REGULATIONS AND SYLLABUS
(University Department)

(For the candidates admitted from the academic year 2026-2027 onwards)

MASTER OF TECHNOLOGY
IN
ENERGY TECHNOLOGY

(Under Choice Based Credit System)

DEPARTMENT OF ENERGY SCIENCE AND TECHNOLOGY

SCHOOL OF ENERGY AND ENVIRONMENTAL SCIENCES

PERIYAR UNIVERSITY

State University - NAAC A++ Grade – NIRF Rank 94
State Public University Rank 40 – SDG Institutions Rank Band: 11-50

SALEM - 636011

TAMIL NADU

Regulations & Scheme

M.Tech., Energy Technology
Choice Based Credit System (CBCS) Regulation
Scheme and Syllabus
(W.e.f. 2026 - 2027 onwards)

1. **Eligibility for Admission**

Candidate who has passed the **B.E / B.Tech Degree in Mechanical / Electrical / Electronics / Agricultural / Energy and Environment / Civil/ Instrumentation / Mechatronics / Aeronautical / Automobile / Chemical / Nanotechnology** or **M.Sc., Degree in Physics / Chemistry / Energy / Material Science** of this University or any other University shall be eligible for admission to M.Tech., Energy Technology degree of this University

2. **Mode of Selection**

The admission is subject to the prevailing rules and regulations for PG admission of this University and as per the norms of Tamil Nadu Government.

3. **Duration of the Course**

The duration of the M.Tech., degree shall be two years consist of four semesters.

4. **Distribution of Credit Points**

The minimum credit requirement for M.Tech., degree shall be 91+2 Credits. The break- up of credits for the Programme is as follows:

- Core Courses : 48 Credits
- Elective Courses : 12 Credits
- Laboratory : 09 Credits
- Project : 15 Credits
- NME : 04 Credits
- Internship : 02 Credits
- Fundamentals of Human Rights : 01 Credit
- Peace Education : 02 (Extra Credits)

5. **Course of Study**

The course of study for the M.Tech., Degree shall be in Energy Technology (CBCS) with internal assessment according to syllabi prescribed from time to time.

METHODS OF EVALUATION (THEORY)	
Internal	25 Marks
External	75 Marks
Total	**100 Marks**

5.1 Components of Internal Evaluation

Internal Tests (Best 1 out of 2)	05 Marks
Model Examination	05 Marks
Seminar	05 Marks
Assignment	05 Marks
Attendance	05 Marks
Total	**25 Marks**

5.2 Practical Internal & External Evaluation (100 Marks)

Internal (40 Marks)			**External (60 Marks)**		
Internal Test I	Internal Test II	Model & Observation (15 + 5)	Record Work	Experimental Work	Viva Voce
10	10	20	10	40	10

Marks allotment for Attendance

Percentage of Attendance	**Marks**
96 - 100	5
91 - 95	4
86- 90	3
81 - 85	2
75- 80	1
Below 75	No marks

6. Details of Project Marks

Project	**Internal (80 Marks)**					**External (120 marks)**		
200 Marks	Review I	Review II	Review III	Attendance	Conference Presentation/ Journal Article/ Patent	Thesis Evaluation (External)	**Viva –Voce (80 Marks)**	
							Internal Examiner	External Examiner
	15	15	30	10	10	40	40	40

The project is an important component of postgraduate programme. Students may be permitted to carry out the project either internal or external mode (i.e., Industrial / Research Organization, etc.,) on the recommendations of the Head of the Department. In case of external Project, a supervisor of the department shall guide the Project work jointly with an expert member as joint supervisor from the Industry/ Organization. The student shall be instructed to meet the supervisor periodically and attend the review committee meetings for evaluating the progress.

7. Question Paper Pattern

Time: 3 Hours **Maximum Marks: 75**

PART – A (20X1= 20 Marks)
Objective Type Questions
PART – B (3X5= 15 Marks)
Answer Any 3 out of 5 (One question from each Unit)
PART – C (5X8= 40 Marks)
Either or Type questions (Two questions from each Unit)

8. Passing Minimum

1. Passing Minimum for External Examination shall be of 50% (Fifty Percentage) of the maximum marks prescribed for the paper.
2. In aggregate (External +Internal) the passing minimum shall be of 50% for each Paper/Practical/Project and Viva-voce.
3. Grading shall be based on overall marks obtained (External +Internal).

8.1 Classification of Successful Candidate

CGPA	Grade	Classification of final result
9.5-10.0	O+	First Class with Exemplary
9.0 and above but below 9.5	O	
8.5 and above but below 9.0	D++	First Class with Distinction
8.0 and above but below 8.5	D+	
7.5 and above but below 8.0	D	
7.0 and above but below 7.5	A++	First Class
6.5 and above but below 7.0	A+	
6.0 and above but below 6.5	A	
5.5 and above but below 6.0	B+	Second Class
5.0 and above but below 5.5	B	
0.0 and above but below 5.0	U	Re-appear

9. Marks and Grades

Range of Marks	Grade points	Letter Grade	Description
90 – 100	9.0 – 10.0	O	**Outstanding**
80-89	8.0 – 8.9	D+	**Excellent**
75-79	7.5 – 7.9	D	**Distinction**
70-74	7.0 – 7.4	A+	**Very Good**
60-69	6.0 – 6.9	A	**Good**
50-59	5.0 – 5.9	B	**Average**
00-49	0.0	U	**Re-Appear**
Absent	**0.0**	AAA	**Absent**

10. Internship

The students may undergo internship training (Research organization / University/ industry) for a period as specified in the curriculum during summer vacation. In this case the training has to be undergone continuously for the entire period.

At the end of internship, the student shall submit a report. The Viva-Voce Examination will be Conducted by External Mode.

INTERNSHIP (100 Marks)

Report	Viva Voce		Total	Credits
External	External	Internal		
40	30	30	100	2

*** Duration of Internship: 15 Days (Minimum) to 60 Days (Maximum)**

11. Non-Major Elective (NME)

Non-Major Elective will be offered in Second Semester (Swayam/MOOC/NPTEL) and Third Semester (Offered to other Departments).

Semester	Courses
Second Semester (NME I)	*Swayam/MOOC/NPTEL
Third Semester (NME II)	Offered to other Departments

* Candidates who have not passed the NME I, should undergo the compulsory paper offered by the department in fourth semester.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

The Energy Technology program seeks to prepare PG students for productive and rewarding careers in the Energy arena. The PEOs are listed below

I. Acquire knowledge and accomplish a decent employment in energy sector and advance to significant positions of leadership in their Profession.
II. Inclination towards advanced research for mitigating the shortcomings in energy systems.
III. Progressing as an energy consultant by providing solutions to improve energy system performance.
IV. Become a successful entrepreneur and be a part of a supply chain or manufacture or market energy products for sustainable development.
V. Lead an ethical life through lifelong learning while developing environmentally friendly and economically affordable energy solutions for societal upliftment.

PROGRAMME OUTCOMES (POs):

After studying Energy Technology, students will exhibit ability to:

PO	Graduate Attribute	Programme Outcome
1	Knowledge	Apply knowledge of mathematics, basic science and engineering science.
2	Problem analysis	Identify, formulate and solve engineering problems.
3	Design/development of solutions	Design a system or process to improve its performance, satisfying its constraints.
4	Conduct investigations of complex problems	Conduct experiments & collect, analyze and interpret the data.
5	Modern tool usage	Apply various tools and techniques to improve the efficiency of the system.
6	Society and Environment	Assess societal, legal, and environmental impacts of engineering solutions.
7	Ethics	Interact in industry, business and society in a professional and ethical manner.
8	Individual and team Work	Function in a multidisciplinary team.
9	Communication	Proficiency in oral and written Communication.
10	Project management and finance	Implement cost effective and improved system.
11	Life-long learning	Continue professional development and learning as a life-long activity.

PROGRAM SPECIFIC OUTCOMES (PSOs):

1. Apply thermal sciences, fluid mechanics, and energy engineering concepts to analyze, design, and integrate conventional with renewable, and energy storage systems, along with performing energy auditing for improved performance.
2. Use modern engineering tools (ANSYS- CFD Fluent, Auto-CAD, Python (AI & ML), PVsyst, MAT Lab, Minitab, etc.,) and techniques to model, analyze, optimize energy generation, conversion, and storage systems for enhanced efficiency, sustainability, and cost-effectiveness.
3. Develop innovative, eco-friendly, and economically viable energy solutions by adhering to ethical practices, while demonstrating entrepreneurial skills in the design, manufacturing, deployment and commercialization of energy technologies for societal benefit.

METHODS OF ASSESSMENT	
Remembering (K1)	• The lowest level of questions require students to recall information from the course content • Knowledge questions usually require students to identify information in the textbook.
Understanding (K2)	• Understanding of facts and ideas by comprehending organizing, comparing, translating, interpolating and interpreting in their own words. • The questions go beyond simple recall and require students to combine data together
Application (K3)	• Students have to solve problems by using / applying a concept learned in the classroom. • Students must use their knowledge to determine an exact response.
Analyze (K4)	• Analyzing the question is one that asks the students to break down something into its component parts. • Analyzing requires students to identify reasons causes or motives and reach conclusions or generalizations.
Evaluate (K5)	• Evaluation requires an individual to make judgment on something. • Questions to be asked to judge the value of an idea, a character, a work of art, or a solution to a problem. • Students are engaged in decision-making and problem – solving. • Evaluation questions do not have single right answers.
Create (K6)	• The questions of this category challenge students to get engaged in creative and original thinking. • Developing original ideas and problem-solving skills

PEO / PO Mapping

Programme Educational Objectives	Programme Outcomes										
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
II	✓	✓						✓		✓	✓
III	✓	✓				✓		✓		✓	✓
IV	✓	✓	✓		✓	✓	✓	✓	✓	✓	
V	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Mapping of Course Outcome and Programme Outcome

Year	Semester	Course Name	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO09	PO10	PO11
I YEAR	Semester 1	Energy Auditing and Management	✓		✓	✓		✓	✓		✓		✓
		Fluid Flow and Heat Transfer	✓	✓	✓	✓	✓	✓				✓	✓
		Digital Energy Systems and IoT Applications	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
		Research Methodology and Intellectual property	✓	✓	✓		✓		✓	✓	✓		✓
		Elective –I											
		Energy Laboratory	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Semester 2	Energy Conservation of Thermal Systems	✓	✓		✓	✓	✓				✓	✓
		Computational Fluid Dynamics	✓	✓	✓	✓	✓	✓				✓	✓
		Machine Learning for Energy Systems	✓	✓	✓	✓	✓	✓			✓	✓	✓
		Elective –II											
		Fundamentals of Human Rights											
		NME –I											
		Analysis and Simulation Laboratory	✓	✓	✓	✓	✓	✓		✓		✓	✓
II YEAR	Semester 3	Energy conservation of Electrical Systems	✓			✓		✓	✓		✓		✓
		Biofuels and Bioenergy Technologies		✓	✓		✓	✓				✓	✓
		Entrepreneurship Development	✓	✓	✓		✓	✓	✓			✓	✓
		Elective –III											
		NME - II											
		Internship	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Energy Auditing Laboratory	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Semester 4	Project with Viva Voce	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

PERIYAR UNIVERSITY, SALEM
UNIVERSITY DEPARTMENT REGULATIONS – 2026
CHOICE BASED CREDIT SYSTEM
M.Tech., ENERGY TECHNOLOGY

CURRICULUM AND SYLLABUS

SEMESTER I

S.No	Course Code	Course Title	Category	L	T	P	C	Int. Mark	Ext. Mark	Total
1	26UPEST2C01	Energy Auditing and Management	C	4	1	0	5	25	75	100
2	26UPEST2C02	Fluid Flow and Heat Transfer	C	4	1	0	5	25	75	100
3	26UPEST2C03	Digital Energy Systems and IoT Applications	C	4	1	0	5	25	75	100
4	26UPEST2C04	Research Methodology and Intellectual Property Rights	C	4	0	0	4	25	75	100
5	-	Elective –I	E	4	0	0	4	25	75	100
6	26UPEST2L01	Energy Laboratory	L	0	0	6	3	40	60	100
			TOTAL	**20**	**3**	**6**	**26**			

SEMESTER II

S.No	Course Code	Course Title	Category	L	T	P	C	Int. Mark	Ext. Mark	Total
1	26UPEST2C05	Energy Conservation of Thermal Systems	C	4	1	0	5	25	75	100
2	26UPEST2C06	Computational Fluid Dynamics	C	4	1	0	5	25	75	100
3	26UPEST2C07	Machine Learning for Energy Systems	C	4	1	0	5	25	75	100
4	-	Elective –II	E	4	0	0	4	25	75	100
5	23UPPGC1H01	Fundamentals of Human Rights	H	2	0	0	1	25	75	100
6	-	NME –I (Swayam/MOOC/NPTEL)	N	2	0	0	2	-	100	100
7	26UPEST2L02	Analysis and Simulation Laboratory	L	0	0	6	3	40	60	100
			TOTAL	**20**	**3**	**6**	**25**			

SEMESTER III

S.No	Course Code	Course Title	Category	L	T	P	C	Int. Mark	Ext. Mark	Total
1	26UPEST2C08	Energy Conservation of Electrical Systems	C	4	1	0	5	25	75	100
2	26UPEST2C09	Biofuels and Bioenergy Technologies	C	5	0	0	5	25	75	100
3	26UPEST2C10	Entrepreneurship Development	C	4	0	0	4	25	75	100
4	-	Elective –III	E	4	0	0	4	25	75	100
5	-	NME - II (Supportive)	N	3	0	0	2	25	75	100
6	26UPEST2I01	Internship	I	0	0	0	2	-	100	100
7	26UPEST2L03	Energy Auditing Laboratory	L	0	0	6	3	40	60	100
			TOTAL	**20**	**1**	**6**	**25**			

S.No	Course Code	Course Title	Category	L	T	P	C	Int. Mark	Ext. Mark	Total
1	-	Peace Education	V	2	0	0	2	25	75	100
			TOTAL	**2**	**0**	**0**	**2**			

SEMESTER IV

S.No	Course Code	Course Title	Category	L	T	P	C	Int. Mark	Ext. Mark	Total
1	26UPEST2P01	Project with Viva Voce	P	0	0	30	15	80	120	200
			TOTAL	**0**	**0**	**30**	**15**			

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF DEGREE = 91 + 2 (Extra Credits)

PROFESSIONAL CORE (C)

S.No	Course Code	Course Title	Category	L	T	P	C
1	26UPEST2C01	Energy Auditing and Management	C	4	1	0	5
2	26UPEST2C02	Fluid Flow and Heat Transfer	C	4	1	0	5
3	26UPEST2C03	Digital Energy Systems and IoT Applications	C	4	1	0	5
4	26UPEST2C04	Research Methodology and Intellectual Property Rights	C	4	0	0	4
5	26UPEST2C05	Energy Conservation of Thermal Systems	C	4	1	0	5
6	26UPEST2C06	Computational Fluid Dynamics	C	4	1	0	5
7	26UPEST2C07	Machine Learning for Energy Systems	C	4	1	0	5
8	26UPEST2C08	Energy Conservation of Electrical Systems	C	4	1	0	5
9	26UPEST2C09	Biofuels and Bioenergy Technologies	C	5	0	0	5
10	26UPEST2C10	Entrepreneurship Development	C	4	0	0	4

LABORATORY (L)

S.No	Course Code	Course Title	Category	L	T	P	C
1	26UPEST2L01	Energy Laboratory	L	0	0	6	3
2	26UPEST2L02	Analysis and Simulation Laboratory	L	0	0	6	3
3	26UPEST2L03	Energy Auditing Laboratory	L	0	0	6	3

PROJECT (P)

S.No	Course Code	Course Title	Category	L	T	P	C
1	26UPEST2P01	Project with Viva Voce	P	0	0	30	15

ELECTIVE (E)

S.No	Course Code	Course Title	Category	L	T	P	C
ELECTIVE - I							
1	26UPEST2E01	Solar Energy Technologies	E	4	0	0	4
2	26UPEST2E02	Wind Energy Conversion Systems	E	4	0	0	4
3	26UPEST2E03	Nuclear Energy Technology	E	4	0	0	4
4	26UPEST2E04	Materials Characterization Techniques	E	4	0	0	4
ELECTIVE - II							
5	26UPEST2E05	Solar Energy Appliances	E	4	0	0	4
6	26UPEST2E06	Hydro Power Systems	E	4	0	0	4
7	26UPEST2E07	Energy Efficient Buildings Design	E	4	0	0	4
8	26UPEST2E08	Nanomaterials for Sustainable Energy	E	4	0	0	4
ELECTIVE - III							
9	26UPEST2E09	Solar Refrigeration and Air Conditioning	E	4	0	0	4
10	26UPEST2E10	Electric and Hybrid Vehicles	E	4	0	0	4
11	26UPEST2E11	Waste Management and Energy Recovery Techniques	E	4	0	0	4
12	26UPEST2E12	Hydrogen Production and Storage	E	4	0	0	4

NON-MAJOR ELECTIVE COURSES (NME-II) (SUPPORTIVE)

S.No	Course Code	Course Title	Category	L	T	P	C
1	26UPESTN01	Alternative Energy Sources	N	3	0	0	2
2	26UPESTN02	Climate Change and CO_2 Emission Assessment	N	3	0	0	2
3	26UPESTN03	Energy Scenario and Policy	N	3	0	0	2
4	26UPESTN04	Erection and Maintenance of Refrigeration and Air Conditioning Equipment	N	3	0	0	2
5	26UPESTN05	Environmental Engineering and Pollution Control	N	3	0	0	2

VALUE ADDED COURSE

S.No	Course Code	Course Title	Category
1	26UPESTV01	PVsyst Software for Energy System	**V**
2	26UPESTV02	Electric Vehicle Charging Infrastructure	**V**
3	26UPESTV03	Green Hydrogen and Decarbonization Technology	**V**
4	26UPESTV04	Circular Economy and Energy Sustainability	**V**
5	26UPESTV05	Industrial Wastewater Pollution, Prevention and Control	**V**
6	26UPESTV06	Instrumentation for Energy Systems	**V**
7	26UPESTV07	Alternate Fuels and Emissions	**V**
8	26UPESTV08	Biomass and its Conversion Technologies	**V**
9	26UPESTV09	First Aid & Fire Fighting Safety Management	**V**
10	26UPESTV10	Refrigeration and Air Conditioning	**V**
11	26UPESTV11	Industrial Robotics	**V**
12	26UPESTV12	Energy Forecasting, Modeling and Project Management	**V**
13	26UPESTV13	Economics and Planning of Energy Systems	**V**

CERTIFICATE PROGRAMME

S.No	Course Code	Course Title	Credits	Category
1	-	Artificial Intelligence Applications in Renewable Energy Systems	**20**	**CP**

S.No.	Course Code	Name of the Papers	Credit	Internal Marks	External Marks	Total Marks
1	26UPESTCP01	Basics of Renewable Energy Systems	4	25	75	100
2	26UPESTCP02	Fundamentals of Artificial Intelligence	4	25	75	100
3	26UPESTCP03	Solar and wind energy systems	4	25	75	100
4	26UPESTCP04	Solar Power Forecasting using Machine Learning	4	25	75	100
5	26UPESTCP05	Wind Energy Prediction & Optimization using AI	4	25	75	100

26UPEST2C01	ENERGY AUDITING AND MANAGEMENT	L	T	P
		4	1	0

COURSE OBJECTIVES

- To Know Global and Indian Energy Scenario and Energy Conservation Act
- To Know the Energy Efficiency and Climate Change Policies
- To Know the Procedure of Energy Audit
- To Understand the Material and Energy Balance in The Production
- To Know the Planning and Targeting of Energy In Industries

UNIT – I: ENERGY SCENARIO AND ENERGY CONSERVATION ACT

Introduction - Primary and Secondary Energy - Final Energy Consumption - India's Energy Scenario - Sector wise Energy Consumption in India - Energy Intensity on Purchasing Power Parity (PPP) - Energy Security - Salient Features of the Energy Conservation Act, 2001 - Scheme of BEE under the Energy Conservation Act-2001 - Electricity Act 2003 - National Action Plan on Climatic Change (NAPCC)

UNIT – II: ENERGY EFFICIENCY AND CLIMATE CHANGE

Energy and Environment - Global Environment Issues - Acid Rain - Ozone Layer Depletion - Global Warming and Climate Change - Impacts - United Nations Framework Convention on Climate Change (UNFCCC) - The Intergovernmental Panel on Climate Change (IPCC) - Conference of Parties (COP) - The Kyoto Protocol - CDM Methodology and Procedure- European Union's Efforts to Combat Climate Change - Sustainable Development

UNIT– III: BASICS OF ENERGY AND ENERGY AUDIT

Introduction - Work, Energy and Power - Electricity Basics - Thermal Energy Basics - Energy Units and Conversions - Objectives of Energy Management - Need for Energy Audit - Types of Energy Audit and Approach – Understanding Energy Costs - Benchmarking - Energy Performance - Matching Energy Usage to Requirement - Maximizing System Efficiencies - Fuel and Energy Substitution - Instruments and Metering for Energy Audit

UNIT- IV: MATERIALS BALANCE, ENERGY BALANCE AND FINANCIAL

Introduction - Components of Materials and Energy Balance - Basic Principles of Material and Energy Balance - Classification of Processes - Material Balance - Energy Balance - Facility as an Energy System - Energy Analysis and the Sankey Diagram - Financial Analysis Techniques-- Energy Performance Contracting and Role of ESCOs - Energy Efficiency in Building through ESCO

UNIT- V: PROJECT MANAGEMENT, ENERGY MONITORING AND TARGETING

Project Planning Techniques - Implementation Plan for Top Management - Planning Budget - Procurement Procedures – Construction - Measurement and Verification - Setting up Monitoring & Targeting - Key elements of Monitoring &Targeting System - Data and Information Sources-- Data and Information Analysis - Energy Management Information System (EMIS)

