrumentation and Control Systems, 2nd Edition, Elsevier, 2021.

References:

1. Holman, J. P. (2012). Experimental Methods for Engineers, 8th Edition, McGraw-Hill.
2. Doebelin, E. O., & Manik, D. N. (2011). Doebelin's Measurement Systems, 6th Edition, McGraw-Hill Education.
3. Kirkup, L. (2019). Experimental Methods for Science and Engineering Students: An Introduction to the Analysis and Presentation of Data, 2nd Edition, Cambridge University Press.
4. Morris, A. S., & Langari, R. (2020). Measurement and Instrumentation: Theory and Application, 3rd Edition, Academic Press, Elsevier.
5. Anderson, N. A. (2017). Instrumentation for Process Measurement and Control, 3rd Edition, CRC Press.

E-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/

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain experimental methods, data acquisition systems, measurement techniques, and data analytics for thermal engineering applications.	PO3 (3)	3	–
CO2	Apply sensor technologies, transducers, calibration techniques, and data acquisition systems for accurate thermal measurements.	PO1 (3), PO3 (3)	3	3
CO3	Analyze thermal measurements of temperature, pressure, flow, humidity, radiation, and material properties using modern instrumentation.	PO1 (3), PO2 (3), PO3 (3)	3	–
CO4	Design and evaluate control systems using PID, PLC, SCADA, DCS, and feedback control principles for thermal engineering processes.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Develop industrial automation and IoT-based monitoring systems for thermal process optimization using modern engineering tools.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) = Low; (2) = Medium; (3) = High

26TE104	Fuels and Combustion	L	T	P	C
		3	0	2	4

Course Objectives:

To introduce the principles of combustion, stoichiometry, flame behaviour, 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.

Unit I	**Combustion Fundamentals**	**9**

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

Unit II	**Solid, Liquid and Gaseous Fuels**	**9**

Solid Fuels: Solid fuel types, properties and analysis, carbonization, gasification, liquefaction, advanced biomass processing and hybrid fuels. Liquid and Gaseous Fuels: Refining and testing of liquid fuels, synthetic fuels, bio and alternative fuels, gaseous fuels, properties, production and applications.

Unit III	**Combustion Devices**	**9**

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

Unit IV	**Emissions and Combustion Safety**	**9**

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

Unit V	**Advanced Combustion Systems**	**9**

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

TOTAL : 45 PERIODS

Lab Experiments

1. Determination of Calorific Value of Solid, Liquid and Gaseous Fuels using a Bomb Calorimeter.
2. Analysis of Exhaust Gas Composition using an Orsat Gas Analyzer.
3. Determination of Properties of Liquid Fuels including Flash Point, Fire Point and Kinematic Viscosity.
4. Characterization of Solid Fuels through Proximate and Ultimate Analysis.
5. Experimental Analysis of Combustion Characteristics of Liquid and Gaseous Fuels.
6. Performance Testing of a Burner for Different Fuel–Air Ratios.
7. Experimental Study of Combustion in a Furnace and Determination of Combustion Efficiency.
8. Determination of Flame Temperature and Combustion Characteristics using Flame Analysis Techniques.
9. Measurement and Analysis of Emissions from Combustion Systems using Gas Analyzers.
10. Determination of NOx, SOx and Particulate Matter Emissions from a Combustion System.
11. Experimental Study of Hydrogen, Ammonia and Biofuel Combustion Characteristics.
12. Experimental Analysis of Carbon Capture and Combustion Emission Reduction Techniques.

Total (Lab) : 30 HOURS

Total (45+30):75 HOURS

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

Assessment Methodology: Quiz (10%), Assignment (10%), Flipped Class (10%), Practical (20%), Competitive Examinations (10%), Internal Examinations (40%).

Text Books:

1. Samir Sarkar, Fuels and Combustion, 3rd Edition, Universities Press, 2009.
2. Kenneth Bryden, Kenneth W. Ragland and Song-Charng Kong, Combustion Engineering, 3rd Edition, CRC Press, 2022.

References:

1. Sarkar, S. (2009). Fuels and Combustion, 3rd Edition, Universities Press.
2. Philips, H. J. (2008). Fuels – Solids, Liquids, and Gases: Their Analysis and Valuation, Bibliolife Publisher.
3. Turns, S. R., & Haworth, D. C. (2021). An Introduction to Combustion: Concepts and Applications, 4th Edition, McGraw-Hill Education.
4. Mishra, D. P. (2010). Fundamentals of Combustion, Revised Edition, PHI Learning.

5. Sharma, S. P., & Mohan, C. (1984). *Fuels and Combustion*, Tata McGraw-Hill.

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/

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the principles of combustion, stoichiometry, flame behavior, combustion characteristics, and emission formation for thermal engineering applications.	PO3 (3)	3	—
CO2	Analyze the properties, classification, testing methods, and applications of solid, liquid, gaseous, and alternative fuels for efficient energy utilization.	PO1 (3), PO3 (3)	3	3
CO3	Evaluate the design, operation, and performance of combustion devices, burners, furnaces, and advanced combustion systems.	PO1 (3), PO2 (3), PO3 (3)	3	—
CO4	Apply emission measurement techniques and combustion safety practices to control pollutants and improve Combustion efficiency.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Assess advanced sustainable combustion technologies, hydrogen and ammonia combustion, carbon-neutral fuels, and life cycle assessment for clean energy applications.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) = Low; (2) = Medium; (3) = High

		L	T	P	C
26TE105	**Technical Seminar - I**	0	0	2	1

Course Objective

To Enhance the ability of self-study

To Improve presentation and communication skills

To Increase the breadth of knowledge.

GUIDELINES

The student shall present a seminar on a current topic related to Thermal Engineering and allied technologies.

The seminar shall be of 30 minutes duration, followed by interaction with the Seminar Assessment Committee (SAC).

A faculty guide shall be allotted to each student to guide and monitor the progress and maintain attendance.

Students shall prepare the seminar based on recent technical literature, research articles, standards, industrial developments or emerging technologies.

Students are encouraged to use appropriate presentation aids such as PowerPoint presentations, models, simulations and demonstrations.

Students shall prepare and submit a seminar report in the prescribed format approved by the Department.

EVALUATION

Technical Seminar – I shall be evaluated as per the academic regulations of the Autonomous Institution. The evaluation shall include the quality of literature survey, technical content, seminar report, presentation, communication skills and interaction
during the seminar.

TOTAL: 30 PERIODS

Semester II

26TE201	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.

Unit I Governing Differential Equations **9**

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, Viscosity, Diffusion, Divergence theorem, Types of Errors.

Unit II Grid Generation **9**

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**.**

Unit III Diffusion **9**

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

Unit IV Convection–Diffusion **9**

1D convection–diffusion problem, Discretization using Central Difference Scheme, Upwind Scheme, QUICK Scheme, Phase Change, Mathematical Formulation, Discretization, Enthalpy Method, Problems.

Unit V Flow Modeling **9**

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

TOTAL : 45 PERIODS

Lab Experiments

1. Numerical Solution of One-Dimensional Governing Equations using Finite Difference Method.
2. Numerical Solution of Two-Dimensional Steady Convection–Diffusion Equation using Finite Difference Method.
3. Generation of Structured and Unstructured Computational Meshes for a Simple Flow Domain.
4. Mesh Quality Assessment and Grid Independence Study for a CFD Model.
5. Numerical Solution of Steady Diffusion Equation using Explicit, Implicit and Crank–Nicolson Schemes.
6. Numerical Simulation of Transient Diffusion Problems and Analysis of Numerical Stability.
7. Discretization and Numerical Solution of the Convection–Diffusion Equation using Central Difference Scheme.
8. CFD Simulation of a Phase-Change Problem using an Appropriate Numerical Model.
9. Simulation of Natural Convection Flow using CFD Software and Analysis of Temperature and Velocity Fields.
10. CFD Simulation of Forced Convection Flow and Evaluation of Heat Transfer Characteristics.
11. CFD Simulation of Turbulent Flow using Standard k–ε, RNG k–ε and k–ω Turbulence Models.
12. Comparative CFD Analysis of Laminar and Turbulent Flow with Validation of Numerical Results.

Total (Lab) : 30 HOURS
Total (45+30):75 HOURS

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

Assessment Methodology: Quiz (10%), Assignment (10%), Flipped Class (10%), Practical (20%), Competitive Examinations (10%), Internal Examinations (40%).

Text Books:

1. H. K. Versteeg and W. Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, 2nd Edition, Pearson Education, 2007.
2. T. J. Chung, Computational Fluid Dynamics, 2nd Edition, Cambridge University Press, 2010.

References:

1. Versteeg, H. K., & Malalasekera, W. (2011). An Introduction to Computational Fluid Dynamics: The Finite Volume Method, 3rd Edition, Pearson Education.
2. Patankar, S. V. (1980). Numerical Heat Transfer and Fluid Flow, 1st Edition, CRC Press.

