M.E. Degree

in

Energy Engineering

CURRICULUM & SYLLABUS (CBCS)

(Innovation and product development for Sustainability)

(For students admitted from the Academic Year 2026-2027)

DEPARTMENT OF MECHANICAL ENGINEERING

St. XAVIER'S CATHOLIC COLLEGE OF ENGINEERING

CHUNKANKADAI, NAGERCOIL – 629 003.

KANYAKUMARI DISTRICT, TAMIL NADU, INDIA

St. XAVIER'S CATHOLIC COLLEGE OF ENGINEERING
Chunkankadai, Nagercoil – 629 003.

AUTONOMOUS COLLEGE AFFILIATED TO ANNA UNIVERSITY

M.E. ENERGY ENGINEERING CURRICULUM

ACADEMIC REGULATIONS 2026

The curriculum incorporates the necessary mechanical engineering fundamentals, advanced technologies, communication and management skills required to solve local, global needs with ethical and society concern. The curriculum shows a close alignment with the program outcome and the program specific outcome. In which, the various courses impart in the curriculum shall inculcate deep knowledge and skills required for a mechanical engineer. The curriculum learning outcomes result successful mechanical engineering professionals with excellent skills as that focused by the program outcome and program specific outcome. The pupil transformation through the curriculum will show a good degree of coherence with the college mission and vision, creating young vibrant technocrats for global society with ethical values.

VISION OF THE INSTITUTION

To be a centre of excellence in engineering education and research for a technically empowered humane society.

MISSION OF THE INSTITUTION

- M 1. Foster a vibrant academic environment for learning fundamental concepts, emerging technologies, and research-oriented practices.
- M 2. Cultivate personal maturity and professional skills through stimulating coaching and practical training.
- M 3. Provide inspiring high calibre faculty to mentor students from diverse backgrounds, especially the underprivileged.
- M 4. Create ample opportunities to transform rural youth into top class professionals and technocrats, capable of serving at the local and global levels with ethical integrity.

I. PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

1	Able to identify, design, analyse and solve complex and evolving problems in energy related sectors.
2	Accomplish through Employment, Entrepreneur and perform advanced research in the fields of energy manufacturing and management.
3	Exhibit excellent communication, leadership qualities, lifelong learning ability with professional ethics and human values in profession/career.

II. PROGRAM OUTCOMES (POs)

PO#	Programme Outcomes
1	An ability to independently carry out research/investigation and development work to solve practical problems
2	An ability to write and present a substantial technical report/document.
3	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.
4	Students should be able to exhibit skill to use modern tools, softwares and techniques to analyse and improve the efficiency of energy systems and management in an organization.
5	Students should be able to work autonomously and also with team towards designing energy products and multidisciplinary task with environment concern and sustainable development.
6	Students should be able to divulge energy solution for business conglomerates and society in ethical manner and develop competence through life-long learning.

III. PROGRAM SPECIFIC OUTCOMES (PSOs) - (3 to 4 statements)

1	Develop necessary skills to design, develop and analyse energy systems using modern tools and technologies.
2	Design and critically analyse the efficient production of energy from bio-mass and other renewable sources.
3	Engage in research process embracing lifelong learning independently with the zeal to start up their own businesses for the welfare of the society.

PEO’s – PO’s & PSO’s MAPPING:

PROGRAMME EDUCATIONAL OBJECTIVES	PROGRAMME OUTCOMES					
	1	2	3	4	5	6
I	3	2	2	-	3	1
II	3	1	3	2	2	-
III	3	1	3	2	2	2

SEMESTER: I

Number of Courses: 7
Total Credits: 22

Course Code	Course Title	Course Type	Classroom Instruction (CI) (in Hours per Semesters)		Lab Instruction (LI) (in Hours per Semesters)	Term Work(TW) and Self Learning(SL) (in Hours per Semesters)	Total Number of Hours (in Hours per Semesters)	Total Credits (C)=(Total Hours/30)	SDG Goal Mapped	Category
			L	T	P					
IP26C07	Induction Programme*	IP	24	0	0	6	30	0	4,8,9,16 ,17	MNC
MA26103	Optimization Techniques and Statistical Modelling for Energy Engineering	TCP	45	15	0	60	120	4	4,7,9, 12,13	BSC
EY26101	Applied Thermodynamic Analysis for Energy Systems	TC	45	15	0	60	120	4	4, 9	PCC
EY26102	Instrumentation and Control	TC	30	15	0	45	90	3	7, 9	PCC
EY26103	Renewable Energy Systems	TCP	30	15	30	45	120	4	7, 11,12, 13,14	PCC
RM26C01	Research Methodology and Intellectual Property Rights	TC	45	15	0	60	120	4	1,2,3,7	RMC
RM26C02	Research Tools Laboratory	PC	0	0	60	0	60	2	4, 9,16 17	EEC
EY26105	Technical Seminar	PC	0	0	30	0	30	1	SDG depends on topic	EEC
	Total		249	105	75	261	590	22		

* - Internally Evaluated Courses

SEMESTER: II

Number of Courses: 8
Total Credits: 21

Course Code	Course Title	Course Type	Classroom Instruction (CI) (in Hours per Semesters)		Lab Instruction (LI) (in Hours per Semesters)	Term Work(TW) and Self Learning (SL) (in Hours per Semesters)	Total Number of Hours (in Hours per Semesters)	Total Credits (C) = (Total Hours/30)	SDG Goal Mapped	Category
			L	T	P					
EY26201	Advanced Fluid Mechanics and Heat Transfer	TC	45	15	0	60	120	4	7.9,12	PCC
EY26202	Computational Fluid Dynamics for Energy Systems	TCP	45	0	30	45	120	4	4,9	PCC
EY26203	Energy Conservation and Management	TC	30	15	0	45	90	3	9	PCC
	Programme Elective - I	TC	30	15	0	45	90	3	As per elective	PEC
	Open Elective	TC	45	0	0	45	90	3	As per elective	OEC
EY26204	Applied Thermal Engineering Laboratory	PC	0	0	60	0	60	2	9	PCC
	Industry Collaborated Course - I	PC	0	0	30	0	30	1	9	EEC
	Self-Learning Course	TC	0	0	0	30	30	1	4	EEC
	Total	-	180	60	120	270	630	21	-	-

PROGRAM ELECTIVE COURSES
SEMESTER II (PROGRAM ELECTIVE I)

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1	EY26001	Modeling and Analysis of Energy Systems	PEC	3	0	0	3	3
2	EY26002	Alternative fuels	PEC	3	0	0	3	3
3	EY26003	Green Buildings	PEC	3	0	0	3	3
4	EY26004	Environmental Engineering and Pollution Control	PEC	3	0	0	3	3

OPEN ELCTIVE COURSES
SEMESTER II (OPEN ELECTIVE I)

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1	EY26901	Energy and Environmental Management	OEC	3	0	0	3	3
2	EY26902	Bioenergy and biomass conversion	OEC	3	0	0	3	3

SEMESTER I

<table>
<tr><td rowspan="2">IP26C07</td><td rowspan="2">INDUCTION PROGRAMME</td><td>L</td><td>T</td><td>P</td><td>TW/ SL</td><td>Total</td><td>C</td><td>SDG</td></tr>
<tr><td>24</td><td>0</td><td>0</td><td>6</td><td>30</td><td>0</td><td>4,8,9,16,17</td></tr>
<tr><td colspan="9">COURSE OBJECTIVES:</td></tr>
<tr><td colspan="9">• To familiarize students with institutional policies, academic regulations, and programme structure.
• To introduce research methodology, ethical practices, and emerging engineering trends.
• To develop communication, technical writing, and presentation skills.
• o create awareness about career opportunities, higher education, and industry expectations.
• To inculcate professional ethics, teamwork, and leadership qualities.</td></tr>
<tr><td colspan="9">COURSE CONTENT:</td></tr>
<tr><td>UNIT 1</td><td>INSTITUTIONAL ORIENTATION</td><td>4</td><td>0</td><td>0</td><td>1</td><td>5</td><td></td><td>4</td></tr>
<tr><td colspan="9">Vision, Mission, and Quality Policy – Organizational structure – Campus facilities – Library, laboratory, and IT infrastructure – Student support systems – Interaction with faculty and peers.
Activities:
Campus Resource Mapping and Group Presentation.</td></tr>
<tr><td>UNIT 2</td><td>ACADEMIC REGULATIONS & PROGRAMME STRUCTURE</td><td>4</td><td>0</td><td>0</td><td>1</td><td>5</td><td></td><td>4,9</td></tr>
<tr><td colspan="9">Choice Based Credit System (CBCS) – Curriculum framework – Credit requirements – Evaluation and assessment procedures – Attendance norms – Examination system – Academic integrity guidelines.
Activities:
Preparation of Individual Academic Plan.</td></tr>
<tr><td>UNIT 3</td><td>RESEARCH METHODOLOGY & EMERGING TECHNOLOGIES</td><td>8</td><td>0</td><td>0</td><td>2</td><td>10</td><td></td><td>4</td></tr>
<tr><td colspan="9">Research process – Problem identification – Literature review – Research ethics and plagiarism – Overview of emerging technologies (AI, Data Science, IoT, etc.) – Interdisciplinary research opportunities.
Activities:
Mini Research Problem Identification and Presentation.</td></tr>
<tr><td>UNIT 4</td><td>SKILL DEVELOPMENT & CAREER PLANNING</td><td>4</td><td>0</td><td>0</td><td>1</td><td>5</td><td></td><td>8</td></tr>
<tr><td colspan="9">Communication skills – Technical writing – Presentation skills – Resume preparation – Career opportunities – Higher studies – Competitive exams – Internship and placement readiness.
Activities:
Resume Preparation and Elevator Pitch Presentation.</td></tr>
<tr><td>UNIT 5</td><td>PROFESSIONAL DEVELOPMENT & WELL-</td><td>4</td><td>0</td><td>0</td><td>1</td><td>5</td><td></td><td>16,17</td></tr>
</table>

	BEING							

Engineering ethics – Professional values – Teamwork and leadership – Innovation and entrepreneurship – Startup ecosystem – Time management – Stress management – Counseling and mentoring support.

Activities:

Case Study Analysis on Ethics and Teamwork.

COURSE OUTCOMES:

1	Apply institutional policies and academic regulations to manage postgraduate studies effectively.
2	Apply research methodologies and ethical principles to identify research problems.
3	Demonstrate communication, technical writing, and presentation skills.
4	Analyze career opportunities and industry expectations for informed decision-making.
5	Apply professional ethics and teamwork skills in academic and organizational environments.

Weightage: Continuous Assessment: 100%

Assessment Methodology: Active Participation (40%), Assignments(30%), Quiz(30%)

REFERENCES:

1	Johri, A., International Handbook of Engineering Education Research, Taylor & Francis, 2023.
2	Murthy, D. N. P., & Page, N. W., Education and Research for the Future, Springer, 2023.
3	Oliveira, T. A., & Hebebci, M. T. (Eds.), Current Academic Studies in Technology and Education 2024, ISRES Publishing, 2024.
4	Kannan, R., Thirumalai, P., & Geetha, T. V. (Eds.), Proceedings of the International Conference on Technology for Education (T4E 2024), Springer, 2024.
5	Rajesh, S., Raghu Prasad, B. K., & Praveen, K. V. (Eds.), Recent Advances in Sustainable Construction Technology, Geotechnics and Structural Engineering, Springer, 2026.