CO1	Adopt energy standards based on various acts officially established for qualitative and quantitative improvement in energy utilization	K1-K6
CO2	Learn Energy efficiency and climate change policies globally	K1-K6
CO3	Familiarized about energy auditing and energy management methods.	K1-K6
CO4	Find the production rate and energy consumption data	K1-K6
CO5	Involve in energy extraction and efficiency rate improvement	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. Bureau of Energy Efficiency, *General Aspects of Energy Management and Energy Audit*, Bureau of Energy Efficiency, 2015, Fourth Edition.
2. Barney L. Capehart, Wayne C. Turner, William J. Kennedy, *Guide to Energy Management*, The Fairmont Press, Inc., 2006, Fifth Edition.
3. L.C. Witte, P.S. Schmidt, D.R. Brown, *Industrial Energy Management and Utilisation*, Hemisphere Publishing, 1988.
4. P.W. Callaghan, *Design and Management for Energy Conservation*, Pergamon Press, 1981.
5. I.G.C. Dryden, *The Efficient Use of Energy*, Butterworths, 1982

CO	PO											PSO		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
1	H	-	-	H	-	H	L	-	L	-	M	H	H	-
2	M	-	-	H	-	H	L	-	L	-	M	M	H	L
3	H	-	M	M	-	H	-	-	L	-	M	M	M	L
4	L	-	-	M	-	H	H	-	M	-	M	H	M	-
5	L	-	-	L	-	H	-	-	M	-	M	H	H	-

26UPEST2C02	**FLUID FLOW AND HEAT TRANSFER**	**L**	**T**	**P**	**C**
		4	1	0	5

COURSE OBJECTIVES

- To Lay the Foundation and Understand the Equations of Euler and Bernoulli.
- To Understand Principles of Laminar and Turbulent Flow
- To Inculcate Conduction, Convection and Radiation Heat Transfer
- To Impart the Knowledge of Boiling and Condensation
- To Provide the Details of Types of Heat Exchangers

UNIT – I: INTRODUCTION AND BASIC CONCEPTS

Classification of fluid flows - Fluid statics - Buoyancy and Stability - Fluids in rigid-body motion - Fluid Kinematics - Lagrangian and Eulerian descriptions - Flow patterns and Flow visualization- Vorticity and Rotationality- Conservation of mass - Bernoulli equation - General energy equation

UNIT – II: ANALYSIS OF FLOW SYSTEMS

The Linear Momentum Equation - The Angular Momentum Equation - Internal Flow - Laminar and Turbulent Flows - Entrance Region - Laminar Flow in Pipes - Turbulent Flow in Pipes - Flow Rate and Velocity Measurement - The Stream Function - The Navier–Stokes Equation -External Flow - Drag and Lift

UNIT– III: CONDUCTION, CONVECTION AND RADIATION HEAT TRANSFER

One-Dimensional Heat Conduction Equation - Steady Heat Conduction in Plane Walls - Heat Conduction in Cylinders and Spheres - Transient Heat Conduction - Lumped System Analysis - fundamentals of convection - external forced convection – internal forced convection - fundamentals of thermal radiation - blackbody radiation - radiation intensity - radiative properties- emissivity

UNIT- IV: BOILING AND CONDENSATION

Boiling heat transfer - pool boiling - boiling regimes and the boiling curve - flow boiling - condensation heat transfer - film condensation - flow regimes - film condensation inside horizontal tubes - dropwise condensation

UNIT – V: HEAT EXCHANGERS

Heat exchangers -Types – merits and demerits – design of compact heat exchangers, plate heat exchangers – performance influencing parameters – limitations - the overall heat transfer coefficient - analysis of heat exchangers - selection of heat exchangers

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Understand various types of fluid flow and able derive basic fundamental equations applied to fluid flow	K1-K6
CO2	Apply correctly the conservation principles of mass, linear momentum, and energy to fluid flow systems.	K1-K6
CO3	Solve the conduction, convection and radiation heat transfer problems	K1-K6
CO4	Understand the boiling and condensation of fluids	K1-K6
CO5	Design of heat exchanger according to industry requirements	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6-Create

TEXT AND REFERENCE BOOKS

1. Y. A. Çengel, J. M. Cimbala, *Fluid Mechanics: Fundamentals and Applications*, McGraw-Hill, 2014, Third Edition.
2. Y. A. Çengel, A. J. Ghajar, *Heat and Mass Transfer: Fundamentals & Applications in SI Units*, McGraw-Hill Education, 2020, Sixth Edition.
3. R. K. Bansal, *Fluid Mechanics*, Laxmi Publications, 2016.
4. L. Streeter, E. B. Wylie, K. W. Bedford, *Fluid Mechanics*, WCB McGraw-Hill, 1998.
5. M. N. Ozisik, *Heat Transfer – A Basic Approach*, McGraw-Hill, 1985.

CO	**PO**											**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	H	H	M	H	L	H	-	-	-	-	H	-	-	L
2	H	H	M	H	L	H	-	-	-	-	H	-	-	H
3	H	H	M	H	L	H	-	-	-	-	H	-	-	H
4	H	H	M	H	M	H	-	-	-	-	H	-	H	H
5	H	H	M	H	M	H	-	-	-	-	H	-	H	H

26UPEST2C03	DIGITAL ENERGY SYSTEMS AND IOT APPLICATIONS	L	T	P	C
		4	1	0	5

COURSE OBJECTIVES

- To Introduce the Fundamentals of Iot in Energy Systems
- To Learn Embedded Systems and Microcontroller Interfacing
- To Explore Cloud Integration and IOT Communication Protocols
- To Apply AI Techniques in Energy Engineering Applications
- To Understand Smart Grid and Modern Energy Applications

UNIT – I: FUNDAMENTALS OF IOT IN ENERGY SYSTEMS

Introduction to IoT and its role in energy engineering, Components: sensors, actuators, microcontrollers, IoT architecture (device–network–cloud), Energy data acquisition systems (smart meters, solar sensors), Communication technologies: Wi-Fi, GSM, Applications in smart homes and energy monitoring

UNIT – II: EMBEDDED SYSTEMS AND IOT HARDWARE BASICS

Introduction to microcontroller- Arduino, ESP32 microcontrollers, Interfacing sensors, Basic circuit configuration- data acquisition using IOT devices- Demonstration of Simple IOT energy Monitoring System

UNIT– III: IOT COMMUNICATION AND CLOUD INTEGRATION

Basics of IoT protocols (MQTT – concept only), Data transmission from device to cloud, Introduction to cloud platforms for IoT, Data storage and remote access, Real-time monitoring dashboards, Case study: Remote monitoring of solar systems.

UNIT- IV: AI APPLICATIONS IN ENERGY SYSTEMS

Role of AI in energy systems (no deep analytics repetition), Prediction concepts (energy demand, renewable output), Fault detection and system health monitoring, AI-enabled decision making in smart grids, Case studies in renewable and industrial energy systems.

UNIT – V: INTEGRATION OF IOT AND AI FOR SMART ENERGY SYSTEMS

IoT and AI architecture (data → intelligence → action), Smart grid and intelligent energy systems, Predictive maintenance using IoT and AI, Energy optimization and automation.

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Understand IoT architecture and its role in energy systems	K1-K6
CO2	Implement embedded systems using microcontrollers	K1-K6
CO3	Apply cloud-based IoT solutions for real-time monitoring	K1-K6
CO4	Utilize AI techniques for energy optimization and fault detection	K1-K6
CO5	Analyze smart grid technologies and applications	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. Bahga, V. Madisetti, *Internet of Things: A Hands-On Approach*, Universities Press, 2014.
2. O. Hersent, D. Boswarthick, O. Elloumi, *The Internet of Things: Key Applications and Protocols*, Wiley, 2012.
3. R. Buyya, A. V. Dastjerdi, *Internet of Things: Principles and Paradigms*, Elsevier, 2016.
4. S. Monk, *Programming Arduino: Getting Started with Sketches*, McGraw-Hill, 2011.
5. Madisetti, *Internet of Things (IoT): A Practical Approach*, Pearson, 2019.
6. S. Russell, P. Norvig, *Artificial Intelligence: A Modern Approach*, Pearson, 2020, Fourth Edition.

CO	**PO**											**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	H	M	L	L	M	L	M	-	L	L	L	-	-	L
2	H	H	M	M	M	L	M	-	L	L	L	-	-	H
3	H	M	H	M	H	L	L	-	M	L	M	-	-	H
4	H	M	M	M	H	L	L	-	L	M	M	-	H	H
5	H	H	H	M	M	L	M	-	L	L	H	-	H	H

26UPEST2C04	RESEARCH METHODOLOGY AND INTELLECTUAL PROPERTY RIGHTS	L	T	P	C
		4	0	0	4

COURSE OBJECTIVES

- To Identify an Appropriate Research Problem in their Interesting Domain
- To Understand Significance, Effective Technical Writing and Report
- To Apply Soft Computing Methods for Optimization and Prediction in Research.
- To Understand About the Intellectual Property Rights (IPR)
- To Understand the Adequate Knowledge on Patent and its Rights

UNIT – I: RESEARCH - A WAY OF THINKING

Meaning of research – characteristics and requirements - Types of research - an eight-step model-formulating a research problem - planning a research study - conceptualizing a research design-constructing an instrument for data collection - selecting a sample - collecting data - processing and displaying data - writing a research report

UNIT – II: LITERATURE REVIEW, TECHNICAL WRITING /EVALUATION

Bringing clarity and focus to your research problem – Searching for the existing literature - Reviewing the selected literature - Developing a theoretical framework - Developing a conceptual framework - analysis Plagiarism - Research ethics - Effective technical writing - Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT – III: SOFT COMPUTING

Computer and its role in research - Use of statistical software SPSS – GRETL, etc., in research. Introduction to evolutionary algorithms - Fundamentals of Genetic algorithms - Simulated Annealing - Neural Network based optimization - Optimization of fuzzy systems

UNIT – IV: INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR)

Intellectual Property - Meaning - Relevance - Business Impact - Protection of Intellectual Property - Intellectual Property as an Instrument of Development - Need for Protecting - Intellectual Property – Policy Consideration – National and International - intellectual Property Rights as Human Right – Copyrights – Trademarks

UNIT – V: PATENTS

Patents - Patentable Subject Matter - Patentability Criteria - Duration of Patents- Law and Policy Consideration - Procedure for Filing of Patent Application and types of Applications - Ownership and Maintenance of Patents - Patent Agent- Qualification and Registration Procedure - Computer Software - Traditional knowledge Case Studies.

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Understand the characteristics, objects of a good research problem	K1-K6
CO2	Understand writing a research report as per format.	K1-K6
CO3	Understand the soft computing methods for optimization and prediction in research.	K1-K6
CO4	Understand about IPR	K1-K6
CO5	Understand about filing patents in R & D	K1-K6

K1- Remember, K2- Understand, K3- Apply , K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. Ranjit Kumar, *Research Methodology: A Step by Step Guide for Beginners*, Sage Publications, 2011, Third Edition.
2. The Institute of Company Secretaries of India, *Intellectual Property Rights – Law and Practice (Module 3)*, The Institute of Company Secretaries of India, 2018.
3. Halbert, *Resisting Intellectual Property*, Taylor & Francis Ltd, 2007.
4. Niebel, *Product Design*, McGraw Hill, 1974.
5. Mayall, *Industrial Design*, McGraw Hill, 1992.

CO	PO											PSO		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
1	H	H	-	-	-	-	H	H	H	-	H	-	-	H
2	H	-	L	-	H	-	H	H	H	-	H	-	-	H
3	H	-	L	-	H	-	H	H	H	-	H	-	-	H
4	H	-	L	-	H	-	H	H	H	-	H	-	-	H
5	H	-	-	-	H	-	H	H	H	-	H	-	-	H

26UPEST2L01	ENERGY LABORATORY	L	T	P	C
		0	0	6	3

COURSE OBJECTIVES

- To obtain the knowledge on working and characterization of Solar PV cell.
- To assess the performance of Wind Energy Generator.
- To characterize the properties various liquid fuel.
- To acquire the principle operation of biogas plant and analyze its constituents.
- To gain practical knowledge on thermal energy Storage system using various PCM.
- To identify the concept of heat transfer in heat exchangers.
- To analyze the solar cell efficiency through solar cell simulator.
- To learn the working of Solar Water heater, Dryer and Desalination.

LIST OF EXPERIMENTS

1. Conduct an experiment to obtain I-V and P-V characteristics of PV module with varying radiation level using solar PV training & research System.
2. Performance analyses of PV module with various tilt angle using solar PV training & research System.
3. Effect of shading on the efficiency of PV module with regards to voltage current and power using Solar PV Training & research system.
4. Performance assessment of Wind Energy Generator based on wind velocity.
5. Determination of the flash point of a given sample using flash point apparatus.
6. Experiment on Nano Floating Drum Biogas Plant and evaluating the percentage of biogas formed for the given amount of organic waste using bio gas analyzer.
7. Experimental evaluation of a Paraffin wax as Phase Change Material for Thermal Energy Storage in TES Training System.
8. Experimental evaluation of a fatty acid as Phase Change Material for Thermal Energy Storage in TES Training System.
9. Experimental evaluation of a Paraffin wax and fatty acid (mixed) as Phase Change Material for Thermal Energy Storage during charging mode in TES Training System.
10. Experimental evaluation of a Paraffin wax and fatty acid (mixed) as Phase Change Material for Thermal Energy Storage during discharging mode in TES Training System.
11. Determination the overall heat transfer coefficient in a plate type heat exchanger at different hot fluid flow rate.
12. Experimental analysis on efficiency of solar cell under varying light intensity using Solar Simulator- SS50 AAA.
13. Evaluation of heat loss and efficiency in thermosyphonic mode of heat flow at different radiation level in Solar Flat Plate Water Heating System.
14. Experimental investigation of solar dryer using various food sources
15. Experimental analysis of a Solar Thermal Desalination using impure water

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Operate solar PV devices under different operating parameter and evaluate their performance	K1-K6
CO2	Investigate the performance of Wind Energy Generator	K1-K6
CO3	Evaluate the flash point and fire point of various liquid fuels	K1-K6
CO4	Operate bio-gas plant and evaluate the composition of bio gas.	K1-K6
CO5	Examine thermal heat storage systems and determine the performance of various PCM materials	K1-K6
CO6	Evaluate the overall heat transfer rate in heat exchangers	K1-K6
CO7	Handle solar simulator and assess solar cell performance	K1-K6
CO8	Understand the working of solar water heater, dryer and Desalination.	K1-K6

K1- Remember, K2- Understand, K3- Apply , K4- Analyze, K5- evaluate and K6- Create

CO	PO											PSO		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
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2	H	H	M	H	H	H	-	H	-	-	M	H	M	H
3	H	H	M	H	H	H	-	H	M	-	M	H	H	H
4	H	H	L	H	H	H	-	H	L	-	M	H	H	H
5	H	H	L	H	H	H	-	H	-	-	M	H	-	H
6	H	H	H	H	H	H	-	H	-	-	H	H	-	-
7	H	H	L	H	H	H	-	H	-	-	M	H	-	H
8	H	H	H	H	H	H	-	H	-	-	H	H	-	-

26UPEST2C05	ENERGY CONSERVATION OF THERMAL SYSTEMS	L	T	P	C
		4	1	0	5

COURSE OBJECTIVES

- To learn importance fuel properties and combustion
- To know the heat transfer modes in boiler and characteristics of steam and efficient utilization of steam
- To understand the operation of furnaces and refractories
- To know the importance of cogeneration in industrial utilities
- To know the process of heat recovery system and heat exchangers

UNIT – I: FUELS AND COMBUSTION

Introduction to Fuels - Properties of Liquid Fuels - Properties of Coal - Properties of Gaseous Fuels - Properties of Agro Residues – Combustion - Combustion of Oil - Combustion of Coal - Combustion of Gas - Combustion of Biomass - Type of Draft System - Type of Combustion Controls

UNIT – II: BOILERS AND STEAM SYSTEM

Introduction - Boiler Systems - Boiler Types and Classifications - Performance Evaluation of Boilers - Boiler Water Treatment - Boiler Blow Down - Improving Boiler Availability - Thermic Fluid Heaters - Energy Conservation Opportunities – Operation and Maintenance of Steam Traps-Performance Assessment of Steam Traps - Efficient steam utilization and Energy Saving Opportunities

UNIT–III: FURNACES, INSULATION AND REFRACTORIES

Types and Classification of Different Furnaces - Performance Evaluation of a Typical Fuel Fired Furnace - General Fuel Economy Measures in Furnaces - Purpose of Insulation - Types and Application - Calculation of Insulation Thickness - Refractories - Properties of Refractories - Classification of Refractories - Typical Refractories in Industrial Use - Selection of Refractories-Heat Losses from Furnace Walls

UNIT-IV: COGENERATION

Need for Cogeneration - Principle of Cogeneration - Technical Options for Cogeneration - Classification of Cogeneration Systems - Factors Influencing Cogeneration Choice - Important Technical Parameters for Cogeneration - Prime Moves for Cogeneration - Typical Cogeneration Performance Parameters - Relative Merits of Cogeneration Systems - Steam Turbine Efficiency-Cogeneration Heat Rate and Efficiency Assessment - Tri-generation - Micro turbine

UNIT – V: WASTE HEAT RECOVERY AND HEAT EXCHANGERS

Introduction - Classification and Application - Benefits of waste Heat Recovery - Development of a Waste Heat Recovery - Commercial Waste Heat Recovery Devices Heat Transfer Basics - Concept of Heat Exchanger - Pinch Analysis and pinch technology Application for process and Energy efficiency Improvements

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Evaluate the performance of fuel and biomass under different operating conditions	K1-K6
CO2	Know the Boiler, Steam and energy efficiency opportunities in steam systems	K1-K6
CO3	Calculate the performance assessment of furnaces and installation of refractories in industries	K1-K6
CO4	Know the working and classification of different cogeneration system	K1-K6
CO5	Know the design of different waste heat recovery and heat exchangers	K1-K6

K1- Remember, K2- Understand, K3- Apply , K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. Bureau of Energy Efficiency, *Energy Manager Training Manual (4 Volumes)*, Bureau of Energy Efficiency, 2004.
2. Yunus A. Çengel, Afshin J. Ghajar, *Heat and Mass Transfer: Fundamentals & Applications in SI Units*, McGraw-Hill Education, 2020, Sixth Edition.
3. S. P. Sharma, Chander Mohan, *Fuels & Combustion*, Tata McGraw Hill Publishing Co. Ltd.,.
4. H. Cohen, G. F. C. Rogers, H. I. H. Saravanamuttoo, *Gas Turbine Theory*, John Wiley, 2001, Fifth Edition.
5. W. F. Stoecker, *Design of Thermal Systems*, McGraw Hill, 2011.

CO	**PO**											**PSO**		
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1	H	H	L	H	M	H	-	-	-	H	H	H	H	L
2	H	H	L	H	M	H	-	-	-	H	H	H	H	L
3	H	H	L	H	M	H	-	-	-	H	H	H	H	M
4	H	H	L	H	M	H	-	-	-	H	H	H	H	M
5	H	H	L	H	M	H	-	-	-	H	H	H	H	M

26UPEST2C06	COMPUTATIONAL FLUID DYNAMICS	L	T	P	C
		4	1	0	5

COURSE OBJECTIVES

- To Make Students Familiarize Basics of Computational Analysis Concepts.
- To Explain the Numerical Analysis of Solving of Steady and Unsteady Diffusion Heat Transfer
- To Explain the Numerical Analysis of Solving of Convection-Diffusion Heat Transfer
- To Provide the Details of Discretization of Incompressible Flow Governing Equations
- To Impart the Knowledge of Combustion and Turbulence Modelling

UNIT – I: FUNDAMENTALS OF CFD

Basics of Heat Transfer, Fluid flow – Mathematical description of fluid flow and heat transfer – Conservation of mass, momentum - energy and chemical species - Initial and Boundary Conditions - Taylor's Series - Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test.

UNIT – II: DIFFUSION PROCESSES: FINITE VOLUME METHOD

Steady one-dimensional diffusion - two - and three - Dimensional steady state diffusion problems, Discretization of unsteady diffusion problems – Explicit, Implicit and Crank- Nicholson's schemes - Stability of schemes

UNIT–III: CONVECTION - DIFFUSION PROCESSES: FINITE VOLUME METHOD

One dimensional convection – Diffusion problem - Central difference scheme - Upwind scheme– Hybrid and power law discretization techniques – QUICK scheme.

UNIT-IV: FLOW PROCESSES: FINITE VOLUME METHOD

Discretization of incompressible flow equations – Pressure based algorithms - SIMPLE, SIMPLER & PISO algorithms.

UNIT – V: MODELLING OF COMBUSTION AND TURBULENCE

Mechanisms of combustion and Chemical Kinetics - Overall reactions and intermediate reactions, Reaction rate - Governing equations for combusting flows - Simple Chemical Reacting System (SCRS) - Turbulence - Algebraic Models - One equation model & $k – \varepsilon$, $k – \omega$ models - Standard and High and Low Reynolds number models.

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Know the basics of computational analysis concepts.	K1-K6
CO2	Learn the finite volume based numerical method for solving diffusion heat transfer problems.	K1-K6
CO3	Learn the finite volume based numerical method for solving convection-diffusion heat transfer problems.	K1-K6
CO4	Understand the finite volume method in incompressible flow	K1-K6
CO5	Recognize the impact of various combustion and turbulence modelling	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. Versteeg, H. K., N. Malalasekera, *An Introduction to Computational Fluid Dynamics: The Finite Volume Method*, Pearson Education Ltd., 2014, Second Edition.
2. P. S. Ghoshdastidar, *Computer Simulation of Flow and Heat Transfer*, Tata McGraw Hill Publishing Company Limited, 1998.
3. K. Muralidhar, T. Sundararajan, *Computational Fluid Flow and Heat Transfer*, Narosa Publishing House, 2003.
4. S. V. Patankar, *Numerical Heat Transfer and Fluid Flow*, Hemisphere Publishing Corporation, 1980.
5. Jiyuan Tu, Guan Heng Yeoh, Chaogun Liu, *Computational Fluid Dynamics: A Practical Approach*, Butterworth–Heinemann (Elsevier), 2008.