3. Tu, J., Yeoh, G. H., Liu, C., & Tao, Y. (2024). Computational Fluid Dynamics: A Practical Approach, 4th Edition, Elsevier.
4. Chung, T. J. (2012). Computational Fluid Dynamics, 2nd Edition, Cambridge University Press.
5. LeVeque, R. J. (2002). Finite Volume Methods for Hyperbolic Problems, Cambridge University Press.

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	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the governing equations of fluid flow, vector calculus, differential equations, and finite volume discretization techniques used in Computational Fluid Dynamics.	PO1 (3), PO2 (2), PO3 (3)	3	—
CO2	Generate computational meshes for complex geometries and evaluate mesh quality using structured and unstructured grid generation techniques.	PO1 (3), PO2 (2), PO3 (3)	3	—
CO3	Apply finite volume methods to solve diffusion problems using explicit, implicit, and Crank–Nicolson numerical schemes.	PO1 (3), PO2 (3), PO3 (3)	3	2
CO4	Analyze convection–diffusion and phase change heat transfer Problems using CFD discretization techniques and numerical solution algorithms.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Simulate turbulent internal and external fluid flows using CFD software and interpret results for thermal engineering design and optimization.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) = Low; (2) = Medium; (3) = High

26TE202	Modeling 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.

Unit I Energy Systems 9

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.

Activity: 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.

Unit II Modeling and Simulation 9

Modeling and Simulation: Modeling: steps and levels, Basics of mathematical modeling, Exponential forms and least square method, Modeling of heat exchangers, Effectiveness-NTU method, Pressure drop, Pumping power, Simulation types: sequential/simultaneous, Flow diagram, Newton-Raphson method, Optimisation basics and problem formulation.

Activity: 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.

Unit III Optimization Techniques 9

Optimization Techniques: Dynamic and geometric programming, Lagrange multipliers and constrained optimization, Linear regression, Thermodynamic property relations, Advanced techniques: Genetic algorithms, Simulated annealing.

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

Unit IV Energy–Economy Analysis 9

Energy-Economy Analysis: Energy-economy modeling, Multiplier analysis, Energy and environmental input-output analysis, Econometric energy demand models, Search techniques, Multi-level and multi-variant analysis.

Activity: Build econometric energy demand models.

Unit V Computational Modeling of Thermal Systems 9

Computational Modelling of Thermal Systems: Mathematical modelling of thermal and fluid systems, formulation of governing equations, numerical solution of heat transfer and fluid flow problems, MATLAB/Python-based computational modelling, FEM/FVM concepts, model validation and performance analysis.

Activity:

Solve PDEs (e.g., heat conduction) using MATLAB/Python; perform FEM/FVM simulations using COMSOL/ANSYS/Open FOAM for thermal or fluid flow problems.

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. C. Balaji, Thermal System Design and Optimization, Springer, 2021.
2. P. L. Dhar and Sridhar Thyageswaran, Thermal System Design and Simulation, 1st Edition, Academic Press, 2026.

References:

1. Ting, D. S. K. (2021). Engineering Design and Optimization of Thermofluid Systems, John Wiley & Sons.
2. Balaji, C. (2021). Thermal System Design and Optimization, 2nd Edition, Springer.
3. Nagrath, I. J., & Gopal, M. (2007). Systems Modelling and Analysis, Tata McGraw-Hill.
4. Patel, V. K., Savsani, V. J., & Tawhid, M. A. (2019). Thermal System Optimization: A Population-Based Metaheuristic Approach, Springer.
5. Mostoufi, N., & Constantinides, A. (2022). Applied Numerical Methods for Chemical Engineers,

1st Edition, Elsevier.

E-resources:

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

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Apply energy conversion principles, system modeling concepts and energy balance methods to analyze thermal systems.	PO3 (3)	3	—
CO2	Develop mathematical models and simulations of thermal systems using numerical methods and computational tools.	PO1 (3), PO3 (3)	3	—
CO3	Apply optimization techniques such as dynamic programming, cons algorithms and simulated annealing to thermal system problems.	PO1 (3), PO2 (3), PO3 (3)	3	2
CO4	Perform energy–economy analysis and evaluate thermal systems considering energy utilization, economics and system performance.	PO1 (3), PO2 (3), PO3 (3)	3	2
CO5	Integrate AI-based methods, numerical techniques and computational tools for modeling, optimization and analysis of energy and thermal systems.	PO1 (3), PO2 (3), PO3 (3)	3	2

(1) = Low; (2) = Medium; (3) = High

26TE203	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.

Unit I	Design Parameters of Heat Exchangers	9

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.

Suggested 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.

Unit II	Shell-And-Tube Heat Exchangers	9

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

Suggested 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.

Unit III	Compact Heat Exchangers	9

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

Suggested 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.).

Unit IV	Extended Surface Heat Exchangers	9

Extended Surface Exchangers: Concept of Constructed heat exchangers, Fin-and-tube heat exchangers: Heat Transfer and Friction Characteristics, Periodic Flow Types, Core Pressure Drop, Flow distribution, Header design, Fins, sizing of heat exchanger.

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

Unit V	Condensers and Evaporators	9

Condensers: Condenser types, Heat transfer coefficient, Operational aspects, Water-cooled, Air-cooled & Evaporative Types, Wilson plot. Evaporators: Types, Flow Patterns, Heat load, Multi-effect systems and testing standards.

Suggested Activities: Plot and interpret Wilson plots using test data or simulated values, Evaluate and compare condenser types for HVAC and power plant applications, Lab observation or virtual demo: Flow visualization in micro-channel evaporators.

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. Sadik Kakaç, Hongtan Liu and Anchasa Pramuanjaroenkij, Heat Exchangers: Selection, Rating, and Thermal Design, 4th Edition, CRC Press, 2020.
2. Dušan P. Sekulić and Ramesh K. Shah, Fundamentals of Heat Exchanger Design, 2nd Edition, John Wiley & Sons, 2023.

References:

1. Ann Marie Flynn, Toshihiro Akashige, Louis Theodore, Kern's Process Heat Transfer, Wiley, 2019.
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.

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 the classification, operating principles, thermal design methods, and performance analysis of heat exchangers using LMTD and NTU methods.	PO3 (3)	3	—
CO2	Design and analyze shell-and-tube heat exchangers using TEMA standards, shell-side analysis, and thermal-hydraulic performance evaluation.	PO1 (3), PO2 (3), PO3 (3)	3	—
CO3	Evaluate the design and performance of compact heat exchangers for enhanced heat transfer in engineering Applications.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Analyze extended surface heat exchangers, finned tube heat exchangers, and advanced heat exchanger configurations for improved thermal efficiency.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Design condensers and evaporators, evaluate their performance, and apply heat exchanger concepts to industrial thermal systems.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) = Low; (2) = Medium; (3) = High

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	Self-Learning Course (SLC)	L	T	P	C
		0	0	0	1

(i) Students shall undergo **ONE Self-Learning Course (SLC)** during the entire M.E. Thermal Engineering programme. The course shall be relevant to Engineering and Technology and shall not duplicate any prescribed course.

(ii) The SLC may be selected from **SWAYAM/NPTEL, Government Institutions, Research Laboratories, reputed Universities, or Institution-approved online learning platforms**, having a defined assessment and grading system.

(iii) Students shall submit a maximum of **THREE SLC choices** to the Head of the Department at least **ONE MONTH before the end of the on-going semester**, along with course contents, duration, instructor details, evaluation method and certification details.

(iv) The proposed SLC shall be scrutinized by the **Departmental Board of Studies (BoS)** and approved by the **Academic Council** or competent academic authority of the Autonomous Institution.

(v) Students shall successfully complete the approved SLC and submit the **Certificate/grade statement** to the Department. If the SLC carries more than one credit, **only ONE credit shall be considered for CGPA computation**.

26TE204	Technical Seminar - II	L	T	P	C
		0	0	2	1

Course Objective:

To enhance the reading ability required for identification of his/her field of interest.
To develop skills regarding professional communication and technical report writing.
To establish the fact that student is not a mere recipient of ideas, but a participant in discovery and inquiry.
To learn how to prepare and publish technical papers.

GUIDELINES

The student shall present a seminar on a current and relevant topic in Thermal Engineering or allied areas.
The seminar shall be of 30 minutes duration, followed by interaction with the Seminar Assessment Committee (SAC).
The seminar shall be evaluated based on the technical content, depth of literature survey, quality of references, analysis, presentation skills and clarity of communication.
A faculty guide shall be allotted to each student to guide and monitor the progress and maintain attendance.
The student shall submit a seminar report in the prescribed format approved by the Department.
The seminar shall be supported by recent research articles, technical papers, standards, industrial reports or other reliable technical sources.
Students are encouraged to use appropriate presentation aids such as PowerPoint presentations, simulations, models and demonstrations.
The seminar report may be developed in the form of a technical paper suitable for presentation/publication in a conference or journal, subject to the Department's guidelines.

EVALUATION

Technical Seminar — II shall be evaluated as per the academic regulations of the Autonomous Institution. The evaluation shall consider the literature survey, technical content, analysis, seminar report, presentation, communication skills and interaction during the seminar.

TOTAL: 30 PERIODS

Semester III

26TE301	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.

