REGULATIONS AND SYLLABUS
(University Department)

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

MASTER OF SCIENCE
IN
ENERGY SCIENCE

(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.Sc., Energy Science

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

1. Eligibility for Admission

Candidates who has passed Bachelor's Degree/ B.Voc in Basic and Applied Sciences or Equivalent degree of this University or any other University shall be eligible for admission of M.Sc., Energy Science

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.Sc., Degree shall be two years consist of four semesters.

4. Distribution of Credit Points

The minimum credit requirement for M.Sc., 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.Sc., Degree shall be in Energy Science (CBCS) with internal assessment according to syllabi prescribed from time to time.

METHODS OF EVALUATION (THEORY)	
Internal	25 Marks
External	75 Marks
	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
	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).

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 at 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 by other Department).

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

* 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 Science 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. Ascending as an energy consultant for providing solutions towards improving the efficacy of energy systems.

IV. Become a successful entrepreneur and be a part of a supply chain ormanufacture or market energy products for sustainable development.

V. Lead an ethical life by engaging in lifelong learning experiences for developing environmentally benign and economically affordable energy products for societal upliftment

PROGRAMME OUTCOMES (POs):

After studying Energy Science, our students will exhibit ability to:

PO	Graduate Attribute	Programme Outcome
1	Knowledge	Apply knowledge of mathematics, basic scienceand engineering science.
2	Problem analysis	Identify, formulate and solve engineering problems.
3	Design/developmentof 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	Function in a multidisciplinary team.
9	Communication	Proficiency in oral and written Communication.
10	Project managementand finance	Implement cost effective and improved system.
11	Ethics	Interact in industry, business and society in a professional and ethical manner.

PROGRAM SPECIFIC OUTCOMES (PSOs):

1. Apply the principles of energy science to design, analyze, and optimize energy generation, conversion, storage, and utilization systems for sustainable development.
2. Conduct energy audits, evaluate energy performance, and recommend effective energy conservation and management strategies for industrial, commercial, and residential sectors.
3. Demonstrate professional ethics, entrepreneurial skills, and innovative thinking to develop sustainable energy solutions, create energy enterprises, and address emerging challenges in the energy sector.

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

		Course Name	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
I YEAR	Semester 1	Energy Scenario, Audit and Management	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
		Fluid Mechanics and Thermal Analysis	✓	✓	✓	✓	✓	✓				✓	✓
		Smart cities and Smart grids	✓	✓			✓	✓					✓
		Renewable Energy Systems	✓	✓	✓	✓	✓	✓		✓			✓
		Elective – I											
		Energy Laboratory	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Semester 2	Thermal Energy Conservation	✓	✓	✓	✓	✓	✓				✓	✓
		Computer Aided Design and Analysis	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
		Introduction to Data Analytics and Machine Learning in Energy Systems	✓	✓	✓	✓	✓	✓			✓	✓	✓
		Elective – II											
		Fundamentals of Human Rights											
		NME – I (Swayam/MOOC/NPTEL)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Computer Aided Design and Simulation Laboratory	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
II YEAR	Semester 3	Electrical Energy Conservation	✓	✓	✓	✓		✓	✓		✓	✓	✓
		Nanomaterials for Energy Applications	✓	✓	✓		✓	✓	✓				✓
		Research Methodology and Intellectual Property Rights	✓	✓	✓		✓		✓	✓	✓		✓
		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.Sc., ENERGY SCIENCE

CURRICULUM AND SYLLABUS

SEMESTER I

S.No	Course Code	Course Title	Category	L	T	P	C	Int. Mark	Ext. Mark	Total
1	26UPEST1C01	Energy Scenario, Audit and Management	C	4	1	0	5	25	75	100
2	26UPEST1C02	Fluid Mechanics and Thermal Analysis	C	4	1	0	5	25	75	100
3	26UPEST1C03	Smart cities and Smart grids	C	4	1	0	5	25	75	100
4	26UPEST1C04	Renewable Energy Systems	C	4	0	0	4	25	75	100
5	-	Elective –I	E	4	0	0	4	25	75	100
6	26UPEST1L01	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	26UPEST1C05	Thermal Energy Conservation	C	4	1	0	5	25	75	100
2	26UPEST1C06	Computer Aided Design and Analysis	C	4	1	0	5	25	75	100
3	26UPEST1C07	Introduction to Data Analytics and Machine Learning in Energy Systems	C	4	1	0	5	25	75	100
4	-	Elective –II	E	4	0	0	4	25	75	100
5	26UPPGC1H01	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	26UPEST1L02	Computer Aided Design 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	26UPEST1C08	Electrical Energy Conservation	C	4	1	0	5	25	75	100
2	26UPEST1C09	Nanomaterials for Energy Applications	C	5	0	0	5	25	75	100
3	26UPEST1C10	Research Methodology and Intellectual Property Rights	C	4	0	0	4	25	75	100
4	-	Elective – III	E	4	0	0	4	25	75	100
5	-	NME-II	N	3	0	0	2	25	75	100
6	26UPEST1I01	Internship	I	0	0	0	2	-	100	100
7	26UPEST1L03	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	26UPGEN1V01	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	26UPEST1P01	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	26UPEST1C01	Energy Scenario, Audit and Management	C	4	1	0	5
2	26UPEST1C02	Fluid Mechanics and Thermal Analysis	C	4	1	0	5
3	26UPEST1C03	Smart cities and Smart grids	C	4	1	0	5
4	26UPEST1C04	Renewable Energy Systems	C	4	0	0	4
5	26UPEST1C05	Thermal Energy Conservation	C	4	1	0	5
6	26UPEST1C06	Computer Aided Design and Analysis	C	4	1	0	5
7	26UPEST1C07	Introduction to Data Analytics and Machine Learning in Energy Systems	C	4	1	0	5
8	26UPEST1C08	Electrical Energy Conservation	C	4	1	0	5
9	26UPEST1C09	Nanomaterials for Energy Applications	C	5	0	0	5
10	26UPEST1C10	Research Methodology and Intellectual Property Rights	C	4	0	0	4