E RESOURCES/E MATERIALS:

1.	https://alison.com/course/essentials-of-research-methodology
2.	https://www.coursera.org/learn/research-methodologies

Mapping of Course Outcomes to Programme Outcomes and Programme Specific Outcomes

COs \ POs	PO1 (Research Capability)	PO2 (Technical Communication)	PO3 (Domain Mastery)
CO1	2	1	2
CO2	3	2	2
CO3	1	3	1
CO4	2	2	2
CO5	1	2	1
CO	1.8	2.0	1.6

MA26103	**OPTIMIZATION TECHNIQUES AND STATISTICAL MODELLING FOR ENERGY ENGINEERING**	**L**	**T**	**P**	**TW/SL**	**Total**	**C**	**SDG**
		45	**15**	**0**	**60**	**120**	**4**	**4,7,9, 12,13**

COURSE OBJECTIVES:

- To familiarize the students with the formulation and construction of mathematical models for a linear programming problem in real-life situations.
- To develop student's ability to formulate and solve real world optimization problems using transportation and assignment models.
- To enable students to understand the concepts of correlation, regression and curve fitting.
- To acquaint the student with mathematical tools needed in evaluating Statistical quality control and to apply in the manufacturing industry.
- To acquaint the knowledge of non-parametric tests which plays an important role in real life problems.

COURSE CONTENT:

UNIT 1	**LINEAR PROGRAMMING**	**9**	**3**	**0**	**12**	**24**		**4,7,9**

Formulation of linear programming problems – Graphical solution method – Canonical and standard form of linear programming problem – Simplex method – Artificial variables: Big-M method.

Activity:

Formulate and solve a linear programming problem to maximize profit from machining operations under resource constraints.

UNIT 2	**TRANSPORTATION AND ASSIGNMENT MODELS**	**9**	**3**	**0**	**12**	**24**		**4,9, 13**

Definition of the transportation model – Mathematical formulation of transportation models – Basic feasible solution: Vogel's approximation method – Optimal solution by modified distribution (MODI)

method – Definition of the assignment model – Mathematical formulation of assignment models – Hungarian method for solving assignment problems. **Activity:** Create an assignment model by assigning workers/machines to tasks (energy system maintenance, machining operations, quality inspection) to minimize total time/cost.								
UNIT 3	**CORRELATION, REGRESSION AND MODEL FITTING**	**9**	**3**	**0**	**12**	**24**		**9, 12**
Correlation (discrete case) – Karl Pearson's coefficient of correlation and Spearman's rank correlation – Linear regression – Regression coefficients – Definitions: Unbiased estimators, Efficiency, Consistency, Sufficiency – Curve fitting by the method of least squares (linear and quadratic forms). **Activity:** Fit linear and quadratic models to generator fuel consumption verses electrical load and evaluate goodness of fit.								
UNIT 4	**STATISTICAL QUALITY CONTROL**	**9**	**3**	**0**	**12**	**24**		**9, 12**
The Control Chart – Nature of the Control limits – Control charts for variables or measurements – $\bar{X}$ and R charts for variables – Control charts for attributes – The p- chart for fraction defective – Control Charts for Number of Defectives – c and np charts. **Activity:** Collect shaft diameter measurements or generator voltage readings and construct control charts for both variable data (measurements) and attribute data (defect counts) to monitor quality in engineering processes.								
UNIT 5	**DESIGN OF EXPERIMENTS AND ANALYSIS OF VARIANCE**	**9**	**3**	**0**	**12**	**24**		**9, 12**
Principles of experimental design: Replication, randomization, local control – ANOVA: One-way and two-way classifications – Design techniques: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD). **Activity:** Demonstration of design of experiment software tool.								
COURSE OUTCOMES:								

1	Apply the graphical method, the simplex method, and the Big-M method to solve linear programming problems and obtain optimal solutions.
2	Solve transportation problems using MODI method, and assignment problems using the Hungarian Method to obtain optimal allocation results.
3	Apply curve fitting, regression and correlation techniques to analyze and interpret experimental data.
4	Construct control charts to analyze quality in manufacturing and management processes.
5	Apply ANOVA techniques to experimental designs for real world data problems.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%	
Assessment Methodology: Internal Assessment Test (70%) and Activity (30%).	
REFERENCES:	
1.	Taha. H.A., “Operation Research: An Introduction”, Eleventh edition, Pearson Education, New Delhi, Reprint 2023.
2.	Kanti Swarup, P. K. Gupta and Man Mohan, “Operation Research”, Twentieth edition, Sultan Chand & sons, 2022.
3.	Johnson. R.A., Miller. I.R and Freund. J.E, "Miller and Freund’s Probability and Statistics for Engineers", Ninth edition, Pearson Education, Asia, Nineth edition, reprint 2024, Reprint 2024.
4.	Spiegel. M.R., Schiller. J. and Srinivasan. R.A., "Schaum’s Outline of Theory and Problems of Probability and Statistics", Fourth edition, Tata McGraw-Hill, Reprint 2023.
5.	Gupta. S.C. and Kapoor. V. K., “Fundamentals of Statistics”, Eighth edition, Himalaya Publishing House, Mumbai, 2023.
E resources/E materials:	
1.	https://nptel.ac.in/courses/110106062
2.	https://www.itl.nist.gov/div898/handbook/
3.	https://nptel.ac.in/courses/111/105/111105090/

Mapping of Course Outcomes to Programme Outcomes

Course Outcomes	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	3	2	1	-
CO2	2	-	3	2	1	-
CO3	2	-	3	2	1	-
CO4	2	-	3	2	1	-
CO5	2	-	3	2	1	-
CO	2	-	3	2	1	-

EY26101	APPLIED THERMODYNAMIC ANALYSIS FOR ENERGY SYSTEMS	L	T	P	TW/ SL	Total	C	SDG
		45	15	0	60	120	4	4, 9

COURSE OBJECTIVES:

- To understand the principles of thermodynamics and their applications.
- To analyze the performance of gas mixtures.
- To evaluate the first and second law analysis of reacting system.
- To apply thermodynamic laws to real-world fuel system.
- To develop problem-solving skills in combustion system.

COURSE CONTENT:

UNIT 1	FUNDAMENTALS OF THERMODYNAMIC ANALYSIS	9	3	0	9	21	4	4, 9

Review of thermodynamic systems and properties, First law and second law analysis, Energy balance for closed and open systems- Entropy and irreversibility

Activities:
Analyze a closed and open system (e.g., compressor, turbine) using First and Second Law to calculate efficiency and work output.

UNIT 2	PROPERTIES OF REAL GAS AND GAS MIXTURES	9	3	0	9	21	4	4, 9

Different equations of state. Principle of corresponding States – Use of generalized charts for enthalpy and entropy departure. Fugacity coefficient, Lee – Kesler generalized three parameter tables. Fundamental property relations for systems of variable composition. Ideal and real gas mixtures.

Activities:
Compare ideal vs real gas behavior in high-pressure systems (e.g., gas storage tanks).

UNIT 3	CHEMICAL THERMODYNAMICS AND EQUILIBRIUM	9	3	0	9	21	4	4, 9

First and second law analysis of reacting systems - Adiabatic flame temperature - entropy change of reacting systems. Criterion for reaction equilibrium. Equilibrium constant for gaseous mixtures and evaluation of equilibrium composition.

Activities:
Analyze a chemical reactor efficiency using enthalpy and entropy changes.

UNIT 4	COMBUSTION CHEMISTRY	9	3	0	9	21	4	4, 9

Combustion of Hydrocarbon Fuels. Combustion and formation. Stoichiometric, fuel rich and oxygen rich reactions. Heating value of fuels. Flames and flammability limits. Diffusion and premixed flames.

Activities:
Analyze combustion efficiency improvements in thermal power plants.

UNIT 5	COMBUSTION PROCESSES AND COMBUSTION CHAMBERS	9	3	0	9	21	4	4, 9
Combustion in IC Engines and Gas turbines. Knocking and Detonation. Design principles of combustion chambers for IC Engines and Gas turbine. Arrangements of gas turbine combustion **Activities:** Calculate air-fuel ratio and combustion efficiency for IC engines.								
COURSE OUTCOMES: At the end of the course, the students will be able to:								
1	Apply the laws of thermodynamics to analyze thermodynamic systems.							
2	Apply the properties of ideal and real gases to solve problems involving variable composition systems.							
3	Analyze chemical thermodynamic principles to evaluate system performance.							
4	Apply thermodynamic concepts to improve combustion efficiency in engineering systems.							
5	Evaluate combustion processes in IC engines and gas turbines using combustion analysis techniques.							
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%								
Assessment Methodology: Internal assessment test (70%), Assignment (30%)								
REFERENCES:								
1	Yunus A. Çengel & Michael A. Boles "Thermodynamics: An Engineering Approach" McGraw-Hill, Ninth Edition. 2019.							
2	P.K. Nag "Engineering Thermodynamics" McGraw-Hill, Sixth Edition. 2017.							
3	Moran, Shapiro, Boettner & Bailey "Fundamentals of Engineering Thermodynamics" Wiley, Tenth Edition. 2020.							
4	G.F.C. Rogers & Y.R. Mayhew "Engineering Thermodynamics: Work and Heat Transfer" Pearson, 2021.							
5	Arora & Domkundwar "A Course in Thermal Engineering" Dhanpat Rai Publications. 2022.							
E RESOURCES/E MATERIALS:								
1	NPTEL "Thermodynamics & Energy Engineering courses" 2022, https://nptel.ac.in							

2	MIT OpenCourseWare “Thermodynamics” 2024, https://ocw.mit.edu
3	NPTEL Syllabus & Lecture Notes, Engine Combustion and Emissions, Prof. B.P. Pundir, 2025, https://archive.nptel.ac.in/content/syllabus_pdf/112104033.pdf?utm_source=chatgpt.com
4	NPTEL – IIT Madras, Fundamentals of Combustion, Prof. V. Raghavan, (2025) https://onlinecourses.nptel.ac.in/noc25_me29/preview?utm_source=chatgpt.com

Mapping of Course Outcomes to Programme Outcomes and Programme Specific Outcomes

Course outcomes	PO					
	1	2	3	4	5	6
CO1	3	2	-	-	-	-
CO2	3	3	-	-	2	-
CO3	3	3	-	-	-	-
CO4	3	3	2	-	-	-
CO5	3	3	2	2	-	-
CO	2	3	2	-	-	2

EY26102	**INSTRUMENTATION AND CONTROL**	**L**	**T**	**P**	**TW/SL**	**Total**	**C**	**SDG**
		30	**15**	**0**	**45**	**90**	**3**	**7, 9**

COURSE OBJECTIVES:

- To impart knowledge about characteristics of measurement system and statistical analysis of measured data.
- To make students conversant with the electrical measurements and signal conditioning circuits.
- To provide insight into the digital measuring techniques of physical quantities and Solar instruments.
- To make the students get acquainted with the measurement of thermo-physical properties and air pollutants.
- To inculcate skills in the design and development of measurement and control systems.