CO	**PO**											**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	H	H	H	H	L	M	-	-	-	L	M	L	H	H
2	H	H	H	H	H	M	-	M	-	L	M	H	H	H
3	H	H	H	H	H	M	-	M	-	-	H	H	H	H
4	H	H	H	H	L	M	-	-	L		H	L	H	H
5	H	H	H	H	L	M	-	-	L	L	M	M	H	H

26UPEST2C07 MACHINE LEARNING FOR ENERGY SYSTEMS

L	T	P	C
4	1	0	5

COURSE OBJECTIVES

- To Understand Machine Learning and its Energy Applications.
- To Handle energy data (Collection, Preprocessing, Visualization).
- To Develop Basic Python skills using Google Colab.
- To Apply ML techniques to energy problems.
- To Interpret results and recognize AI's role in sustainable energy.

UNIT – I: INTRODUCTION TO MACHINE LEARNING FOR ENERGY SYSTEMS

Introduction to Machine Learning, Role of Machine Learning in energy systems and sustainability, Types of Machine Learning, Machine Learning workflow, Applications, Case study: AI in smart meters and rural microgrids.

UNIT – II: DATA FUNDAMENTALS FOR ENERGY APPLICATIONS

Data, Types of data (numerical, categorical, time-series), Data sources: sensors, smart meters, weather data, Data preprocessing: missing values, noise, outliers, Spreadsheet tools (Excel/Google Sheets), Data visualization: bar, line, scatter plots, Practical: Explore a real energy dataset (solar generation / electricity bill data).

UNIT– III: PYTHON PROGRAMMING FOR MACHINE LEARNING

Introduction to Python and Google Colab, Variables, data types, operators, Conditional statements and loops, Functions and Read an energy CSV file, display statistics, plot a graph analysis and plotting.

UNIT- IV: SUPERVISED LEARNING TECHNIQUES

Regression: Linear and Polynomial, Classification: Logistic Regression, KNN, Model training and testing, Overfitting and underfitting, Evaluation metrics: MAE, RMSE, Accuracy, Practical: Predict monthly electricity consumption using Linear Regression on Colab.

UNIT – V: UNSUPERVISED LEARNING AND APPLICATIONS

Introduction to unsupervised learning, Clustering: K-Means clustering, Hierarchical clustering, PCA (basic concept), Applications: load analysis, theft detection, site selection, Practical: Cluster households by electricity usage pattern using K-Means on Colab.

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Explain basic Machine Learning concepts, types, and their relevance to energy systems	K1-K6
CO2	Perform data collection, cleaning, and visualization using Python (Pandas, Matplotlib) for energy datasets	K1-K6
CO3	Write simple Python programs to solve energy-related computational problems	K1-K6
CO4	Apply supervised learning algorithms (regression, classification) to predict and analyses energy data.	K1-K6
CO5	Use unsupervised learning techniques (clustering, PCA) to identify patterns in energy consumption and production.	K1-K6

K1- Remember, K2- Understand, K3- Apply , K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. Reema Thareja, *Python Programming Using Problem Solving Approach*, Oxford University Press, 2017, First Edition.
2. Andreas C. Müller, Sarah Guido, *Introduction to Machine Learning with Python: A Guide for Data Scientists*, O'Reilly Media, 2016, First Edition.
3. Wes McKinney, *Python for Data Analysis*, O'Reilly Media, 2022, Third Edition.
4. Kenneth A. Lambert, *Fundamentals of Python: First Programs*, Cengage Learning, 2019, Third Edition.
5. Aurélien Géron, *Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow*, O'Reilly Media, 2022, Third Edition.
6. Tom M. Mitchell, *Machine Learning*, McGraw-Hill, 1997.
7. Christopher M. Bishop, *Pattern Recognition and Machine Learning*, Springer, 2006.

CO	**PO**											**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	H	M	L	M	L	-	-	-	L	M	L	H	M	L
2	M	H	M	M	M	L	-	-	L	M	L	M	H	M
3	M	M	H	M	M	-	-	-	L	L	L	M	M	H
4	H	H	M	H	M	L	-	-	M	M	M	H	H	M
5	M	H	M	H	M	L	-	-	M	M	L	M	H	M

23UPPGC1H01	**FUNDAMENTALS OF HUMAN RIGHTS**	**L**	**T**	**P**	**C**
		2	0	0	1

UNIT – I: INTRODUCTION

Meaning and Definitions of Human Rights – Characteristics and Importance of Human Rights – Evolution of Human Rights – Formation, Structure and Functions of the UNO - Universal Declaration of Human Rights – International Covenants – Violations of Human Rights in the Contemporary Era.

UNIT – II: HUMAN RIGHTS IN INDIA

Development of Human Rights in India – Constituent Assembly and Indian Constitution – Fundamental Rights and its Classification – Directive Principles of State Policy – Fundamental Duties

UNIT–III: RIGHTS OF MARGINALIZED AND OTHER DISADVANTAGED PEOPLE

Rights of Women – Rights of Children – Rights of Differently Abled – Rights of Elderly - Rights of Scheduled Castes – Rights of Scheduled Tribes – Rights of Minorities – Rights of Prisoners– Rights of Persons Living with HIVAIDS – Rights of LGBT.

UNIT-IV: HUMAN RIGHTS MOVEMENTS

Peasant Movements (Tebhaga and Telangana) – Scheduled Caste Movements (Mahar and Ad- Dharmi) – Scheduled Tribes Movements (Santhal and Munda) – Environmental Movements (Chipko and Narmada Bachao Andolan) – Social Reform Movements (Vaikom and Self Respect).

UNIT – V: REDRESSAL MECHANISMS

Protection of Human Rights Act, 1993 (Amendment 2019) – Structure and Functions of National and State Human Rights Commissions – National Commission for SCs – National Commission for STs – National Commission for Women – National Commission for Minorities – Characteristics and Objectives of Human Rights Education.

TEXT AND REFERENCE BOOKS

1. Sudarshanam Gankidi, *Human Rights in India: Prospective and Retrospective*, Rawat Publications, 2019.
2. Satvinder Juss, *Human Rights in India*, Routledge, 2020.
3. Namita Gupta, *Social Justice and Human Rights in India*, Rawat Publications, 2021.
4. Mark Frezo, *The Sociology of Human Rights*, John Wiley & Sons, 2014.
5. Chiranjivi J. Nirmal, *Human Rights in India: Historical, Social and Political Perspectives*, Oxford University Press, 2000.
6. S. Mehartaj Begum, *Human Rights in India: Issues and Perspectives*, APH Publishing Corporation, 2010.
7. Asha Kiran, *The History of Human Rights*, Mangalam Publications, 2011.
8. Bani Borgohain, *Human Rights*, Kanishka Publishers & Distributors, 2007.
9. Jayant Chaudhary, *A Textbook of Human Rights*, Wisdom Press, 2011.

26UPEST2L02	ANALYSIS AND SIMULATION LABORATORY	L	T	P	C
		0	0	6	3

COURSE OBJECTIVES

- To Analyze steady-state and transient heat conduction problems with heat generation and various boundary conditions using computational methods.
- To Simulate laminar and turbulent internal flows through pipes and complex geometries including mixing regions and porous media.
- To Perform computational analysis of external aerodynamics including airfoils, cylinders, Ahmed bodies, and exhaust manifolds.
- To Model compressible flows in convergent-divergent nozzles and conjugate heat transfer combining convection and radiation.
- To Investigate advanced applications including battery thermal management, catalytic converters, and fins using CFD techniques.

LIST OF EXPERIMENTS

1. Analysis of the one-dimensional steady state heat diffusion with and without heat generation in uniformly heated aluminium plate
2. Simulate the two-dimensional steady state heat diffusion in uniformly heated copper plate by applying different boundary condition.
3. Simulation and analysis of laminar flow through a pipe using computational fluid dynamics
4. Simulation and analysis of turbulent flow in a pipe using computational fluid dynamics
5. Computational analysis of mixing of hot and cold fluid through a pipe under steady flow conditions.
6. Two-dimensional computational analysis of steady compressible flow in a Convergent – Divergent nozzle
7. Aerodynamic analysis of two-dimensional steady state incompressible flow over an air foil using CFD
8. Computational analysis of flow over an Ahmed body at specified inlet velocity.
9. Numerical Investigation of 2D air flow over a cylinder using CFD
10. Modeling and analysis of transient heat transfer in Aluminium fins using CFD
11. Numerical simulation and analysis of air flow in an exhaust manifold using CFD.
12. Performance simulation nitrogen gas flow through a porous media in catalytic convertor using CFD
13. Analysis of combined natural convection and radiation heat transfer in a three-dimensional square box on a mesh consisting of hexahedral elements.
14. Simulate and observe fluid flow and heat transfer in the area of the mixing region of elbow.
15. Analysis of discharge behavior of a lithium-ion battery (MSMD Battery Model) using CFD

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Apply computational fluid dynamics principles to solve heat transfer and fluid flow problems.	K1-K6
CO2	Simulate steady-state and transient thermal diffusion problems with various boundary conditions.	K1-K6
CO3	Analyze laminar, turbulent, compressible, and incompressible flows using CFD software.	K1-K6
CO4	Model complex geometries including airfoils, nozzles, fins, and porous media.	K1-K6
CO5	Evaluate heat transfer phenomena combining convection and radiation.	K1-K6

K1- Remember, K2- Understand, K3- Apply , K4- Analyze, K5- evaluate and K6- Create

CO	**PO**											**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	H	H	-	H	H	H	-	H	-	M	H	H	M	-
2	H	H	M	H	H	H	-	H	-	L	M	H	M	H
3	H	H	M	H	H	H	M	H	M	L	M	H	H	H
4	H	H	L	H	H	H	L	H	L	H	M	H	H	H
5	H	H	L	H	H	H	-	H	-	-	M	H	-	H

26UPEST2C08	ENERGY CONSERVATION OF ELECTRICAL SYSTEMS	L	T	P	C
		4	1	0	5

COURSE OBJECTIVES

- To Learn Electrical Transmission and Distribution System and Electrical Motors
- To Obtain Knowledge on Working of Air Compressed System
- To Know the HVAC and Refrigeration Systems Adopted in Industries
- To Understand the Operation of Pumps Selection of Pumps and Fans Based on Application
- To Know the Energy Conservation in Lighting System

UNIT – I: ELECTRICAL SYSTEM AND ELECTRICAL MOTORS

Introduction to Electrical Power Supply Systems - Electricity Billing - Power Factor – Transformers - Distribution Losses in Industrial System - Assessment of T&D Losses in Power Systems - Estimation of T&D Losses in Distribution System - Demand Side Management (DSM) – Harmonics - Analysis of Electrical Power System- Motor Types - Motor Characteristics - Motor Efficiency - Motor Selection - Energy Efficient Motors

UNIT – II: COMPRESSED AIR SYSTEM

Introduction - Compressor Types - Compressor Performance - Compressed Air System Components - Efficient Operation of Compressed Air System - Compressor Capacity Assessment

UNIT – III: HVAC AND REFRIGERATION SYSTEM

Introduction - Psychometrics and Air Conditioning Process - Types of Refrigeration System - Common Refrigerants and Properties - Compressor Types and Application - Selection of a Suitable Refrigeration System - Performance Assessment of Refrigeration Plants - Factors Affecting Performance and Energy Efficiency of Refrigeration Plants - Performance Assessment of Window , Split, and Package Air Conditioning Units

UNIT– IV: FANS, BLOWERS AND PUMPING SYSTEM

Introduction - Fan Types - Fan Performance Evaluation - Fan Design and Selection Criteria - Flow Control Strategies - Energy Saving Opportunities - Pump Types - System Characteristics - Flow Control Strategies - Boiler Feed Water Pumps - Municipal Water Pumps - Sewage Water Pumps - Agricultural Pumping System - Energy Conservation Opportunities in pumping Systems

UNIT- V: LIGHTING SYSTEM

Basic Parameters and Terms in Lighting System - Light Source and Lamp Types - General Energy Saving Opportunities - Energy Efficient Lighting Controls

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Evaluate the efficiency and losses in electrical system	K1-K6
CO2	Adopt the compressed air system based on application with energy conservation	K1-K6
CO3	Familiarized about the use of HVAC and refrigeration system	K1-K6
CO4	Determine the performance fans, blowers and pumping system and understand the parameters and terminologies used	K1-K6
CO5	Know the energy conservative measures and efficient in lighting systems	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. Bureau of Energy Efficiency, *Energy Manager Training Manual (4 Volumes)*, Bureau of Energy Efficiency, 2015.
2. The Energy and Resources Institute (TERI), *Handbook on Energy Efficiency*, TERI, 2001.
3. Barney L. Capehart, Wayne C. Turner, William J. Kennedy, *Guide to Energy Management*, The Fairmont Press, 2016, Eighth Edition.
4. B. L. Theraja, A. K. Theraja, *A Textbook of Electrical Technology: Volume 2 (AC and DC Machines)*, S. Chand Publishing.
5. O. P. Jakhar, *Energy Conservation in Buildings*, Khanna Publications.

CO	**PO**											**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	H	-	-	H	-	H	L	-	L	-	M	H	H	-
2	M	-	-	H	-	H	L	-	L	-	M	M	H	L
3	H	-	M	M	-	H	-	-	L	-	M	M	M	L
4	L	-	-	M	-	H	H	-	M	-	M	H	M	-
5	L	-	-	L	-	H	-	-	M	-	M	H	H	-

26UPEST2C09	**BIOFUELS AND BIOENERGY TECHNOLOGIES**	**L**	**T**	**P**	**C**
		5	0	0	5

COURSE OBJECTIVES

- To detail on the types of biofuels and bioenergy, its surplus availability and characteristics.
- To understand the basic knowledge of crop oils, algae fuel and biodiesel.
- To impart knowledge on production of ethanol from various sources
- To provide insight to the possibilities of producing energy from waste
- To elucidate on the influence of thermochemical conversion of biomass

UNIT – I: INTRODUCTION TO BIOFUELS AND BIOENERGY

Fundamental concepts of biofuel and bioenergy production, Global energy consumption trends and current energy scenario, Comparison between fossil fuels and renewable energy resources- Economic aspects and impact of biofuels, Comparison of various bioenergy sources.

UNIT– II: CROP OILS, ALGAE FUEL AND BIODIESEL

Vegetable oils: sources, production, and composition, Use of vegetable oils as alternative diesel fuels, Microalgae: types, growth conditions, and significance in biofuel production, Algae harvesting methods and oil extraction techniques, Biodiesel: concept, importance, and applications, Transesterification process for biodiesel production, Properties and performance characteristics of biodiesel.

UNIT– III: PRODUCTION OF ETHANOL

Ethanol as a renewable fuel and its importance, Feedstocks: sugar, starch, and lignocellulosic biomass, Ethanol production process: pretreatment, hydrolysis, fermentation, and distillation,- By products and their utilization, Environmental and economic aspects of ethanol production- Indian ethanol policy: National Policy on Biofuels – Ethanol Blended Petrol Programme – targets for ethanol blending (E20), promotion of 1G and 2G ethanol, incentives for ethanol production and use of agricultural residues.

UNIT – IV: CONVERSION OF WASTE TO ENERGY

Types of waste: agricultural, municipal, and industrial wastes, Waste preparation and pretreatment methods, Thermochemical conversion: combustion, incineration, gasification, and pyrolysis, Biological conversion processes, Waste-to-energy technologies and systems, Production of biofuels from waste, Economic and environmental aspects of waste conversion, Future trends in waste-to-energy technologies.

UNIT- V: PYROLYSIS AND GASIFICATION OF BIOMASS

Biomass: types, characteristics, and utilization, Thermochemical conversion of biomass, Pyrolysis concept, types, and products, Gasification principles and process – Reactions of partial oxidation, steam gasification, and Boudouard- Production and applications of biosyngas, Tar formation and its control.

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Estimate the surplus biomass availability and conversion to bioenergy	K1-K6
CO2	Design a process for extracting biodiesel from vegetable source	K1-K6
CO3	Determine and compare the various ethanol production process	K1-K6
CO4	Synthesize of biofuels, bioproducts and bioenergy for power generation from waste biomass	K1-K6
CO5	Analyze the influence of process governing parameters in thermochemical conversion of biomass	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6-Create

TEXT AND REFERENCE BOOKS

1. Sunggyu Lee, Y. T. Shah, *Biofuels and Bioenergy: Processes and Technologies*, CRC Press, 2005.
2. Tom B. Reed, *Biomass Gasification: Principles and Technology*, Noyes Data Corporation, 1981.
3. David Boyles, *Bioenergy Technology: Thermodynamics and Costs*, Ellis Horwood (Chichester), 1984.
4. K. C. Khandelwal, S. S. Mahdi, *Biogas Technology: A Practical Handbook*, Tata McGraw Hill, 1986.
5. R. C. Maheswari, *Bio Energy for Rural Energisation*, Concepts Publications, 1997.

CO	**PO**											**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	-	M	-	-	M	H	M	L	-	L	L	M	-	L
2	-	M	H	-	H	M	L	-	-	L	L	M	-	L
3	M	H	H	-	H	H	M	-	-	L	L	M	-	L
4	-	M	L	-	M	M	M	M	-	L	-	M	-	L
5	-	-	-	-	-	H	M	M	-	-	-	M	-	-

26UPEST2C10	**ENTREPRENEURSHIP DEVELOPMENT**	**L**	**T**	**P**	**C**
		4	0	0	4

COURSE OBJECTIVES

- To develop and strengthen entrepreneurial quality and motivation in students and to impart basic entrepreneurial skills and understanding to run a business efficiently and effectively.
- To Promote First Generation Businessman and Industrialists
- To facilitate strategic decision making among entrepreneurs.
- To Provide Knowledge about Government Plans and Programmes
- To Remove Doubts of Entrepreneurs, Give Solutions and Suggest Remedies of Problems

UNIT – I: ENTREPRENEURSHIP

Entrepreneur – Types of Entrepreneurs – Difference between Entrepreneur and Intrapreneur Entrepreneurship in Economic Growth, Entrepreneurial competencies and skills, Opportunities in energy sector: solar, wind, biomass, EVs.

UNIT – II: MOTIVATION

Major Motives Influencing an Entrepreneur – Achievement Motivation Training, Self Rating, Business Games, Thematic Apperception Test – Stress Management, Entrepreneurship Development Programs – Need, Objectives.

UNIT–III: BUSINESS

Small Enterprises – Definition, Classification – Characteristics, Ownership Structures – Project Formulation – Steps involved in setting up a Business – identifying, selecting a Good Business opportunity, Market Survey and Research, Techno Economic Feasibility Assessment – Preparation of Preliminary Project Reports – Project Appraisal – Sources of Information – Classification of Needs and Agencies.

UNIT-IV: FINANCING AND ACCOUNTING

Need – Sources of Finance, Term Loans, Capital Structure, Financial Institution, Management of working Capital, Costing, Break Even Analysis, Government schemes, subsidies, and incentives in energy sector, marketing strategies for energy products/services.

UNIT – V: SUPPORT TO ENTREPRENEURS

Sickness in small Business – Concept, Magnitude, Causes and Consequences, Corrective Measures - Business Incubators – Government Policy for Small Scale Enterprises – Growth Strategies in small industry – Expansion, Diversification, Joint Venture, Merger and Sub Contracting.

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Gain knowledge and skills needed to run a business successfully.	K1-K6
CO2	Familiarize the students with the latest programs of the government authorities in promoting small and medium industries.	K1-K6
CO3	Imparts essential knowledge of how to start one's own business venture and the various facts that influence successful setting up and operations.	K1-K6
CO4	Realize skills and inspiration for developing an entrepreneurial mindset.	K1-K6
CO5	Have a basic idea of the economics of Entrepreneurship.	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. Entrepreneurship Development Institute of India (EDII), *Faulty and External Experts: A Handbook for New Entrepreneurs*, Entrepreneurship Development Institute of India, Ahmedabad, 1986.
2. Robert D. Hisrich, Michael P. Peters, *Entrepreneurship*, Tata McGraw-Hill, 2013, Eighth Edition.
3. Mathew J. Manimala, *Entrepreneurship: Theory at Cross Roads – Paradigms and Praxis*, Dreamtech Press, 2005, Second Edition.
4. Rajeev Roy, *Entrepreneurship*, Oxford University Press, 2011, Second Edition.
5. Donald F. Kuratko, *Entrepreneurship: Theory, Process and Practice*, Cengage Learning, 2014, Ninth Edition.
6. S. S. Khanka, *Entrepreneurial Development*, S. Chand & Co. Ltd., 2013.

CO	**PO**											**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	-	-	-	-	-	M	L	L	L	-	L	-	-	-
2	-	-	-	-	-	M	L	L	L	-	L	-	L	-
3	-	-	-	-	-	M	M	L	L	H	L	-	L	-
4	-	-	-	-	-	M	M	-	L	L	L	-	L	-
5	-	-	-	-	-	M	M	-	L	-	L	-	L	-

26UPEST2I01	**INTERNSHIP**	**L**	**T**	**P**	**C**
		0	0	0	2

COURSE OBJECTIVES

The students may undergo internship training (Research organization / University/ industry) for a period as specified in the curriculum during summer vacation. In this case the training has to be undergone continuously for the entire period.

At the end of internship, the student shall submit a report. The Viva-Voce Examination will be Conducted by External Mode.

INTERNSHIP (100 Marks)

Report	**Viva Voce**		**Total**	**Credits**
External	**External**	**Internal**		
40	30	30	100	2

*** Duration of Internship: 15 Days (Minimum) to 60 Days (Maximum)**

26UPEST2L03	**ENERGY AUDITING LABORATORY**	**L**	**T**	**P**	**C**
		0	0	6	3

COURSE OBJECTIVES

- Operate thermal imaging and radiation measurement instruments to assess surface temperatures and solar energy potential.
- Measure environmental parameters including light intensity, wind velocity, sound levels, and indoor air quality using specialized meters.
- Analyze water quality through determination of pH, electrical conductivity, total dissolved solids, and temperature.
- Evaluate electrical power systems by measuring current, voltage, power consumption, and harmonic distortion.
- Assess combustion efficiency and emissions through flue gas analysis including oxygen, carbon dioxide, carbon monoxide, and excess air calculation.