LABORATORY (L)

S.No	Course Code	Course Title	Category	L	T	P	C
1	26UPEST1L01	Energy Laboratory	L	0	0	6	3
2	26UPEST1L02	Computer Aided Design and Simulation Laboratory	L	0	0	6	3
3	26UPEST1L03	Energy Auditing Laboratory	L	0	0	6	3

PROJECT (P)

S.No	Course Code	Course Title	Category	L	T	P	C
1	26UPEST1P01	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	26UPEST1E01	Power Plant Engineering	E	4	0	0	4
2	26UPEST1E02	Bio Energy Conversion	E	4	0	0	4
3	26UPEST1E03	Waste Management and Energy Recovery Techniques	E	4	0	0	4
4	26UPEST1E04	Hydro Energy Systems	E	4	0	0	4
ELECTIVE - II							
5	26UPEST1E05	Solar Photovoltaic Science and Technology	E	4	0	0	4
6	26UPEST1E06	Industrial Instrumentation	E	4	0	0	4
7	26UPEST1E07	Wind Energy conversion	E	4	0	0	4
8	26UPEST1E08	Material Science	E	4	0	0	4
ELECTIVE - III							
9	26UPEST1E09	Innovation and Entrepreneurship Development	E	4	0	0	4
10	26UPEST1E10	Hydrogen Energy Technologies	E	4	0	0	4
11	26UPEST1E11	Energy water Management in High Performance Building	E	4	0	0	4
12	26UPEST1E12	Electric Vehicle Systems	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 CO2 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 Sustainable Development	**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, Modelling 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

		L	T	P	C
26UPEST1C01	**ENERGY SCENARIO, AUDIT AND MANAGEMENT**	4	1	0	5

COURSE OBJECTIVES

- To provide an Indian energy scenario, consumption patterns, energy security, regulations in energy
- To introduce fundamental concepts of energy, work, and power.
- To develop knowledge of energy audit principles, methodologies, and tools
- To provide knowledge on energy and material balance, for improving energy efficiency.
- To develop skills in project planning, implementation, and energy monitoring systems

UNIT – I: ENERGY SCENARIO AND MANAGEMENT

An overview of Indian Energy Scenario, Sector wise Energy Consumption in India, Energy needs of Growing Economy, Long Term Energy Scenario for India. Reasons to save energy (both financial and environmental), Energy Intensity on Purchasing Power Parity (PPP) - Energy Security, Energy Conservation Act and related policies, Bureau of Energy Efficiency (BEE) Regulations.

UNIT – II: BASICS OF ENERGY AND ITS VARIOUS FORMS

Introduction - Work, Energy and Power - Electricity Basics - Thermal Energy Basics - Energy Units and Conversions

UNIT– III: ENERGY AUDIT

Energy audit concepts, Scope of energy audit, types of energy audit, general procedure for a energy audit, various energy audit methodologies, instruments and metering for energy audit, general procedure for a detailed energy audit, preparation of detailed energy audit report, benefits of energy audit.