COURSE CONTENT:

UNIT 1	**MEASUREMENT SYSTEM: CHARACTERISTICS AND STATISTICAL ANALYSIS**	**6**	**3**	**0**	**9**	**12**		**7**

Introduction to measurement system, Errors in Measurement, Static and Dynamic characteristics of transducers, Statistical analysis of experimental data – Uncertainty analysis, Regression analysis, Design

of experiments – Full and Half factorial design. **Activities:** Conduct experiments on a transducer and plot its calibration curve.								
UNIT 2	**ELECTRICAL MEASUREMENTS AND SIGNAL CONDITIONING**	**6**	**3**	**0**	**9**	**12**		**7**
Voltage, Current, Power, Energy, Time and Frequency measurement, Frequency Counter, Signal conditioning Circuits: Wheatstone bridge – Differential Amplifier – V to I Converter, I to V Converter, Integrator, Differentiator, Instrumentation Amplifier. **Activities:** Measure voltage and current using a multimeter and note the readings.								
UNIT 3	**DIGITAL MEASUREMENT OF PHYSICAL QUANTITIES**	**6**	**3**	**0**	**9**	**12**		**7,9**
Digital measuring techniques of Displacement, Temperature, Pressure, Force, Torque, Vibration, Acceleration, Velocity, Level, Flow, Thermal and Nuclear Radiation. Solar instruments: Pyrheliometers – Pyranometers– Sunshine recorder. **Activities:** Observe and compare pressure and force measurements using digital instruments, Conduct a basic experiment to measure flow or level using suitable sensors.								
UNIT 4	**MEASUREMENT OF THERMO-PHYSICAL PROPERTIES AND AIR POLLUTANTS**	**6**	**3**	**0**	**9**	**12**		**9**
Measurement of Thermal Conductivity – Solids, Liquids and Gas, Viscosity, Gas Diffusion. Calorimetry – Bomb Calorimeter – Continuous flow Calorimeter. Measurement of Heat Transfer, Humidity, Heat flux, pH, Future fuels-biofuels, green hydrogen, ammonia, synthetic fuels, nuclear fusion and EV battery systems. **Activities:** Determine viscosity of a fluid using a suitable method, Prepare a short presentation on future fuels like biofuels, hydrogen, and EV batteries.								
UNIT 5	**CONTROL SYSTEMS**	**6**	**3**	**0**	**9**	**12**		**9**
Introduction to Arduino and Raspberry Pi – Interfacing with I/O devices of system: Sensors, Display devices, Stepper and Servo motors. Measurement by Data Acquisition System. Introduction to Internet of Things (IoT) – Application of IoT with Raspberry Pi for Process monitoring and control – Energy management. **Activities:** Read temperature from a sensor and display it, Record sensor data using a basic system.								
COURSE OUTCOMES: At the end of the course, the students will be able to:								
1	Utilize measurement systems, error analysis and statistical methods for analysing experimental data.							
2	Implement electrical measurement methods and signal conditioning circuits for signal processing applications							

3	Demonstrate digital techniques for measuring physical quantities and solar radiation parameters.
4	Implement measurement techniques for thermo-physical properties and analyse the performance of future fuel systems in engineering applications.
5	Develop IoT-based monitoring and control applications using Arduino, Raspberry Pi and data acquisition systems.

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

Assessment Methodology: Assignments (70%), Activities (30%)

TEXT BOOKS:

1	Lipták, B. G. (Ed.)., "Instrument engineers' handbook: Process measurement and analysis", CRC Press, 2018.
2	Datta, A., & Goel, P., "Practical guide to instrumentation, automation and robotics", Elsevier, 2023.
3	Dunn, W. C. Fundamentals of Industrial Instrumentation and Process Control, 2nd Edition, McGraw Hill, 2023.
4	William Bolton, "Instrumentation and Control Systems", Elsevier (Newnes), third Edition, 2021.
5	William C. Dunn, "Fundamentals of Industrial Instrumentation and Process Control", McGraw Hill, Second Edition, 2023.

E resources/E materials:

1.	NPTEL, "Instrumentation And Control – Video Lectures and Course NPTEL –https:// https://nptel.ac.in/courses/103103037
2.	MIT OpenCourseWare , Instrumentation And Control, https://ocw.mit.edu/search/?q=INSTRUMENTATION+AND+CONTROL

Mapping of Course Outcomes to Programme Outcomes and Programme Specific Outcomes

Course outcomes	PO					
	1	2	3	4	5	6
CO1	2	1	2	1	3	1
CO2	2	1	2	3	3	1
CO3	2	1	3	2	3	1
CO4	3	1	3	2	3	2

CO5	2	2	3	3	3	2
CO	2.2	1.2	2.6	2.2	3.0	1.4

EY26103	**RENEWABLE ENERGY SYSTEMS**	**L**	**T**	**P**	**TW/ SL**	**Total**	**C**	**SDG**
		30	**15**	**30**	**45**	**120**	**4**	**7, 11, 12, 13, 14**

COURSE OBJECTIVES:

- To know the Indian and global energy scenario
- To learn the various solar energy technologies and its applications.
- To educate the various wind energy technologies.
- To explore the various bio-energy technologies.
- To study the ocean and geothermal technologies.

COURSE CONTENT:

UNIT 1	**ENERGY SCENARIO**	**6**	**0**	**6**	**3**	**15**		**7, 11, 13**

Indian energy scenario in various sectors – domestic, industrial, commercial, agriculture, transportation and others – Present conventional energy status – Present renewable energy status-Potential of various renewable energy sources-Global energy status-Per capita energy consumption - Future energy plans

Practical:

1. Determining the characteristics of solar photovoltaic materials and estimation of MPP(I-V curve)

Activities: Seminar on Present Energy scenario in India.

UNIT 2	**SOLAR ENERGY**	**6**	**0**	**6**	**3**	**15**		**7, 11, 13**

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

Practical:

Estimation of solar radiation using measurement devices

Performance evaluation of solar cookers (box type and concentrating type)

Activities: Think – Pair – Share on Solar energy

UNIT 3	**WIND ENERGY**	**6**	**0**	**6**	**3**	**15**		**7, 11, 13**

Wind data and energy estimation – Betz limit - Site selection for windfarms – characteristics - Wind resource assessment - Horizontal axis wind turbine – components - Vertical axis wind turbine – Wind turbine generators and its performance – Hybrid systems – Environmental issues - Applications.

Practical:

1. Synthesis of biodiesel –energy and mass balancing

Activities: Review paper writing on Wind energy

UNIT 4	**BIO-ENERGY**	**6**	**0**	**6**	**3**	**15**		**7, 11, 12**

Bio resources – Biomass direct combustion – thermochemical conversion - biochemical conversion - mechanical conversion - Biomass gasifier - Types of biomass gasifiers - Cogeneration –- Carbonisation – Pyrolysis - Biogas plants – Digesters –Biodiesel production – Ethanol production - Applications.

Practical:

Testing of biomass Gasifier in down draught mode.

Estimation of properties (Flash & Fire point, Viscosity, density and Calorific Value) of biofuel.

Synthesis of biodiesel –energy and mass balancing

Activities: Assignment on Different biomass gasifiers and its applcations

UNIT 5	**OCEAN AND GEOTHERMAL ENERGY**	**6**	**0**	**6**	**3**	**15**		**7, 11, 13, 14**

Small hydro - Tidal energy – Wave energy – Open and closed OTEC Cycles – Limitations – Geothermal energy – Geothermal energy sources - Types of geothermal power plants – Applications – Environmental impact.

Practical:

1. Performance evaluation of engine on biodiesel

Activities: Case study-based learning (real life applications)

COURSE OUTCOMES:

1	Identify the present energy status of Indian and global energy scenario.
2	Describe the basic principles of renewable energy systems.
3	Construct the components, working and technologies involved in solar, wind and bioenergy systems.
4	Distinguishing the different types of solar, wind, ocean and bioenergy systems.
5	Recall the technologies, advantages and applications of renewable energy systems.

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

Assessment Methodology: Activities (20%), Practical (20%), Internal Examinations (60%)

REFERENCES:

1	Godfrey Boyle, “Renewable Energy, Power for a Sustainable Future”, Oxford University Press, U.K., 2022.
2	Rai.G.D., “Non-Conventional Energy Sources”, Khanna Publishers, New Delhi, 2024.
3	Sukhatme.S.P., “Solar Energy: Principles of Thermal Collection and Storage”, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2025.
4	Tiwari G.N., “Solar Energy – Fundamentals Design, Modelling and applications”, Alpha

	Science Intl Ltd, 2025.
5	Twidell, J.W. & Weir A., “Renewable Energy Resources”, EFNSpon Ltd., UK, 2025.

Mapping of Course Outcomes to Program Outcomes

Course Outcomes	PO					
	1	2	3	4	5	6
CO1	2	1	1	1	2	1
CO2	2	2	2	1	2	1
CO3	3	3	2	1	2	1
CO4	3	2	2	-	-	2
CO5	3	2	1	1	2	1
CO	3	2	2	1	2	1

RM26C01	**RESEARCH METHODOLOGY AND INTELLECTUAL PROPERTY RIGHTS**	**L**	**T**	**P**	**TW/ SL**	**Total**	**C**	**SDG**
		45	**15**	**0**	**60**	**120**	**4**	**1,2,3,7**

COURSE OBJECTIVES:

- To understand modern research processes, ethics, and data-driven decision making.
- To familiarize students with research design, data collection, and analysis methods.
- To develop skills in technical writing, publication, and presentation.
- To create awareness on Intellectual Property Rights and patent systems.
- To introduce contemporary research tools and innovation protection mechanisms.

COURSE CONTENT:

UNIT 1	**RESEARCH DESIGN AND MODERN RESEARCH APPROACHES**	**9**	**3**	**0**	**12**	**24**		**1**

Research ecosystem and lifecycle, types of research, problem identification, literature gap analysis, research questions and hypotheses, AI-assisted literature review tools, research design frameworks, qualitative and quantitative research, experimental and survey methods, research ethics and plagiarism awareness.
Activities: Literature gap identification, ethics discussion.

Unit 2	Data Collection, Sources and Preparation	9	3	0	12	24		3

Primary and secondary data sources, digital and open datasets, measurement scales, questionnaire design, sampling techniques, sample size estimation, data preprocessing, cleaning, transformation, and

<table>
<tr><td colspan="8">basic data visualization.
Activities: Questionnaire design, data visualization exercise.</td></tr>
<tr><td>UNIT 3</td><td>DATA ANALYSIS, INTERPRETATION AND SCIENTIFIC COMMUNICATION</td><td>9</td><td>3</td><td>0</td><td>12</td><td>24</td><td></td><td>2</td></tr>
<tr><td colspan="9">Descriptive and inferential statistics, hypothesis testing, correlation and regression basics, introduction to multivariate analysis, use of analytical tools (Excel/SPSS/Python – overview), interpretation of results, technical report writing, journal and conference paper formats (IEEE/IET), presentation techniques.
Activities: Data analysis demo, paper formatting.</td></tr>
<tr><td>UNIT 4</td><td>INTELLECTUAL PROPERTY RIGHTS AND INNOVATION ECOSYSTEM</td><td>9</td><td>3</td><td>0</td><td>12</td><td>24</td><td></td><td>7</td></tr>
<tr><td colspan="9">Concept, meaning, and significance of Intellectual Property Rights (IPR); types of IPR including patents, copyrights, trademarks, industrial designs, and geographical indications; role of IPR in innovation, research, and economic development; overview of national IPR framework with reference to Indian Patent Office and international agreements under World Intellectual Property Organization; importance of IPR in academia, industry, and technology-driven entrepreneurship. Activities: IPR case study.</td></tr>
<tr><td>UNIT 5</td><td>PATENTS AND TECHNOLOGY PROTECTION</td><td>9</td><td>3</td><td>0</td><td>12</td><td>24</td><td></td><td>2,7</td></tr>
<tr><td colspan="9">Patent concepts and objectives, patentability criteria, novelty and inventive step, patent specifications, prior art search, types of patent applications, patent filing process, examination and grant, licensing and technology valuation, career opportunities in patent and innovation management.
Activities: Patent search exercise.</td></tr>
<tr><td colspan="9">COURSE OUTCOMES: At the end of the course, the students will be able to:</td></tr>
<tr><td>1</td><td colspan="8">Apply suitable research methodologies to formulate research problems.</td></tr>
<tr><td>2</td><td colspan="8">Design data collection instruments and choose appropriate sampling methods.</td></tr>
<tr><td>3</td><td colspan="8">Analyze and interpret research data using basic analytical tools.</td></tr>
<tr><td>4</td><td colspan="8">Apply appropriate IP strategies for safeguarding innovations and research outputs.</td></tr>
<tr><td>5</td><td colspan="8">Apply principles of IPR, patents, and ethical research practices in research and innovation activities.</td></tr>
<tr><td colspan="9">Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%</td></tr>
<tr><td colspan="9">Assessment Methodology: Internal Assessment Test (70%), Activities (30%)</td></tr>
<tr><td colspan="9">TEXT BOOKS:</td></tr>
</table>