LIST OF EXPERIMENTS

1. Measurement and analysis of temperature distribution of different surfaces using a thermal imager.
2. Measurement of illuminance (light intensity) using a lux meter.
3. Measurement of wind velocity using an anemometer.
4. Determination of pH, electrical conductivity (EC), total dissolved solids (TDS), and temperature of a water sample.
5. Measurement of solar radiation and tilt angle using a solar power meter.
6. Measurement and analysis of sound intensity (noise level) at different locations using a sound level meter.
7. Measurement of ambient temperature and relative humidity using a humidity and temperature meter.
8. Measurement of electrical parameters such as current, voltage, power, and harmonics using a clamp meter.
9. Experimental analysis of flue gas composition (O_2, CO_2, CO), flue gas temperature, and excess air using flue gas analyzer.
10. Measurement and assessment of indoor air quality (IAQ) by determining CO_2 concentration, temperature, and relative humidity using an Air Quality meter.

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Accurately measure and interpret thermal distributions, solar radiation, and ambient environmental conditions using industry-standard instruments.	K1-K6
CO2	Perform comprehensive water quality assessments and indoor air quality evaluations for environmental monitoring applications.	K1-K6
CO3	Analyze electrical parameters and power quality metrics essential for energy auditing and system optimization.	K1-K6
CO4	Conduct combustion gas analysis to determine efficiency and emissions compliance in industrial processes.	K1-K6
CO5	Compile, analyze, and report measurement data to support energy conservation, environmental compliance, and system performance evaluations.	K1-K6

K1- Remember, K2- Understand, K3- Apply , K4- Analyze, K5- evaluate and K6- Create

CO	PO											PSO		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
1	H	H	-	H	H	H	-	H	-	M	H	H	M	-
2	H	H	M	H	H	H	-	H	-	L	M	H	M	H
3	H	H	M	H	H	H	M	H	M	L	M	H	H	H
4	H	H	L	H	H	H	L	H	L	H	M	H	H	H
5	H	H	L	H	H	H	-	H	-	-	M	H	-	H

26UPEST2P01 **PROJECT WITH VIVA VOCE**

L	T	P	C
0	0	30	15

COURSE OBJECTIVES

To enable students to apply theoretical knowledge to real-world engineering problems through independent or industry/research-based projects, fostering problem-solving, teamwork, and professional skills.

EVALUATION

<table>
<tr><th>Project</th><th colspan="5">Internal (80 Marks)</th><th colspan="3">External (120 marks)</th></tr>
<tr><td rowspan="3">200 Marks</td><td rowspan="2">Review I</td><td rowspan="2">Review II</td><td rowspan="2">Review III</td><td rowspan="2">Attendance</td><td rowspan="2">Conference Presentation/ Journal Article/ Patent</td><td rowspan="2">Thesis Evaluation (External)</td><td colspan="2">Viva –Voce (80 Marks)</td></tr>
<tr><td>Internal Examiner</td><td>External Examiner</td></tr>
<tr><td>15</td><td>15</td><td>30</td><td>10</td><td>10</td><td>40</td><td>40</td><td>40</td></tr>
</table>

Students may be permitted to carry out the project either internal or external mode (i.e., Industrial / Research Organization, etc.,) on the recommendations of the Head of the Department. In case of external Project, a supervisor of the department shall guide the Project work jointly with an expert member as joint supervisor from the Industry/ Organization. The student shall be instructed to meet the supervisor periodically and attend the review committee meetings for evaluating the progress.

OUTCOME

The students would apply the knowledge gained from theoretical and practical courses in solving problems, to give confidence to the students to be creative, well-planned, organized, coordinated project outcome of the aimed work.

ELECTIVES

26UPEST2E01	SOLAR ENERGY TECHNOLOGIES	L	T	P	C
		4	0	0	4

COURSE OBJECTIVES

- To Understand Solar Radiation Fundamentals, Measurement Techniques, and Surface Calculations.
- To Analyze Radiation Heat Transfer Principles and Laws.
- To Design and Evaluate Flat-Plate and Concentrating Solar Thermal Collectors.
- To Study Photovoltaic Cell Operation, System Design, and Hybrid Applications.
- To Select Appropriate Energy Storage Systems for Solar Process Integration.

UNIT – I: FUNDAMENTALS

The Sun- The Solar Constant - Spectral Distribution and Variation of Extraterrestrial Radiation & Direction of Beam Radiation - Angles for Tracking Surfaces – Shading – Measurement of Solar Radiation - Beam and Diffuse Radiation - Radiation on Sloped Surfaces – Utilizability – Daily and monthly average radiation – Estimation of solar radiation on tilted surfaces.

UNIT – II: HEAT TRANSFER AND RADIATION CHARACTERISTICS

The Electromagnetic Spectrum - Photon Radiation - The Blackbody - Planck's Law and Wien's Displacement Law - Stefan-Boltzmann Equation - Radiation Intensity and Flux - Radiation Heat Transfer Coefficient -Wind Convection Coefficients - Absorptance and Emittance - Kirchhoff's Law - Calculation of Emittance and Absorptance - Reflection of Radiation - Absorption by Glazing

UNIT– III: SOLAR THERMAL COLLECTORS

Flat-Plate Collectors - Basic Flat-Plate Energy Balance Equation - Temperature Distribution - Collector Overall Heat Loss Coefficient - Collector Heat Removal Factor and Flow Factor - Effects of Dust and Shading - Concentrating Collectors - Collector Configurations - Concentration Ratio - Thermal Performance of Concentrating Collectors - Paraboloidal Concentrators – Central - Receiver Collectors

UNIT- IV: SOLAR PHOTOVOLTAICS

Introduction – Description and principle of working – performance characteristics of a solar cell– Problems - types of solar cell – cost – problems – photovoltaic system and applications - photovoltaics thermal collectors

UNIT – V: ENERGY STORAGE

Process Loads and Solar Collector - Energy Storage in Solar Process Systems - Water Storage - Stratification in Storage Tanks (SST) - Packed-Bed Storage - Storage Walls- Seasonal Storage - Phase Change Energy Storage - Chemical Energy Storage- Battery Storage

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Calculate solar radiation availability and optimum collector orientations.	K1-K6
CO2	Apply blackbody radiation laws to solar thermal system design.	K1-K6
CO3	Determine thermal performance of flat-plate and concentrating collectors.	K1-K6
CO4	Design PV systems and assess economic viability.	K1-K6
CO5	Integrate thermal and battery storage for reliable solar energy supply	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. S. P. Sukhatme, *Solar Energy: Principles of Thermal Collection and Storage*, Tata McGraw Hill Publishing Company Ltd., 2009, —.
2. S. P. Sukhatme, J. K. Nayak, *Solar Energy*, Tata McGraw Hill, 2017, Fourth Edition.
3. Michael Stix, *The Sun: An Introduction*, Springer, 2002, Second Edition.
4. Chetan Singh Solanki, *Solar Photovoltaics: Fundamentals, Technologies and Applications*, PHI Publications, 2011, Second Edition.
5. Joshua Earnest, *Wind Power Technologies*, Eastern Economy Edition, 2014, Second Edition.

CO	**PO**											**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	H	H	H	L	L	L	-	-	-	-	L	-	L	L
2	H	H	H	M	M	M	-	-	-	-	L	-	L	L
3	H	H	H	H	H	M	-	-	-	-	L	-	M	M
4	H	H	H	H	H	M	-	-	-	-	-	-	H	H
5	M	M	H	H	L	M	-	-	-	-	-	-	H	H

26UPEST2E02	**WIND ENERGY CONVERSION SYSTEMS**	**L**	**T**	**P**	**C**
		4	0	0	4

COURSE OBJECTIVE

- To Understand the Basic of Wind Energy and its Measurements
- To Understand the Aerodynamic Characteristics of Wind Turbine
- To Acquire the Knowledge to Design the Wind Turbine
- To Know the Controlling Methods and Fault Detection in Wind Turbine
- To Know the Methods of Wind Energy Storage

UNIT – I: MEASUREMENT AND INSTRUMENTATION

Nature of the Wind - Geographical Variation in the Wind Resource – Turbulence - Gust Wind Speeds - Wind-speed Prediction and Forecasting - Turbulence in Wakes and Wind Farms - Turbulence in Complex Terrain – Instrumentation for Wind Measurements

UNIT – II: WIND TURBINES AND CHARACTERISTICS

HAWT, VAWT– Momentum theory - Power coefficient - The Betz limit - Rotor Blade Theory- Effects of a Discrete Number of Blades - Performance Curves - Stall regulation - Pitch regulation - Aerodynamic Performance Assessment - Yaw control

UNIT– III: DESIGN OF WIND TURBINE

Blade materials and properties – Gearbox - Variable loads during operation - Braking loads – Generator - Induction generators – Variable speed generators - Variable speed using doubly fed induction generator - Yaw Drive – Tower

UNIT- IV: WIND TURBINE CONTROL

Introduction - Wind Turbine Control Systems - Wind Turbine Sensors -Wind Turbine Controllers - Control of Turbine Processes - Grid-connected Turbine Operation - Operating States - Fault Diagnosis - Dynamic Control Theory and Implementation.

UNIT – V: WIND ENERGY STORAGE TECHNOLOGIES

Parameters of an energy storage device - Energy storage technologies, Battery energy storage - Flow battery energy storage - Flywheel energy storage - Supercapacitor energy storage - Hydrogen energy storage system - Load management – Grid Integration of Wind Power

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Learn wind sources and its measurements	K1-K6
CO2	Gain aerodynamic characteristics of wind turbine	K1-K6
CO3	Design the components of wind turbine	K1-K6
CO4	Analyze Wind Power Control and detect the fault	K1-K6
CO5	Know Wind energy storage methods	K1-K6

K1- Remember, K2- Understand, K3- Apply , K4- Analyze, K5- evaluate and K6-Create

TEXT AND REFERENCE BOOKS

1. T. Burton et al., *Wind Energy Handbook*, John Wiley & Sons, 2011, Second Edition.
2. Wei Tong, *Wind Power Generation and Wind Turbine Design*, WIT Press, 2010, —.
3. J. F. Manwell, J. G. McGowan, *Wind Energy Explained: Theory, Design and Application*, John Wiley & Sons, 2009, Second Edition.
4. D. A. Spera, *Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering*, ASME Press, 2009, Second Edition.
5. Joshua Earnest, *Wind Power Technology*, Eastern Economy Edition, 2015, Second Edition.

CO	**PO**											**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	H	M	L	-	-	-	-	-	-	-	M	H	M	-
2	H	M	L	-	-	-	-	-	-	-	M	H	M	-
3	H	M	L	-	-	-	-	-	-	-	M	H	M	-
4	H	M	L	-	-	-	-	-	-	-	M	H	M	-
5	H	M	L	-	-	-	-	-	-	-	M	H	M	-

26UPEST2E03	NUCLEAR ENERGY TECHNOLOGY	L	T	P	C
		4	0	0	4

COURSE OBJECTIVES

- To Know the Main Aspects of Nuclear Energy
- To Learn about the Nuclear Fuels.
- To Familiarize in Nuclear Reactors Types and its Fission and the Chain Reaction.
- To Impart the Knowledge of Waste Disposal and Radiation Protection
- To Know the Various Applications of Nuclear Radiation in Industry, Agriculture, Food Processing, and Water Treatment.

UNIT – I: BASIC NUCLEAR CONCEPTS

Atomic Structure, Nuclear models, Equivalence of mass and energy, binding energy, Radio activity, half-life, mechanism of nuclear fission and fusion, decay chains, critical mass and composition, neutron reactions

UNIT – II: NUCLEAR FUELS

Nuclear fuel reserves of Uranium and Thorium, Nuclear fuel cycles, characteristics, production and purification, other fuels Zirconium, Beryllium, Reprocessing of nuclear fuels.

UNIT– III: NUCLEAR REACTORS

Nuclear reactors and classification, boiling water reactors (BWR), pressurized heavy water reactor (PHWR), fast breeder reactor (FBR), basics of nuclear fusion reactor

UNIT- IV: NUCLEAR POWER PLANT -WASTE MANAGEMENT AND SAFETY

Nuclear Power Plant, Nuclear power plant safety systems, Nuclear Accidents- consequences– case study, criteria for safety, Nuclear Waste management, International Convention on safety aspects, radiation hazards and their prevention.

UNIT – V: NUCLEAR RADIATION APPLICATIONS

Radiation processing of food and allied products, applications of radio isotopes in Industry and Agriculture, Industrial radiotracer applications in Ground water exploration, Desalination

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Explain atomic structure, nuclear reactions, radioactivity, and energy equivalence principles.	K1-K6
CO2	Describe nuclear fuel types, fuel cycles, and processing methods including uranium and thorium utilization.	K1-K6
CO3	Understand the working principles and classifications of nuclear reactors such as BWR, PHWR, and FBR.	K1-K6
CO4	Analyze nuclear power plant safety systems, radiation hazards, and methods of nuclear waste management.	K1-K6
CO5	Evaluate the applications of nuclear radiation in industry, agriculture, food processing, and water treatment.	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. T. J. Cannoly, *Fundamentals of Nuclear Engineering*, John Wiley & Sons, 2014.
2. J. R. Lamarsh, *Introduction to Nuclear Reactor Theory*, Prentice-Hall, 2001.
3. J. G. Collier, G. F. Hewitt, *Introduction to Nuclear Power*, Hemisphere Publishing, 2001.
4. S. Glasstone, A. Sesonske, *Nuclear Reactor Engineering*, Van Nostrand Reinhold Company, 1969.

CO	**PO**											**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	H	H	M	M	L	L	-	H	-	-	L	M	M	-
2	H	H	M	M	M	M	L	H	-	-	M	M	M	-
3	H	H	M	M	L	M	-	H	-	-	M	M	M	-
4	H	H	M	H	M	-	M	H	-	-	-	M	M	-
5	H	H	M	L	H	M	M	H	-	-	M	M	M	-

26UPEST2E04	**MATERIAL CHARACTERIZATON TECHNIQUES**	**L**	**T**	**P**	**C**
		4	0	0	4

COURSE OBJECTIVES

- To Introduce Students to Various Thermal Analysis Techniques and their Applications in Material Characterization
- To Provide Knowledge of Microscopic Techniques for Analyzing Material Structure and Properties
- To Familiarize Students with Electron Microscopy and Scanning Probe Methods for Advanced Material Analysis
- To Explain Electrical and Optical Characterization Techniques Used in Material Science
- To Impart Understanding of X-Ray and Spectroscopic Methods for Phase Identification and Structural Analysis

UNIT – I: THERMAL ANALYSIS

Introduction – thermogravimetric analysis (TGA) – instrumentation – determination of weight loss and decomposition products – differential thermal analysis (DTA) - cooling curves – differential scanning calorimetry (DSC) – instrumentation – specific heat capacity measurements – determination of thermomechanical parameters

UNIT – II: MICROSCOPIC METHODS

Optical Microscopy: optical microscopy techniques – Bright field optical microscopy – Dark field optical microscopy – Dispersion staining microscopy - phase contrast microscopy –differential interference contrast microscopy - fluorescence microscopy - confocal microscopy - digital holographic microscopy - oil immersion objectives - quantitative metallography - image analyzer.

UNIT– III: ELECTRON MICROSCOPY AND SCANNING PROBE MICROSCOPY

SEM, EDAX, EPMA, TEM: working principle and Instrumentation – sample preparation –Data collection, processing and analysis- Scanning tunneling microscopy (STEM) - Atomic force microscopy (AFM) - Scanning new field optical microscopy.

UNIT- IV: ELECTRICAL METHODS AND OPTICAL CHARACTERISATION

C-V characteristics – Schottky barrier capacitance – impurity concentration – electrochemical C-V profiling – limitations. Photoluminescence – light – matter interaction – instrumentation – electroluminescence – instrumentation – Applications.

UNIT – V: X-RAY AND SPECTROSCOPIC METHODS

Principles and instrumentation for UV-Vis-IR, FTIR spectroscopy, Raman spectroscopy, XPS -Powder diffraction - Powder diffractometer -interpretation of diffraction patterns - indexing - phase identification - residual stress analysis - Particle size, texture studies - X-ray fluorescence spectroscopy - uses.

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Understand and interpret thermal analysis techniques such as TGA, DTA, and DSC for evaluating material properties..	K1-K6
CO2	Apply optical microscopy techniques for analyzing microstructures and performing quantitative metallography.	K1-K6
CO3	Explain and utilize electron microscopy and scanning probe methods for material characterization.	K1-K6
CO4	Analyze materials using electrical (C-V) and optical characterization techniques like photoluminescence and electroluminescence.	K1-K6
CO5	Evaluate material composition and structure using spectroscopic techniques and X-ray diffraction methods.	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. Yang Leng, *Materials Characterization: Introduction to Microscopic and Spectroscopic Methods*, Wiley, 2013, Second Edition.
2. Sam Zhang, Lin Li, Ashok Kumar, *Materials Characterization Techniques*, CRC Press, 2009.
3. Robert F. Speyer, *Thermal Analysis of Materials*, CRC Press, 1994, —.
4. Charles Kittel, *Introduction to Solid State Physics*, Wiley, 2005, Eighth Edition.
5. Joseph Goldstein et al., *Scanning Electron Microscopy and X-ray Microanalysis*, Springer, 2003, Third Edition.
6. C. N. Banwell, E. M. McCash, *Fundamentals of Molecular Spectroscopy*, McGraw Hill, 1994, Fourth Edition.
7. B. D. Cullity, S. R. Stock, *Elements of X-ray Diffraction*, Pearson, 2001, Third Edition.

CO	PO											PSO		
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1	H	M	–	H	M	–	M	–	–	L	–	M	M	-
2	H	M	–	H	H	–	M	–	–	L	–	M	M	-
3	H	H	–	H	H	–	M	–	–	L	–	M	M	-
4	H	M	–	H	H	M	M	–	–	L	L	M	M	-
5	H	H	–	H	H	–	M	–	–	L	–	M	M	-

26UPEST2E05	**SOLAR ENERGY APPLIANCES**	**L**	**T**	**P**	**C**
		4	0	0	4

COURSE OBJECTIVES

- To learn the principle behind operation of solar PV cell and its application in lighting system.
- To understand the principle of working of solar cooker with types and its solar applications.
- To learn the need for solar drying and operation of different dryer types.
- To learn about various desalination techniques and factors influencing productivity of solar still with its types.
- To know about solar furnaces and its components

UNIT – I: SOLAR LIGHTING

Solar cell – Working principle of a solar cell – Solar home lighting systems – Solar street lighting systems - Solar lanterns – Applications - Rural electrification process – Case studies

UNIT – II: SOLAR COOKING

Introduction – Types of solar cookers – Advantages and disadvantages - Box type – Parabolic dish cooker - Performance evaluation of solar cookers – Testing of a solar cooker – Applications of solar cooking - Case studies.

UNIT– III: SOLAR DRYING

Introduction – Need for solar drying - Basics of solar drying – Types of solar dryers – Direct type solar dryer – Mixed mode type solar dryer – Forced circulation type dryers – Hybrid dryer– Bin type dryer – Solar timber drying – Applications - Case studies

UNIT- IV: SOLAR DESALINATION

Introduction – Necessity for desalination – Study on various desalination techniques – Comparison between conventional and solar desalination – Basics of solar still - Simple solar still – Material problems in solar still – Solar disinfection and its methods – Case studies on various desalination techniques

UNIT – V: SOLAR FURNACES

Introduction – Types of solar furnaces – Components of solar furnaces – Concentrator – Heliostat– Sun tracking – Typical solar furnace designs – Single concentrator furnace – Single heliostat solar furnace - Multiple heliostats solar furnace - Case studies on solar furnaces

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Will be familiar with concepts of solar home lighting and solar street lighting systems.	K1-K6
CO2	Identify the solar cooker technologies for suitable applications.	K1-K6
CO3	Recognize the applications and types of solar dryers.	K1-K6
CO4	Aware about various desalination techniques and material problems in solar still	K1-K6
CO5	know about solar furnaces and its components	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. S. P. Sukhatme, J. K. Nayak, *Solar Energy: Principles of Thermal Collection and Storage*, Tata McGraw Hill, 2008.
2. H. P. Garg, J. Prakash, *Solar Energy: Fundamentals and Applications*, Tata McGraw Hill, 2010.
3. G. D. Rai, *Solar Energy Utilization*, Khanna Publishers, 2010.
4. Michael Grupp, *Time to Shine: Applications of Solar Energy Technology*, John Wiley & Sons, 2012.
5. S. M. Sze, K. K. Ng, *Physics of Semiconductor Devices*, John Wiley & Sons, 2007, Third Edition.

CO	PO											PSO		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
1	H	H	L	L	-	-	-	-	-	-	-	-	-	-
2	H	L	H	L	-	-	-	-	-	-	-	-	-	-
3	H	L	H	L	-	-	-	-	-	-	-	-	-	-
4	H	L	H	L	-	-	-	-	-	-	-	-	-	-
5	H	L	L	L	-	-	-	-	-	-	-	-	-	-

26UPEST2E06	HYDRO POWER SYSTEMS	L	T	P	C
		4	0	0	4

COURSE OBJECTIVES

- To understand the process of generation of hydropower, its potential & energy extraction.
- To provide knowledge of planning, design and development of hydroelectric power plants
- To understand the aerodynamic principle of turbine blade design and maintenance.
- To know about the operation and maintenance of civil engineering works in reservoirs.
- To understand the recent developments and technologies in the hydro energy

UNIT – I: INTRODUCTION

Overview of Hydropower Systems - Preliminary Investigation - Determination Requirements Preparation of Reports and Estimates - Review of World Resource Cost of Hydroelectric Power -Basic Factors in Economic Analysis of Hydropower Projects - Project Feasibility - Load Prediction and Planned Development.

UNIT – II: DEVELOPMENT OF PROTOTYPE SYSTEMS

Advances in Planning, Design and Construction of Hydroelectric Power Stations - Trends Development of Generating Plant and Machinery - Plant Equipment for Pumped Store Schemes-Some aspects of Management and Operation - Uprating and Refurbishing of turbines.