UNIT- IV: UTILITY RATE STRUCTURES AND FINANCIAL ANALYSIS

Introduction to Material and Energy Balance - Classification of Processes - Energy Analysis and the Sankey Diagram - Financial Analysis Techniques - Economic Evaluation Methods - 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)

COURSE OUTCOME

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

CO1	Explain the current energy scenario in India and sector-wise energy consumption trends.	K1-K6
CO2	Define and relate work, energy, and power concepts.	K1-K6
CO3	Describe the concepts, scope, and types of energy audits	K1-K6
CO4	Apply material and energy balance principles in process analysis.	K1-K6
CO5	Develop implementation and budgeting plans for energy projects.	K1-K6

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

TEXT AND REFERENCE BOOKS

1. C. B. Smith, *Energy Management Principles*, Pergamon Press, New York, Vol. 1, Reprint Edition, 2015.
2. Wayne C. Turner and Steve Doty, *Energy Management Handbook*, Taylor & Francis, CRC Press, Vol. 1, 8th Edition, 2012.
3. Frank Kreith and D. Yogi Goswami, *Energy Management and Conservation Handbook*, Taylor & Francis, CRC Press, Vol. 1, 2nd Edition, 2017.
4. Albert Thumann, Terry Niehus, and William J. Younger, *Handbook of Energy Audits*, Taylor & Francis, CRC Press, Vol. 1, 9th Edition, 2012.
5. Rajiv Shanker, *Energy Auditing in Electrical Utilities*, Viva Books Pvt. Ltd., New Delhi, Vol. 1, 1st Edition, 2010.
6. Bureau of Energy Efficiency, *General Aspects of Energy Management and Energy Audit*, Bureau of Energy Efficiency, New Delhi, Vol. 1, Revised Edition, 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	-	M	H	H	-
2	H	H	-	H	-	H	L	-	L	-	M	M	H	L
3	H	H	M	M	-	H	-	-	L	H	M	M	M	L
4	H	H	-	M	-	H	H	-	M	H	M	H	M	-
5	L	-	-	L	-	H	-	-	M	H	M	H	H	-

26UPEST1C02	FLUID MECHANICS AND THERMAL ANALYSIS	L	T	P	C
		4	1	0	5

COURSE OBJECTIVES

- To Introduce the Fundamental Properties of Fluids and their Significance in Engineering Applications.
- To provide knowledge of pressure measurement principles and various manometric devices.
- To develop an understanding of fluid flow behavior and governing equations.
- To impart knowledge of heat transfer mechanisms through conduction and convection.
- To provide understanding of radiation heat transfer and heat exchanger design concepts.

UNIT - I : PROPERTIES OF FLUIDS

Introduction – Density – Specific Weight – Specific Volume – Specific Gravity – Viscosity – Kinematic Viscosity - Dynamic Viscosity - Compressibility and Bulk Modulus-Surface Tension and Capillarity

UNIT – II: PRESSURE MEASURING DEVICES

Pascal‟s law – Absolute gauge – Atmospheric and vacuum pressures –manometers – simple manometer – piezometer –U tube manometer- single column manometer-differential manometer- U tube differential manometer –inverted U tube differential manometer

UNIT–III: FLUID FLOW

Types of flows- Rate of Flow (Or) Discharge- Continuity Equation- Euler's Equation of Motion Bernoulli's Equation from Euler's Equation –Application Of Bernoulli's Equation-Venture Orifice Meter - Pitot-Tube

UNIT- IV: CONDUCTION AND CONVECTION

General Differential equation of Heat Conduction– Cartesian and Polar Coordinates – One Dimensional Steady State Heat Conduction - free and Forced Convection – Hydrodynamic and Thermal Boundary Layer. Free and Forced Convection during external flow over Plates and Cylinders and Internal flow through tubes

UNIT – V: RADIATION AND HEAT EXCHANGERS

Black Body Radiation – Grey body radiation – Shape Factor – Electrical Analogy – Radiation Shields. Radiation through gases- Heat exchanger – **e** – NTU - approach and design procedure – compact heat exchanger.

COURSE OUTCOME

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

CO1	Evaluate fluid properties such as density, viscosity, compressibility, and surface tension	K1-K6
CO2	Apply principles of pressure measurement using different manometers.	K1-K6
CO3	Analyze fluid flow using continuity and Bernoulli's equations and evaluate flow measurement devices.	K1-K6
CO4	Apply heat transfer principles to analyze conduction and convection problems in systems	K1-K6
CO5	Evaluate radiation heat transfer processes and analyze the performance of heat exchangers using design methods.	K1-K6

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

TEXT AND REFERENCE BOOKS

1. Yunus A. Çengel and John M. Cimbala, *Fluid Mechanics: Fundamentals and Applications*, McGraw-Hill Education, Vol. 1, 3rd Edition, 2014.
2. R. K. Bansal, *Fluid Mechanics*, Laxmi Publications Pvt. Ltd., Vol. 1, 2nd Edition, 2016.
3. Yunus A. Çengel and Afshin J. Ghajar, *Heat and Mass Transfer: Fundamentals and Applications in SI Units*, McGraw-Hill Education, Vol. 1, 6th Edition, 2020.
4. Victor L. Streeter, E. Benjamin Wylie, and Keith W. Bedford, *Fluid Mechanics*, WCB McGraw-Hill, Boston, Vol. 1, 9th Edition, 1998.
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CO	**PO**											**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	H	H	M	M	L	L	-	-	-	L	M	H	M	H
2	H	H	H	M	L	L	-	-	-	L	M	H	M	H
3	H	H	H	H	L	L	-	-	-	L	M	H	H	H
4	H	H	M	H	M	H	-	-	-	L	H	-	-	H
5	H	H	M	H	M	H	-	-	-	-	H	-	-	H