1.	John W. Creswell, J. David Creswell, “Research Design: Qualitative, Quantitative, and Mixed Methods Approaches”, Fifth Edition, Sage Publications, 2023
2.	Deborah E. Bouchoux, “Intellectual Property: Patents, Trademarks, Copyrights and Trade Secrets”, Fifth Edition, Cengage Learning, 2021
REFERENCES:	
1.	Pamela S. Schindler, “Business Research Methods”, Fourteenth eEdition, McGraw Hill, 2025.
2.	Deborah E. Bouchoux, “Intellectual Property: Patents, Trademarks, Copyrights and Trade Secrets”, Fifth edition, Cengage Learning, 2021.
3.	David Hitchcock, “Patent Searching Made Easy”, Second eEdition, Routledge, 2020.
4.	Wayne C. Booth, Gregory G. Colomb, Joseph M. Williams, Joseph Bizup, William T. FitzGerald, “The Craft of Research”, Fifth edition, University of Chicago Press, 2024.
5.	V.K. Ahuja, “Intellectual Property Rights: Law and Practice”, Third edition, LexisNexis, 2022.
E resources/E materials:	
1.	WIPO IP Portal – Online learning modules on Intellectual Property Rights and patents.(https://www.wipo.int/academy)
2.	Google Scholar – Scholarly literature search and citation tracking platform.(https://scholar.google.com)
3.	Indian Patent Office (IPO) Website – Patent search, filing procedures, and legal guidelines. (https://ipindia.gov.in)

Mapping of Course Outcomes to Programme Outcomes

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	1	1
CO2	3	3	3	2	2	1
CO3	3	3	2	3	3	1
CO4	2	2	3	2	2	3
CO5	2	2	2	2	1	3

RM26C02	RESEARCH TOOLS LABORATORY	L	T	P	TW /SL	Total	C	SDG
		0	0	60	0	60	2	4, 9,16 17

COURSE OBJECTIVES:

- To provide hands-on training in modern research and project management tools.
- To develop skills in literature review, reference management, and plagiarism checking.
- To train students in research paper formatting, writing, and publication workflow.
- To introduce data analysis and visualization tools for research applications.
- To enable preparation of professional research reports and technical presentations.

LIST OF ACTIVITIES:

1. Research Planning and Project Management
1.1 Research lifecycle, milestones, and project planning
1.2 Gantt chart preparation using MS Project / Notion / OneNote

2. Literature Review and Reference Management
2.1 Advanced literature search using Google Scholar / Scopus
2.2 Reference management using Mendeley / Zotero

3. Research Problem Identification
3.1 Literature gap analysis, AI-assisted literature gap analysis
3.2 Research problem, objectives, and hypothesis formulation

4. Research Paper Formatting
4.1 IEEE / IET journal and conference templates
4.2 Professional writing using Overleaf , Grammarly

5. Publication Workflow
5.1 Journal selection using Elsevier Journal Finder
5.2 Peer review process and reviewer response simulation

6. Data Analysis – Basic Tools
6.1 Data entry, cleaning, and preprocessing
6.2 Descriptive statistics and graphical visualization

7. Data Analysis – Advanced Tools
7.1 Introduction to SPSS / MATLAB for research analysis
7.2 Interpretation of results and inference

8. Plagiarism Detection and Research Ethics
8.1 Plagiarism checking using Turnitin / Urkund
8.2 Ethical paraphrasing and citation practices

9. Referencing and Citation Standards

9.1 IEEE, APA referencing styles 9.2 Automated citation generation and consistency check 10. AI in Research and Automation 10.1 AI tools for research assistance, ChatGPT ,Perplexity AI -Automated summarization, idea generation 10.2 Ethical use of AI in research	
COURSE OUTCOMES: At the end of the course, the students will be able to:	
1	Plan and manage research activities using modern research tools.
2	Conduct systematic literature review and manage references effectively.
3	Analyze and interpret research data using suitable software tools.
4	Prepare plagiarism-free research papers and technical reports.
5	Present research findings professionally through reports and presentations.
Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%	
Assessment Methodology: Evaluation of Student's work, Observation, Record, Activities etc.(75%), Model Practical Exam (25%)	
REFERENCES:	
1.	Wayne C. Booth, Gregory G. Colomb, Joseph M. Williams, Joseph Bizup, William T. FitzGerald, "The Craft of Research", Fifth edition, University of Chicago Press, 2024.
2.	John W. Creswell, J. David Creswell, "Research Design: Qualitative, Quantitative, and Mixed Methods Approaches", Fifth edition, SAGE Publications, 2023.
3.	Mark N. K. Saunders, Philip Lewis, Adrian Thornhill, "Research Methods for Business Students", Ninth edition, Pearson Education, 2023.
4.	Herman Aguinis, "Research Methodology: Best Practices for Rigorous, Credible, and Impactful Research", SAGE Publications, 2025.
5.	Jiawei Han, Micheline Kamber, Jian Pei, "Data Mining: Concepts and Techniques", Third edition, 2025
E resources/E materials:	
1.	Reference organization, citation generation, PDF management https://www.mendeley.com

2.	Collaborative LaTeX writing for research papers https://www.overleaf.com
3.	Plagiarism detection and originality reports https://www.turnitin.com

Mapping of Course Outcomes to Programme Outcomes

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	3	3	1
CO2	2	3	2	3	3	1
CO3	3	3	2	3	3	1
CO4	2	2	3	2	2	3
CO5	2	2	2	2	2	2
CO	2	2	2	2	2	1

EY26105	**TECHNICAL SEMINAR**	**L**	**T**	**P**	**TW /SL**	**Total**	**C**	**SDG**
		0	**0**	**30**	**0**	**30**	**1**	**-**

OBJECTIVES	
1	To Enhance the ability of self-study
2	To Improve the presentation and communication skills
3	To Increase the breadth of knowledge.

GUIDELINES

Activity	**Instructions**	**Submission week**	**Evaluation**
Selection of area of interest and Topic	You are requested to select an area of interest, topic and state an objective	2nd week	5 % Based on clarity of thought, current relevance Stating an and clarity in writing
Collecting Information about your	1. List 2 journals 2. List 2 conferences, symposia or workshops 3.	3rd Week	5 % (the selected information must be area specific and of international and national standard)

area & topic	List 3 web presences (mailing lists, forums, news sites) 4. List 3 authors who publish regularly in your area.		
Collection of Journal papers in the topic in the context of the objective collect 10	Students have to provide a complete list of references you will be using Based on your objective Search various digital libraries and Google Scholar When picking papers to read - try to Pick papers that are related to each other in some ways and/or that are in the same field so that you can write a meaningful survey out of them. Favour more recent papers.	4th Week	10 % (the list of standard papers and reason for selection)
Draft outline and Linking papers	Prepare a draft Outline, your survey goals, along with a classification / categorization diagram	6th week	10% (this component will be evaluated based on the linking and classification among the papers)
Abstract	Prepare a draft abstract and give a presentation	7th week	10% (Clarity, purpose and conclusion)
Sections of the paper	Write the sections of your paper based on the classification / categorization diagram in keeping with the goals of your survey	9th week	10% (this component will be evaluated based on the linking and classification among the papers)
Final Draft	Complete the final draft of your paper 13th week 10% (formatting, English, Clarity and linking)	11th Week	10% Plagiarism Check Report
Seminar	A brief 15 slides on your paper	12th to 14th Week	40% (based on presentation and Viva-voce)
		Total	30

OUTCOMES: At the end of the course the students would be able to	
1	Identify a relevant technical topic in the field of engineering.
2	Examine technical literature related to the selected topic.
3	Summarize the key findings from the reviewed literature.
4	Develop a structured technical report for the selected topic
5	Present the technical content effectively using appropriate tools

Mapping of Course Outcomes to Programme Outcomes

Course outcomes	PO					
	1	2	3	4	5	6
CO 1	3	2	1	1	1	1
CO 2	3	2	1	1	1	1
CO 3	3	2	1	1	1	2
CO 4	3	2	1	1	1	1
CO	3	2	1	1	1	1

SEMESTER 2

EY26201	**ADVANCED FLUID MECHANICS AND HEAT TRANSFER**	**L**	**T**	**P**	**TW/ SL**	**Total**	**C**	**SDG**
		45	**15**	**0**	**60**	**120**	**4**	**7.9,12**

COURSE OBJECTIVES:

- To apply governing equations of fluid flow to analyze engineering systems.
- To apply incompressible and compressible flow behavior in practical applications.
- To apply heat transfer principles (conduction, convection, radiation) in thermal systems.
- To analyze turbulent flow and its impact on heat transfer performance.
- To design different type of heat exchangers for industrial applications.

COURSE CONTENT:

UNIT 1	**BASIC EQUATION AND BOUNDARY LAYER THEORY**	**9**	**0**	**0**	**9**	**18**		**7, 9, 12**

Three dimensional forms of governing equations – Mass, Momentum and Energy equations. stream and potential functions. Boundary Layer – displacement, momentum and energy thickness – laminar and turbulent boundary layers in flat plates and circular pipes.

Activities:

Solve numerical problems on boundary layer thickness and drag over flat plates.

UNIT 2	**INCOMPRESSIBLE AND COMPRESSIBLE FLOWS**	**9**	**0**	**0**	**9**	**18**		**7, 9, 12**

Flow through circular pipe – friction factor – smooth and rough pipes – Moody diagram –Pipes in series and parallel – transmission of power through pipes. One dimensional compressible flow analysis – flow through variable area passage – nozzles and diffusers.

Activities:

Analyze pipe networks using Moody chart and calculate friction losses.

UNIT 3	**CONDUCTION AND RADIATION HEAT TRANSFER**	**9**	**0**	**0**	**9**	**18**		**7, 9, 12**

Governing Equation and Extended surface heat transfer, Transient conduction (Lumped system analysis) – Use of Heisler- Conduction with moving boundaries, Stefan and Neumann problem.

Activities:

Experimental or simulation study of fin efficiency (extended surfaces).

UNIT 4	**TURBULENT FORCED CONVECTIVE HEAT TRANSFER**	**9**	**0**	**0**	**9**	**18**		**7, 9, 12**

Turbulence theory – mixing length concept – turbulence model – analogy between heat and momentum transfer – Reynolds, Colburn, Prandtl turbulent flow in a tube – high speed flows.

Activities:

Calculate heat transfer coefficients using Reynolds and Prandtl analogies.

UNIT 5	**PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGER**	**9**	**0**	**0**	**9**	**18**		**7, 9, 12**

Condensation on bank of tubes – boiling – pool and flow boiling, Heat exchanger – Є – NTU approach and design procedure – compact heat exchanger.

Activities:

Design a shell-and-tube heat exchanger using ε–NTU method.

COURSE OUTCOMES:

At the end of the course, the students will be able to:

1	Apply mass, momentum, and energy equations to analyze fluid flow and boundary layer characteristics.
2	Apply principles of incompressible and compressible flows to evaluate pipe systems, nozzles, and diffusers.
3	Apply conduction and radiation heat transfer principles to solve steady and transient thermal problems.
4	Apply turbulent flow theories to evaluate convective heat transfer in engineering systems.