UNIT– III: POWER STATION OPERATION AND MAINTENANCE

Operation of hydroelectric power stations – Governing of water turbines – Functions of turbine governors – Conditions for governing stability – Surge tank oscillations and their control – Speed regulation problems – Maintenance practices for turbines, generators, and auxiliaries – Future trends in turbine governing and automation.

UNIT- IV: RESERVOIRS

Problem of Management - Maintenance of Civil Engineering Works - Maintenance of electrical Engineering Works

UNIT – V: INFORMATION TECHNOLOGY IN HYDRO POWER SYSTEMS

Development of Software. Computer Aided Hydropower System Analysis - Design – Execution Testing - Operation and Control and Monitoring of Hydropower Services

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Understand the planning, feasibility, and economic aspects of hydropower projects.	K1-K6
CO2	Explain the design, construction, and development of hydroelectric power stations and their equipment.	K1-K6
CO3	Analyze the operation, governing, and maintenance of turbines and hydropower plants.	K1-K6
CO4	Evaluate reservoir management practices and maintenance of civil and electrical systems in hydropower plants.	K1-K6
CO5	Apply modern information technology tools for analysis, design, monitoring, and control of hydropower systems.	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. L. Monition, M. Lenir, J. Roux, *Micro Hydro Electric Power Station*, Elsevier, 1984.
2. Allen R. Inversin, *Micro Hydro Power Source Book*, Intermediate Technology Publications (Practical Action Publishing), 1986.
3. Tyler G. Hicks, *Power Plant Evaluation and Design*, McGraw Hill, 1988.
4. Edwin Panks, Laren Keller, *Hydro Power Engineering*, Educational Publishers, 2017.

CO	**PO**											**PSO**		
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2	H	H	-	L	L	H	-	-	-	-	-	M	L	L
3	H	M	-	-	L	H	-	L	-	M	M	L	L	H
4	H	L	-	L	-	H	-	-	-	-	-	M	L	M
5	H	M	-	L	M	H	-	M	-	M	M	M	L	H

		L	T	P	C
26UPEST2E07	**ENERGY EFFICIENT BUILDINGS DESIGN**	4	0	0	4

COURSE OBJECTIVES

- To Understand ECBC Compliance and Building Energy Standards
- To Design Energy-Efficient Building Envelopes and Landscapes
- To Implement Passive Cooling and Natural Ventilation Strategies
- To Analyze Heat Transmission and Thermal Load Calculations
- To Integrate Renewable Energy Systems for Building Cooling

UNIT – I: INTRODUCTION

Introduction - Building Definition as in the Energy Conservation (amendment) Bill 2010 Energy Conservation Building Code (ECBC) - Compliance Approaches - ECBC Guidelines on Building Envelope - ECBC Guidelines on Electrical Power - Building Water Pumping Systems - Uninterruptible Power Supply - Escalators and Elevators - Building Management System (BMS) - Star Rating of Buildings - Energy Efficiency Measures in Buildings

UNIT – II: LANDSCAPE AND BUILDING ENVELOPES

Energy efficient landscape design – Micro climates – various methods – Shading, water bodies– Building envelope: Building materials - Envelope heat loss and heat gain and its evaluationpaints – insulation - Design methods and tools

UNIT– III: HEATING, VENTILATION AND AIR CONDITIONING

Natural Ventilation - Passive cooling and heating: Thermal mass effects – Application of wind-water and earth for cooling - evaporative cooling - radiant cooling – Hybrid methods – energy conservation measures - thermal storage integration in buildings

UNIT– IV: HEAT TRANSMISSION IN BUILDINGS

Surface co-efficient - 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 - Thermal load estimation - Heat balance method - Degree day method for seasonal energy consumption

UNIT – V: BUILDING COOLING AND RENEWABLE ENERGY IN BUILDINGS

Passive cooling concepts - Application of wind - water and earth cooling - shading - paints and cavity walls for cooling - roof radiation traps - Earth air tunnel. Solar sorption cooling and Solar vapour compression cooling for buildings – Solar water heating systems in buildings – Small wind turbines - standalone PV - Hybrid systems for residential buildings with economics

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Understand the future building aspects and need for modern living.	K1-K6
CO2	Design the energy efficient landscape system	K1-K6
CO3	Develop novel solutions for storage integration in buildings and will evolve passive building Strategies	K1-K6
CO4	Perform building load estimates.	K1-K6
CO5	Explain the importance of renewable integration in buildings	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. D. Duffie, W. A. Beckman, *Solar Engineering of Thermal Processes*, John Wiley & Sons, 1991.
2. S. P. Sukhatme, *Solar Energy*, Tata McGraw Hill, 2017.
3. Ursula Eicker, *Solar Technologies for Buildings*, Wiley Publications, 2003.
4. Bureau of Energy Efficiency (BEE), *Guide Book for National Certification Examination for Energy Managers and Energy Auditors*, Bureau of Energy Efficiency (www.energymanagertraining.com).
5. Michael Bauer, Peter Mosle, Michael Schwarz, *Green Building: Guidebook for Sustainable Architecture*, 2009.
6. R. Velraj, *Sensible Heat Storage for Solar Heating and Cooling Systems*, in *Advances in Solar Heating and Cooling*, Elsevier, 2016, pp. 399–428.

CO	**PO**											**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	L	M	L	-	-	M	-	-	-	-	M	H	-	-
2	L	M	L	L	-	M	-	-	-	-	M	H	L	-
3	L	L	M	M	-	M	-	-	-	-	M	H	L	-
4	L	L	M	M	-	M	-	-	-	-	M	H	L	-
5	H	M	M	M	-	M	-	-	-	-	M	H	M	-

26UPEST2E08 NANOMATERIALS FOR SUSTAINABLE ENERGY

L	T	P	C
4	0	0	4

COURSE OBJECTIVES

- To Understand Nanomaterials Properties and Synthesis Approaches
- To Study the Fundamental Concepts of Energy Conversion Systems.
- To Study Photovoltaic Systems using Nanomaterials
- To Impart Knowledge in Different Semiconducting Materials Introduced in Batteries
- To Gain Knowledge in Field of Electrochemical Batteries

UNIT – I: INTRODUCTION TO NANOMATERIALS

Introduction, Emergence of Nanotechnology, Bottom-Up and Top-Down Approaches - Challenges in Nanotechnology - Physical Chemistry of Solid Surfaces - Surface Energy - Chemical Potential as a Function of Surface Curvature - Electrostatic Stabilization - Steric Stabilization - Thermal Properties - Electrical Properties - Mechanical Properties - Optical Properties

UNIT – II: ENERGY CONVERSION SYSTEMS

Issues and Challenges of functional Nanostructured Materials for electrochemical Energy - Conversion Systems - Fuel Cells - Principles and nanomaterials design for - Proton exchange membrane fuel cells (PEMFC) - Direct methanol fuel cells (DMFC) - Solid-oxide fuel cells (SOFC) - Current status and future trends.

UNIT– III: PHOTOVOLTAIC SYSTEMS

Principles of photovoltaic energy conversion (PV) - Types of photovoltaic Cells - Physics of photovoltaic cells - Organic photovoltaic cell cells - thin-film Dye-Sensitized Solar Cells - Quantum dot (QD) Sensitized Solar Cells (QD-SSC) - Organic-Inorganic Hybrid Bulk Heterojunction (BHJ-SC) Solar cells - Current status and future trends.

UNIT- IV: ENERGY STORAGE SYSTEM - BATTERIES

Issues and Challenges of functional Nanostructured Materials for electrochemical Energy Storage Systems - Primary and Secondary Batteries (Lithium-ion Batteries) - Cathode and anode materials - Nanostructured Carbon-based materials - Nano-Oxides - Novel hybrid electrode materials - Current status and future trends.

UNIT – V: ELECTROCHEMICAL CAPACITORS

Capacitor - Electrochemical supercapacitors - electrical double layer model - Principles and materials design - Nanostructured Carbon-based materials - Redox capacitor Nano oxides - conducting polymers-based materials - Current status and future trends.

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Characterize Nanomaterials: Explain surface energy, electrostatic/steric stabilization, and unique thermal/electrical properties	K1-K6
CO2	Appraise the working of fuel cells	K1-K6
CO3	Understand the photovoltaic cells	K1-K6
CO4	Demonstrate the working principles of batteries Synthesize liquid biofuels for power generation from biomass	K1-K6
CO5	Analyze the importance of electrochemical energy storage devices with improved performance using nanoscience	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. Guozhong Cao, *Nanostructures and Nanomaterials: Synthesis, Properties and Applications*, Imperial College Press, 2004.
2. Antonio Luque, Steven Hegedus, *Handbook of Photovoltaic Science and Engineering*, Wiley, 2011, Second Edition.
3. Thomas B. Reddy, David Linden, *Linden's Handbook of Batteries*, McGraw Hill, 2011, Fourth Edition.
4. Allen J. Bard, Larry R. Faulkner, *Electrochemical Methods: Fundamentals and Applications*, John Wiley & Sons, 2004, Second Edition.
5. Ryan O'Hayre, Suk-Won Cha, Whitney G. Colella, Fritz B. Prinz, *Fuel Cell Fundamentals*, Wiley, 2016, Third Edition.
6. M. Wakihara, O. Yamamoto (Eds.), *Lithium Ion Batteries: Fundamentals and Performance*, Wiley-VCH, 1998.

CO	**PO**											**PSO**		
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1	H	M	L	-	L	H	M	-	-	-	H	-	-	-
2	H	M	M	-	L	H	M	-	-	-	H	M	L	-
3	H	M	H	-	M	H	H	-	-	M	H	M	L	-
4	H	M	H	-	M	H	H	-	-	M	H	M	L	-
5	M	M	H	-	M	H	H	-	-	M	H	M	L	-

26UPEST2E09 SOLAR REFRIGERATION AND AIR CONDITIONING

L	T	P	C
4	0	0	4

COURSE OBJECTIVES

- To Understand Solar Cooling Potential and System Types
- To Analyze Vapor Absorption/Compression Refrigeration Cycles
- To Perform Thermal Modeling and Simulation
- To Study Desiccant and Advanced Solar Cooling Systems
- To Evaluate Economics of Solar Cooling Technologies

UNIT – I: INTRODUCTION

Potential and scope of solar cooling - Types of solar cooling systems - solar collectors and storage systems for solar refrigeration and air-conditioning

UNIT – II: REFRIGERATION CYCLES

Solar operation of vapor absorption and compression refrigeration cycles - Comparison between vapor compression and absorption systems – Hybrid solar refrigeration systems – Assessment and efficiency evaluation of solar-operated refrigeration cycles.

UNIT– III: THERMAL MODELLING

Introduction to thermal modelling – Energy balance equations for solar cooling systems – Mathematical modelling of continuous and intermittent solar refrigeration systems – Simulation techniques for solar air-conditioning systems – Use of computational tools for performance prediction.

UNIT- IV: SOLAR COOLING SYSTEMS

Solar desiccant cooling systems - Open cycle absorption/ desorption solar cooling alternatives - Advanced solar cooling systems - Refrigerant storage for solar absorption cooling systems

UNIT – V: ECONOMICS

Economic analysis of solar cooling systems – Cost estimation and life cycle cost analysis – Payback period and feasibility studies – Comparison with conventional cooling systems – Control and monitoring of solar cooling systems.

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Select appropriate solar collectors/storage for refrigeration needs	K1-K6
CO2	Compare solar-driven absorption vs. compression refrigeration performance	K1-K6
CO3	Develop thermal models for continuous/intermittent solar cooling	K1-K6
CO4	Configure desiccant cooling, open cycle absorption, and refrigerant storage	K1-K6
CO5	Calculate cost-benefit analysis for solar cooling vs. conventional systems	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. S. Domkundwar, S. C. Arora, *A Course in Refrigeration & Air Conditioning*, 2006.
2. T. Nejat Veziroğlu, *Solar Cooling & Heating (Volumes I, II, III)*, 1976.
3. Ursula Eicker, *Low Energy Cooling for Sustainable Buildings*, John Wiley & Sons, 2009.
4. Hans-Martin Henning, *Solar-Assisted Air Conditioning in Buildings: A Handbook for Planners*, Springer, 2007, —.
5. M. Santamouris, D. Asimakopoulos, *Passive Cooling of Buildings*, Earthscan, 1996.
6. M. Sayigh, J. C. McVeigh, *Solar Air Conditioning and Refrigeration*, Pergamon Press, 1992.

CO	PO											PSO		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
1	H	H	-	L	M	H	L	M	-	-	-	M	L	L
2	H	H	-	L	L	H	-	-	-	-	-	M	L	L
3	H	M	-	-	L	H	-	L	-	M	M	L	L	H
4	H	L	-	L	-	H	-	-	-	-	-	M	L	M
5	H	M	-	L	M	H	-	M	-	M	M	M	L	H

26UPEST2E10	ELECTRIC AND HYBRID VEHICLES TECHNOLOGIES	L	T	P	C
		4	0	0	4

COURSE OBJECTIVES

- To Understand EV/HEV Configurations, Drive Trains, and Power Flow Control
- To Analyze Energy Storage Systems Including Batteries, Fuel Cells, and Supercapacitors
- To Design Drive Systems and Implement Energy Management Strategies
- To Develop Battery Management Systems and Charging Infrastructure
- To Evaluate E-Mobility Policies, Connectors, and Smart Grid Integration

UNIT – I: INTRODUCTION TO HEV AND EV

Introduction to Electric Vehicles and Hybrid Electric Vehicles: General Configuration of Electric Vehicles, Types of EV Drive train and power flow control, Energy saving potential of Hybrid Electric Drive train, Architecture of Hybrid Electric Drive Trains, Power flow control in HEV. Electric Drives: Configuration and control of - DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, and Switched reluctance motors.

UNIT – II: HYBRID ELECTRICAL DRIVES

Energy storage system: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery-based energy storage and its analysis, Fuel Cell-based energy storage and its analysis, Super capacitors and ultra capacitors, Hybridization of different energy storage devices.

UNIT– III: DRIVE SYSTEM SIZING AND ENERGY MANAGEMENT STRATEGIES

Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selection of appropriate energy storage technology, Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification, and comparison of energy management strategies, Implementation issues.

UNIT– IV BATTERY MANAGEMENT SYSTEM AND EV CHARGING

Battery Management System: Battery Management System, Requirement of Battery Monitoring, Battery State of Charge Estimation methods, Energy & Power estimation, Battery thermal management system, Battery Cell equalization problem. EV charging standards: V2G, G2V, V2B, V2H.

UNIT– E-MOBILITY AND CONNECTORS

Introduction: E-mobility, Connected Mobility and Autonomous Mobility, Indian E-mobility Roadmap. Policy: EVs in infrastructure system, integration of EVs in smart grid, social dimensions of EVs. Connectors: Types of EV charging connectors- North American EV Standards, DC Fast charge CCS (Combined Charging System), Tesla, European EV Plug Standards.

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Configure EV/HEV Systems: Design electric and hybrid drive trains with DC, induction, and permanent magnet motors	K1-K6
CO2	Analyze and hybridize battery, fuel cell, and supercapacitor systems for optimal performance	K1-K6
CO3	Understanding the Match propulsion motors, power electronics, and energy storage for vehicle applications	K1-K6
CO4	Develop battery management systems and implement V2G/V2H charging standards	K1-K6
CO5	Learn the Design charging connectors (CCS, Tesla, European standards) and smart grid integration	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOK

1. Iqbal Hussain, *Electric & Hybrid Vehicles: Design Fundamentals*, CRC Press, 2011, —.
2. R. D. A. J. Rand, R. Woods, R. M. Dell, *Batteries for Electric Vehicles*, Research Studies Press (UK), 1998.
3. David Linden, Thomas B. Reddy (Eds.), *Handbook of Batteries and Fuel Cells*, McGraw Hill, 2002, Third Edition.
4. Mehrdad Ehsani, Yimin Gao, Sebastian E. Gay, Ali Emadi, *Modern Electric, Hybrid and Fuel Cell Vehicles: Fundamentals, Theory and Design*, CRC Press, 2004.

CO	**PO**											**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
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2	H	M	H	H	M	-	-	-	-	-	L	L	M	M
3	M	H	M	M	L	M	-	-	-	-	-	-	-	H
4	M	L	M	M	H	L	-	-	-	H	-	-	-	M
5	L	M	M	H	M	L	-	-	-	M	M	-	M	L

26UPEST2E11	WASTE MANAGEMENT AND ENERGY RECOVERY TECHNIQUES	L	T	P	C
		4	0	0	4

COURSE OBJECTIVES

- To Provide Information on Various Methods of Waste Management
- To Familiarize Students with Recent Energy Generation Techniques
- To Detail on the Recent Technologies of Waste Disposal
- To Evaluate Transformation Technologies for Energy/Material Recovery
- To Manage Hazardous Wastes and Implement Recycling Strategies

UNIT – I: CHARACTERISTICS AND PERSPECTIVES

Sources – Types – Composition – Generation – Estimation Techniques – Characterization – Types of Collection System – Transfer Stations – Transfer Operations – Material Recycle / Recovery Facilities

UNIT – II: UNIT OPERATIONS & TRANSFORMATION TECHNOLOGIES

Separation & Processing: Size Reduction – Separation through Density Variation - Magnetic / Electric Field: Densification - Physical, Chemical and Biological Properties -Transformation Technologies – Selection of Proper Mix of Technologies

UNIT– III: WASTE DISPOSAL

Landfill Classification – Types – Siting Considerations – Landfill Gas (Generation, Extraction, Gas Usage Techniques) – Leachates Formation – Movement - Control Techniques – Environmental Quality Monitoring – Layout - Closure & Post Closure Operation – Reclamation

UNIT- IV: TRANSFORMATION TECHNOLOGIES AND VALUE ADDITION

Physical Transformation - Component Separation & Volume Reduction: Chemical Transformation – Combustion / Gasification / Pyrolysis - Energy Recovery - Biological Transformation – Aerobic Composting – Anaerobic Digestion

UNIT – V: HAZARDOUS WASTE MANAGEMENT & WASTE RECYCLING

Definition – Sources – Classification – Incineration Technology - Incineration vs Combustion Technology – Refuse Derived Fuel (RDF) / Mass Firing – Material Recycling: Paper / Glass / Plastics etc., - Disposal of White Goods & E-Wastes

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Waste characterization, Segregation, Disposal will be made known	K1-K6
CO2	Technologies that are available for effective waste disposal along with pros /cons will become cleaner to students	K1-K6
CO3	Able to convert waste into useful energy.	K1-K6
CO4	Select combustion/gasification/composting methods	K1-K6
CO5	Get awareness to handle e-waste, plastics, and hazardous disposal	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6-Create

TEXT AND REFERENCE BOOKS

1. P. Jayarama Reddy, *Municipal Solid Waste Management*, CRC Press (Taylor & Francis Group), 2011.
2. Howard S. Peavy, Donald R. Rowe, George Tchobanoglous, *Environmental Engineering*, McGraw Hill International Edition, 1985.
3. M. LaGrega, P. Buckingham, J. Evans, *Hazardous Waste Management*, McGraw Hill, 2001, Second Edition.
4. Stanley E. Manahan, *Hazardous Waste Chemistry*, *Toxicology and Treatment*, Lewis Publishers, 1990.
5. Colin Parker, Thomas Roberts, *Energy from Waste: An Evaluation of Conversion Technologies*, Elsevier Applied Science, 1985.

CO	**PO**											**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	-	M	-	-	M	H	M	L	-	L	L	M	-	L
2	-	M	H	-	H	M	L	-	-	L	L	M	-	L
3	M	H	H	-	H	H	M	-	-	L	L	M	-	L
4	-	M	L	-	M	M	M	M	-	L	-	M	-	L
5	-	-	-	-	-	H	M	M	-	-	-	M	-	-

26UPEST2E12	HYDROGEN PRODUCTION AND STORAGE	L	T	P	C
		4	0	0	4

COURSE OBJECTIVES

- To Understand the Fundamental Properties and Significance of Hydrogen as an Energy Carrier.
- To Study Various Hydrogen Production Technologies.
- To Learn Different Hydrogen Storage Methods and their Performance.
- To Assess System Performance and Energy Losses in Production-Storage Chains
- To Analyze Efficiency, Safety, and Regulatory Aspects of Hydrogen Systems.

UNIT – I: INTRODUCTION

Basic Properties of Hydrogen, Engineering Thermodynamics, Hydrogen and Environment, Hydrogen and Sustainability, Hydrogen Production Methods, Green Hydrogen Sources, Hydrogen as an Energy Carrier, Historical Background and Current Applications.

UNIT – II: HYDROGEN PRODUCTION METHODS

Steam methane reforming, Electrolysis (alkaline, PEM, and solid oxide electrolysis), Coal/Biomass Gasification, Solar and Wind-based Hydrogen Production, Emerging Hydrogen Generation Technologies.

UNIT– III: HYDROGEN STORAGE TECHNIQUES

Compressed Gas Storage, Liquid Hydrogen Storage, Chemical Storage (hydrogenation, metal hydrides), Physical Storage Using Nanostructured and Porous Materials, Underground Hydrogen Storage, Emerging Hydrogen Storage Technologies.

UNIT- IV: HYDROGEN STORAGE PERFORMANCE

Efficiency Considerations in Hydrogen Generation, Energy Losses and Efficiency of Different Storage Methods, Performance Assessment of Hydrogen Production and Storage Systems.

UNIT – V: SAFETY AND REGULATIONS

Safety Considerations in Hydrogen Handling and Storage, Codes and Standards for Hydrogen Storage Systems, Risk Assessment and Mitigation Strategies, Case Studies of Hydrogen-related Incidents.