26UPEST1C03	**SMART CITIES AND SMART GRIDS**	**L**	**T**	**P**	**C**
		4	1	0	5

COURSE OBJECTIVES

- To Understand the Concepts and Components of Smart Cities and Smart Grids.
- To Analyze the Role of Ict, Iot, and AI in Developing Smart Cities.
- To Explore the Design, Implementation, and Operation of Smart Grids.
- To Evaluate the Integration of Renewable Energy in Smart Grids.
- To Discuss Policies, Challenges, and Future Trends in Smart Cities and Grids.

UNIT - I : SMART CITIES-INTRODUCTION

Concept and Need for Smart Cities, Key Elements of smart cities - Mobility, Energy, Environment, Infrastructure, Urbanization Trends and Challenges- Role of ICT in Smart Cities, Global Smart City Initiatives and Case Studies

UNIT – II: SMART CITY INFRASTRUCTURE AND TECHNOLOGIES

Urban Infrastructure Planning in Smart Cities: Sensors, Networks, and Platforms- Smart Transportation and Mobility, Smart Water and Waste Management- Smart Governance and Citizen Engagement

UNIT–III: INTRODUCTION TO SMART GRIDS

Evolution of the Electrical Grid to Smart Grid, Smart Grid Architecture and Components - Advanced Metering Infrastructure (AMI), Demand Response and Load Management- Grid Automation and Monitoring Systems

UNIT- IV: COMMUNICATION AND INFORMATION TECHNOLOGIES IN SMART GRIDS

Communication Protocols: Zigbee, Wi-Fi, cellular networks, ethernet, OpenADR, SCADA, IoT Integration to smart grids, Cybersecurity in Smart Grids, Overview of Big Data Analytics and Cloud Computing - Overview of AI and Machine Learning in Grid Management.

UNIT – V: SUSTAINABILITY, CHALLENGES, AND POLICY FRAMEWORK

Integration of Renewable Energy Sources, Energy Storage Systems and Microgrids, Economic, Social, and Environmental Impact, Standards, Policies, and Regulatory Issues,Future Trends and Innovations in Smart Cities and Grids.

COURSE OUTCOME

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

CO1	Explain the structure and key elements of Smart Cities.	K1-K6
CO2	Demonstrate knowledge of Smart Grid architecture and components.	K1-K6
CO3	Analyze the communication technologies used in Smart Cities and Smart Grids.	K1-K6
CO4	Evaluate case studies and real-world implementations of smart infrastructure.	K1-K6
CO5	Propose sustainable and efficient solutions for urban development and energy systems.	K1-K6

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

TEXT AND REFERENCE BOOKS

1. V. Angelakis, E. Tragos, H. Pöhls, A. Kapovits, and A. Bassi, *Designing, Developing, and Facilitating Smart Cities*, Springer International Publishing, Vol. 1, 1st Edition, 2017.
2. Stuart Borlase, *Smart Grids: Infrastructure, Technology and Solutions*, CRC Press, Vol. 1, 1st Edition, 2013.
3. Krishna Kumar, Gaurav Saini, Duc Manh Nguyen, Narendra Kumar, and Rachna Shah, *Smart Cities: Concepts, Practices and Applications*, CRC Press, Vol. 1, 1st Edition, 2022.
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CO	**PO**											**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	H	M	-	-	-	L	-	-	-	-	H	H	M	L
2	H	M	-	-	-	L	-	-	-	-	H	H	M	L
3	H	M	-	-	H	L	-	-	-	-	H	H	M	L
4	H	M	-	-	-	L	-	-	-	-	H	H	M	L
5	H	M	-	-	H	L	-	-	-	-	H	H	M	L

26UPEST1C04 **RENEWABLE ENERGY SYSTEMS**

L	T	P	C
4	0	0	4

COURSE OBJECTIVES

- To Provide an understanding of renewable energy resources, their significance in sustainable development.
- To educate the various wind energy technologies.
- To learn the various solar energy technologies and its applications.
- To explore the various bio-energy technologies.
- To study the ocean and geothermal technologies

UNIT – I: RENEWABLE ENERGY RESOURCES

Environmental consequences of fossil fuel use, Importance of renewable sources of energy, Sustainable Design and development, Types of RE sources, Limitations of RE sources, Present Indian and international energy scenario of conventional and RE sources

UNIT – II: WIND ENERGY

Power in the Wind – Types of Wind Power Plants (WPPs)–Components of WPPs-Working of WPPs-Siting of WPPs-Grid integration issues of WPPs.