Unit I	AI in Energy Systems	9

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

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

Unit II	Forecasting and Optimization in Energy Systems	9

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 micro grid optimization using AI.

Suggested 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 simple Genetic Algorithm or Particle Swarm Optimization for battery scheduling

Unit III	Intelligent Control and Fault Detection	9

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.

Suggested 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.

Unit IV	Smart Grids and Energy Analytics	9

AI in smart grid management and demand-side response, AI in grid stability, Outage detection, Cyber-physical systems, Big data and cloud platforms (e.g., TensorFlow, AWS IoT) for energy analytics,

Suggested Activities: Apply AI algorithms for outage detection from grid event logs.

Unit V	Load Analytics and Ai Applications	9

Load disaggregation and consumption pattern analysis, Case studies on AI-powered utilities and smart meters.

Suggested Activities: Perform load disaggregation using machine learning on household energy data, Deploy a simple AI-based energy monitoring dashboard using cloud/IoT platform.

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. Patrick Bangert, Machine Learning and Data Science in the Power Generation Industry: Best Practices, Tools, and Case Studies, 1st Edition, Elsevier, 2021.
2. Denis N. Sidorov, Ed., Machine Learning for Energy Systems, MDPI Books, 2020.

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	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the fundamentals of Artificial Intelligence, Machine Learning, data acquisition, and IoT applications in modern energy systems.	PO3 (3)	3	—
CO2	Apply AI and ML techniques for forecasting energy generation, demand prediction, optimization, and scheduling in renewable energy systems.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO3	Analyze intelligent control systems and develop AI-based fault detection and predictive maintenance models for thermal and energy systems.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Evaluate AI-driven energy analytics, smart grid management, demand-side response, and optimization using machine learning algorithms.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Design AI and ML-based solutions for energy management, consumption analysis, predictive analytics, and sustainable smart energy applications.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) = Low; (2) = Medium; (3) = High

		L	T	P	C
26TE302	**Project Work I**	0	0	16	8

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.

		L	T	P	C
26TE303	**Industrial Training**	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

26TE401	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.

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PROGRAMME ELECTIVE COURSES

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26TE001	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.

Unit I — Coal-Based — 9

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

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

Unit II — Diesel and Gas Turbine — 9

Diesel Engine cycle, Plant layout performance, Cooling and lubrication systems, Gas turbines, Brayton cycle, Advantages, limitations with intercooling, Reheating, Regeneration, Analysis and improvement.

Suggested 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.

Unit III — Cogeneration and Hydro Power Plants — 9

Cogeneration types, Heat-to-power ratio, Performance, Combined Heat and Power, Binary and Polygene ration cycles, MHD, Open/Closed cycles, Hybrid MHD-steam systems. Hydro types, Components, Pumped storage, Micro/mini plants, Nuclear fuels, Fertile fuels, Moderators, Coolants, Reactor types, Safety measures and environmental concerns.

Suggested Activities: Comparison chart of different cogeneration systems (steam, gas, IC engine-based), Simulation or animation-based learning of MHD generation principles, 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.

Unit IV — Economics and Environmental Issues — 9

Load parameters and load curve analysis, Site selection, Capital and operating cost, Power tariffs, Pollution control, and Waste disposal from power plants.

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

Unit V — Smart Power Plant Operation and Sustainability — 9

Smart power plant monitoring, Digital twin technology, Artificial Intelligence (AI) and Internet of Things (IoT) applications in power plants, Predictive maintenance, Performance optimization, Carbon capture and storage (CCS), Renewable energy integration, Net-zero emission strategies.

Suggested Activities: Develop a digital monitoring model for a power plant using simulation software, Analyze plant performance using AI-based tools, Prepare a case study on carbon capture or renewable energy integration in thermal power plants

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. Sudipta De, Nag's Power Plant Engineering, 5th Edition, McGraw-Hill Education, 2021.
2. Allen J. Wood, Bruce F. Wollenberg and Gerald B. Sheblé, Power Generation, Operation, and Control, 3rd Edition, John Wiley & Sons, 2017.

References:

1. Nag, P. K. (2017). Power Plant Engineering, 4th Edition, McGraw-Hill Education.
2. Haywood, R. W. (1991). Analysis of Engineering Cycles: Power, Refrigerating and Gas Liquefaction Plant, 4th Edition, Pergamon Press.
3. Wood, A. J., Wollenberg, B. F., & Sheblé, G. B. (2013). Power Generation, Operation, and Control, 3rd Edition, John Wiley & Sons.
4. Gill, A. B. (1984). Power Plant Performance, Butterworths.
5. Lamarsh, J. R., & Baratta, A. J. (2022). Introduction to Nuclear Engineering, 4th Edition, Pearson.

E-resources:

https://nptel.ac.in/courses/112107291
https://nptel.ac.in/courses/108102047
https://ocw.mit.edu/courses/2-60j-fundamentals-of-advanced-energy-conversion-spring-2020/
https://ocw.mit.edu/courses/2-60j-fundamentals-of-advanced-energy-conversion-spring-2020/resources/lecture-notes/
https://ocw.mit.edu/courses/22-06-engineering-of-nuclear-systems-fall-2010/

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the principles, components and operation of coal-based, diesel, gas turbine and hydro power plants.	PO3 (3)	3	—
CO2	Analyze the performance, operating parameters and energy conversion processes of various conventional and combined power plants.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO3	Evaluate cogeneration systems, hydro power systems and power plant economics, considering efficiency, cost and operational requirements.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Assess environmental impacts, pollution control measures and sustainable practices associated with thermal and other power generation systems.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Apply smart monitoring, digital technologies, AI, IoT, carbon capture and renewable-energy integration concepts for modern and sustainable power plants.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) = Low; (2) = Medium; (3) = High

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26TE002	Turbo machines	L	T	P	C
		3	0	0	3

Course Objectives:

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

Unit I	Turbo Machine Energy Interactions	9

Energy transfer in fluid 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.

Suggested Activities: Draw and analyze velocity triangles for different turbo machines, Use software to plot fan laws and dimensionless parameters, Case study on Cordier diagram.

Unit II	Fans and Blowers	9

Centrifugal blowers: Velocity triangles, Characteristic curves, Impeller, Casing, Inlet, Volute, Diffusers, Losses (leakage, mechanical), Multi-vane impellers, Cross-flow fans. Axial flow fans: Rotor design, Cascade effects, Blade twist, Stage design, Surge, Stall, Stator and Casing.

Suggested Activities: CAD model/simulation of centrifugal blower, Analysis of axial fan blade profiles, Airflow simulation.

Unit III	Compressors	9

Centrifugal compressors: Velocity triangles, Performance, Part-load operation, Capacity control, Selection for different applications, Axial flow compressors.

Suggested Activities: Identify compressor components, Performance simulation under part-load conditions.

Unit IV	Design and Applications	9

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 HVAC systems.

Suggested Activities: Ventilation system design, Air distribution system design, Industrial visit/report

Unit V	Selection, Performance and Industrial Applications	9

Selection criteria for fans, blowers and compressors, Performance characteristics and testing methods, Fan and compressor matching, Energy-efficient operation, Troubleshooting, Maintenance practices, Industrial applications in HVAC systems, Cooling towers, Ventilation systems, Turbochargers and Process industries.

Suggested Activities: Performance testing of a fan/compressor using characteristic curves, Selection of suitable turbo machines for a given industrial application, Case study on HVAC or Process industry installations.

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. S. Larry Dixon, Cesare Hall and Dan Zhao, Fluid Mechanics and Thermodynamics of Turbomachinery, 8th Edition, Butterworth-Heinemann/Elsevier, 2025.
2. WTW (Bill) Cory, Fans and Ventilation: A Practical Guide, 1st Edition, Elsevier, 2005.

References:

1. Dick, E. (2022). Fundamentals of Turbomachines, 2nd Edition, Springer.
2. Lewis, R. I. (1996). Turbomachinery Performance Analysis, 1st Edition, Elsevier.
3. Bleier, F. P. (1998). Fan Handbook: Selection, Application, and Design, 1st Edition, McGraw-Hill.
4. Brown, R. N. (2005). Compressors: Selection and Sizing, 3rd Edition, Elsevier.
5. Cory, W. (2005). Fans and Ventilation: A Practical Guide, 1st Edition, Elsevier.

E-resources:

https://nptel.ac.in/courses/112107291
https://nptel.ac.in/courses/108102047
https://ocw.mit.edu/courses/2-60j-fundamentals-of-advanced-energy-conversion-spring-2020/
https://ocw.mit.edu/courses/2-60j-fundamentals-of-advanced-energy-conversion-spring-2020/resources/lecture-notes/
https://ocw.mit.edu/courses/22-06-engineering-of-nuclear-systems-fall-2010/

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the fundamentals of turbo machines, velocity triangles, Euler's equation, dimensional analysis, and performance characteristics of fluid machines.	PO3 (3)	3	—
CO2	Analyze the performance and design characteristics of Centrifugal fans, blowers, axial flow fans, and compressors for engineering applications.	PO1 (3), PO2 (3), PO3 (3)	3	—
CO3	Evaluate the operating principles, performance parameters, and selection criteria of compressors under various operating conditions.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Design HVAC air distribution systems and select appropriate turbo machinery components for industrial and commercial applications.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Assess the performance of fans and compressors through testing, troubleshooting, and energy-efficient operation Using modern engineering practices.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) = Low; (2) = Medium; (3) = High

26TE003	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.