4	Apply phase change heat transfer and heat exchanger concepts for thermal system design and analysis.
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%	
Assessment Methodology: Internal assessment test (70%), Assignment (30%)	
TEXT BOOKS:	
1	Yunus A. Çengel & John M. Cimbala "Fluid Mechanics: Fundamentals and Applications", Fourth edition, McGraw Hill, 2018.
2	Yunus A. Çengel "Heat and Mass Transfer: Fundamentals and Applications", Sixth eEdition, McGraw Hill, 2020.
3	Holman J P, "Heat Transfer", Tenth special edition, TMH Ltd., 2020.
4	Bergman, T. L., Lavine, A. S., Incropera, F. P., & DeWitt, D. P., "Fundamentals of Heat and Mass Transfer", Eighth edition, Wiley, 2020.
5	Greg F. Naterer, "Advanced Heat Transfer", Third edition, CRC Press (Taylor & Francis), 2022.
E RESOURCES/E MATERIALS:	
1.	**NPTEL** "Fluid Mechanics, Heat Transfer, Convective Heat Transfer" 2023, https://nptel.ac.in
2.	**MIT OpenCourseWare "**Fluid Mechanics & Heat Transfer" 2024, **https://ocw.mit.edu**
3.	**Coursera** "Thermal Engineering Courses" 2022, https://www.coursera.org
4	**ANSYS Learning Hub "CFD & Thermal Simulation" 2024,** https://www.ansys.com/academic

Mapping of Course Outcomes to Programme Outcomes and Programme Specific Outcomes

Course outcomes	PO					
	1	2	3	4	5	6
CO1	3	2	3	1	1	2
CO2	3	2	3	2	1	2

CO3	3	2	3	1	1	2
CO4	2	2	3	2	2	2
CO5	3	3	3	2	2	3

EY26202	**COMPUTATIONAL FLUID DYNAMICS FOR ENERGY SYSTEMS**	**L**	**T**	**P**	**TW/SL**	**Total**	**C**	**SDG**
		45	**0**	**30**	**45**	**120**	**4**	**4,9**

COURSE OBJECTIVES:

- To establish the mathematical framework of fluid conservation laws and fundamental Finite Volume discretization principles..
- To architect high-fidelity computational domains using strategic mesh topology and rigorous quality validation.
- To formulate numerical solutions for multidimensional heat diffusion using advanced temporal discretization schemes.
- To apply numerical discretization schemes and enthalpy methods for solving convection-diffusion and phase-change problems in energy systems.
- To utilize pressure-velocity coupling algorithms and turbulence models for the simulation of incompressible flows in engineering applications.

COURSE CONTENT:

UNIT 1	**GOVERNING DIFFERENTIAL EQUATIONS AND DISCRETISATION TECHNIQUES**	**9**	**0**	**6**	**9**	**18**		**4**

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

Activities: Variational Method Application and Discretization Strategy

Practicals: Heat transfer analysis through two walls in steady-state Conduction.

UNIT 2	**GRID GENERATION**	**9**	**0**	**6**	**9**	**18**		**4,9**

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.
Activities: Element Formulation and Thermal Analysis.
Practicals: Transient thermal analysis of a pipe support bracket.

UNIT 3	**DIFFUSION**	**9**	**0**	**6**	**9**	**18**		**4,9**

Multidimensional diffusion problems, Discretisation of steady & unsteady diffusion equations – Explicit, Implicit and Crank-Nicholson's schemes, Stability of schemes, Numerical Solutions.
Activities: 2D Thermal Modeling Task
Practicals: Transient heat transfer analysis through fins and Analysis of thermal radiation between two concentric cylinders.

UNIT 4	**CONVECTION-DIFFUSION**	**9**	**0**	**6**	**9**	**18**		**4,9**

1D convection – diffusion problem, Discretisation using Central difference scheme, upwind scheme, QUICK scheme. Phase Change – Mathematical Formulation, Discretisation, Enthalpy method, Problems
Activities: Axisymmetric Analysis Project
Practicals: Thermal analysis of steel casting process and Convective heat transfer analysis based on Velocity boundary layer concept.

UNIT 5	**FLOW MODELLING**	**9**	**0**	**6**	**9**	**18**		**4,9**

Pressure-velocity coupling algorithms – SIMPLE, SIMPLEC, PISO, Turbulence Models – Governing equation for turbulent kinetic energy & dissipation (k-ε model), Large Eddy Simulation
Activities: Software Workflow Demo
Practicals: Analysis of a laminar flow through a circular pipe, Analysis of a turbulent fluid flow through a flat plate and Thermal analysis of Internal forced convection in a pipe.

COURSE OUTCOMES:
At the end of the course, the students will be able to:

1	Apply discretization techniques and boundary conditions to transform partial differential equations into numerical algebraic formats.
2	Implement coordinate transformations and grid refinement techniques to generate high-quality meshes for complex engineering domains.
3	Solve multidimensional steady and unsteady diffusion heat transfer problems using explicit and implicit numerical schemes.
4	Construct computational models for 1D transport phenomena and phase-change processes using Upwind/QUICK schemes and enthalpy formulations.
5	Solve incompressible fluid flow and energy system problems by implementing SIMPLE/PISO algorithms and k-ϵ turbulence models.

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

Assessment Methodology: Activities (20%), Practical (20%), Internal Examinations (60%)

REFERENCES:

1.	Tu, J., Yeoh, G. H., and Liu, C., "Computational Fluid Dynamics: A Practical Approach", Fourth edition, Elsevier / Butterworth-Heinemann, 2023.

2.	Pletcher, R. H., Tannehill, J. C., and Anderson, D., "Computational Fluid Mechanics and Heat Transfer", Fourth Edition, CRC Press / Taylor & Francis, 2020.
3.	Anderson, J. D., "Computational Fluid Dynamics: The Basics with Applications", Second Edition (International Edition), McGraw Hill Education, 2021.
4.	Zikanov, O., "Essential Computational Fluid Dynamics", Second edition, Wiley, 2020.
5.	Biswas, G. and Chakraborty, S., "Computational Fluid Dynamics", First edition, Wiley, 2024.
E resources/E materials:	
1.	IITKGP, "Introduction to CFD", Prof. Suman Chakraborty, NPTEL - 2020. https://onlinecourses.nptel.ac.in/noc20_me51/preview
2.	IITG, "Computational Fluid Dynamics", Prof. Amaresh Dalal, NPTEL - 2021. https://onlinecourses.nptel.ac.in/noc21_me51/preview
3.	IITM, "Computational Fluid Dynamics", Prof. Sreenivas Jayanti, NPTEL - 2022. https://nptel.ac.in/courses/112106064
4	IITKGP, "Computational Fluid Dynamics", Prof. Somnath Roy, NPTEL - 2021. https://onlinecourses.nptel.ac.in/noc21_me124/preview

Mapping of Course Outcomes to Programme Outcomes and Programme Specific Outcomes

Course outcomes	PO					
	1	2	3	4	5	6
CO1	3	3	3	2	3	1
CO2	3	3	3	2	3	-
CO3	2	3	3	2	3	-
CO4	3	3	3	2	3	-
CO5	3	3	3	2	3	-
CO	3	3	3	2	3	-

EY26203	ENERGY CONSERVATION AND MANAGEMENT	L	T	P	TW/SL	Total	C	SDG
		30	15	0	45	90	3	9

COURSE OBJECTIVES: The course aims to enable students to:

- To understand the fundamentals of energy, energy resources, and conservation principles.
- To analyze energy use patterns in industrial and commercial sectors.
- To learn techniques for performance evaluation of thermal and electrical systems.
- To understand energy auditing methodologies and management strategies.
- To explore modern energy conservation technologies and practices.

COURSE CONTENT:

UNIT 1	ENERGY BASICS AND RESOURCES	6	3	0	6	15		9

Energy forms and units – Primary and secondary energy – Commercial and non-commercial energy – Energy scenario (global and national) – Energy resources: conventional and renewable – Energy conservation principles – Energy efficiency and its importance.

Activities:
1. Calculate energy consumption for common household/industrial appliances.
2. Prepare a short report on India's current energy mix and trends.
3. Group discussion on renewable vs conventional energy sources.

UNIT 2	ENERGY AUDITING	6	3	0	6	15		9

Energy audit: Definition, need, and types – Preliminary and detailed energy audit – Energy audit instruments – Data collection and analysis – Energy flow diagrams – Benchmarking – Energy performance indicators – Energy audit reports.

Activities:
1. Conduct a mini energy audit of a classroom/lab/building.
2. Develop a simple energy flow diagram for a system.
3. Prepare a mock energy audit report based on collected data.

UNIT 3	THERMAL ENERGY MANAGEMENT	6	3	0	6	15		9

Boilers: Types and efficiency – Furnace performance – Steam systems and heat recovery – Insulation and refractory – Waste heat recovery techniques – Cogeneration and trigeneration – Energy conservation opportunities in boilers.

Activities:
1. Visit to a boiler or thermal plant (or virtual lab simulation).
2. Calculate boiler efficiency using direct/indirect methods (numerical exercise).
3. Identify heat loss areas in a given system diagram.

UNIT 4	ELECTRICAL ENERGY MANAGEMENT	6	3	0	6	15		9

Electrical load management – Power factor improvement –Electric motors: types, losses, and efficiency – Energy efficient motors and drives – Lighting systems and energy savings – Demand side management. **Activities:** 1. Measure and analyze power factor in a lab setup. 2. Compare energy consumption of conventional vs LED lighting. 3. Solve numerical problems on demand charges and billing.								
UNIT 5	**ENERGY CONSERVATION TECHNIQUES**	**6**	**3**	**0**	**6**	**15**		**9**
Energy conservation in pumps and compressors – HVAC systems – Cooling towers – Building energy management – Smart energy systems – Energy conservation policies and regulations – Role of energy managers. **Activities:** 1. Audit of a pump or fan system for efficiency improvement. 2. Study and presentation on HVAC energy-saving techniques. 3. Seminar on smart grids and future energy systems.								

COURSE OUTCOMES:
At the end of the course, the students will be able to:

1	Classify and compare different forms of energy and energy resources for various applications.
2	Examine energy consumption patterns through energy audits.
3	Assess and recommend performance improvement measures for thermal systems.
4	Determine methods to enhance the efficiency of electrical systems.
5	Implement suitable energy conservation techniques in industrial and commercial applications.

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

Assessment Methodology: Assignments (70%), Activities (30%)

REFERENCES:

1.	Bureau of Energy Efficiency (BEE), Energy Manager Training Manual, 4 vols. New Delhi, India: Ministry of Power, Government of India, 2020.
2.	L. C. Witte, P. S. Schmidt, and D. R. Brown, Industrial Energy Management and Utilisation. Washington, DC, USA: Hemisphere Publishing, 2021.

3.	L. A. Kumar and G. Ganesan, “Energy Audit and Management: Concept, Methodologies, Procedures, and Case Studies”, Boca Raton, FL, USA: CRC Press, 2023.
4.	D. Y. Goswami and F. Kreith, Eds., “Energy Efficiency and Renewable Energy Handbook”, Second edition, Boca Raton, FL, USA: CRC Press, 2021.
5.	M. Fathi, E. Zio, and P. M. Pardalos, Eds., “Handbook of Smart Energy Systems. Cham”, Switzerland: Springer, 2023.
E resources/E materials:	
1.	Bureau of Energy Efficiency (BEE), *Energy Manager Training Modules and Energy Audit Manuals*, Ministry of Power, Government of India, Digital Learning Resources. Available at: https://www.beeindia.gov.in
2.	University of Colorado Boulder (LearnChemE), *Thermodynamics, Energy Systems Simulations, HVAC, Heat Transfer and Energy Analysis Screencasts*, Department of Chemical and Biological Engineering, Open Educational Resources. Available at: https://www.learncheme.com
3.	International Energy Agency (IEA), *Energy Efficiency Policies, Reports and Data Tools for Industrial and Electrical Energy Systems*, Open Data and Publications Portal. Available at: https://www.iea.org
4	National Renewable Energy Laboratory (NREL), *Energy Systems Integration, Waste Heat Recovery and Industrial Energy Efficiency Resources*, Technical Publications and Simulation Tools. Available at: https://www.nrel.gov
5	MIT OpenCourseWare (MIT OCW), *Energy, Thermodynamics, Electrical Energy Systems and Sustainability Courses*, Open Learning Materials. Available at: https://ocw.mit.edu

Mapping of Course Outcomes to Programme Outcomes

Course outcomes	PO					
	1	2	3	4	5	6
CO1	3	2	1	3	2	-
CO2	3	3	2	3	3	-
CO3	3	2	3	3	3	-
CO4	2	2	3	3	3	-
CO5	3	3	3	3	3	-
CO	3	2	2	3	3	-

EY26204	APPLIED THERMAL ENGINEERING LABORATORY	L	T	P	TW/ SL	Total	C	SDG
		0	0	60	0	60	2	9

COURSE OBJECTIVES:

- To educate the students on the realities of thermal engineering.
- To educate the students about calibration and its essentiality in thermal systems.
- To Educate the students on thermal engineering concepts
- To develop the ability to perform experimental investigations on heat transfer, refrigeration, combustion and fluid flow systems using modern laboratory instruments.
- To enhance analytical and problem-solving skills for evaluating the performance characteristics and efficiency of applied thermal engineering systems.