UNIT–III: SOLAR PV AND THERMAL SYSTEMS

Solar Radiation, Radiation Measurement, Solar Thermal Power Plant, Central Receiver Power Plants, Solar Ponds. Thermal Energy storage system with PCM- Solar Photovoltaic systems : Basic Principle of SPV conversion – Types of PV Systems- Types of Solar Cells, Photovoltaic cell concepts: Cell, module, array ,PV Module I-V Characteristics, Efficiency & Quality of the Cell, series and parallel connections, maximum power point tracking, Applications

UNIT-IV: BIOMASS ENERGY

Introduction-Bio mass resources –Energy from Bio mass: conversion processes-Biomass Cogeneration-Environmental Benefits. Geothermal Energy: Basics, Direct Use, Geothermal Electricity. Mini/micro hydropower: Classification of hydropower schemes, Classification of water turbine, Turbine theory, Essential components of hydroelectric system.

UNIT – V: OTHER ENERGY SOURCES

Tidal Energy: Energy from the tides, Barrage and Non Barrage Tidal power systems. Wave Energy: Energy from waves, wave power devices. Ocean Thermal Energy Conversion (OTEC)- Hydrogen Production and Storage- Fuel cell : Principle of working- various types – construction and applications. Energy Storage System- Hybrid Energy Systems

COURSE OUTCOME

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

CO1	Analyze the importance, types, limitations, and environmental impacts of renewable energy resources of sustainable energy systems.	K1-K6
CO2	Compare various solar energy technologies and identify its applications	K1-K6
CO3	Infer wind data and compare various wind energy systems.	K1-K6
CO4	Examine various bio-energy technologies and identify their application	K1-K6
CO5	Interpret ocean and geothermal energy conversion technologies	K1-K6

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

TEXT AND REFERENCE BOOKS

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2. Mehmet Kanoglu, *Fundamentals and Applications of Renewable Energy*, McGraw Hill Education, Indian Edition, Vol. 1, 1st Edition, 2020.
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4. S. P. Sukhatme, *Solar Energy: Principles of Thermal Collection and Storage*, Tata McGraw-Hill Publishing Company Ltd., New Delhi, Vol. 1, 3rd Edition, 2009.
5. John Twidell and Tony Weir, *Renewable Energy Resources*, Taylor & Francis (EFN Spon Ltd.), Vol. 1, 3rd Edition, 2015.

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

		L	T	P	C
26UPEST1L01	**ENERGY LABORATORY**	0	0	6	3

COURSE OBJECTIVES

- To obtain the knowledge on working and characterization of Solar PVcell.
- 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. Evaluation of heat loss and efficiency in thermosyphonic mode of heat flow at different radiation level in Solar Flat Plate Water Heating System.
2. Conduct an experiment to obtain I-V and P-V characteristics of PV module with varying radiation level using solar PV training & research System.
3. Performance analyses of PV module with various tilt angle using solar PV training & research System.
4. Effect of shading on the efficiency of PV module with regards to voltage current and power using Solar PV Training & research system.
5. Performance assessment of Wind Energy Generator based on wind velocity.
6. Determination of the flash point of a given sample using flash point apparatus.
7. 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.
8. Experimental evaluation of a Paraffin wax as Phase Change Material for Thermal Energy Storage in TES Training System.
9. Experimental evaluation of a fatty acid as Phase Change Material for Thermal Energy Storage in TES Training System.
10. 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.
11. 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.
12. Determination the overall heat transfer coefficient in a plate type heat exchanger at different hot fluid flow rate.
13. Experimental analysis on efficiency of solar cell under varying light intensity using Solar Simulator- SS50 AAA.
14. A study experiment on tools used in the assessment of illuminance (lux meter), wind speed (anemometer), pH level (pH indicator), Humidity (humidity sensor), Temperature (K-Type Thermocouple), sound level (sound meter).
15. Experimental investigation of solar dryer using various food sources
16. 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 theoverall heat transfer rate in heatexchangers	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

	PO											**PSO**		
CO	**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
6	H	H	H	H	H	H	-	H	-	-	H	H	-	-

26UPEST1C05 THERMAL ENERGY CONSERVATION

L	T	P	C
4	1	0	5

COURSE OBJECTIVES

- To learn the classification of Fuel
- To know the process of the thermal energy utilities
- To understand the operation of furnaces and boiler
- To know the importance of cogeneration in industrial utilities
- To know the process of heat recovery system and heat exchangers

UNIT – I: FUEL CLASSIFICATION

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: THERMAL ENERGY UTILITY SYSTEMS

Boilers Types, combustion in boilers, performance evaluation, analysis of losses, feed water treatment, blow down. Steam systems: Properties of steam, assessment of steam distribution losses, steam leakages, steam trapping, condensate and flash steam recovery system.