Unit I | Energy from Waste & Waste Characterization | 9

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

Unit II | Combustion & Thermal Conversion Technologies | 9

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.

Unit III | Gasification and Pyrolysis Technologies | 9

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.

Unit IV | Biological & Emerging Waste-to-Energy Technologies | 9

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

Unit V | Waste-To-Energy Applications And Resource Recovery | 9

Applications of waste-to-energy technologies in municipal solid waste (MSW) management, Industrial waste utilization, Agricultural waste valorization, RDF-based power generation, Biomass-based power plants, Wastewater treatment and energy recovery, Circular economy concepts, Resource recovery from waste, Environmental and economic assessment of waste-to-energy systems.

Suggested Activities: Case study on waste-to-energy plants, Design of a small-scale waste-to-energy system using locally available biomass or municipal waste, Comparative analysis of different waste-to-energy technologies based on efficiency, environmental impact, and economic feasibility.

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1.Anju Dahiya, Ed., Bioenergy: Biomass to Biofuels and Waste to Energy, 2nd Edition, Elsevier, 2020.
2.Pratima Bajpai, Biomass to Energy Conversion Technologies: The Road to Commercialization, Elsevier, 2020.

References:

1. Van Loo, S., & Koppejan, J. (2008). The Handbook of Biomass Combustion and Co-firing, 1st Edition, Routledge.

2. Dayton, D. C., & Foust, T. D. (2019). Analytical Methods for Biomass Characterization and Conversion, 1st Edition, Elsevier.
3. Rosendahl, L. (Ed.). (2013). Biomass Combustion: Science, Technology and Engineering, 1st Edition, Woodhead Publishing/Elsevier.
4. Speight, J. G. (2022). Biomass Processes and Chemicals, 1st Edition, Elsevier.
5. Khanal, S. K., Surampalli, R. Y., Zhang, T. C., Lamsal, B. P., Tyagi, R. D., & Kao, C. M. (Eds.). (2010). Bioenergy and Biofuel from Biowastes and Biomass, ASCE.

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/

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the characteristics, classification, and energy potential of municipal, industrial, agricultural, and hazardous wastes for waste-to-energy applications.	PO3 (3)	3	—
CO2	Analyze thermochemical conversion technologies including combustion, gasification, pyrolysis, and hydrothermal processing for energy recovery from waste.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO3	Evaluate biochemical conversion processes such as anaerobic digestion, biogas production, fermentation, and microbial fuel cells for sustainable energy generation.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Assess waste-to-energy technologies, resource recovery methods, environmental impacts, and economic feasibility for integrated waste management systems.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Design and recommend sustainable waste-to-energy systems by integrating modern technologies, resource recovery, circular economy concepts, and environmental management practices.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) = Low; (2) = Medium; (3) = High

26TE004	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.

Unit I — Fundamentals of Polygeneration and Energy System Integration — 9

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

Unit II — Components and Conversion Processes In Polygeneration — 9

Processes: Internal combustion engines, steam cycles, gas turbines, Organic Rankin 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, Micro grid systems using gas turbines and fuel cells in commercial buildings, Solar-biomass hybrid plants in agro-processing and dairy farms

Unit III — Performance and Thermo economic Evaluation of Polygeneration — 9

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, Thermo economic analysis and multi-objective optimization

Applications: Exergy and cost optimization in refineries and petrochemical plants, Energy-efficiency audits and thermo economic 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

Unit IV — Applications in Buildings and Industries — 9

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

Unit V — Industrial Applications of Polygeneration Systems — 9

Industrial Energy Systems: Energy-intensive industrial processes and their electrical, heating, cooling and steam requirements; industrial waste heat and waste-gas utilization. Industrial Polygeneration: Integration of gas turbines, steam turbines, organic Rankine cycles, waste-heat boilers and renewable energy sources; combined heat, power and cooling for industrial applications. Advanced Energy Integration: Process heat recovery, thermal energy storage, hydrogen integration and hybrid renewable–conventional polygeneration systems. System Optimization and Control: Energy management, exergy-based performance improvement, economic optimization, environmental assessment and smart control of industrial polygeneration systems.

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. Francesco Calise, Massimo Dentice D’Accadia, Laura Vanoli and Maria Vicidomini, Polygeneration Systems: Design, Processes and Technologies, 1st Edition, Academic Press, 2021.
2. Majid Amidpour and Mohammad Hasan Khoshgoftar Manesh, Cogeneration and Polygeneration Systems, Academic Press, 2020.

References:

1. Dincer, I., & Rosen, M. A. (2021). Exergy: Energy, Environment and Sustainable Development, 3rd Edition, Elsevier.
2. Mehrpooya, M., Asadnia, M., Karimi, A. H., & Allahyarzadeh-Bidgoli, A. (2023). Hybrid Polygeneration Energy Systems: Thermal Design and Exergy Analysis, 1st Edition, Academic Press/Elsevier.
3. Dincer, I., Rosen, M. A., & Ahmadi, P. (2017). Optimization of Energy Systems, 1st Edition, John

Wiley & Sons.
4. Khalilpour, K. R. (Ed.). (2019). Polygeneration with Polystorage, 1st Edition, Academic Press/Elsevier.
5. Dincer, I., & Zamfirescu, C. (2014). Advanced Power Generation Systems, 1st Edition, Academic Press/Elsevier.

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	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the fundamentals, architecture, energy integration, and multi-output capabilities of polygeneration systems for sustainable energy applications.	PO3 (3)	3	—
CO2	Analyze energy conversion processes and the integration of renewable energy sources, fuel cells, energy storage, and combined energy systems in polygeneration.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO3	Evaluate the thermodynamic, environmental, and economic performance of integrated polygeneration systems using energy and exergy analysis.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Design and assess building-scale and industrial polygeneration systems by integrating HVAC, heat pumps, hydrogen technologies, and renewable energy resources.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Develop sustainable polygeneration solutions using AI, digital twins, smart grid integration, and advanced energy management techniques for modern energy systems.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) = Low; (2) = Medium; (3) = High

26TE005	Thermal Management in Electronics and Batteries	L	T	P	C
		3	0	0	3

Course Objectives:

To understand the fundamentals of thermal management in electronic devices and battery systems, including heat dissipation, cooling technologies, and thermal performance

Unit I	Thermal Fundamentals in Electronics	9

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

Activities: Simulate heat sink design (ANSYS/Solid Works), 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).

Unit II	Cooling Technologies	9

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

Activities: CFD simulation of micro channel/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

Unit III	Applications	9

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)

Unit IV	Battery Systems and Thermal Management	9

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

Unit V	Battery Thermal Management Applications	9

Theory: Battery pack design for electric vehicles and hybrid vehicles, Thermal safety in energy storage systems, Prevention of battery aging and thermal runaway, Efficient Battery Thermal Management Systems (BTMS) for drones, Power tools and portable electronic devices.

Activities: Case study on EV battery thermal management, Comparative analysis of air, liquid and PCM-based BTMS, Thermal simulation of battery packs under different operating conditions.

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. Younes Shabany, Heat Transfer: Thermal Management of Electronics, CRC Press, 2010.
2. Marc A. Rosen and Aida Farsi, Battery Technology: From Fundamentals to Thermal Behavior and Management, 1st Edition, Academic Press, 2023.

References:

1. yeh, L.-T. (2016). Thermal Management of Microelectronic Equipment, 2nd Edition, ASME Press.
2. Vassighi, A., & Sachdev, M. (2006). Thermal and Power Management of Integrated Circuits, Springer.
3. Rosen, M. A., & Farsi, A. (2023). Battery Technology: From Fundamentals to Thermal Behavior and Management, 1st Edition, Academic Press/Elsevier.
4. Santhanagopalan, S., Smith, K., Neubauer, J., Kim, G.-H., Pesaran, A. A., & Keyser, M. (2014). Design and Analysis of Large Lithium-Ion Battery Systems, 1st Edition, Artech House.

5. Ali, H. M. (Ed.). (2024). Thermal Management for Batteries: From Basic Design to Advanced Simulation and Management Methods, 1st Edition, Academic Press/Elsevier.

E-resources:

https://nptel.ac.in/courses/112101097
https://www.jedec.org/ https://nptel.ac.in/courses/112106282
https://nptel.ac.in/courses/112105129
https://nptel.ac.in/courses/108106170

CO	**Description of CO**	**Mapped POs**	**PSO1**	**PSO2**
CO1	Explain the fundamentals of heat transfer, thermal properties of electronic components, and cooling techniques used in electronic systems.	PO3 (3)	3	—
CO2	Analyze advanced cooling methods including micro channels, jet impingement, heat pipes, vapor chambers, and thermoelectric cooling for electronic devices.	PO1 (3), PO2 (3), PO3 (3)	3	—
CO3	Evaluate thermal management solutions for electronic devices, data centers, electric vehicles, and aerospace applications using modern engineering techniques.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Analyze battery thermal management systems (BTMS), thermal runaway, battery ageing, and thermal safety for lithium-ion battery applications.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Design and optimize thermal management systems for electronics and batteries using simulation tools and advanced cooling technologies for sustainable Applications.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) = Low; (2) = Medium; (3) = High

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26TE006	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.