LIST OF ACTIVITIES:

1. Experimental Studies on Thermal Boundary Layer for different geometries.
2. Calibration of Temperature Transducers (Thermocouple, RTD & (Thermistors).
3. Calibration of Pressure Transducers.
4. Experimental Analysis of Organic Rankine Cycle.
5. Fluid and Thermal Transfer Properties of Liquid Fuels/Heat Transfer Fluids.
6. Experimental Studies on Pool Boiling of Water using Flow Visualization Technique.
7. Flow Characteristic occurrence between Bodies in Wind Tunnel.
8. Experimental Studies on Fluidization of Solid Fuels.
9. Studies on Absorption Refrigeration System.
10. Experimental Studies on Drying of Agro Products.
11. Determining the Actual p-v Diagram of an IC Engine.

COURSE OUTCOMES: At the end of the course, the students will be able to:

1	Construct the error curve and correction curve for different measuring instruments.
2	Analyze the critical/influential properties of thermal systems.
3	Interpret the heat transfer and mass transfer in thermal devices
4	Conduct experiments on thermal engineering systems and interpret the obtained experimental data using appropriate engineering principles.
5	Evaluate the performance, efficiency and operating characteristics of thermal systems through experimentation and data analysis.

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

Assessment Methodology:
Evaluation of Student’s work, Observation, Record, Activities etc..: 75%   Test : 25%

REFERENCES:	
1.	Hemant B. Mehta, Manish K. Rathod, Rufat Abiev, Müslüm Arıcı (Eds.), "Recent Advances in Thermal Sciences and Engineering", First edition, Springer, 2023.
2.	L. M. Das, Abhishek Sharma, Fitwi Yohaness Hagos, Sumit Tiwari (Eds.), "Recent Trends in Thermal Engineering", First edition, Springer Singapore, 2022.
3.	Veeredhi Vasudeva Rao, Adepu Kumaraswamy, Sahil Kalra, Ambuj Saxena (Eds.), "Computational and Experimental Methods in Mechanical Engineering: Proceedings of ICCEMME 2021", First edition, Springer Nature, 2021.
4.	Debi Prasad Mishra, Ashok Kumar Dewangan, Achhaibar Singh (Eds.), "Recent Trends in Thermal and Fluid Sciences", First edition, Springer Singapore, 2023.
5.	Yunus A. Çengel, Michael A. Boles, Mehmet Kanoglu, "Thermodynamics: An Engineering Approach", Tenth edition, McGraw-Hill Education, 2024.
E resources/E materials:	
1.	MIT OpenCourseWare – Heat Transfer - Open educational resources on heat transfer, thermodynamics, refrigeration and experimental methods.
2.	NPTEL Mechanical Engineering Courses - Online lectures and laboratory-oriented courses on thermal engineering, IC engines, refrigeration and instrumentation.
3.	ASME Digital Collection - Research articles and journals related to thermal engineering, fluid mechanics, heat transfer and experimental studies.

Mapping of Course Outcomes to Programme Outcomes and Programme Specific Outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	-	3	1
CO2	2	-	3	2	2	1
CO3	2	1	3	2	2	1
CO4	3	2	2	1	3	1
CO5	3	2	3	3	3	2
CO	2	1	3	2	3	1

PROGRAM ELECTIVES
SEMESTER I

EY26001	MODELING AND ANALYSIS OF ENERGY SYSTEMS	L	T	P	TW /SL	Total	C	SDG
		45	0	0	45	90	3	7
COURSE OBJECTIVES:								
1	To study energy balance concepts and modeling tools for energy system analysis.							
2	To learn modeling and simulation approaches used in energy systems.							
3	To study optimization techniques and their applications in energy system problems.							
4	To learn the fundamentals of energy-economy and econometric modeling.							
5	To illustrate optimization applications and uncertainty analysis in energy systems.							
COURSE CONTENT:								
UNIT – I	INTRODUCTION	9	0	0	9	18		7
Primary energy analysis - energy balance for closed and control volume systems - applications of energy analysis for selected energy system design - modeling overview - levels and steps in model development - Examples of models – curve fitting and regression analysis **Activities:** Group Discussion on Energy Conservation								
UNIT – II	MODELLING AND SYSTEMS SIMULATION	9	0	0	9	18		7
Modeling of energy systems – heat exchanger - solar collectors – distillation -rectification turbo machinery components - refrigeration systems - information flow diagram - solution of set of non-linear algebraic equations - successive substitution - Newton Raphson method- examples of energy systems simulation **Activities:** Identify Inputs and Outputs of an Energy System								
UNIT – III	OPTIMISATION TECHNIQUES	9	0	0	9	18		7
Objectives - constraints, problem formulation - unconstrained problems - necessary and sufficiency conditions. Constrained optimization - Lagrange multipliers, constrained variations, Linear Programming - Simplex tableau, pivoting, sensitivity analysis - New generation optimization								

techniques – Genetic algorithm and simulated annealing – examples.
Activities:
Debate on Conventional Vs Modern Optimization Techniques.

UNIT – IV	ENERGY- ECONOMY MODELS	9	0	0	9	18		7

Multiplier Analysis - Energy and Environmental Input / Output Analysis - Energy Aggregation – Econometric Energy Demand Modeling - Overview of Econometric Methods - Dynamic programming- Search Techniques - Univariate / Multivariate.

Activities:
Study an electricity bill and identify major energy-consuming loads.

UNIT – V	APPLICATIONS AND CASE STUDIES	9	0	0	9	18		7

Case studies of optimization in Energy systems problems- Dealing with uncertainty- probabilistic techniques – Trade-offs between capital and energy using Pinch analysis

Activities:
Seminar on Energy Efficiency and Sustainable Energy Practices.

OUTCOMES: At the end of the course the students would be able to

1	Utilize primary energy analysis and energy balance principles for closed and control volume systems to evaluate and model energy system performance.
2	Implement mathematical modeling and simulation techniques to analyze energy systems such as heat exchangers, solar collectors, and refrigeration systems.
3	Apply optimization methods including linear programming, Lagrange multipliers, and modern techniques like genetic algorithms to solve energy system optimization problems.
4	Employ energy-economy modeling approaches such as input-output analysis, econometric methods, and dynamic programming to assess energy demand and economic interactions.
5	Integrate optimization, probabilistic techniques, and pinch analysis to evaluate and improve real-world energy systems under practical constraints.

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

Assessment Methodology: Assignments (70%), Activities (30%)

References

1	*Balaji, C., Thermal System Design and Optimization, 2nd Ed., Springer, 2021.*
2	*Sayyaadi, H., Modeling, Assessment, and Optimization of Energy Systems, Elsevier, 2020.*

3	*Ghadertootoonchi, A. et al., Energy System Modeling and Optimization: A Practical Guide Using Pyomo, Springer, 2024.*
4	*Verma, V., et al. (Eds.), Highly Efficient Thermal Renewable Energy Systems: Design, Optimization and Applications, CRC Press, 2024.*
5	Dhar, P. L. and Thyageswaran, S., *Thermal System Design and Simulation*, Second Edition, Elsevier, 2026.
E resources/E materials:	
1	NPTEL Courses – Courses on Energy Engineering, Optimization Techniques, Operations Research, and Modeling.
2	IEEE Xplore Digital Library – Journals and conference papers on energy and power systems.
3	ASME Digital Collection – Thermal engineering and energy system resources.
4	SpringerLink – E-books and journals on thermal systems and energy modeling

CO	PO					
	1	2	3	4	5	6
CO 1	3	2	-	1	-	-
CO 2	2	2	1	2	3	-
CO 3	2	3	2	1	2	-
CO 4	2	2	1	2	1	2
CO 5	2	3	3	1	1	2
CO	2	2	2	1	2	2

EY26002	**ALTERNATIVE FUELS**	**L**	**T**	**P**	**TW /SL**	**Total**	**C**	**SDG**
		45	**0**	**0**	**45**	**90**	**3**	**7,9, 11,12, 13,15**
COURSE OBJECTIVES:								
1	To create an awareness of alternative fuels in the present scenario.							

2	To learn the methodology of the fuel extraction from the plants.
3	To study about the alternative gaseous fuels
4	To study the hydrogen production as an alternative.
5	To Know the impact of biogas in IC engine.

COURSE CONTENT:

UNIT – I	**OVERVIEW**	**9**	**0**	**0**	**9**	**18**		**7,13**

Introduction – Alternative fuels – Potential solid - liquid - and gaseous fuels. – Alcohols – ethanol, methanol, M85, E85 and gashol – properties – SI engine combustion performance and emission characteristics. Alcohols for CI engine – Alcohol fumigation – Dual fuel injection – Surface ignition and spark ignition- storage, dispensing and safety – material compatibility.

Activities:

A case study on locally available sources for the alternative fuels

UNIT – II	**VEGETABLE OILS AND OTHER SIMILAR FUELS DERIVED**	**9**	**0**	**0**	**9**	**18**		**7,12, 13**

Vegetable oils- properties – advantages and disadvantages – Biodiesel – trans-esterification -Factors affecting the process – Properties- Biodiesel blends – engine combustion, performance and emission characteristics- material compatibility , other alternative liquid fuels – benzol – acetone – diethyl ether.

Activities:

Hands on training for biodiesel extraction process

UNIT – III	**NATUARAL GAS AND LPG**	**9**	**0**	**0**	**9**	**18**		**7,11, 13**

Alternative gaseous fuels – natural gas and LPG – production – properties of natural gas and LPG – CNG conversion kits – Advantages and disadvantages of NG and LPG – comparison of gasoline and LPG – CNG and LPG fuel feed system – LPG & CNG for CI engine – methods of fuel induction engine combustion, performance and emission characteristics.

Activities:

Prepare a table comparing Natural Gas, LPG, and Gasoline, Conduct a short debate session

UNIT – IV	**HYDROGEN AS ALTERNATIVE FUEL**	**9**	**0**	**0**	**9**	**18**		**7,9, 13**

Hydrogen energy – properties, production, thermo- chemical methods – Hydrogen storage – Delivery – conversion – safety – Hydrogen engines, methods of usage in SI and CI engine – Hydrogen injection system – Hydrogen induction in SI engine.

Activities:

Visit green hydrogen production industry from water and watch demonstration videos

UNIT – V	BIOGAS FOR IC ENGINES	9	0	0	9	18		7,12, 13,15

Biogas – properties – Biogas for running IC engine – Biogas as vehicle fuel – biogas consumption – engine performance and emission- Biomass gasification – producer gas – consumption – dual fuel operation – engine performance and emission.

Activities:

Visit household biogas plants, Assignment on recent advancements in biogas plants

OUTCOMES: At the end of the course the students would be able to

1	Examine and utilize the properties of alcohol fuels to interpret their effects on SI and CI engine combustion, performance, and emission characteristics.
2	Implement and demonstrate the transesterification process to produce biodiesel and evaluate the influence of fuel properties, blends, and material compatibility on engine behavior.
3	Analyze gaseous fuel system concepts to compare CNG and LPG fuel feed systems, conversion kits, and their impact on engine efficiency and emissions.
4	Investigate and apply hydrogen production, storage, and utilization techniques to assess its performance, safety, and combustion characteristics in SI and CI engines.
5	Analyze biogas and producer gas systems to determine fuel consumption, dual-fuel operation, engine performance, and emission characteristics.