UNIT–III: FURNACES

Types and Classification of Different Furnaces - General Fuel Economy Measures in Furnaces - Purpose of Insulation – Economic Thickness of Insulation - Refractories - Properties of Refractories - Classification of Refractories - Heat Losses from Furnace Walls.

UNIT-IV: COGENERATION

Definition, need, application, advantages and classification. Technical parameters for Cogeneration – Prime movers for Cogeneration – Performance parameter – Merits of Cogeneration system – Cogeneration Heat rate and efficiency assessment – Trigeneration.

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	Identify the classification of fuel	K1-K6
CO2	Evaluate the performance of Boiler and Furnace under different operating conditions	K1-K6
CO3	Know the Boiler, Steam and energy efficiency opportunities in steam systems	K1-K6
CO4	Understand the classification and working 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. W. R. Corliss, *Direct Energy Conversion*, Vol. 1, 1st Edition, 2021.
2. D. V. Begamudre and R. K. Rajput, *Energy Conversion Principles*, New Age International Publishers, Vol. 1, 1st Edition, 2005.
3. Bureau of Energy Efficiency, *Energy Manager Training Manual* (4 Volumes), Bureau of Energy Efficiency, Ministry of Power, Government of India, Vols. 1–4, Revised Edition, 2015.
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7. W. F. Stoecker, *Design of Thermal Systems*, McGraw-Hill Education, Vol. 1, 3rd Edition, 2011.
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CO	**PO**											**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	H	H	M	H	M	H	-	-	-	H	H	H	H	L
2	H	H	-	H	M	H	-	-	-	H	H	H	H	L
3	H	H	-	H	M	H	-	-	-	H	H	H	H	M
4	H	H	-	H	M	H	-	-	-	H	H	H	H	M
5	H	H	-	H	M	H	-	-	-	H	H	H	H	M

26UPEST1C06 COMPUTER AIDED DESIGN AND ANALYSIS

L	T	P	C
4	1	0	5

COURSE OBJECTIVES

- To introduce the fundamentals of CAD/CAM, design processes, and geometric transformations used in computer-aided design.
- To provide knowledge of geometric modeling techniques, curves, and surface representations used in CAD.
- To develop understanding of solid modeling concepts and various representation schemes.
- To introduce the basic concepts and workflow of computational fluid dynamics.
- To provide knowledge of CFD applications, boundary conditions, and advanced modeling techniques.

UNIT – I: INTRODUCTION TO CAD

Definition and scope of CAD/CAM, Introduction to design process and role of computers in the design process. Transformations: 2D and 3D transformations, Types of file formats & their exchange, Graphics standards.

UNIT – II: CURVES AND SURFACES

Analytical, Synthetic curves with advantages, Disadvantages, Comparison with parametric curves, Geometric modeling curves and surfaces, Representation, Wire frame models, Parametric representations, Parametric curves and surfaces, Manipulations of curves and surfaces, DDA, Bresenham's /Mid point line, circle, ellipse algorithms.

UNIT–III: SOLID MODELING

Solid models, Fundamentals of solid modeling, Different solid representation schemes, Half -spaces, Boundary representation (B-rep), Constructive solid geometry (CSG), Sweep representation, Analytic.

UNIT-IV: INTRODUCTION TO CFD FUNDAMENTALS

Introduction to Computational Fluid Dynamics (CFD), Steps involved in CFD analysis: geometry creation, meshing, solution, and post-processing, Types of mesh: structured and unstructured, Mesh Refinement and Sensitivity study.

UNIT – V: ISOPARAMETRIC FORMULATION AND ADVANCED TOPICS

CFD analysis of flow in pipes and ducts, Heat transfer analysis, Boundary conditions in CFD: inlet, outlet, and wall conditions, Introduction to turbulence modeling and its importance, post-processing and visualization of results: contours, velocity vectors, and temperature fields.

COURSE OUTCOME

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

CO1	Explain CAD concepts, design processes, and apply 2D/3D transformations and file standards in engineering graphics.	K1-K6
CO2	Analyze and construct curves and surfaces using parametric representations and basic drawing algorithms	K1-K6
CO3	Evaluate different solid modeling techniques such as B-rep and CSG for representing engineering components.	K1-K6
CO4	Apply CFD procedures including geometry creation, meshing, and solution techniques for fluid flow problems.	K1-K6
CO5	Analyze fluid flow and heat transfer problems using CFD with appropriate boundary conditions and interpret simulation results.	K1-K6

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

TEXT AND REFERENCE BOOKS

1. P. S. Ghoshdastidar, *Computer Simulation of Flow and Heat Transfer*, Tata McGraw-Hill Publishing Company Ltd., Vol. 1, 1st Edition, 1998.
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3. P. Niyogi, S. K. Chakrabarty, and M. K. Laha, *Introduction to Computational Fluid Dynamics*, Pearson Education, Vol. 1, 1st Edition, 2006.
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5. Suhas V. Patankar, *Numerical Heat Transfer and Fluid Flow*, Taylor & Francis, Vol. 1, 1st Edition, 1978.
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8. Vivek V. Ranade, *Computational Flow Modeling for Chemical Reactor Engineering*, Academic Press, Vol. 1, 1st Edition, 2002.
9. Joel H. Ferziger and Milovan Perić, *Computational Methods for Fluid Dynamics*, Springer, Vol. 1, 3rd Edition, 2002.