Unit I | Hydrogen Energy – Fundamentals, Properties, and Policies | 9

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

Unit II | Applications: National Green Hydrogen Mission (India) | 9

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).

Unit III | Hydrogen Generation and Storage Technologies | 9

Hydrogen production methods: Steam reforming, partial oxidation, Coal gasification and biomass conversion, Electrolysis (Alkaline, PEM, SOE), Photo catalytic 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),

Unit IV | Fuel Cell Technology - Fundamentals, Classification, and Performance | 9

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 micro grids, 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)

Unit V | Green Hydrogen Ecosystem And Future Trends | 9

Theory: Future trends in hydrogen energy: Hydrogen corridors, Green hydrogen hubs, Ammonia economy, Policy, Funding mechanisms (e.g., India's National Green Hydrogen Mission), Integration of hydrogen with renewable energy systems, Industrial decarburization strategies.

Applications: Case studies on Green Hydrogen Mission projects, Comparative analysis of hydrogen production and utilization pathways, Assessment of hydrogen
economy for sustainable energy systems.

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. Pratibha Sharma, A Textbook on Hydrogen Energy: Production, Storage, Transport and Utilization, 1st Edition, Springer, 2026.
2. Bent Sørensen and Giuseppe Spazzafumo, Hydrogen and Fuel Cells: Emerging Technologies and Applications, 3rd Edition, Academic Press, 2018.

References:

1. Gupta, R. B. (2009). Hydrogen Fuel: Production, Transport, and Storage, 1st Edition, CRC Press.
2. Godula-Jopek, A. (2015). Hydrogen Production: By Electrolysis, Wiley-VCH.

3. Hirscher, M. (Ed.). (2010). Handbook of Hydrogen Storage: New Materials for Future Energy Storage, 1st Edition, Wiley-VCH.
4. Dicks, A. L., & Rand, D. A. J. (2018). Fuel Cell Systems Explained, 3rd Edition, John Wiley & Sons.
5. O'Hayre, R., Cha, S.-W., Colella, W. G., & Prinz, F. B. (2016). Fuel Cell Fundamentals, 3rd Edition, John Wiley & Sons.

E-resources:

https://mnre.gov.in https://niti.gov.in
https://www.fchea.org
https://www.iea.org
https://nptel.ac.in/courses/103106116
https://www.indiah2alliance.com

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the properties, production methods, storage techniques, safety aspects, and applications of hydrogen as a sustainable energy carrier.	PO3 (3)	3	—
CO2	Analyze the National Green Hydrogen Mission, hydrogen production technologies, and transportation, storage, and distribution systems for energy applications.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO3	Evaluate the operating principles, classifications, performance characteristics, and applications of fuel cells for clean energy systems.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Design and assess hydrogen-based energy systems by integrating fuel cells, hydrogen infrastructure, and renewable energy sources for sustainable applications.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Develop sustainable hydrogen energy solutions by evaluating emerging technologies, future hydrogen ecosystems, policies, and industrial applications.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) = Low; (2) = Medium; (3) = High

26TE007	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, include electric drives, motor control, and energy storage and management systems.

Unit I — Introduction to Hybrid & Electric Vehicles — 9

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 IC 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.

Unit II — Hybrid Electric Drive Trains — 9

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

Unit III — Electric Drives & Control — 9

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.

Unit IV — Energy Storage & Management — 9

Energy Storage Requirements in Hybrid and Electric Vehicles, Battery, fuel cell, and super capacitor 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 super capacitors in terms of energy density, cost, and life, Energy Management Strategy Simulation – Use MATLAB to test rule-based vs. fuzzy logic EMS.

Unit V — Applications of Hybrid and Electric Vehicles — 9

Theory: Applications of hybrid and electric vehicles in passenger cars, commercial vehicles, public transportation and industrial mobility, Vehicle performance evaluation, Selection of suitable energy storage systems, Comparison of hybrid and electric vehicle configurations, Environmental and economic assessment of HEVs/EVs.

Activities: Case study on commercial HEVs/EVs, Comparative analysis of hybrid and electric vehicle configurations, Evaluation of vehicle performance and energy management strategies using simulation tools.

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. Mehrdad Ehsani, Yimin Gao, Stefano Longo and Kambiz M. Ebrahimi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design, 3rd Edition, CRC Press, 2018.
2. James Larminie and John Lowry, Electric Vehicle Technology Explained, 2nd Edition, John Wiley & Sons, 2012.

References:

1. Husain, I. (2021). Electric and Hybrid Vehicles: Design Fundamentals, 3rd Edition, CRC Press.
2. Mi, C., & Masrur, M. A. (2025). Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, 3rd Edition, John Wiley & Sons.
3. Williamson, S. S. (2013). Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, 1st Edition, Springer.
4. Plett, G. L. (2015). Battery Management Systems, Volume 1: Battery Modeling, Artech House.
5. Lee, C. H. T. (Ed.). (2024). Emerging Technologies for Electric and Hybrid Vehicles, 1st Edition, Springer.

E-resources:

https://nptel.ac.in/courses/108108176 https://www.mathworks.com/solutions/automotive.html
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https://nptel.ac.in/courses/108105131

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the fundamentals, architecture, power sources, performance characteristics, and energy management principles of hybrid and electric vehicles.	PO3 (3)	3	—
CO2	Analyze hybrid electric drive trains, vehicle power flow, transmission systems, and energy efficiency using modern engineering tools.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO3	Evaluate electric drives, motors, motor controllers, drive System efficiency, and control strategies for hybrid and electric vehicles.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Design and assess energy storage systems, battery management systems (BMS), fuel cells, super capacitors, and energy management strategies for electric vehicles.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Develop sustainable hybrid and electric vehicle solutions by integrating advanced propulsion systems, energy optimization techniques, and environmental impact assessment.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) = Low; (2) = Medium; (3) = High

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26TE008	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.

Unit I — ML Introduction & Mathematical Foundations — 9

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.

Unit II — Supervised Learning Techniques — 9

Regression: Linear, Lasso, logistic, Over fitting, under fitting, cross-validation, Support vector machines (SVM), kernel methods, K-nearest neighbors, 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.

Unit III — Unsupervised & Reinforcement Learning — 9

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.

Unit IV — Probabilistic Methods & ML for IC Engines — 9

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.

Unit V — Machine Learning Applications In IC Engines — 9

Theory: Applications of machine learning in engine performance prediction, Emission analysis, Fault diagnosis, Predictive maintenance, Combustion analysis, Fuel consumption prediction, Engine calibration, Real-time engine monitoring and intelligent engine control systems.

Activities: Case study on ML-based engine diagnostics, Comparative analysis of different ML models for engine applications, Development of a simple prediction model using engine experimental data.

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. Kevin P. Murphy, Probabilistic Machine Learning: An Introduction, MIT Press, 2022.
2. Jihad Badra, Pinaki Pal, Yuanjiang Pei and Sibendu Som, Artificial Intelligence and Data Driven Optimization of Internal Combustion Engines, 1st Edition, Elsevier, 2022.

References:

1. Steven L. Brunton and J. Nathan Kutz, Data-Driven Science and Engineering: Machine Learning, Dynamical Systems, and Control, 2nd Edition, Cambridge University Press, 2022.
2. Trevor Hastie, Robert Tibshirani and Jerome Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, 2nd Edition, Springer, 2009.
3. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 3rd Edition, O'Reilly Media, 2022.
4. Andreas C. Müller and Sarah Guido, Introduction to Machine Learning with Python: A Guide for Data Scientists, O'Reilly Media, 2016.
5. Stephen Marsland, Machine Learning: An Algorithmic Perspective, 2nd Edition, CRC Press, 2015.

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https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-042j-mathematics-for-computer-science-fall-2005/ https://nptel.ac.in/courses/106106179
https://nptel.ac.in/courses/106106126
https://course.fast.ai/ https://nptel.ac.in/courses/106106140

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the fundamentals of machine learning, mathematical concepts, and data preprocessing techniques for internal combustion engine applications.	PO3 (3)	3	—
CO2	Apply supervised learning algorithms to predict engine Performance, emissions, fuel consumption, and combustion characteristics using experimental data.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO3	Analyze engine operating conditions using unsupervised learning and reinforcement learning techniques for pattern Recognition and optimization.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Develop probabilistic machine learning models for fault diagnosis, predictive maintenance, combustion analysis, and intelligent engine control.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Design AI and machine learning-based solutions for engine performance prediction, emission control, predictive diagnostics, and intelligent thermal systems.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) = Low; (2) = Medium; (3) = High

26TE009	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

Unit I	**Overview of Energy Storage Systems**	**9**

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

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.