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Understand the basic properties of hydrogen, including its chemical and physical characteristics, and its role as an energy carrier.	K1-K6
CO2	Select a suitable hydrogen generation technique based on the mechanisms, performance characteristics, and applicability.	K1-K6
CO3	Able to Select storage method for applications	K1-K6
CO4	Understand the Calculate system energy losses	K1-K6
CO5	Get awareness on the Safety and regulation	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6-Create

TEXT AND REFERENCE BOOKS

1. Zhang, J. Z.; Li, J.; Li, Y.; Zhao, Y., *Hydrogen Generation, Storage and Utilization*, John Wiley & Sons, 2014.
2. Dinçer, I.; Zamfirescu, C., *Sustainable Hydrogen Production*, Elsevier, 2016.
3. Iulianelli, A.; Basile, A., *Advances in Hydrogen Production, Storage and Distribution*, Elsevier, 2014.
4. Gupta, R. B., *Hydrogen Fuel: Production, Transport, and Storage*, CRC Press, 2008.
5. Altalhi, T. A.; Adnan, S. M.; Amin, M. A., *Materials for Hydrogen Production, Conversion, and Storage*, John Wiley & Sons, 2023.
6. Winter, C. J.; Nitsch, J., *Hydrogen as an Energy Carrier: Technologies, Systems, Economy*, Springer Science & Business Media, 2012.
7. Sherif, S. A.; Goswami, D. Y.; Stefanakos, E. L.; Steinfeld, A., *Handbook of Hydrogen Energy*, CRC Press, 2014.

CO	**PO**											**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	-	M	-	-	M	H	M	L	-	L	L	M	-	L
2	-	M	H	-	H	M	L	-	-	L	L	M	-	L
3	M	H	H	-	H	H	M	-	-	L	L	M	-	L
4	-	M	L	-	M	M	M	M	-	L	-	M	-	L
5	-	-	-	-	-	H	M	M	-	-	-	M	-	-

NON-MAJOR ELECTIVE – I

25UPESTSW1	**SOLAR ENERGY**	**L**	**T**	**P**	**C**
		2	0	0	2

COURSE OBJECTIVES

- To understand the basics of solar energy and its measurements.
- To learn about different solar thermal systems like water heaters and air heaters.
- To explore energy storage methods such as sensible heat, latent heat, and chemical storage.
- To gain knowledge of photovoltaic (PV) systems and different types of solar cells.
- To understand the economic aspects of solar energy, including costs and savings.

UNIT – I: INTRODUCTION TO SOLAR ENERGY

Solar Spectrum - Terrestrial and Extraterrestrial Regions - Solar Time - Pyrheliometer - Pyranometer - Sunshine Recorder - Sun-Earth Angles - Availability of Solar Radiation on an Inclined Surface - Monthly Average Daily Radiation on Sloped Surfaces - Solar Radiation on Horizontal Surface (CSP).

UNIT – II: SOLAR THERMAL ENERGY

Liquid Flat-Plate Collectors - Evacuated Solar Collector - Solar Water Heating System - Solar Air Heaters - Solar Crop Drying - Solar Distillation - Concentrating Collectors - Thermal Energy Storage - Solar Pond.

UNIT–III: THERMAL ENERGY STORAGE

Sensible Heat Storage - Liquid Media Storage - Well Mixed Liquid Storage - Space Heat and Hot Water - Solid Media Storage - Packed-bed Storage - Dual Media Storage - Ground Collector - Basics of Latent Heat Storage - Heat Transfer in PCM - Thermal Analysis of Freezing of Top of Ponds - Analysis of Phase Change Material - Chemical Storage.

UNIT-IV: PHOTOVOLTAIC SYSTEMS

Introduction – Doping – Fermi Level – p-n Junction – p-n Junction Characteristics – Photovoltaic Effect – Photovoltaic Material – Single Crystal Solar Cell – Thin Film Solar Cell – Amorphous Silicon Solar Cells – Tandem Solar Cell – Concentrating Solar Cell – Module – Single Crystal Solar Cells Module – Cell Temperature.

UNIT – V: ECONOMIC ANALYSIS

Initial and Annual Costs – Definitions – Present Worth Calculation – Repayment of Loan in Equal Annual Installments – Annual Savings – Cumulative Savings and Life Cycle Savings – Economic Analysis of Add-on Solar Systems – Payback Period – Clean Development Mechanism.

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Demonstrate knowledge of solar radiation principles and calculate solar energy availability on inclined and horizontal surfaces	K1-K6
CO2	Apply concepts of solar thermal technologies to design and analyze solar water heaters, air heaters, crop dryers, and distillation systems.	K1-K6
CO3	Assess energy storage techniques, including phase change materials (PCMs) and packed-bed storage, for efficient thermal energy management.	K1-K6
CO4	Understand photovoltaic system operation, material characteristics, and performance metrics for different solar cell technologies.	K1-K6
CO5	Perform economic analysis of solar energy systems, considering initial costs, payback periods, and long-term financial viability.	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. H. P. Garg; J. Prakash, *Solar Energy: Fundamentals and Applications*, McGraw Hill Education (India), 2000 (22nd reprint 2015).
2. S. P. Sukhatme; J. K. Nayak, *Solar Energy: Principles of Thermal Collection and Storage*, McGraw Hill Education (India), 2008 (19th reprint 2015).
3. G. N. Tiwari, *Solar Energy: Fundamentals, Design, Modelling and Applications*, Narosa Publishing House, 2002 (Revised Edition 2013, Reprint 2014).
4. D. Yogi Goswami, *Principles of Solar Engineering*, CRC Press, Taylor & Francis Group, 2015.
5. Michael E. Mackay, *Solar Energy: An Introduction*, OUP Oxford, 2015.

CO	**PO**											**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	H	H	H	L	L	L	H	H	H	-	L	-	L	L
2	L	H	H	M	M	M	-	-	-	-	L	-	L	L
3	L	M	H	H	H	M	-	-	-	-	L	-	M	M
4	H	H	H	M	H	M	-	-	-	-	-	-	H	H
5	M	M	H	H	L	M	-	-	-	-	-	-	H	H

NON-MAJOR ELECTIVES-II

		L	T	P	C
26UPESTN01	**ALTERNATIVE ENERGY SOURCES**	3	0	0	2

COURSE OBJECTIVES

- To Acquire Knowledge about the Conventional and Non-Conventional Energy Sources
- To Analyze the Working of Solar Thermal and PV systems
- To Gain Knowledge on Wind Energy Conversion
- To Know the Importance and Methods of Conversion of Bio-Based Waste into useful form of energy.
- To Obtain Information on the Source and Utilization of Geothermal Energy

UNIT – I: ENERGY SOURCES

Environment and sustainable development - Energy sources - Sun as the source of energy – Photosynthesis - classification of energy sources - fossil fuel reserves and resources - Overview of global/ India’s energy scenario.

UNIT – II: SOLAR ENERGY

Solar radiation: measurements and prediction - Solar thermal energy conversions systems: Flat plate collectors - solar concentrators and other applications - Solar Photovoltaic: Principle of photovoltaic conversion of solar energy.

UNIT–III: WIND ENERGY

Wind Resource: Meteorology of wind, India’s wind energy potential and challenges - distribution across the world - Eolian features - Biological indicators - Wind measurement systems - Wind Energy Conversion Systems.

UNIT-IV: BIOENERGY

Biomass as energy resources - Classification and Estimation of biomass - Source and Characteristics of biofuels – Biodiesel – Bioethanol – Biogas - Waste to energy conversions.

UNIT – V: GEOTHERMAL ENERGY

Introduction - Geothermal sources - Advantages and disadvantages of geothermal energy over other energy forms - Geothermal energy in India: Prospects - Applications of Geothermal energy - Material selection for geothermal power plants

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Awareness and familiarization in the different forms of energy sources	K1-K6
CO2	Able to select the suitable Solar energy source based on the working principle.	K1-K6
CO3	The knowledge about importance of wind energy conservation and the impact on environment	K1-K6
CO4	Understand the concept of conversion of bio-based waste into useful form of energy.	K1-K6
CO5	Awareness on the existence of various mechanisms for conversion using geothermal	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. J. W. Twidell; A. Weir, *Renewable Energy Resources*, EFN Spon Ltd., UK, 2015.
2. Godfrey Boyle, *Renewable Energy: Power for a Sustainable Future*, Oxford University Press, UK, 2012.
3. S. P. Sukhatme, *Solar Energy: Principles of Thermal Collection and Storage*, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2012.
4. S. P. Sukhatme, *Solar Energy*, Tata McGraw Hill, 2017.
5. G. N. Tiwari, *Solar Energy – Fundamentals, Design, Modelling and Applications*, Alpha Science International Ltd., 2015.

CO	PO											PSO		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
1	H	H	H	L	L	L	H	H	H	-	L	-	L	L
2	L	H	H	M	M	M	-	-	-	-	L	-	L	L
3	L	M	H	H	H	M	-	-	-	-	L	-	M	M
4	H	H	H	M	H	M	-	-	-	-	-	-	H	H
5	M	M	H	H	L	M	-	-	-	-	-	-	H	H

		L	T	P	C
26UPESTN02	**CLIMATE CHANGE AND CO_2 EMISSION ASSESSMENT**	3	0	0	2

COURSE OBJECTIVES

- To Study the Energy Consumption and Economic Implications
- To Familiarize about Impact of Climate Changes on the Environment.
- To Analyze CO_2 Emission Assessment Methods
- To Know the Carbon Footprint Calculation
- To Understand the Concept of Carbon Credit.

UNIT – I: INTRODUCTION TO ENERGY

Introduction to Energy: Overview of energy sources and technologies - energy consumption Pattern - social and economic implications of energy uses - equity and disparity

UNIT – II: INTRODUCTION TO GLOBAL CLIMATE CHANGE

Introduction to global climate change: theory of global climate change - mechanism of Greenhouse Gases Emission - theory and proof of climate change impacts - global overview - International concern on Climate change and mitigation efforts.

UNIT– III: CARBON DIOXIDE (CO_2) EMISSIONS AND CONVERSION/CONSUMPTION

Carbon dioxide (CO2) emissions in relation to energy conversion/consumption: theory of CO2 emission in relation to energy conversion processes.

UNIT- IV: METHODOLOGY FOR CO_2 ASSESSMENT/CARBON FOOT PRINT

Methodology for CO2 assessment/carbon foot print: estimation of emission from fossil fuel combustion (Fuels and their composition - fuel to energy conversion - concept of emission factor) - emission from major sectors (industry – transport – agriculture – domestic - service)

UNIT – V: CARBON CREDIT

Carbon credit: Definition - concept and examples - Carbon credit - national policies vis-à-vis international market scenario - Current efforts and future prospect/limitation of carbon trading mechanism.

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Depth knowledge in energy consumption and economic implications	K1-K6
CO2	Obtained elaborate knowledge about impact of climate changes on the environment.	K1-K6
CO3	Able to analysis emission characteristics and its impact on the globe.	K1-K6
CO4	Knowledge on carbon dioxide conversion and carbon footprint	K1-K6
CO5	Knowledge on concept of carbon credit and their importance	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. M. J. Franchetti; D. S. Apul, *Carbon Footprint Analysis: Concepts, Methods, Implementation and Case Studies*, CRC Press, 2013.
2. UNFCCC, *Clean Development Mechanism*, http://cdm.unfccc.int/
3. N. Stern, *The Economics of Climate Change: The Stern Review*, Cambridge University Press, 2007.
4. S. Barrett, *Why Cooperate? The Incentive to Supply Global Public Goods*, Oxford University Press, 2007.

CO	PO											PSO		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
1	-	-	L	M	M	H	M	-	-	L	-	M	L	-
2	-	-	L	M	M	H	M	-	-	L	-	M	L	-
3	-	-	L	M	H	H	M	-	-	L	-	M	L	-
4	-	-	L	M	M	H	M	-	-	L	-	M	L	-
5	-	-	L	M	M	H	M	-	-	L	-	M	L	-

26UPESTN03	ENERGY SCENARIO AND POLICY	L	T	P	C
		3	0	0	2

COURSE OBJECTIVE

- To Know the Energy Scenario in India and Global
- To Know Indian Energy Conservation Act
- To Understand the details on government policies in energy.
- To Know the energy efficiency and climate change policies
- To Know Measures the Impact of Energy Savings on Environment

UNIT – I: ENERGY SCENARIO

Introduction - Primary and Secondary Scenario - Final Energy Consumption - India's Energy Scenario - Sector wise Energy Consumption in India - Energy Intensity on Purchasing Power Parity (PPP) - Energy Security

UNIT – II: ENERGY CONSERVATION ACT

Salient Features of the Energy Conservation Act, 2001 - Scheme of BEE under the Energy Conservation Act-2001 - Electricity Act 2003 - National Action Plan on Climatic Change (NAPCC)

UNIT–III: ENERGY POLICY

Global energy issues - National & State level energy issues - National & State energy policy - Industrial energy policy - Energy security - Energy vision - Energy pricing & Impact of global variations - Energy productivity (National & Sector wise productivity).

UNIT-IV: ENERGY EFFICIENCY AND CLIMATE CHANGE

Energy and Environment - Global Environment Issues - Acid Rain - Ozone Layer Depletion - Global Warming and Climate Change - Global Warming and Climatic Change Impacts - United Nations Framework Convention on Climate Change (UNFCCC) - The Intergovernmental Panel on Climate Change (IPCC) - Conference of Parties (COP) - The Kyoto Protocol

UNIT – V: IMPACT OF ENERGY ON ECONOMY AND DEVELOPMENT

Energy for Sustainable Development - Energy and Environmental policies - Need for use of new and renewable energy sources, present status and future of nuclear and renewable energy - Energy Policy Issues related Fossil Fuels, Renewable Energy, Power sector reforms, restructuring of energy supply sector, energy strategy for future.

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Familiar knowledge in energy scenario globally and locally.	K1-K6
CO2	Gain knowledge on Indian Energy Conservation Act	K1-K6
CO3	Acquire information on government energy policies	K1-K6
CO4	Understand the Energy efficiency and climate change policies.	K1-K6
CO5	Evaluate energy's environmental impact	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. Bureau of Energy Efficiency, *General Aspects of Energy Management and Energy Audit*, 4th Edition, New Delhi, India, 2015.
2. S. P. Sukhatme, *Solar Energy: Principles of Thermal Collection and Storage*, Tata McGraw-Hill, 2017.
3. R. Loulou; J.-P. Waaub; G. Zaccour (Eds.), *Energy and Environment Set: Mathematics of Decision Making*, Springer, 2005.
4. R. A. Ristinen; J. J. Kraushaar; J. P. Ristinen, *Energy and the Environment*, 2nd Edition, John Wiley, New York, 2006.

CO	PO											PSO		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
1	H	-	-	H	-	H	L	-	L	-	M	H	H	-
2	M	-	-	H	-	H	L	-	L	-	M	M	H	L
3	H	-	M	M	-	H	-	-	L	-	M	M	M	L
4	L	-	-	M	-	H	H	-	M	-	M	H	M	-
5	L	-	-	L	-	H	-	-	M	-	M	H	H	-

		L	T	P	C
26UPESTN04	**ERECTION AND MAINTENANCE OF REFRIGERATION AND AIR CONDITIONING EQUIPMENT**	3	0	0	2

COURSE OBJECTIVE

- To Understand Refrigeration/AC Plant Layout
- To Analyze Vapor Compression Refrigeration.
- To Study Alternative Refrigeration Systems
- To Apply Psychrometric Calculations
- To Perform AC Load Estimation

UNIT – I: INTRODUCTION

Refrigeration and air-conditioning plant layout, parameters affecting the location.

Fundamentals of refrigeration and air-conditioning systems; classification of refrigeration systems; basic working principles of air-conditioning systems; components of refrigeration and air-conditioning plant layout; considerations in plant layout design; factors influencing the selection of plant location such as space requirements, safety, accessibility, maintenance convenience, ventilation, noise control, and economic aspects.

UNIT – II: VAPOUR COMPRESSION REFRIGERATION SYSTEM

Vapor compression cycle: p-h and T-s diagrams - deviations from theoretical cycle – subcooling and super heating- effects of condenser and evaporator pressure on COP- multi-pressure system –low temperature refrigeration - Cascade systems – problems. equipment: Type of Compressors, Condensers, Expansion devices, Evaporators.

UNIT– III: OTHER REFRIGERATION SYSTEMS

Working principles of Vapour absorption systems and adsorption cooling systems – Steam jet refrigeration- Ejector refrigeration systems- Thermoelectric refrigeration- Air refrigeration – Magnetic Vortex and Pulse tube refrigeration systems.

UNIT- IV: PSYCHROMETRIC PROPERTIES AND PROCESSES

Properties of moist Air-Gibbs Dalton law, Specific humidity, Dew point temperature, Degree of saturation, Relative humidity, Enthalpy, Humid specific heat, Wet bulb temperature Thermodynamic wet bulb temperature, Psychrometric chart; Psychrometric of air-conditioning processes, mixing of air streams.

UNIT – V: LOAD ESTIMATION

Air conditioning loads: Outside and inside design conditions; Heat transfer through structure, Solar radiation, Electrical appliances, Infiltration and ventilation, internal heat load; Apparatus selection; fresh air load, human comfort & IAQ principles, effective temperature & chart, calculation of summer & winter air conditioning load

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Explain the basic concepts of Refrigeration	K1-K6
CO2	Explain the Vapor compression Refrigeration systems	K1-K6
CO3	Discuss the various types of Refrigeration systems	K1-K6
CO4	Calculate the Psychrometric properties and its use in psychrometric processes	K1-K6
CO5	Explain the concepts of Air conditioning and to solve problems	K1-K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. C. P. Arora, *Refrigeration and Air Conditioning*, McGraw Hill Education, India, 2010.
2. R. S. Khurmi; J. K. Gupta, *A Textbook of Refrigeration and Air Conditioning*, S. Chand Publishing, 2012.
3. S. C. Arora; Domkundwar, *A Course in Refrigeration and Air Conditioning*, Dhanpat Rai Publications, 2013.
4. W. F. Stoecker; J. W. Jones, *Refrigeration and Air Conditioning*, McGraw-Hill, 1982.
5. P. L. Ballaney, *Refrigeration and Air Conditioning*, Khanna Publishers, 2000.
6. ASHRAE, *ASHRAE Handbook – Fundamentals*, ASHRAE Inc., 2017.

CO	**PO**											**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	-	-	L	L	M	H	M	-	-	M	H	M	L	L
2	-	-	L	L	M	H	M	-	-	M	H	M	L	L
3	-	-	L	L	M	H	M	-	-	M	M	M	L	L
4	-	-	L	L	M	H	M	-	-	M	M	M	L	L
5	-	-	L	L	M	M	M	-	-	M	H	M	M	L

26UPEST2N05	ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL	L	T	P	C
		3	0	0	2

COURSE OBJECTIVES

- To Impart Knowledge on the Atmosphere and its Present Condition and, Global Warming.
- To Detail on the Sources of Water Pollution and Possible Solutions for Mitigating their Degradation.
- To Detail on the Sources of Air Pollution and Possible Solutions for Mitigating their Degradation.
- To Detail on the Sources of solid Waste and possible ways to dispose them safely.
- To Impart Knowledge on Hazardous Waste Management.

UNIT – I: INTRODUCTION

Man & Environment – Types of Pollution – Global Environmental issues – Environmental Impact Assessment – Global Warming Issues –CO_2 Mitigation – Basic definition of Pollution Indicators – Noise Pollution.

UNIT – II: WATER POLLUTION

Pollutants in Water & Wastewater – Physical and Chemical Treatment Methods – (An Overview) Neutralization – Aeration –Color / Odor Removal - Sludge dewatering – Biological Treatment including Aerobic & Anaerobic Treatment.

UNIT– III: AIR POLLUTION

Sources – Ambient Air Quality Standards – Emission Limits – Equipment for Ambient Air & Stack Monitoring – Principles of operation of Particulate Control Equipment (ESPs, Bag Filters, Cyclone Separators etc.,) – Vehicular Pollution and its Control

UNIT- IV: SOLID & HAZARDOUS WASTE MANAGEMENT

Types & Sources – Types (Municipal, Biomedical, Industrial, Hazardous etc.,) – Waste Generation – Composition – Physical / Chemical / Biological Properties – Transformation Technologies for Waste Treatment – Landfill Management – Leachate Generation – e Waste Disposal.