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

Assessment Methodology: Assignments (70%), Activities (30%)

References

1	Anand Krishnasamy, Saurabh K. Gupta, Alternative Fuels for IC Engines, First edition, McGraw Hill Education (India), 2024.
2	Akhilendra Pratap Singh, Dhananjay Kumar, Avinash Kumar Agarwal (Eds.), Alternative Fuels and Advanced Combustion Techniques as Sustainable Solutions for Internal Combustion Engines, First edition, Springer Singapore, 2021.
3	Lee, Sunggyu, - “Alternative Fuels”, CRC Press, First edition, 2023
4	Zongyu Yue, Haifeng Liu (Eds.), Advanced Research on Internal Combustion Engines and Engine Fuels, First edition, MDPI, 2024
5	S. M. Ashrafur Rahman (Ed.), Alternative Fuels and Their Application to Combustion Engines, First edition, MDPI Books, 2021.

E resources/E materials:	
1	https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_ch88
2	https://afdc.energy.gov/fuels
3	https://www.sciencedirect.com/topics/engineering/alternative-fuel
4	https://alternative-fuels-observatory.ec.europa.eu/general-information/alternative-fuels
5	https://www.hnei.hawaii.edu/research/alternative-fuels/

CO	PO					
	1	2	3	4	5	6
CO 1	2	1	3	1	2	1
CO 2	3	2	3	2	3	2
CO 3	2	1	3	2	2	1
CO 4	2	1	3	2	2	2
CO 5	3	2	3	2	3	3
CO	2	1	3	2	2	2

EY26003	**GREEN BUILDINGS**	**L**	**T**	**P**	**TW/SL**	**Total**	**C**	**SDG**
		45	**0**	**0**	**45**	**90**	**3**	**9,11**

COURSE OBJECTIVES:	
1	To assert the need, opportunities and demand of green buildings
2	Classify different climatic zones and comfort environment.
3	Incorporate and assess various passive solar techniques in building design.
4	Modeling of heat distribution in the built environment.
5	Design & assess the energy efficient landscape through modification of microclimate.

<table>
<tr><td colspan="9">COURSE CONTENT:</td></tr>
<tr><td>UNIT – I</td><td>INTRODUCTION</td><td>45</td><td>0</td><td>0</td><td>45</td><td>90</td><td></td><td>9,11</td></tr>
<tr><td colspan="9">Concept in building - thermal analysis and design for human comfort - thermal comfort; Criteria and various parameters; psychometric chart; thermal indices, climate and comfort Zones; concept of sol-air temperature and its significance; calculation of instantaneous heat Gain through building envelope.
Activity:
Case study analysis of a thermally comfortable building design.</td></tr>
<tr><td>UNIT – II</td><td>SOLAR RADIATION IN BUILDING</td><td>45</td><td>0</td><td>0</td><td>45</td><td>90</td><td></td><td>9,11</td></tr>
<tr><td colspan="9">Calculation of solar radiation on buildings; building orientation; Introduction to design of shading devices; Overhangs; Factors that effects energy use in buildings; Ventilation and its significance; Air-conditioning systems; Energy conservation techniques in air-conditioning systems
Passive Cooling And Heating Concepts - Passive heating concepts: Direct heat gain, indirect heat gain, isolated gain and sunspaces; Passive cooling concepts: Evaporative cooling, radiative cooling; Application of wind, water and earth for cooling; Shading, paints and cavity walls for cooling; Roof radiation traps; Earth air-tunnel.
Activity:
Perform a building orientation study and evaluate energy implications.</td></tr>
<tr><td>UNIT – III</td><td>HEAT TRANSFER IN BUILDING</td><td>45</td><td>0</td><td>0</td><td>45</td><td>90</td><td></td><td>9,11</td></tr>
<tr><td colspan="9">Heat transmission in Buildings – surface coefficient air cavity – internal and external surfaces, overall thermal transmittance, wall and windows; Heat transfer due to ventilation/infiltration, internal heat transfer; solar temperature; Decrement factor; Phase lag. Design of day lighting.
Activity:
Perform a daylighting analysis using manual methods or simulation tools.</td></tr>
<tr><td>UNIT – IV</td><td>BUILDING LOADS</td><td>45</td><td>0</td><td>0</td><td>45</td><td>90</td><td></td><td>9,11</td></tr>
<tr><td colspan="9">Estimation of building loads – study state method, network method, numerical method - correlations; Computer packages for carrying out thermal design of buildings and predicting performance.
Bioclimatic Classification - Bioclimatic classification of India; Passive concepts appropriate for the various climatic zones in India; Typical design of selected buildings in various climatic zones; Thumb rules for design of buildings and building codes.
Activity:
Conduct a comparative study of load estimation methods (manual vs. software).</td></tr>
<tr><td>UNIT – V</td><td>BULIDING DESIGN</td><td>45</td><td>0</td><td>0</td><td>45</td><td>90</td><td></td><td>9,11</td></tr>
<tr><td colspan="9">Energy Efficient Landscape Design -Modification of microclimatic through landscape element for energy conservation; Energy conservation through site selection, planning, and design; Siting and orientation – GRIHA – Certification of Green Buildings.
Activity:</td></tr>
</table>

Conduct a case study of a certified green building.	
OUTCOMES: At the end of the course the students would be able to	
1	Utilize the principles of green buildings, thermal comfort, psychrometric analysis, and sol-air temperature to evaluate building performance.
2	Implement building orientation, shading devices, ventilation strategies, and passive heating/cooling techniques to enhance energy efficiency in buildings.
3	Employ heat transfer principles to calculate thermal transmittance, phase lag, ventilation heat transfer, and overall building thermal performance.
4	Operate building load estimation methods and software tools to predict and assess building energy performance
5	Integrate energy-efficient site planning, landscape design, and green building certification frameworks for sustainable building development.
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%	
Assessment Methodology: Assignments (70%), Activities (30%)	
References	
1	Kibert, C.J., Sustainable Construction: Green Building Design and Delivery, 5th Edition, Wiley, 2022.
2	Yudelson, J. and Meyer, U., The World Guide to Sustainable Enterprise, Routledge, 2021.
3	Jain, A.K., Green Buildings and Sustainable Engineering, Khanna Publishers, 2021.
4	Balaras, C.A. and Santamouris, M., Energy and Climate in the Urban Built Environment, CRC Press, 2021.
5	Lechner, N., Heating, Cooling, Lighting: Sustainable Design Methods for Architects, 5th Edition, Wiley, 2024.
E resources/E materials:	
1	NPTEL, Energy Efficient Buildings and Green Architecture – https://nptel.ac.in
2	MNRE, Ministry of New and Renewable Energy (MNRE) – https://mnre.gov.in

3	GRIHA Council, GRIHA Council – https://www.grihaindia.org
4	IGBC, Indian Green Building Council (IGBC) – https://igbc.in
5	ASHRAE Learning Resources – https://www.ashrae.org

CO	PO					
	1	2	3	4	5	6
CO 1	2	2	1	-	2	-
CO 2	3	2	1	-	1	-
CO 3	3	2	1	-	2	-
CO 4	2	2	1	-	1	-
CO 5	3	2	1	-	2	-
CO	3	2	1	-	2	-

EY26004	**ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL**	**L**	**T**	**P**	**TW/SL**	**Total**	**C**	**SDG**
		45	**0**	**0**	**45**	**90**	**3**	**3,6,7,11,12,13**

COURSE OBJECTIVES:

1	To impart knowledge on the atmosphere and its present condition and, global warming.
2	To detail on the sources of water pollution and possible solutions for mitigating their degradation.
3	To detail on the sources of air pollution and possible solutions for mitigating their degradation.
4	To detail on the sources of solid waste and possible ways to dispose them safely.
5	To impart knowledge on hazardous waste management.

COURSE CONTENT:

UNIT – I	**INTRODUCTION**	**9**	**0**	**0**	**9**	**18**		**11,13**

Man & Environment – Types of Pollution – Global Environmental issues – Environmental Impact Assessment – Global Warming Issues – CO2 Mitigation – Basic definition of Pollution Indicators – Noise Pollution **Activities**: • Analyze an EIA report & Mitigation measure of a solar or wind or thermal energy project. • **Noise Mapping Exercise** – Measure noise levels at different campus locations using mobile apps or sound level meters and compare with standards.								
UNIT – II	**WATER POLLUTION**	**9**	**0**	**0**	**9**	**18**		**3,6**
Pollutants in Water & Wastewater – Physical and Chemical Treatment Methods – (An Overview) Neutralization – Aeration –Colour / Odour Removal - Sludge dewatering – Biological Treatment including Aerobic & Anaerobic Treatment **Activities:** **Water Quality Analysis –** Test pH, turbidity, TDS, hardness, and dissolved oxygen of local water samples. **Visit to Sewage Treatment Plant (STP)** and prepare a technical report on aerobic and anaerobic treatment systems.								
UNIT – III	**AIR POLLUTION**	**9**	**0**	**0**	**9**	**18**		**3,11**
Sources – Ambient Air Quality Standards – Emission Limits – Equipment for Ambient Air & Stack Monitoring – Principles of operation of Particulate Control Equipments -ESPs, Bag Filters, Cyclone Separators– Vehicular Pollution and its Control – BS standards **Activities:** **Ambient Air Quality Monitoring** – Measure $PM_{2.5}$, PM_{10}, CO_2, and compare results with standards. **Vehicle Emission Survey** – Analyze emissions from different vehicles and study BS-VI compliance.								
UNIT – IV	**SOLID WASTE MANAGEMENT**	**9**	**0**	**0**	**9**	**18**		**11,12**
Types & Sources – Types– Waste Generation – Composition – Physical, Chemical and Biological Properties – Transformation Technologies for Waste Treatment – Landfill Management – Layout, Closure & Post Closure Operation – Reclamation Leachate Generation – e Waste Disposal **Activities:** **Waste Characterization Study** – Visit a local dump yard and study the waste segragation into biodegradable, recyclable, and hazardous categories. Also prepare a report on it **Biogas Production** using municipality waste and estimation of energy generation potential.								
UNIT – V	**HAZARDOUS WASTE MANAGEMENT**	**9**	**0**	**0**	**9**	**18**		**3,7,12**
Sources – Classification – Characterization of waste - health effects - Incineration– Radioactive Waste from nuclear power plants and disposal options - RDF- Mass Firing – Material Recycling **Activities:** **Life Cycle Assessment (LCA) study** of an energy-related product (solar panel, battery, etc.). **Case Study Presentation** on nuclear power plant waste management and disposal practices.								

OUTCOMES: At the end of the course the students would be able to	
1	Apply environmental assessment tools to evaluate pollution sources, environmental impacts, and climate change mitigation strategies in energy systems.
2	Implement suitable physical, chemical, and biological treatment methods for controlling water and wastewater pollution in industrial and energy sectors.
3	Utilize air quality standards and pollution control equipment principles to monitor and reduce atmospheric emissions.
4	Employ appropriate solid waste management and landfill practices for sustainable waste treatment and resource recovery.
5	Employ hazardous waste treatment, disposal, recycling, and energy recovery methods in compliance with environmental safety requirements.
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%	
Assessment Methodology: Assignments (70%), Activities (30%)	
References	
1	**Suresh K. Dhameja:** *Environmental Engineering and Management*, S.K. Kataria & Sons, 2020.
2	**C.S. Rao:** *Environmental Pollution Control Engineering*, New Age International Publishers, Year: 2021
3	Mackenzie L. Davis & David A. Cornwell: Introduction to Environmental Engineering (6th Edition), McGraw-Hill Education, 2023.
4	Tchobanoglous, Stensel, Tsuchihashi & Burton: Wastewater Engineering: Treatment and Resource Recovery (6th Edition), McGraw-Hill Education, 2023
5	Tchobanoglous & Kreith: Handbook of Solid Waste Management (3rd Edition Updated Reprint), McGraw-Hill Education, 2021
E resources/E materials:	
1	**NPTEL COURSE: Basic Environmental Engineering and Pollution Abatement, IIT Roorkee, Prof. P. Mondal** nptel.ac.in/courses/103107215
2	**NPTEL COURSE: Environmental Quality Monitoring & Analysis, IIT Madras, Prof. Ravi Krishna R**

	nptel.ac.in/courses/103106162
3	**Journal: Environmental Science & Technology, ACS Publications, https://pubs.acs.org/journal/esthag**
4	**Journal:** ***Journal of Environmental Management*** (JEM) https://www.sciencedirect.com/journal/journal-of-environmental-management
5	**Journal: Waste management** https://www.sciencedirect.com/journal/waste-management

CO	PO					
	1	2	3	4	5	6
CO 1	3	-	3	2	2	3
CO 2	2	-	3	-	3	2
CO 3	2	-	3	-	2	2
CO 4	2	-	3	-	3	3
CO 5	2	-	3	-	2	3
CO	2	-	3	2	2	3

SEMESTER II
OPEN ELECTIVES

EY26901	**ENERGY AND ENVIRONMENTAL MANAGEMENT**	**L**	**T**	**P**	**TW /SL**	**Total**	**C**	**SDG**
		45	**0**	**0**	**45**	**90**	**3**	**7**

COURSE OBJECTIVES:	
1	To introduce the fundamentals of energy resources, energy consumption and environmental sustainability.
2	To explain the environmental impacts associated with conventional and renewable energy systems.
3	To develop the knowledge on energy conservation, energy efficiency and environmental management practices.
4	To familiarize the students with energy and environmental auditing methodologies.