Unit II	**Thermal Energy Storage**	**9**

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.

Unit III	**Electrochemical and Electrical Storage**	**9**

Lead-acid, NiCd, NiMH, Li-ion, zinc-air batteries, battery performance and safety, super capacitors, ultra capacitors, SMES, emerging technologies: solid-state batteries, fast charging systems, Vehicle to Grid(V2G) technology, I 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.

Unit IV	**Hydrogen Energy Storage**	**9**

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.

Unit V	**Energy Storage Applications And System Integration**	**9**

Theory: Applications of thermal, electrochemical, electrical and hydrogen energy storage systems in renewable energy integration, Electric vehicles, Smart grids, Industrial energy management, Battery health monitoring, Vehicle-to-Grid (V2G), System optimization and safety considerations.

Activities: Comparative study of different energy storage technologies for renewable energy applications, Case study on EV battery systems or smart grid storage, Performance evaluation and optimization of integrated energy storage systems using simulation tools.

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. İbrahim Dinçer and Marc A. Rosen, Thermal Energy Storage: Systems and Applications, 3rd Edition, John Wiley & Sons, 2021.
2. Robert A. Huggins, Energy Storage: Fundamentals, Materials and Applications, 2nd Edition, Springer, 2016.

References:

1. Luisa F. Cabeza, Ed., Advances in Thermal Energy Storage Systems: Methods and Applications, 2nd Edition, Elsevier, 2020.
2. Patrick T. Moseley and Jürgen Garche, Eds., Electrochemical Energy Storage for Renewable Sources and Grid Balancing, Elsevier, 2015.
3. Ru-Shi Liu, Lei Zhang, Xueliang Sun, Hansan Liu and Jiujun Zhang, Eds., Electrochemical Technologies for Energy Storage and Conversion, Wiley-VCH, 2012.

4. Wolf-Dieter Steinmann, Thermal Energy Storage for Medium and High Temperatures: Concepts and Applications, Springer, 2013.
5. Robert A. Huggins, Advanced Batteries: Materials Science Aspects, Springer, 2009.

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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 principles, classification, characteristics, and performance of electrical, thermal, mechanical, and hydrogen energy storage technologies.	PO3 (3)	3	—
CO2	Analyze thermal energy storage systems, electrochemical energy storage, batteries, super capacitors, and flywheel energy storage systems for engineering applications.	PO1 (3), PO3 (3)	3	3
CO3	Evaluate hydrogen production, storage methods, transportation, safety aspects, and hybrid energy storage systems for sustainable energy applications.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Design and optimize integrated energy storage systems for electric vehicles, renewable energy systems, smart grids, and industrial applications using modern engineering tools.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Assess the performance, reliability, and sustainability of advanced energy storage technologies and recommend suitable storage solutions for modern energy systems.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) = Low; (2) = Medium; (3) = High

Course Code	Course Title	L	T	P	C
26TE010	**Solar Photovoltaic Technology and Systems**	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.

Unit I PV Modules 9

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

Unit II Standalone PV systems 9

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.

Unit III Grid-Connected PV Systems 9

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

Unit IV Hybrid Systems 9

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

Unit V PV System Applications and Performance Analysis 9

Theory: Applications of standalone, grid-connected and hybrid PV systems, Performance evaluation of PV installations, System sizing and design considerations, Grid code compliance, Renewable energy integration, Operation and maintenance of PV systems.

Activities: Comparative analysis of standalone, grid-connected and hybrid PV systems,
Case study on rooftop and utility-scale PV plants, Performance assessment and optimization of PV systems using simulation tools

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. Chetan Singh Solanki, Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers, PHI Learning, 2013.
2. Weidong Xiao, Photovoltaic Power System: Modelling, Design and Control, John Wiley & Sons, 2017.

References:

1. A. Goetzberger, V. U. Hoffmann, and 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, 3rd Edition, PHI Learning, 2019.
4. T. Markvart, Solar Electricity, 2nd Edition, John Wiley & Sons, 2000.
5. R. A. Messenger and Homayoon “Amir” Abtahi, Photovoltaic Systems Engineering, 5th Edition, CRC Press, 2025.

E-resources:

https://nptel.ac.in/courses/117/108/117108150/ https://www.pveducation.org/
https://nptel.ac.in/courses/108/105/108105101/ https://nptel.ac.in/courses/115/107/115107117/
https://www.homerenergy.com/
https://nptel.ac.in/courses/112/107/112107289/

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the principles, characteristics, components, and performance of photovoltaic cells and solar PV modules for energy generation.	PO3 (3)	3	—
CO2	Analyze standalone PV systems, MPPT techniques, battery integration, and system modelling for efficient solar energy utilization.	PO1 (3), PO3 (3)	3	3
CO3	Evaluate grid-connected PV systems, inverter operation, net metering, grid codes, and PV system integration using engineering analysis.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Design and assess hybrid photovoltaic systems integrated with diesel generators, wind energy, microgrids, and electric vehicles for sustainable applications.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Develop and optimize solar PV systems through performance analysis, operation, maintenance, and renewable energy integration using modern engineering tools.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) = Low; (2) = Medium; (3) = High

26TE011	Carbon Sequestration and Utilization	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.

Unit I	Introduction to CCUS and Climate Context	9

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

Unit II	CO_2 Capture and Compression Technologies	9

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

Unit III	CO_2 Transport, Utilization, and Geological Storage	9

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.

Unit IV	Economics, Policies, and Regulatory Frameworks	9

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).

Unit V	CCUS Applications And Sustainability Assessment	9

Applications of CCUS in power generation, Cement, Steel, Refineries, Fertilizer and Chemical industries, Role of CCUS in industrial decarbonisation, Carbon utilization pathways, Environmental impact assessment, Techno-economic analysis, Life Cycle Assessment (LCA), Sustainability evaluation and future deployment of CCUS technologies.

Case study on an Indian CCUS project, Comparative assessment of different CO_2 capture and utilization technologies, Techno-economic analysis of a CCUS system using published data.

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. Steve A. Rackley, Carbon Capture and Storage, 2nd Edition, Elsevier, 2017.
2. Deepak Pant, Ashok Kumar Nadda, Kamal Kishore Pant and Avinash Kumar Agarwal, Eds., Advances in Carbon Capture and Utilization, Springer, 2021.

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.
4. S. M. Aithal Carbon Capture, Utilization and Storage: Technologies and Indian, Initiatives,TERI Press,2021,1st Edition.
5. IPCC Special Report Carbon Dioxide Capture and Storage, Cambridge University Press, (for IPCC),2005,1st Edition.

E-resources:

https://www.iea.org/topics/carbon-capture-utilisation-and-storage
https://www.globalccsinstitute.com
https://niti.gov.in https://moef.gov.in
https://www.teriin.org

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CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the fundamentals of climate change, greenhouse gas emissions, carbon capture, utilization, and storage (CCUS) technologies and their role in sustainable development.	PO3 (3)	3	—
CO2	Analyze carbon capture technologies, CO_2 compression, transport, storage methods, and utilization pathways for industrial and power plant applications.	PO1 (3), PO3 (3)	3	3
CO3	Evaluate CO_2 transportation, geological storage, monitoring, verification, and enhanced recovery techniques using engineering principles.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Assess the economic, environmental, policy, and regulatory aspects of CCUS projects through techno-economic and sustainability analysis.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Design and recommend sustainable carbon sequestration and utilization strategies by integrating life cycle assessment, carbon management, and emerging CCUS technologies.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) = Low; (2) = Medium; (3) = High

26TE012	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.

Unit I	Refrigeration Cycles	9

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.

Unit II	Refrigerants & Lubricants	9

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.

Unit III	System Components	9

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.

Unit IV	Load Analysis & Advanced Systems	9

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

Unit V	Refrigeration System Applications And Performance Evaluation	9

Applications of refrigeration systems in domestic, commercial, industrial and cold-chain sectors, Selection of refrigeration systems for various applications, Energy-efficient operation, Performance evaluation, Environmental impact of refrigerants, Operation and maintenance of refrigeration systems.

Activities: Comparative study of conventional and advanced refrigeration systems, Case study on cold storage or commercial refrigeration plants, Performance assessment and energy analysis using simulation software.

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. C. P. Arora, Refrigeration and Air Conditioning, 4th Edition, McGraw-Hill Education, 2021.
2. İbrahim Dinçer and Mehmet Kanoğlu, Refrigeration Systems and Applications, 3rd Edition, John Wiley & Sons, 2017.

References:

1. Roy J. Dossat and Thomas J. Horan, Principles of Refrigeration, 5th Edition, Prentice Hall, 2002.
2. W. F. Stoecker and J. W. Jones, Refrigeration and Air Conditioning, 2nd Edition, McGraw-Hill, 1982.
3. Eugene Silberstein, Jason Obrzut, John Tomczyk, Bill Whitman and Bill Johnson, Refrigeration & Air Conditioning Technology, 10th Edition, Cengage Learning, 2025.
4. Rex Miller and Mark R. Miller, Air Conditioning and Refrigeration, 2nd Edition, McGraw-Hill, 2011.
5. Thomas H. Kuehn, James W. Ramsey and James L. Threlkeld, Thermal Environmental Engineering, 3rd Edition, Prentice Hall, 1998.