UNIT – V: GLOBAL WARMING & CLIMATE CHANGE

Impact of Global Warming / Climate Change on various sectors – Green House Gases & Effect– Carbon Cycle – CDM – Carbon Trading – Carbon Sequestration – Carbon Capture & Storage– UNFCCC – IPCC Protocols

COURSE OUTCOME

Upon completion of this course, the students will be able to

CO1	Types and effects of each type of pollution on man – earth will be made known.	K1-K6
CO2	Technical aspects of water pollution will make them understand the impact they have on climate	K1-K6
CO3	Technologies that are available for reduction of pollutants dumped into the atmosphere	K1-K6
CO4	Cursory / superficial formation - the students – had in Hazardous waste, waste disposal hitherto will be deep & sensible enough after studying this subject	K1-K6
CO5	Comprehend the different techniques available for safe disposal of hazardous waste	K1-K6

K1- Remember, K2- Understand, K3- Apply , K4- Analyze, K5- evaluate and K6- Create

TEXT AND REFERENCE BOOKS

1. C. S. Rao, Environmental Pollution Control Engineering, New Age International Publishers, 2006

2. Peavy, H.S. and D.R. Rowe, G.Tchobanoglous: Environmental Engineering – McGraw Hill Book Company, New York, 1985

3. G. Masters: Introduction to Environmental Engineering and Science, Prentice Hall of India Pvt Ltd, New Delhi, 2003

4. Ludwig, H. W.Evans: Manual of Environmental Technology in Developing Countries, International Book Company, Absecon Highlands, N.J, 1991

5. Arcadio P Sincero and G. A. Sincero, Environmental Engineering – A Design approach, Prentice Hall of India Pvt Ltd, New Delhi, 2002

CO	**PO**											**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	H	M	-	L	-	-	-	-	-	-	-	H	-	L
2	M	M	L	L	-	-	-	-	-	-	-	H	-	L
3	M	L	L	L	-	-	-	-	-	-	-	H	-	L
4	H	L	M	L	-	-	-	-	-	-	-	H	-	L
5	M	L	L	M	M	-	-	-	-	-	-	H	-	M

PEACE EDUCATION

a. On successful completion of this course, the students will be able to

Course Outcomes		Level
C01	Understand the importance of Peace	Understand
C02	Explain how to recover the state of Peace	Understand
C03	Internalize and Practice the Values of Peace	Apply
C04	Understand sustainable Peace and the role of oneself	Understand
C05	Become the peace messenger who spreads the culture of Peace	Apply

Units	Content	Hours
I	**Introduction to Peace Education and HWPL** Aims and objectives of Peace Education Development of Peace work of HWPL-Making groups for assignments – Rapportbuiling	11
II	**Finding Peace, and me** Diversity Harmony Original State of All Creation Connectivity Value-Role-Duty - Interpersonal relationship - Greed - Love - Order	11
III	**Peace Values** Gratitude- Consideration Sacrifice Understanding - Forgiveness - Respect for Parents, Teachers and Peace - Scripture - Cultural sphere	11
IV	**Peace Citizen** Heritage World Peace Great legacy, a case of Peace Law -Law-abiding Spirit Treaty - DPCW-NGO; HWPL - Peace Citizen - Courage-Peace-loving Heart - Messenger of Peace	11
V	**Peace Messenger** Peace Messenger-Peace experience- Will for Peace	10

Task and assignment:

- Writing an Essay on World Peace and Gratitude
- Engaging in debates on topics related to Peace.
- Group Project for practicing Peace Values.
- Group Project to promote the importance of Peace

References

https://www.un.org/en/
https://www.youtube.com/watch?v=18LhBZc6Sn4
https://www.hwpl.kr/language/en/home-hwpl_en/
Heavenly Culture World Peace Restoration of Light, (2022), Road to Peace
Oh Ik-soo, (1996), Youth Group Counseling

c. Mapping of Program Outcomes with Course Outcomes

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

VALUE ADDED COURSE

26UPESTV01 PVsyst SOFTWARE FOR ENERGY SYSTEMS

COURSE OBJECTIVES

- To Understand solar PV fundamentals and system components
- To Master PVsyst software for system design
- To Analyze PV system performance and economics

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UNIT – I: SOLAR ENERGY FUNDAMENTALS & PV SYSTEM BASICS

Solar radiation: components, measurement, and estimation, Solar geometry and sun path, Basics of photovoltaic systems, Types of PV systems: standalone, grid-connected, hybrid, PV system components: modules, inverters, batteries, charge controllers

UNIT – II: PVsyst SOFTWARE & SYSTEM DESIGN

Introduction to PVsyst: features and interface, Project creation and site selection, Importing meteorological data, PV module and inverter selection, System sizing and configuration, Array design, tilt angle, and orientation, Shading analysis and loss factors.

UNIT – III: SIMULATION, ANALYSIS & APPLICATIONS

Simulation of PV systems using PVsyst, Performance analysis: energy yield, performance ratio, efficiency, Loss analysis and system optimization, Economic evaluation: cost, payback period, LCOE, Case studies of grid-connected and standalone systems, Applications in energy management and smart grid integration

COURSE OUTCOME

Upon completion of this course, the students will be able to

- Understand solar PV fundamentals and system components
- Master PVsyst software for system design
- Analyze PV system performance and economics

TEXT AND REFERENCE BOOKS

1. Photovoltaic Systems Engineering, Roger A. Messenger & Amir Abtahi, 4th Edition (CRC Press, 2017)
2. Solar Engineering of Thermal Processes, Photovoltaics and Wind, John A. Duffie, William A. Beckman & Nathan Blair, 5th Edition (Wiley, 2020)
3. Handbook of Photovoltaic Science and Engineering, Antonio Luque & Steven Hegedus, 2nd Edition (Wiley, 2011)
4. PV System Technology (German Solar Energy Society – DGS), Routledge / Earthscan
5. André Mermoud (PVsyst SA), www.pvsyst.com

26UPESTV02 ELECTRIC VEHICLE CHARGING INFRASTRUCTURE

COURSE OBJECTIVES

- To Study EV charging architectures
- To Analyze power converter topologies
- To Explore advanced charging technologies

UNIT – I: CHARGING ARCHITECTURES FOR ELECTRIC VEHICLES

Classification of EV charging architectures, Onboard Chargers, Level 1: Dedicated Converter (Slow Charging), Level 2: Integrated Converter (Semi-fast Charging), Off-Board Chargers, Level 3: Dedicated Off-Board DC Chargers (Fast Charging), Common AC Bus Architecture, Common DC Bus Architecture.

UNIT – II: CONVERTER TOPOLOGIES FOR CHARGING STATION

Vienna Rectifier, Multipulse Rectifier with DC Active Power Filter, Non-isolated Multichannel Interleaved Buck Converter, Phase-Shifted ZVS Full-Bridge Converter, Grid-connected cascaded H-bridge converter, Gridconnected Modular Multilevel Converter based integrated charger for split integrated battery pack, Neutral-Point Clamped Converter.

UNIT – III: LATEST DEVELOPMENTS IN EV CHARGING

Inductive Charging, Vehicle-to-Grid (V2G) and Vehicle-to-Home (V2H), EV charging safety configuration and considerations, Grid-Tied Residential charging Systems, Grid-Tied Public charging Systems, EV cable communication protocols, Charging cable standards.

COURSE OUTCOME

Upon completion of this course, the students will be able to

- Study EV charging architectures
- Analyze power converter topologies
- Explore advanced charging technologies

TEXT AND REFERENCE BOOKS

1. Sulabh Sachan, P. Sanjeevikumar, Sanchari Deb, Smart Charging Solutions for Hybrid and Electric Vehicles, Wiley- Scrivener Publishing LLC, 2022.

2. Mary Murphy " Electric and Hybrid Vehicles: Principles, Design and Technology ", Larsen and Keller Education, 2019

26UPESTV03 GREEN HYDROGEN AND DECARBONISATION TECHNOLOGY

COURSE OBJECTIVES

- To understand hydrogen as a clean energy carrier
- To explore green hydrogen production, storage, and utilization
- To analyze decarbonisation strategies across sectors

UNIT – I: FUNDAMENTALS OF HYDROGEN ENERGY

Introduction to hydrogen economy, Types of hydrogen: Grey, Blue, Green, Turquoise, Properties of hydrogen as a fuel (physical & chemical), Thermodynamics and electrochemistry of hydrogen production, Water electrolysis principles, Overview of electrolyzer technologies: Alkaline, PEM, Solid Oxide, Renewable energy integration for hydrogen production

UNIT – II: GREEN HYDROGEN TECHNOLOGIES & APPLICATIONS

Hydrogen production using renewable energy (solar, wind, biomass), Hydrogen storage methods: compressed, liquid, metal hydrides, Transportation and distribution of hydrogen, Fuel cells: Types (PEMFC, SOFC, AFC) and working principles, Applications, Safety standards.

UNIT – III: DECARBONISATION STRATEGIES AND POLICIES

Climate change and carbon emissions overview, Sector-wise decarbonisation, Role of green hydrogen in net-zero pathways, Carbon capture, utilization, and storage (CCUS), Life Cycle Assessment (LCA) of hydrogen systems, Policy frameworks and global initiatives, Economic analysis and challenges.

COURSE OUTCOME

Upon completion of this course, the students will be able to

- Understand hydrogen production and utilization technologies
- Evaluate the role of hydrogen in reducing carbon emissions
- Analyze techno-economic and policy aspects of decarbonisation

TEXT AND REFERENCE BOOKS

1. Photovoltaic Systems Engineering, Roger A. Messenger & Amir Abtahi, 4th Edition (CRC Press, 2017)
2. Solar Engineering of Thermal Processes, Photovoltaics and Wind, John A. Duffie, William A. Beckman & Nathan Blair, 5th Edition (Wiley, 2020)
3. Handbook of Photovoltaic Science and Engineering, Antonio Luque & Steven Hegedus, 2nd Edition (Wiley, 2011)
4. PV System Technology (German Solar Energy Society – DGS), Routledge / Earthscan
5. André Mermoud (PVsyst SA), www.pvsyst.com

26UPESTV04 CIRCULAR ECONOMY FOR SUSTAINABLE DEVELOPMENT

COURSE OBJECTIVES

- To understand the fundamental principles and concepts of circular economy and sustainable development
- To analyze circular economy models and their applications across industries
- To evaluate the role of circular economy in achieving environmental, economic, and social sustainability

UNIT – I: INTRODUCTION TO CIRCULAR ECONOMY

Introduction Concept of circular economy and its core principles (reduce, reuse, recycle, recover); Comparison of the linear and circular economy models. Drivers and Challenges- Environmental implications of the linear economy, Drivers for transitioning to a circular economy, Challenges of implementing circular economy practices. Circular Economy and SDGs: Links between circular economy and the UN Sustainable Development Goals (SDGs).

UNIT – II: CIRCULAR ECONOMY MODELS AND APPLICATIONS

Circular Economy Models- Analysis of different models (e.g., circular product design, closed-loop recycling, sharing economy). Real-world examples of circular economy practices across various industries; Case Studies- Development of a case study on a company successfully implementing circular economy principles; Evaluation of the potential economic and environmental benefits of circular economy models

UNIT – III: BENEFITS AND FUTURE OF CIRCULAR ECONOMY

Social, Economic, and Environmental Benefits- Analysis of the social, economic, and environmental benefits of a circular economy; Emerging Trends and Innovations Discussion of emerging trends and innovations in circular economy practices; The Future of Circular Economy-Exploring the potential of circular economy for achieving sustainable development.

COURSE OUTCOME

Upon completion of this course, the students will be able to

- Explain the principles, drivers, and challenges of circular economy
- Analyze circular economy models and their real-world applications.
- Evaluate the benefits and future potential of circular economy for sustainable development.

TEXT AND REFERENCE BOOKS

1. Walter R Stahel, The Circular Economy A User's Guide, CRC Press, 2019.

2. Peter Lacy, Jessica Long, Wesley Spindler, The Circular Economy Handbook: Realizing The Circular Advantage, Palgrave Macmillan, 2020.

26UPESTV05 INDUSTRIAL WASTEWATER, POLLUTION- PREVENTION AND CONTROL

COURSE OBJECTIVES

- To understand the principle of various processes applicable to industrial wastewater treatment
- To impart knowledge on the concept and application of Industrial pollution prevention, cleaner technologies.
- To identify the best applicable technologies for wastewater treatment from the perspective of yield production.

UNIT – I: INTRODUCTION

Industrial scenario in India– industrial activity and environment - uses of water by industry – sources and types of industrial wastewater – nature and origin of pollutants - industrial wastewater and environmental impacts – regulatory requirements for treatment of industrial wastewater – industrial waste survey – industrial wastewater monitoring and sampling - generation rates, characterization and variables – toxicity of industrial effluents and bioassay tests – major issues on water quality management

UNIT – II: INDUSTRIAL POLLUTION PREVENTION & WASTE MINIMISATION

Digital Prevention of industrial pollution – benefits and barriers – waste management Hierarchy - source reduction techniques – periodic waste minimization assessments – evaluation of pollution prevention options – cost benefit analysis – pay-back period – implementing & promoting pollution prevention programs in industries

UNIT – III: INDUSTRIAL WASTEWATER TREATMENT

Flow and load equalization – solids separation – removal of fats, oil & grease- neutralization removal of inorganic constituents – precipitation, heavy METAL removal, nitrogen & phosphorous removal, Ion exchange, adsorption, membrane filtration, electro dialysis & evaporation – removal of organic constituents – biological treatment processes, chemical oxidation processes, advanced oxidation processes – treatability studies

COURSE OUTCOME

Upon completion of this course, the students will be able to

- Identify different areas of alternate fuels and energy system.
- Knowledge on applications of alternative fuels in day-to-day life.
- Understand the emission norms

TEXT AND REFERENCE BOOKS

1. "Industrial wastewater management, treatment & disposal, Water Environment" Federation Alexandria Virginia, Third Edition, 2008.

2. Lawrance K. Wang, Yung Tse Hung, Howard H.Lo and Constantine Yapijakis “handlook of Industrial and Hazardous waste Treatment”, Second Edition, 2004.

3. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017

4. Nelson Leonard Nemerow, “industrial waste Treatment”, Elsevier, 2007.

5. Wesley Eckenfelder W., “Industrial Water Pollution Control”, Second Edition, Mc Graw Hill, 2000.

26UPESTV06 INSTRUMENTATION FOR ENERGY SYSTEMS

COURSE OBJECTIVES

- To understand the characteristics of measurement systems
- To develop knowledge of electrical measurements
- To gain insight into digital measurement techniques for various physical quantities

UNIT – I: MEASUREMENT SYSTEMS, STATISTICS & ELECTRICAL MEASUREMENTS

Introduction to measurement systems and errors Static & dynamic characteristics of transducers Statistical analysis: uncertainty, regression, design of experiments (full & half factorial) Electrical measurements: voltage, current, power, energy, time, frequency Signal conditioning circuits: Wheatstone bridge, amplifiers, converters (V–I, I–V), integrator, differentiator, filters, attenuators DAC, ADC, PID controller basics.

UNIT – II: DIGITAL MEASUREMENT & INSTRUMENTATION

Digital measurement techniques for physical quantities: displacement, temperature, pressure, force, torque, vibration, acceleration, velocity, level, flow Measurement of thermal and nuclear radiation Solar instruments: pyrheliometers, pyranometers, albedometers, pyrradiometers, pyrgeometers, sun photometers.

UNIT – III: THERMO-PHYSICAL MEASUREMENTS, POLLUTION & CONTROL SYSTEMS

Measurement of thermo-physical properties: thermal conductivity (solids, liquids, gases), viscosity, gas diffusion, Calorimetry: bomb and continuous flow calorimeters, Measurement of heat transfer, humidity, heat flux, Ph, Air pollution measurement: sampling techniques, particulate matter, SO_2, combustion products, opacity, odour, Control systems: Arduino, Raspberry Pi, sensors, actuators (stepper & servo motors), Data acquisition systems and IoT applications in process monitoring, energy management, and smart instrumentation

COURSE OUTCOME

Upon completion of this course, the students will be able to

- Apply digital techniques to measure various physical quantities.
- Evaluate thermo-physical properties, heat transfer parameters.
- Perform electrical measurements and design appropriate signal conditioning circuits.

TEXT AND REFERENCE BOOKS

1. Barney G.C., "Intelligent instrumentation: microprocessor applications in measurement and control", Prentice Hall, 1988.
2. Bell C., "Beginning Sensor Networks with Arduino and Raspberry Pi", Apress, 2013.
3. Doebelin E. and ManikD.N., "Doebelin's Measurement Systems", Tata McGraw Hill, 2011.
4. George, B., Roy, J.K., Kumar, V.J., Mukhopadhyay, S.C., "Advanced Interfacing Techniques for Sensors", Springer, 2017.
5. Holman J.P., "Experimental methods for Engineers", Tata McGraw Hill, 2007.

26UPESTV07 ALTERNATE FUELS AND EMISSIONS

COURSE OBJECTIVES

- To present a problem oriented in depth knowledge of Alternate fuel and energy system
- To address the underlying concepts and methods behind alternate fuel and energy system
- To know the of engine emission standards.

UNIT – I: INTRODUCTION

IC engines classifications (SI & CI engine, 2-stroke & 4-stroke engine), Thermodynamic Cycles Combustion in IC engine: Thermochemistry of Fuel-Air mixture, characterization of flame, Combustion stoichiometry, Chemical equilibrium, Chemical kinetics Properties of fuel and its effect on combustion: Engine knock & detonation, abnormal combustion

UNIT – II: ALTERNATE FUELS, PROPERTIES, SUITABILITY AND EMISSIONS

Compressed natural gas - Liquefied Petroleum Gas – Hydrogen gas – Hythane - Di-Methyl Ether - Ethanol - Biodiesel.

UNIT– III: NOVEL TECHNOLOGIES AND STRATEGIES TO CURB EMISSIONS

Homogeneous charge CI engines, Premixed Charge Compression Ignition, Emission control technologies - Exhaust gas recirculation - Selective catalytic reduction - Diesel Oxidation Catalysts - Diesel particulate filter.

COURSE OUTCOME

Upon completion of this course, the students will be able to

- Identify different areas of alternate fuels and energy system.
- Knowledge on applications of alternative fuels in day-to-day life.
- Understand the emission norms

TEXT AND REFERENCE BOOKS

1. Internal Combustion engine fundamentals: J B Heywood, Tata Mc-Graw Hill Publications, 2011
2. Internal Combustion Engines: V Ganeshan, Tata Mc-Graw Hill Publications, 2012
3. IC Engines: Combustion and Emissions: BP Pundir, Narosa Publishing House, 2010
4. The Internal combustion Engine in theory and practice: C F Taylor, MIT Press, Cambridge, 1985
5. Alternative Fuels Guidebook, Properties, Storage, Dispensing, and Vehicle Facility Modifications: RL. Bechtold, SAE Publications, 1997

26UPESTV08 BIOMASS AND ITS CONVERSION TECHNOLOGIES

COURSE OBJECTIVES

- Identify potential biomass feedstocks including energy crops;
- Have an understanding of the existing and emerging biomass to energy technologies;
- Develop a critical thinking about sustainability & resilience; and

UNIT – I: INTRODUCTION

Origin of Biomass: Resources: Classification and characteristics; Techniques for biomass assessment; Application of remote sensing in forest assessment; Biomass estimation

UNIT – II: THERMO-CHEMICAL CONVERSION

Direct combustion, incineration, pyrolysis, gasification and liquefaction; Economics of Thermo- chemical conversion. biomass processing, briquetting, palletization, biomass stoves, biomass carbonization, production of syngas from biomass.

UNIT– III: BIOMASS PRODUCTIVITY

Energy plantation and power Programme. Biomass renewable energy program of central govt. and state government Regulations, policies, feed in tariff policies, grid injection, hybrid systems, and cost economics.

COURSE OUTCOME

Upon completion of this course, the students will be able to

- Acquiring the knowledge of biomass energy.
- Understanding Biomass as a renewable energy and its importance with respect to environment protection
- To design bio-energy systems.

TEXT AND REFERENCE BOOKS

1. Fuel Cells by Bockris and Srinivasan; McGraw Hill,1969.
2. Solar Energy: Fundamentals and Applications by H.P. Garg& Jai Prakash, Tata McGraw Hill.
3. Wind Power Technology, Joshua Earnest, PHI Learning, 2014
4. Non-Conventional Energy Resources by S. Hasan Saeed and D. K. Sharma, S. K. Kataria & Sons, 2019.

26UPESTV09 FIRST AID & FIRE FIGHTING SAFETY MANAGEMENT

COURSE OBJECTIVES

- Learn about FIRST AID measures
- Learn about accident investigations and preventive measures
- Understand safety, best practices and expectations

UNIT – I: FIRST AID

First Aider and Managing Incidents: First aider - Protection from infection - Dealing with a casualty - Requesting help - The use of medication - Remember your own needs - Action at an emergency – and Electrical incidents.

UNIT – II: INDUSTRIAL SAFETY

Accident History: Fundamentals of Safety, Importance of Safety Policy – Accident Types, Causes, Theories, Accident Prevention Measures.

UNIT– III: FIRE FIGHTING

Causes of Fires: Types of Flammable Materials – Solids – Liquids – Gases ; Fire Triangle. Types of Fires: Classifications of Fires – Gas Fires – Liquid Fires – Solid Fire – Electrical Fire – Metal Fire; Kitchen Fire.

COURSE OUTCOME

Upon completion of this course, the students will be able to

- Students get practical knowledge FIRST AID measures
- Understanding importance of Industrial Safety
- To acquire knowledge about Fire Fighting

TEXT AND REFERENCE BOOKS

1. Fire Safety Management Handbook Third Edition By Daniel E Della Giustina, CRC Press, 2014
2. AIChE/CCPS, Guidelines for Hazard Evaluation Procedures second edition. Centre for Chemical Process Safety, American Institute of Chemical Engineers, New York,1992
3. V.J. Davies and K. Tomasin, Construction Safety Handbook.

26UPESTV10 REFRIGERATION AND AIR CONDITIONING

COURSE OBJECTIVES

- Explaining the different types of refrigerant, their properties, and selecting appropriate refrigerant for a HVAC system. Learn about accident investigations and preventive measures
- Explaining different types and components of RAC systems.
- Applying the safety and types of control in HVAC systems.

UNIT – I: INTRODUCTION, REFRIGERANTS AND THEIR ENVIRONMENTAL ISSUE

Applications of air-conditioning and refrigeration, energy usage in air-conditioning/buildings - Designation of refrigerants, Selection of refrigerants, Ozone Depletion Potential (ODP) and Global Warming (GW), Montreal and Kyoto protocols Total Equivalent Warming Index (TEWI), Azeotropic and zeotropic mixtures, alternative to existing CFC and HCFC refrigerants.

UNIT – II: AIR CONDITIONING SYSTEM TYPES AND AIR DISTRIBUTION

Major system types in air-conditioning: unitary, package, central chilled water based systems; components of chilled water system, concept of primary-secondary chilled water pumping; concept of variable flow systems, components of non-chilled water based system, types and role for energy efficiency, comparison of variable refrigerant flow and constant flow systems

UNIT– III: OTHER REFRIGERATION SYSTEMS, CONTROLS AND SAFETY IN RAC

Introduction to Building Management System, major components and use of BMS, instrumentation requirements, concept of Direct Digital Control.

COURSE OUTCOME

Upon completion of this course, the students will be able to

- Explain the different types of refrigerant, their properties, and select appropriate refrigerant for a HVAC system.
- Explain different types and components of RAC systems.
- Apply the safety and types of control in HVAC systems

TEXT AND REFERENCE BOOKS

1. Arora C P, Refrigeration and Air Conditioning, 3rd Edition, Tata McGraw-Hill, 2017.
2. Stoecker W.F and Jones J.W, Refrigeration and Air Conditioning, 2nd Edition, Tata McGrawHill, 1982.
3. ASHRAE Handbook Series: Fundamentals, Refrigeration, Systems and Equipments and HVAC Applications, 2014-18, ASHRAE Inc, Atlanta, USA

26UPESTV011 **INDUSTRIAL ROBOTICS**

COURSE OBJECTIVES

- Explaining the concepts of industrial robots with respect to its classification, specifications and coordinate systems. Reviewing the need and application of robots in different engineering fields
- Exemplifying the different types of robot drive systems as well as robot end effectors.
- Implementing robots in various industrial sectors and interpolating the economic analysis of robots

UNIT – I: FUNDAMENTALS OF ROBOT

Robot - Definition - Robot Anatomy – Co-ordinate Systems, Work Envelope Types and Classification-Specifications-Pitch, Yaw, Roll, Joint Notations, Speed of Motion, Pay Load- Robot Parts and their Functions-Need for Robots-Different Applications.