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1	H	H	M	M	L	-	-	-	L	-	M	M	H	H
2	H	H	H	M	M	-	-	L	-	-	M	H	H	H
3	H	H	H	H	M	-	-	L	-	-	M	H	H	H
4	H	H	M	H	H	L	-	L	-	-	M	H	H	H
5	H	H	H	H	H	M	-	M	L	L	H	H	H	H

26UPEST1C07	**INTRODUCTION TO DATA ANALYTICS AND MACHINE LEARNING IN ENERGY SYSTEMS**	**L T P C** 4 1 0 5

COURSE OBJECTIVES

- To Understand basic concepts of data and its importance in energy systems
- To Learn simple tools like Excel for handling energy data
- To Develop basic problem-solving skills
- To Understand simple prediction and pattern concepts using real-life examples
- To Apply knowledge to rural energy systems and sustainability

UNIT – I: BASICS OF ENERGY, DATA AND INTRODUCTION TO AI/ML

Introduction to energy systems. What is data? Types and simple examples, Importance of data in Energy Science, Introduction to Artificial Intelligence and Machine Learning, ML in energy: smart meters, solar prediction, demand forecasting.

UNIT – II: WORKING WITH ENERGY DATA

Types of data: numerical and categorical, Data collection in energy systems, Using Excel/Google Sheets for data entry and handling, Data visualization: bar charts, line graphs, Introduction to data cleaning.

UNIT–III: INTRODUCTION TO PROGRAMMING AND TOOLS FOR ML

Introduction to coding and its importance in energy applications, Using Google Colab, Basic Python concepts: variables, lists, simple operations, Introduction to libraries: Pandas (data), Matplotlib (graphs), Loading and viewing simple energy datasets.

UNIT-IV: BASIC MACHINE LEARNING FOR PREDICTION

What is prediction? Concept of supervised learning, Simple trend understanding Linear relationship, Simple ML model idea, Applications: energy consumption prediction, solar power estimation using simple AI/ML tools.

UNIT – V: PATTERNS AND SIMPLE ML CONCEPTS IN ENERGY USAGE

Patterns in data, Introduction to unsupervised learning, Grouping similar data-household energy usage patterns, Applications-identifying high/low energy users, rural energy planning, Concept of anomaly detection.

COURSE OUTCOME

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

CO1	Explain basic data concepts in energy applications	K1-K6
CO2	Handle simple datasets using spreadsheets	K1-K6
CO3	Understand basic prediction concepts	K1-K6
CO4	Identify patterns in energy usage	K1-K6
CO5	Apply learning to real-world rural energy problems	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, 2025, Vol. 1, 3rd Edition.
2. Andreas C. Müller and Sarah Guido, *Introduction to Machine Learning with Python*, O'Reilly Media, 2016, Vol. 1, 1st Edition.
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4. Kenneth A. Lambert, *Fundamentals of Python: First Programs*, Cengage Learning, 2019, Vol. 1, 3rd Edition.
5. Aurélien Géron, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*, O'Reilly Media, 2022, Vol. 1, 3rd Edition.
6. Tom M. Mitchell, *Machine Learning*, McGraw-Hill Education, 1997, Vol. 1, 1st Edition.
7. Christopher M. Bishop, *Pattern Recognition and Machine Learning*, Springer, 2006, Vol. 1, 1st Edition.

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

26UPPGC1H01 FUNDAMENTALS OF HUMAN RIGHTS

L	T	P	C
2	0	0	2

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, Jaipur, 2019, Vol. 1, 1st Edition.
2. Satvinder S. Juss, *Human Rights in India*, Routledge India, New Delhi, 2020, Vol. 1, 1st Edition.
3. Namita Gupta, *Social Justice and Human Rights in India*, Rawat Publications, Jaipur, 2021, Vol. 1, 1st Edition.
4. Mark Frezzo, *The Sociology of Human Rights*, John Wiley & Sons, United Kingdom, 2014, Vol. 1, 1st Edition.
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9. Jayant Chaudhary, *A Textbook of Human Rights*, Wisdom Press, New Delhi, 2011, Vol. 1, 1st Edition.