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https://www.ashrae.org/technical-resources/refrigeration
https://www.ashrae.org/technical-resources/ashrae-handbook/description-ashrae-handbook-refrigeration

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the principles of refrigeration cycles, refrigerants, performance parameters, and environmental aspects of refrigeration systems.	PO3 (3)	3	—
CO2	Analyze refrigerants, lubricants, refrigeration system components, and their performance characteristics for efficient refrigeration applications.	PO1 (3), PO3 (3)	3	3
CO3	Evaluate cooling load estimation, air-conditioning systems, psychrometric processes, and refrigeration equipment for residential and industrial applications.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Design refrigeration and air-conditioning systems by selecting suitable components, refrigerants, and operating conditions to improve energy efficiency.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Assess the performance, environmental impact, and sustainability of conventional and advanced refrigeration systems using modern engineering tools and energy analysis techniques.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) Low; (2) = Medium; (3) = High

26TE013	Air-Conditioning Systems	L	T	P	C
		3	0	0	3

Course Objectives:

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

Unit I	Air Conditioning Principles & Comfort Design	9

Air conditioning basics, psychometric 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.

Unit II	Load Analysis & Sustainability	9

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

Unit III	Air Distribution Systems	9

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.

Unit IV	Operation of Different Systems	9

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

Unit V	Air Conditioning Applications and Energy Management	9

Applications of air conditioning systems in residential, commercial, industrial, healthcare, clean room and data centre buildings, Selection of suitable air conditioning systems, Indoor Air Quality (IAQ) management, Energy-efficient operation, Sustainable cooling practices and system performance evaluation.

Activities: Case study on HVAC applications in commercial buildings or hospitals, Comparative analysis of different air conditioning systems, Performance evaluation and energy analysis using simulation tools.

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. Faye C. McQuiston, Jerald D. Parker, Jeffrey D. Spitler and Hessam Taherian, Heating, Ventilating, and Air Conditioning: Analysis and Design, 7th Edition, John Wiley & Sons, 2023.
2. C. P. Arora, Refrigeration and Air Conditioning, 3rd Edition, McGraw-Hill Education, 2009.

References:

1. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), 2025 ASHRAE Handbook—Fundamentals, ASHRAE, 2025.
2. Robert McDowall, Fundamentals of HVAC Systems, 1st Edition, Elsevier, 2007.
3. H. B. Awbi, Ventilation of Buildings, 2nd Edition, Spon Press/Routledge, 2003.
4. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), 2024 ASHRAE Handbook—HVAC Systems and Equipment, ASHRAE, 2024.
5. Edward G. Pita, Air Conditioning Principles and Systems: An Energy Approach, 4th Edition, Pearson Education, 2018.

E-resources:

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

https://comfort.cbe.berkeley.edu/ https://beeindia.gov.in/

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the fundamentals of air conditioning, psychrometric processes, indoor air quality (IAQ), thermal comfort, and HVAC design principles.	PO3 (3)	3	—
CO2	Analyze cooling load estimation, building heat gain, energy-efficient building design, and sustainable cooling techniques for HVAC applications.	PO1 (3), PO3 (3)	3	3
CO3	Design and evaluate air distribution systems, ducts, diffusers, fans, and ventilation systems for efficient airflow and thermal comfort.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Assess the performance and selection of centralized and decentralized air conditioning systems for residential, commercial, and industrial applications.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Develop energy-efficient HVAC solutions by integrating indoor air quality management, energy management strategies, and sustainable air Conditioning technologies.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) = Low; (2) = Medium; (3) = High

26TE014	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.

Unit I	Energy Auditing	9

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.

Unit II	Electrical Motor & Lighting Audit	9

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.

Unit III	HVAC and Building Audits	9

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

Unit IV	Energy Audit Instruments	9

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 man.

Unit V	Energy Audit Applications and Reporting	9

Applications of energy auditing in industrial, commercial and residential sectors, Interpretation of audit results, Energy conservation opportunities, Cost-benefit analysis, Preparation of energy audit reports, Carbon footprint assessment, Energy management practices and implementation of audit recommendations.

Activities: Conduct a comprehensive energy audit case study, Prepare a complete energy audit report for a selected facility, Compare energy-saving measures and recommend suitable energy conservation strategies

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. Moncef Krarti, Energy Audit of Building Systems: An Engineering Approach, 4th Edition, CRC Press, 2026.
2. Albert Thumann, Terry Niehus and William J. Younger, Handbook of Energy Audits, 9th Edition, CRC Press, 2012.

References:

1. Steve Doty, Commercial Energy Auditing Reference Handbook, 3rd Edition, Fairmont Press, 2016.
2. Frank Kreith and D. Yogi Goswami, Eds., Energy Management and Conservation Handbook, 2nd Edition, CRC Press, 2016.
3. Barun Kumar De, Energy Management, Audit and Conservation, Vrinda Publications, 2007.
4. ASHRAE, Procedures for Commercial Building Energy Audits, 2nd Edition, ASHRAE, 2011.
5. C. B. Smith and Kelly E. Parmenter, Energy Management Principles: Applications, Benefits, Savings, 2nd Edition, Elsevier, 2015.

E-resources:

https://nptel.ac.in/courses/115/105/115105122/
https://nptel.ac.in/courses/108/108/108108076/
https://nptel.ac.in/courses/112/107/112107293/
https://nptel.ac.in/courses/108/105/108105153/
https://www.energystar.gov/buildings https://www.ashrae.org/

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the principles, procedures, standards, and methodologies of energy auditing for thermal and electrical utilities, including energy performance assessment.	PO3 (3)	3	—
CO2	Analyze electrical utilities, lighting systems, motors, power factor improvement, and energy-saving opportunities using energy audit techniques.	PO1 (3), PO3 (3)	3	3
CO3	Evaluate HVAC systems, building energy performance, cooling load, thermal insulation, and energy conservation measures through detailed energy audits.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Apply modern energy audit instruments and measurement techniques to assess the performance of thermal and electrical systems and identify energy-saving measures.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Develop comprehensive energy audit reports and recommend energy management, carbon reduction, and sustainability strategies for industrial, commercial, and residential applications.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) = Low; (2) = Medium; (3) = High

26TE015	Sustainability in Buildings	L	T	P
		3	0	0

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.

Unit I	Foundations of Sustainable Building Design	9

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.

Unit II	Sustainable Landscaping and Building Envelopes	9

Energy-efficient landscaping: microclimate modification, xeriscaping, shading devices, arbors, green roofs, Role of vegetation in passive design, Building envelope design: thermal comfort, psychometric, 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.

Unit III	Passive Strategies and Climate-Responsive Architecture	9

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, Day lighting 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.

Unit IV	Building Performance, Renewable Integration & Simulation	9

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.

Unit V	Sustainable Building Applications and Green Certification	9

Applications of sustainable building principles in residential, commercial, institutional and industrial buildings, Green building certification procedures (LEED, GRIHA, IGBC and WELL), Building performance evaluation, Energy-efficient retrofitting, Carbon footprint assessment and sustainable building operation and maintenance.

Applications: Comparative assessment of green building projects, Case study on certified green buildings, Performance evaluation using Energy Plus/eQuest/IES-VE for compliance with green building standards.

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. Francis D. K. Ching and Ian M. Shapiro, Green Building Illustrated, 2nd Edition, John Wiley

& Sons, 2020.

2. Dorothy Gerring, Renewable Energy Systems for Building Designers: Fundamentals of Net Zero and High Performance Design, 1st Edition, Routledge, 2023.

References:

1. Moncef Krarti, Energy Audit of Building Systems: An Engineering Approach, 3rd Edition, CRC Press, 2024.
2. Charles Eley, Design Professional’s Guide to Zero Net Energy Buildings, Island Press, 2016.
3. Andreas Athienitis and William O’Brien (Eds.), Modeling, Design, and Optimization of Net-Zero Energy Buildings, Wilhelm Ernst & Sohn, 2015.
4. Miles Keeping and David Shiers (Eds.), Sustainable Built Environments: Principles and Practice, John Wiley & Sons, 2017.
5. Benjamin Duraković, Zero Energy Buildings: Fundamentals, Materials and Technologies for a Sustainable Future, 1st Edition, Springer, 2026.

E-resources:

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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	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the principles of sustainable building design, green building concepts, climate-responsive architecture, and environmental rating systems.	PO3 (3)	3	—
CO2	Analyze sustainable building materials, landscaping, passive design strategies, and energy-efficient construction practices for green buildings.	PO1 (3), PO3 (3)	3	3
CO3	Evaluate passive heating, cooling, day lighting, natural ventilation, and climate-responsive building techniques to improve energy efficiency and indoor comfort.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Design and assess energy-efficient buildings by integrating renewable energy systems, building performance simulation, and thermal analysis using modern engineering tools.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Assess sustainable building performance using green building rating systems, energy audits, life cycle assessment, and environmental sustainability principles.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) =Low; (2) = Medium; (3) = High

26TE016	Air and Chilled Water Systems for HVAC Applications	L	T	P	C
		3	0	0	3

Course Objectives:

. To understand chilled water systems and chiller configurations, design HVAC systems including piping, ducts and air distribution, and apply smart controls for energy-efficient and IAQ-compliant building environments.