UNIT – II: SENSORS AND MACHINE VISION

Requirements of a sensor, Principles and Applications of the types of sensors and Digitizing Image Data Signal Conversion, Image Storage, Lighting Techniques, Image Processing and Analysis-Data Reduction, Segmentation, Feature Extraction, Object Recognition, Other Algorithms, Applications, Inspection, Identification, Visual Serving and Navigation.

UNIT– III: IMPLEMENTATION AND ROBOT ECONOMIC

RGV, AGV; Implementation of Robots in Industries-Various Steps; Safety Considerations for Robot Operations - Economic Analysis of Robots.

COURSE OUTCOME

Upon completion of this course, the students will be able to

- Explain the concepts of industrial robots with respect to its classification, specifications and coordinate systems. Review the need and application of robots in different engineering fields.
- Apply the different sensors and image processing techniques in robotics to improve the ability of robots.
- Implement robots in various industrial sectors and interpolate the economic analysis of robots

TEXT AND REFERENCE BOOKS

1. Craig J.J., “Introduction to Robotics Mechanics and Control”, Pearson Education, 2009.
2. Deb S.R., “Robotics Technology and Flexible Automation” Tata McGraw Hill Book Co., 2013.
3. Koren Y., “Robotics for Engineers", McGraw Hill Book Co., 1992
4. Maja J Mataric, “The Robotics Primer “Universities Press. 2013.

26UPESTV12 ENERGY FORECASTING, MODELING AND PROJECT MANAGEMENT

COURSE OBJECTIVES

- To understand about National energy scenario.
- To predict the energy demand using various forecasting models.
- To develop an optimization model for the effective utilization of energy sources.

UNIT – I: ENERGY SCENARIO

Role of energy in economic development and social transformation: Energy & GDP, GNP and its dynamics - Energy Sources and Overall Energy demand and Availability - Energy Consumption in various sectors and its changing pattern -Status of Nuclear and Renewable Energy: Present Status and future promise.

UNIT – II: FORECASTING AND OPTIMIZATION MODEL

Forecasting Techniques - Regression Analysis - Double Moving Average - Double Experimental Smoothing - Triple Exponential Smoothing – ARIMA model- Validation techniques – Qualitative forecasting – Delphi technique - Concept of Neural Net Works. Principles of Optimization - Formulation of Objective Function - Constraints - Multi Objective Optimization – Mathematical Optimization Software – Development of Energy Optimization Model

UNIT– III: PROJECT MANAGEMENT AND ENERGY POLICY

Project Preparation – Feasibility Study – Detailed Project Report - Project Appraisal – Social-cost benefit Analysis - Project Cost Estimation – Project Risk Analysis - Project Financing – Financial Evaluation. National & State Level Energy Issues - National & State Energy Policy - Energy Security - National solar mission - state solar energy policy - Framework of Central Electricity Authority (CEA),

COURSE OUTCOME

Upon completion of this course, the students will be able to

- Have knowledge in the National energy scenario
- Do Energy prediction using various forecasting techniques.
- Develop optimization model for energy planning and project management.

TEXT AND REFERENCE BOOKS

1. Armstrong J.Scott (ed.), Principles of forecasting: a hand book for researchers and practitioners, Norwell, Massachusetts: Kluwer Academic Publishers.2001

2. DhandapaniAlagiri, Energy Security in India Current Scenario, The ICFAI University Press, 2006.

3. Fred Luthans, Brett C. Luthan, Kyle W. Luthans, Organisational Behaviour: An Evidence- Based Approach, Information Age Publishing; 13 edition, 2015.

4. Spyros G. Makridakis, Steven C. Wheelwright, Rob J. Hyndman, Forecasting: Methods and Applications, 4th Edition, ISBN: 978-0-471-53233-0,2003.

5. Yang X.S., Introduction to mathematical optimization: From linear programming to Metaheuristics,

26UPESTV13 **ECONOMICS AND PLANNING OF ENERGY SYSTEMS**

COURSE OBJECTIVES

- To impart knowledge on market parameters governing economic analysis and energy conservation.
- To impart knowledge on regional and national level energy policies.

UNIT – I: INTRODUCTION AND BASIC CONCEPTS OF ENERGY ECONOMICS

Law of demand, Elasticities of demand, Theory of firm: Production function, Output maximization, Cost minimization and profit maximization principles. Theory of market, National income and other macroeconomic parameters. Calculation of unit cost of power generation from different sources with examples, Ground rules for investment in Energy sector, Payback period, NPV, IRR and Benefit-cost analysis with example.

UNIT – II: SOCIO-ECONOMIC EVALUATION OF ENERGY CONSERVATION

Net Social Benefit incorporating Free riding concept and Rebound effects, Energy-GDP elasticity. Analysis of Environmental Pollution through decomposition of different sectors using I-O model, Interdependence of energy, economy and environment, Modeling concepts and application of SIMA model and I-O model for energy policy analysis

UNIT– III: OVERVIEW OF ENERGY POLICIES AND FORECASTING

National energy policy in the last plan periods, Energy use and Energy supply - Overview of renewable energy policy and the Five Year Plan programmes, Basic concept of Input-Output analysis, Concept of energy multiplier - Implication of energy multiplier for analysis of regional and national energy policy. Simulation and forecasting of future energy demand consistent with macroeconomic parameters in India

COURSE OUTCOME

Upon completion of this course, the students will be able to

- To gain knowledge on market parameters governing economic analysis and energy conservation.
- To gain knowledge on regional and national level energy policies.
- To gain knowledge on various modeling concepts and forecasting methods.

TEXT AND REFERENCE BOOKS

1. EA Diulio, Macroeconomic Theory, Schaum’s Outline Series, 2nd Ed, McGraw-Hill Publishing Company (1990)

2. R Loulou, P R Shukla and A Kanudia, Energy and Environment Policies for a sustainable Future, Allied Publishers Ltd, New Delhi, 1997

3. J Parikh, Energy Models for 2000 and Beyond, Tata McGraw-Hill Publishing Company Ltd, New Delhi,1997.

4. Energy Economics -A.V.Desai (Wiley Eastern) Energy Economics - Simple Payback Period, Time Value of Money, IRR, NPV, Life Cycle Costing, Cost of Saved Energy, Cost of Energy generated, Examples from energy generation and conservation 2021.

CERTIFICATE PROGRAMME

26UPESTCP01 BASICS OF RENEWABLE ENERGY SYSTEMS

Course Objectives

- To introduce fundamental concepts of renewable energy resources and systems.
- To understand the working principles of solar PV and wind energy systems.
- To study hybrid renewable energy systems and their configurations.
- To analyze challenges in renewable energy integration with the grid.
- To understand variability, uncertainty, and reliability issues in renewable systems.

Course Outcomes

After completing the course, students will be able to:

CO1 – Explain the fundamentals of renewable energy systems and resource assessment.
CO2 – Describe design and operation of solar photovoltaic systems.
CO3 – Analyze wind energy conversion systems and performance parameters.
CO4 – Evaluate hybrid renewable energy system configurations.
CO5 – Identify integration challenges and variability issues in renewable energy deployment.

UNIT I – Introduction to Renewable Energy Systems (8 Hours)

Global energy scenario and environmental impacts-Conventional vs renewable energy systems-Classification of renewable energy resources-Solar, wind, biomass, hydro, geothermal – overview-Energy conversion principles-Resource assessment techniques
Sustainability and energy policies

UNIT II – Solar Photovoltaic (PV) Systems (10 Hours)

Solar radiation fundamentals-Solar geometry and measurement-Working principle of PV cell-I–V and P–V characteristics-PV modules, arrays, and configurations-Maximum Power Point Tracking (MPPT) – basics-Grid-connected and standalone PV systems-Balance of System (BOS) components-Performance analysis and efficiency

UNIT III – Wind Energy Systems (10 Hours)

Wind energy potential and site assessment-Aerodynamics of wind turbines-Betz limit and power coefficient-Types of wind turbines (HAWT, VAWT)-Wind turbine components Wind energy conversion systems (WECS)-Control strategies (Pitch, Stall control)-Grid integration basics-Performance characteristics

UNIT IV – Hybrid Renewable Energy Systems (8 Hours)

Need for hybrid systems-Solar–Wind hybrid systems-Solar–Wind–Battery systems- Diesel–Renewable hybrid systems-Energy storage technologies (Battery, Pumped hydro, Hydrogen – overview)-System sizing and configuration-Economic analysis basics (LCOE concept)

UNIT V – Renewable Energy Integration & Challenges (9 Hours)

Grid integration challenges-Voltage and frequency stability issues-Power quality problems-Intermittency and variability-Forecasting basics (solar & wind)-Uncertainty analysis-Smart grid and microgrid concepts-Regulatory and policy challenges

Textbooks

1. B.H. Khan, Non-Conventional Energy Resources, McGraw Hill Education.
2. G.D. Rai, Non-Conventional Energy Sources, Khanna Publishers.
3. John Twidell & Tony Weir, Renewable Energy Resources, Routledge.

Reference Books

1. Gilbert M. Masters, Renewable and Efficient Electric Power Systems, Wiley.
2. S.P. Sukhatme, Solar Energy: Principles of Thermal Collection and Storage, McGraw Hill.

Suggested Laboratory/Practical Components (Optional)

- Solar panel performance measurement
- Wind turbine model testing
- PV system simulation using MATLAB/Simulink
- Hybrid system simulation
- Case study on grid integration

26UPESTCP02 FUNDAMENTALS OF ARTIFICIAL INTELLIGENCE

Course Objectives

- To introduce fundamental concepts of Artificial Intelligence and Machine Learning.
- To understand different types of learning paradigms.
- To apply regression and classification techniques for problem-solving.
- To understand neural networks and deep learning basics.
- To gain hands-on experience with AI tools such as Python, Scikit-learn, TensorFlow, and MATLAB.

Course Outcomes

After completing the course, students will be able to:
CO1 – Explain fundamental concepts of AI and ML.
CO2 – Differentiate supervised, unsupervised, and reinforcement learning techniques.
CO3 – Implement regression and classification models.
CO4 – Describe architecture and training of neural networks.
CO5 – Use AI tools for developing basic intelligent models.

UNIT I – Introduction to Artificial Intelligence & Machine Learning (8 Hours)

Definition and scope of Artificial Intelligence-History and evolution of AI-AI vs ML vs Deep Learning-Applications of AI (Energy, Healthcare, Robotics, Finance, etc.)AI problem formulation-Data types and preprocessing basics-Ethics and responsible AI

UNIT II – Machine Learning Paradigms (9 Hours)

Overview of Machine Learning-Supervised Learning – concept and work flow- Unsupervised Learning – clustering and dimensionality reduction-Reinforcement Learning – agent, environment, reward mechanism -Training, validation, testing concepts-Bias–variance tradeoff-Overfitting and underfitting

UNIT III – Regression & Classification Techniques (10 Hours)

Regression: Linear Regression-Multiple Linear Regression-Polynomial Regression- Model evaluation metrics (MSE, RMSE, R^2)- Classification:Logistic Regression- K-Nearest Neighbors (KNN)-Decision Trees-Support Vector Machines (SVM)-Confusion matrix, precision, recall, F1-score

UNIT IV – Neural Networks & Deep Learning (10 Hours)

Biological neuron vs artificial neuron - Perceptron model -Multi-Layer Perceptron (MLP)-Activation functions (Sigmoid, ReLU, Tanh)-Backpropagation algorithm-Introduction to Deep Learning-Convolutional Neural Networks (CNN) – basicsApplications of deep learning

UNIT V – AI Tools & Practical Implementation (8 Hours)

Python for AI -Introduction to Python-NumPy and Pandas basics- Data visualization (Matplotlib)-Machine Learning Libraries- Scikit- learn – regression and classification implementation-TensorFlow – basic neural network model building-MATLAB – AI toolbox overview- Mini Project: Build and evaluate a simple regression or classification model

Textbooks

1. Stuart Russell & Peter Norvig, Artificial Intelligence: A Modern Approach, Pearson.
2. Tom M. Mitchell, Machine Learning, McGraw Hill.

Reference Books

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press.
2. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow, O'Reilly.

Suggested Laboratory Components

- Implement Linear Regression using Scikit-learn
- Build a classification model using Decision Tree
- Develop a simple neural network using TensorFlow
- Perform clustering using K-Means
- Mini AI application (energy forecasting / image classification / anomaly detection)

26UPESTCP03 **SOLAR AND WIND ENERGY SYSTEMS**

Course Objectives

- To understand the principles and technologies of solar photovoltaic and solar thermal systems.
- To study power conditioning techniques and Maximum Power Point Tracking (MPPT).
- To analyze wind turbine aerodynamics and components.
- To understand wind power conversion systems and grid integration.
- To evaluate performance and design aspects of solar and wind energy systems.

Course Outcomes

After completing the course, students will be able to:

CO1 – Explain working principles of solar PV and solar thermal systems.
CO2 – Design basic power conditioning and MPPT techniques.
CO3 – Analyze wind turbine aerodynamics and performance parameters.
CO4 – Describe wind turbine components and operation.
CO5 – Evaluate wind power conversion systems and their integration.

UNIT I – Solar Photovoltaic (PV) Technology (10 Hours)

Solar radiation fundamentals and measurement - Semiconductor physics for PV -Working principle of solar cell - I–V and P–V characteristics - PV modules, arrays, and configurations - Series and parallel connections - Efficiency and performance -parameters - Grid-connected and standalone PV systems - Recent advances in PV technology

UNIT II – Power Conditioning & MPPT (8 Hours)

Need for power conditioning - DC–DC converters (Buck, Boost, Buck-Boost) - Inverters – single-phase and three-phase - Pulse Width Modulation (PWM) - Maximum Power Point Tracking (MPPT) techniques - Perturb & Observe (P&O) - Incremental Conductance -Constant Voltage method - Harmonics and power quality issues -Grid synchronization basics

UNIT III – Solar Thermal Systems (8 Hours)

Solar thermal energy fundamentals - Flat plate collectors - Evacuated tube collectors - Concentrated solar power (CSP) systems - Solar water heating systems - Solar drying and industrial applications - Thermal energy storage systems - Performance analysis of solar thermal systems

UNIT IV – Wind Turbine Aerodynamics (10 Hours)

Wind characteristics and site assessment - Wind speed distribution (Weibull analysis) - Aerodynamic principles of wind turbines - Betz limit - Tip speed ratio - Lift and drag forces - Power coefficient and performance curves -Blade design basics

UNIT V – Wind Turbine Components & Wind Power Conversion Systems (10 Hours)

Wind Turbine Components - Rotor and blades – Nacelle – Gearbox – Generator Tower - Yaw and pitch control mechanisms - Wind Power Conversion Systems (WPCS)- Fixed speed and variable-speed systems - Induction generators -Synchronous generators - Power electronic interfaces - Grid integration basics -Protection systems -Offshore wind systems – overview

Textbooks

1. B.H. Khan, Non-Conventional Energy Resources, McGraw Hill.
2. G.D. Rai, Non-Conventional Energy Sources, Khanna Publishers.
3. John Twidell & Tony Weir, Renewable Energy Resources, Routledge.

Reference Books

1. Gilbert M. Masters, Renewable and Efficient Electric Power Systems, Wiley.
2. S.P. Sukhatme, Solar Energy: Principles of Thermal Collection and Storage, McGraw Hill.

Laboratory Components (Suggested)

- Measurement of PV module characteristics
- Design and simulation of MPPT using MATLAB/Simulink
- Solar thermal collector efficiency experiment
- Wind turbine model performance testing
- Wind data analysis using Weibull distribution
- Grid-connected inverter simulation

26UPESTCP04 SOLAR POWER FORECASTING USING MACHINE LEARNING

Course Objectives

- To understand solar radiation fundamentals and characteristics of solar power generation.
- To analyze the time-series nature of solar data.
- To apply preprocessing and feature engineering techniques for forecasting.
- To implement machine learning and deep learning models for solar forecasting.
- To evaluate forecasting models using standard performance metrics.

Course Outcomes

After successful completion of the course, students will be able to:
CO1 – Explain solar radiation fundamentals and solar data characteristics.
CO2 – Apply preprocessing and feature engineering techniques to solar datasets.
CO3 – Implement ML models for short-term and long-term solar forecasting.
CO4 – Develop ANN and LSTM-based forecasting models.
CO5 – Evaluate and compare forecasting models using standard metrics.

UNIT I – Solar Radiation Fundamentals (8 Hours)

Solar geometry and extraterrestrial radiation - Global Horizontal Irradiance (GHI), DNI, DHI - Clearness index - Solar resource assessment - PV output dependency on irradiance and temperature - Variability of solar power generation - Data acquisition from solar plants

UNIT II – Time-Series Nature of Solar Data (8 Hours)

Characteristics of time-series data - Deterministic vs stochastic components - Trend, seasonality, cyclic behavior - Stationarity and autocorrelation - Lag features and rolling statistics - Short-term vs long-term forecasting concepts -Persistence model (benchmark method)

UNIT III – Data Preprocessing & Feature Engineering (10 Hours)

Data Preprocessing: Handling missing values - Outlier detection - Data normalization and scaling - Noise filtering - Train–validation–test split - Cross-validation techniques Feature Engineering: Time-based features (hour, day, month) - Weather parameters (temperature, humidity, wind speed, cloud cover) - Irradiance transformations Lag features and moving averages - Feature selection techniques

UNIT IV – Machine Learning Models for Solar Forecasting (10 Hours)

Classical ML Models: Linear Regression - Support Vector Machines (SVM)- Random Forest Regressor- Artificial Neural Networks: Feedforward ANN architecture- Training using backpropagation - Hyperparameter tuning - Deep Learning Models: Recurrent Neural Networks (RNN) - Long Short-Term Memory (LSTM) networks - Sequence-to-sequence forecasting - Comparison of models for forecasting accuracy and computational complexity.

UNIT V – Forecasting Horizons & Performance Evaluation (9 Hours)

Forecasting Types: Very short-term forecasting (minutes to 1 hour) - Short-term forecasting (1 hour to 24 hours) - Medium and long-term forecasting - Performance Metrics: Root Mean Square Error (RMSE) - Mean Absolute Error (MAE) - Mean Absolute Percentage Error (MAPE) R^2 score - Forecast skill score

Textbooks

1. James P. Taylor, Forecasting: Principles and Practice.
2. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow, O'Reilly.

Reference Books

1. S.P. Sukhatme, Solar Energy: Principles of Thermal Collection and Storage, McGraw Hill.
2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press.

Laboratory / Practical Components

- Solar dataset collection and visualization
- Preprocessing and feature engineering using Python
- Implement Linear Regression & SVM models
- Random Forest forecasting model
- ANN model development
- LSTM-based time-series forecasting
- Model comparison using RMSE, MAE, MAPE
- Mini Project: Day-ahead solar power forecasting model

26UPESTCP05 WIND ENERGY PREDICTION & OPTIMIZATION USING AI

Course Objectives

- To understand wind resource assessment and statistical modeling.
- To apply AI techniques for wind speed and wind power prediction.
- To develop ANN and deep learning models for forecasting.
- To optimize wind turbine placement using AI-based methods.
- To implement AI-based pitch control and reinforcement learning for wind farm optimization.

Course Outcomes

After completion of the course, students will be able to:
CO1 – Analyze wind resource data using statistical models.
CO2 – Model wind speed using Weibull distribution and AI techniques.
CO3 – Develop ANN and deep learning models for wind power prediction.
CO4 – Apply optimization algorithms for wind turbine siting.
CO5 – Design AI-based control strategies for wind farms.

UNIT I – Wind Resource Assessment (8 Hours)

Wind characteristics and measurement techniques - Anemometry and wind data acquisition - Wind speed distribution analysis-Power density estimation -Site suitability analysis -Seasonal and diurnal variations -Weibull Distribution: Probability density function (PDF) - Cumulative distribution function (CDF)- Shape and scale parameters
Parameter estimation methods - Application of Weibull distribution in wind modeling

UNIT II – Wind Speed Modeling & Prediction (8 Hours)

Time-series characteristics of wind data - Autocorrelation and stationarity -Deterministic vs stochastic modelling - Persistence model- Statistical wind speed prediction models -Data preprocessing and feature engineering

UNIT III – Wind Power Prediction using AI (10 Hours)

Artificial Neural Networks (ANN) - Feedforward neural networks - Training and validation
Hyperparameter tuning - Deep Learning Approaches - Recurrent Neural Networks (RNN)
Long Short-Term Memory (LSTM) - Convolutional Neural Networks (CNN) for time-series
Hybrid ML Models - ANN + Optimization algorithms - Statistical + ML hybrid models
Ensemble learning methods - Model comparison using RMSE, MAE, MAPE.

UNIT IV – Optimization of Wind Turbine Placement (9 Hours)

Wind farm layout design principles - Wake effect modelling - Objective functions (maximize power, minimize cost) - Constraints in wind farm design -Optimization techniques: Genetic Algorithm (GA) - Particle Swarm Optimization (PSO)-Differential Evolution (DE) - AI-based layout optimization case studies

UNIT V – AI-based Control & Wind Farm Optimization (10 Hours)

AI-based Pitch Angle Control - Aerodynamic principles -Pitch control strategies -ANN-based pitch control- Adaptive control techniques - Reinforcement Learning for Wind Farm Optimization - RL fundamentals (Agent, State, Action, Reward)- Q-learning-Deep Reinforcement Learning (DRL) -Multi-agent RL for wind farms -Real-time optimization strategies- Applications in smart grids and energy markets.

Textbooks

1. Tony Burton, David Sharpe, Nick Jenkins, Wind Energy Handbook, Wiley.
2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press.

Reference Books

1. John Twidell & Tony Weir, Renewable Energy Resources, Routledge.
2. Simon Haykin, Neural Networks and Learning Machines, Pearson.