5	To introduce the carbon management, climate change mitigation and sustainable energy practices.							
COURSE CONTENT:								
UNIT – I	**ENERGY RESOURCES AND ENVIRONMENT**	**9**	**0**	**0**	**9**	**18**		**7**
Global and Indian energy scenario – Energy resources: conventional and non-conventional – Primary and secondary energy sources – Renewable and non-renewable energy resources – Energy demand and supply – Energy consumption patterns – Energy security – Energy and sustainable development. **Activity:** Prepare a comparative chart for energy-resource profile of India and Tamil Nadu.								
UNIT – II	**ENVIRONMENTAL POLLUTION AND ENERGY SYSTEMS**	**9**	**0**	**0**	**9**	**18**		**7**
Air pollution – Sources and classification of air pollutants – Particulate and gaseous pollutants – Effects of air pollution on human health and environment – Water pollution – Thermal pollution – Soil pollution – Solid and hazardous waste generation from energy systems – Pollution control technologies **Activity:** Conduct a case study of pollution generated by a selected thermal power plant or energy-intensive industry.								
UNIT – III	**ENERGY CONSERVATION AND ENVIRONMENTAL MANAGEMENT**	**9**	**0**	**0**	**9**	**18**		**7**
Energy conservation principles – Energy efficiency – Energy management systems – Energy conservation opportunities in industries – Energy-efficient equipment – Energy-efficient buildings – Green buildings – Life-cycle energy analysis – Environmental Management Systems (EMS) – ISO 14001 – Environmental policy and objectives – Environmental performance indicators. **Activity:** Conduct an energy survey of a classroom, laboratory or academic building.								
UNIT – IV	**ENERGY- ECONOMY MODELS**	**9**	**0**	**0**	**9**	**18**		**7**
Energy audit – Objectives and types of energy audits – Preliminary and detailed energy audit – Energy audit methodology – Energy accounting and energy balance –Energy audit instruments – Measurement and verification – Economic analysis of energy conservation measures **Activity:** Carry out a mini energy audit of a selected laboratory or building or an industry.								
UNIT – V	**CLIMATE CHANGE AND SUSTAINABLE ENERGY MANAGEMENT**	**9**	**0**	**0**	**9**	**18**		**7**
Greenhouse effect – Greenhouse gases – Global warming and climate change – Carbon footprint – Carbon accounting – Carbon mitigation strategies - Renewable energy integration – Sustainable energy management – Circular economy – Cleaner production – Waste-to-energy – Sustainable Development								

Goals. **Activity:** Identify major sources of greenhouse-gas emissions and prepare a practical carbon-reduction and sustainable-energy action plan.	
OUTCOMES: At the end of the course the students would be able to	
1	Explain different energy resources and their relationship with environmental sustainability.
2	Identify and assess the environmental impacts associated with energy production and utilization.
3	Apply energy conservation and environmental management principles to improve energy and environmental performance.
4	Conduct basic energy and environmental audit studies and evaluate suitable improvement measures.
5	Analyze climate-change mitigation strategies and sustainable energy management practices.
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%	
Assessment Methodology: Assignments (70%), Activities (30%)	
References	
1	Dincer, I. and Rosen, M. A., Exergy: Energy, Environment and Sustainable Development, Third edition, Elsevier, 2021.
2	Twidell, J., Renewable Energy Resources, Fourth edition, Routledge, 2021.
3	Boyle, G., Renewable Energy: Power for a Sustainable Future, Fourth edition, Oxford University Press, 2019.
4	Moran, M. J., Shapiro, H. N., Boettner, D. D. and Bailey, M. B., Fundamentals of Engineering Thermodynamics, Ninth edition, Wiley, 2018.
5	Kalogirou, S. A., Solar Energy Engineering: Processes and Systems, Third edition, Academic Press/Elsevier, 2023.
E resources/E materials:	
1	Energy Resources - https://www.savemyexams.com/as/environmental-management/cie/20/ revision-notes/5-managing-resources/5-2-energy-resources/5-2-1-energy-resources/

2	Energy, Environment and Sustainability (EES) Division, CSIR-NIScPR - https://niscpr.res.in/divisions/ees
3	Energy & Environment Management - https://ojs.awpublishing.org/eem/en

CO	PO					
	1	2	3	4	5	6
CO 1	2	1	1	2	1	3
CO 2	2	2	1	2	2	3
CO 3	2	2	2	3	2	3
CO 4	3	3	2	3	3	2
CO 5	2	2	2	3	2	3
CO	2	2	2	1	2	2

EY26902	**BIOENERGY AND BIOMASS CONVERSION**	**L**	**T**	**P**	**TW /SL**	**Total**	**C**	**SDG**
		45	**0**	**0**	**45**	**90**	**3**	**7**

COURSE OBJECTIVES:

1	To introduce the fundamentals, characteristics and availability of biomass as a renewable energy resource.
2	To explain various thermochemical and biochemical conversion technologies for producing useful energy and fuels from biomass.
3	To develop an understanding of biogas, bioethanol, biodiesel, bio-oil, producer gas and other biomass-derived fuels.
4	To familiarize students with biomass-based power generation, integrated biorefineries and waste-to-energy systems.
5	To enable students to evaluate biomass conversion technologies from technical, economic and environmental perspectives.

COURSE CONTENT:

UNIT – I	**BIOMASS RESOURCES AND CHARACTERIZATION**	**9**	**0**	**0**	**9**	**18**		**7**

Biomass as a renewable energy resource – Global and Indian biomass resources – Classification of biomass – Primary and secondary biomass – Agricultural residues – Forest residues – Energy crops – Animal wastes – Municipal and industrial organic wastes – Algal biomass – Biomass availability and assessment – Physical properties – Proximate analysis – Ultimate analysis.

Activity

Biomass Resource Mapping:

Students identify biomass resources available in their local region and prepare a simple biomass resource map showing source, type of biomass, approximate availability, present utilization and possible energy conversion route.

UNIT – II	**THERMOCHEMICAL CONVERSION OF BIOMASS**	**9**	**0**	**0**	**9**	**18**		**7**

Fundamentals of thermochemical conversion – Combustion of biomass – Gasification – Types of gasifiers – Updraft, downdraft and fluidized-bed gasifiers – Gasification reactions – Producer gas composition – Gas cleaning – Pyrolysis – Slow, fast and flash pyrolysis – Bio-oil – Biochar – Syngas – Torrefaction – Densification – Briquetting and pelletization – Applications of thermochemical conversion products.

Activity

Conversion Technology Comparison:

Student teams compare combustion, gasification and pyrolysis for a selected biomass residue such as rice husk, coconut shell or sugarcane bagasse.

UNIT – III	**ENERGY CONSERVATION AND ENVIRONMENTAL MANAGEMENT**	**9**	**0**	**0**	**9**	**18**		**7**

Biochemical conversion principles – Anaerobic digestion – Microbial stages of anaerobic digestion – Hydrolysis – Acidogenesis – Acetogenesis – Methanogenesis – Factors affecting anaerobic digestion – C/N ratio – pH – Temperature – Retention time – Organic loading rate – Types of biogas digesters – Fixed-dome digester – Floating-drum digester –Biogas composition and properties – Biogas purification and upgrading – Biomethane – Digestate utilization.

Activity

Biogas Digester Case Study:

Students study a domestic, dairy-farm or community biogas plant and prepare a process flow diagram identifying feedstock preparation, digestion, gas collection, gas utilization and digestate management.

UNIT – IV	**LIQUID BIOFUELS AND ADVANCED BIOMASS CONVERSION**	**9**	**0**	**0**	**9**	**18**		**7**

Bioethanol – Feedstocks for ethanol production – First-, second- and third-generation biofuels – Pretreatment of lignocellulosic biomass – Hydrolysis – Fermentation – Distillation – Ethanol recovery – Biodiesel – Vegetable oils and animal fats – Transesterification – Catalysts – Biodiesel properties – Algal biofuels – Bio-oil upgrading – Biobutanol – Biohydrogen – Microbial conversion.

Activity:

Biofuel Production Pathway Study:

Students select one biofuel such as bioethanol, biodiesel, biobutanol or algal biofuel and prepare a process flow chart from feedstock to final fuel.

UNIT – V	**BIOMASS POWER GENERATION AND SUSTAINABILITY**	**9**	**0**	**0**	**9**	**18**		**7**

Biomass-based heat and power generation – Steam power generation using biomass – Biomass gasifier-engine systems – Combined heat and power – Co-generation – Biomass-based distributed generation. Carbon emissions and greenhouse gas balance – Techno-economic assessment – Sustainability indicators – Environmental impacts.

Activity

Think pair share – Biomass energy system in a college campus or dairy farm or food-processing unit

OUTCOMES: At the end of the course the students would be able to

1	Identify and characterize different biomass resources suitable for energy applications.
2	Explain and compare thermochemical conversion technologies such as combustion, gasification and pyrolysis.
3	Analyse the principles and operation of biochemical conversion systems, particularly anaerobic digestion and biogas production.
4	Describe the production pathways and applications of bioethanol, biodiesel, bio-oil, biohydrogen and other biomass-derived fuels.
5	Evaluate biomass-based energy systems considering energy efficiency, environmental sustainability and techno-economic aspects.

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

Assessment Methodology: Assignments (70%), Activities (30%)

References

1	Dahiya, A. (Ed.), Bioenergy: Biomass to Biofuels and Waste to Energy, Second edition, Academic Press, Elsevier, 2020.
2	Srivastava, M., Srivastava, N. and Singh, R. (Eds.), Bioenergy Research: Basic and Advanced Concepts, Springer, 2021.
3	Gurunathan, B. and Sahadevan, R. (Eds.), Biofuels and Bioenergy: A Techno-Economic Approach, Elsevier, 2022.
4	Verma, P. (Ed.), Biorefineries: A Step Towards Renewable and Clean Energy, Springer, 2020.

5	Srivastava, M., Srivastava, N. and Singh, R. (Eds.), Bioenergy Research: Biomass Waste to Energy, Springer, 2021.
E resources/E materials:	
1	Bioenergy and Biomass Conversion Technologies https://zenodo.org/records/14189767
2	Biomass Energy Sources and Conversion Technologies for Production of Biofuels https://link.springer.com/chapter/10.1007/698_2020_613

CO	PO					
	1	2	3	4	5	6
CO 1	3	2	1	1	-	2
CO 2	3	3	2	2	1	2
CO 3	3	3	3	2	1	2
CO 4	3	3	2	2	2	2
CO 5	3	3	3	3	3	3
CO	3	3	2	2	1	2