Unit I	Water Chillers – Fundamentals & Configurations	9

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

Unit II	Chiller Design & System Components	9

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.

Unit III	Air Handling Units & Duct Design	9

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

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

Unit IV	Air Distribution Systems	9

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.

Unit V	Ventilation, Filtration & Air Quality Control	9

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.

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. Herbert W. Stanford III, HVAC Water Chillers and Cooling Towers: Fundamentals, Application, and Operation, 2nd Edition, CRC Press, 2011.
2. Althouse, Turnquist and Bracciano, Modern Refrigeration and Air Conditioning, 20th Edition, Goodheart-Willcox, 2018.

References:

1. Herbert W. Stanford III, HVAC Water Chillers and Cooling Towers: Fundamentals, Application, and Operation, 2nd Edition, CRC Press, 2011.
2. Howard J. McKew (Ed.), Air-Conditioning System Design Manual, 3rd Edition, ASHRAE, 2019.
3. ASHRAE, Duct Systems Design Guide, ASHRAE.
4. Roger W. Haines and Douglas C. Hittle, Control Systems for Heating, Ventilating, and Air Conditioning, 6th Edition, Springer, 2003.
5. Shan K. Wang, Handbook of Air Conditioning and Refrigeration, 2nd Edition, McGraw-Hill, 2001.

E-resources:

https://nptel.ac.in/courses/112105129
https://nptel.ac.in/courses/112106271
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 the fundamentals, configurations, components, and performance characteristics of chilled water systems and HVAC applications.	PO3 (3)	3	—
CO2	Analyze chiller plant design, chilled water piping, thermal energy storage, and system optimization for energy-efficient HVAC systems.	PO1 (3), PO3 (3)	3	3
CO3	Design and evaluate Air Handling Units (AHUs), duct systems, air distribution networks, and airflow characteristics for indoor environmental quality.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Assess air distribution systems, hydronic heat pumps, VAV/CAV systems, heat recovery, and energy-efficient HVAC operation using engineering principles.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Develop energy-efficient HVAC solutions by integrating ventilation systems, indoor air quality (IAQ), filtration, smart controls, and sustainable building practices.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) Low; (2) = Medium; (3) = High

26TE017	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.

Unit I	Fundamentals & Applications of Low-Temperature Refrigeration	9

Temperature limits, material behavior, 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

Unit II	Gas Liquefaction & Purification	9

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

Unit III	Cryo-Coolers	9

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

Unit IV	Storage, Transport & Instrumentation	9

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

Unit V	Applications Of Low-Temperature Refrigeration Systems	9

Applications of cryogenic refrigeration systems in industrial gas production, Medical and healthcare systems, Space and aerospace technologies, Superconducting systems, Food preservation, LNG production and storage, Cryogenic safety practices, Performance evaluation and operation of low-temperature refrigeration systems.

Activities: Case study on LNG or medical cryogenic systems, Comparative analysis of cryogenic refrigeration applications, Performance evaluation of low-temperature refrigeration systems using simulation or experimental data.

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. Thomas M. Flynn, Cryogenic Engineering, 2nd Edition, CRC Press, 2004.
2. Alexander Alekseev, Process Design for Cryogenics, Wiley, 2024.

References:

1. Alexander Alekseev, Process Design for Cryogenics, 1st Edition, Wiley-VCH, 2024.
2. Mamata Mukhopadhyay, Fundamentals of Cryogenic Engineering, PHI Learning, 2010.
3. Pipkov, Fundamentals of Vacuum Engineering, Mir Publishers.
4. Randall F. Barron, Cryogenic Systems, 2nd Edition, Oxford University Press, 1985.
5. Thomas M. Flynn, Cryogenic Engineering: Revised and Expanded, 2nd Edition, CRC Press, 2004.

E-resources:

https://nptel.ac.in/courses/112105153
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 the fundamentals of low-temperature refrigeration, cryogenic principles, gas liquefaction, and material behavior at cryogenic temperatures.	PO3 (3)	3	—
CO2	Analyze gas liquefaction, purification systems, cryogenic cycles, and low-temperature refrigeration processes for industrial applications.	PO1 (3), PO3 (3)	3	3
CO3	Evaluate the performance of cryo-coolers, regenerative refrigeration systems, magnetic refrigeration, and advanced cryogenic technologies.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Design cryogenic storage, transportation, insulation, Instrumentation, and safety systems for handling liquefied gases and low-temperature applications.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Assess the applications of low-temperature refrigeration systems in industrial gas production, medical, aerospace, superconducting, and food processing industries using modern engineering tools.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) Low; (2) = Medium; (3) = High

26TE018	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.

Unit I	Wave Motion & Shock Waves	9

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.

Unit II	Air-Breathing Engines	9

Aircraft propulsion theory, turboprop, turbojet, turbofan, turbo shaft, 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.

Unit III	Thermodynamics of Aircraft Engines	9

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.

Unit IV	Rocket Propulsion	9

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.

Unit V	Rocket Staging & Performance	9

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.

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. John D. Anderson, Jr., Modern Compressible Flow: With Historical Perspective, 4th Edition, McGraw-Hill Education, 2021.
2. Pasquale M. Sforza, Theory of Aerospace Propulsion, 2nd Edition, Butterworth-Heinemann, 2016.

References:

1. Philip G. Hill and Carl R. Peterson, Mechanics and Thermodynamics of Propulsion, 2nd Edition, Pearson, 1991.
2. S. M. Yahya, Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion, 3rd Edition, New Age International, 2010.
3. George P. Sutton, Oscar Biblarz and James H. Morehart, Rocket Propulsion Elements, 10th Edition, John Wiley & Sons, 2026.
4. K. Ramamurthi, Rocket Propulsion, 2nd Edition, Trinity Press/Laxmi Publications, 2016.
5. James E. A. John and Theo G. Keith, Gas Dynamics, 3rd Edition, Pearson Prentice Hall, 2006.

E-resources:

https://nptel.ac.in/courses/101104007
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https://www.nasa.gov/glenn
https://arc.aiaa.org

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the fundamentals of gas dynamics, compressible flow, shock waves, expansion waves, and wave motion for aerospace and propulsion applications.	PO3 (3)	3	—
CO2	Analyze the performance and operating principles of air-breathing propulsion systems, including turbojet, turbofan, ramjet, scramjet, and pulsejet engines.	PO1 (3), PO3 (3)	3	3
CO3	Evaluate engine–aircraft matching, inlet and nozzle design, propulsion system performance, and aerodynamic characteristics using engineering principles.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Design and assess rocket propulsion systems, propellants, combustion processes, thrust generation, and advanced Propulsion technologies for space applications.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Assess the performance of rocket and space propulsion systems by applying mission analysis, stage optimization, payload estimation, and modern computational tools.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1) =Low; (2) = Medium; (3) = High

26TE019	**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.

Unit I Energy And Environment — **9**

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.

Unit II Solar Energy — **9**

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.

Unit III Wind Energy — **9**

Wind data and energy estimation – Betz limit - Site selection for wind farms – 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

Unit IV Bio-Energy — **9**

Bio resources – Thermochemical Conversion: combustion, gasification, pyrolysis and carbonization – 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.

Unit V Hydro & Wave Energy Systems — **9**

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.

TOTAL : 45 PERIODS

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

Assessment Methodology: Quiz (10%), Assignment (20%), Flipped Class (10%), Competitive Examinations (20%), Internal Examinations (40%).

Text Books:

1. John Twidell, Renewable Energy Resources, 4th Edition, Routledge, 2021.
2. John A. Duffie, William A. Beckman and Nathan Blair, Solar Engineering of Thermal Processes, Photovoltaics and Wind, 5th Edition, John Wiley & Sons, 2020.

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 Edition.

E-resources:

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https://www.classcentral.com/course/swayam-renewable-energy-power-plants-503053
https://www.classcentral.com/course/swayam-renewable-energy-technologies-473693

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the fundamentals of renewable energy resources, Energy–environment interactions and the role of renewable energy in sustainable development.	PO3 (3)	3	—
CO2	Analyze the design, performance, and applications of solar energy systems, including solar thermal and photovoltaic technologies.	PO1 (3), PO3 (3)	3	3
CO3	Evaluate wind energy conversion systems, biomass energy technologies, biofuels, and waste-to-energy systems for efficient energy utilization.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Design and assess hydro, wave, geothermal, and hybrid renewable energy systems by applying engineering principles and performance analysis techniques.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO5	Develop sustainable renewable energy solutions by integrating multiple renewable energy technologies, environmental assessment, and energy management for real-world applications.	PO1 (3), PO2 (3), PO3 (3)	3	3

(1)=Low; (2) = Medium; (3) = High

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