		L	T	P	C
26UPEST1L02	**COMPUTER AIDED DESIGN AND SIMULATION LABORATORY**	0	0	6	3

COURSE OBJECTIVES

- To develop skills in creating basic geometric entities using different coordinate systems in CAD.
- To enable standard engineering drawings with proper annotations and symbols.
- To impart knowledge of drafting complex curves and their representation techniques.
- To develop the ability to generate orthographic projections and dimensioning of components.
- To introduce modeling of mechanical components and interpretation of pictorial views.
- To provide knowledge of numerical methods for heat transfer analysis using computational techniques.
- To develop skills in computational fluid dynamics for analyzing fluid flow and mixing problems.

LIST OF EXPERIMENTS

1. Creation of simple block using polar, relative and absolute coordinate methods
2. Creation of rectangle using polar, relative and absolute coordinate methods
3. Drafting of a Title Block with necessary Text and Projection Symbol
4. Drafting of curves like parabola, spiral, involute using B-spline or Cubic spline.
5. Drafting of front view and top view of simple solids like prism, pyramid, cylinder, cone, etc, and dimensioning
6. Drawing front view, top view and side view of objects from the given pictorial views (eg. V-block, Base of a mixie, simple stool, object with hole and curves)
7. Draw the plan view of 3D Model gear and Connecting rod
8. Computational Analysis of One-Dimensional Steady State Heat Diffusion with And Without Sources
9. Computational Analysis of Two-Dimensional Steady State Heat Diffusion with Different Boundary Condition
10. Computational Analysis of Laminar Flow Through A Pipe
11. Computational Analysis of Turbulent Flow Through A Pipe
12. Computational Analysis of Mixing of Hot and Cold Fluid Through A Pipe

COURSE OUTCOME

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

CO1	Apply absolute, relative, and polar coordinate methods to construct basic geometrical shapes accurately.	K1-K6
CO2	Create professional engineering drawings including title blocks, text, and standard projection symbols.	K1-K6
CO3	Construct curves such as parabola, spiral, and involute using spline techniques.	K1-K6
CO4	Draft and interpret orthographic views of solids and objects with correct dimensioning practices.	K1-K6
CO5	Analyze pictorial views and develop corresponding multi-view drawings and 3D model representations.	K1-K6
CO6	Analyze one-dimensional and two-dimensional steady-state heat diffusion problems under various boundary conditions.	K1-K6
CO7	Evaluate laminar and turbulent flow behavior and simulate fluid mixing in pipe systems using computational methods.	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
6	H	H	H	H	H	H	-	H	-	-	H	H	-	-

		L	T	P	C
23UPEST1C08	**ELECTRICAL ENERGY CONSERVATION**	4	1	0	5

COURSE OBJECTIVES

- To learn the basics of electrical energy conversion
- To learn about HVAC & Refrigeration system
- To understand the operation of pumps selection of pumps and fans based on application
- To obtain knowledge on working of air system
- To know the energy conservation in lighting system

UNIT – I: ELECTRICAL ENERGY

Introduction to Electrical Power Supply Systems - Electricity Billing - Power Factor Improvement and Benefits - Transmission and distribution losses, pilferage, Transformer losses. Electricity Tariff, load management and maximum demand control, power factor improvement and its benefits, selection and location of capacitors etc. Electric motors: Types, losses in induction motors, motor efficiency, factors affecting motor performance rewinding and motor replacement issues , Energy efficient motors

UNIT – II: HVAC AND REFRIGERATION SYSTEM

HVAC, Refrigeration and Air conditioning: Vapor compression refrigeration cycle, refrigerants, coefficient of performance, capacity, Factors affecting refrigeration and air conditioning system performance, Vapor absorption refrigeration systems: Working principle, type and comparison with vapor compression system.

UNIT – III: PUMPING SYSTEM AND COOLING TOWERS

Pumps and pumping systems: Types, performance evaluation, efficient system operation, flow of control strategies, variable speed drives. Cooling towers: Types, performance evaluation, efficient system operation, flow of control strategies, assessment of saving opportunities

UNIT– IV: COMPRESSED AIR SYSTEM, FANS AND BLOWERS

Compressed air system: Types of air compressors, compressor efficiency, efficient compressor operations, compressed air system components, capacity assessment, and leakage test, factors affecting the performance. Fans and blowers: Types, performance evaluation, efficient system operation, flow of control strategies

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	Summarize the electrical energy generation process	K1-K6
CO2	Understand about the HVAC & Refrigeration system	K1-K6
CO3	Determine the performance fans, blowers and pumping system and understand the parameters and terminologies used	K1-K6
CO4	Adopt the compressed air system based on application with energy conservation	K1-K6
CO5	Familiarized about the use of HVAC and refrigeration system	K1-K6

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

TEXT AND REFERENCE BOOKS

1. Direct energy conversion : M.A. Kettani, 2008
2. Energy Manager Training Manual (4Volumes) available at www.energymanager training.com, a website administered by Bureau of Energy Efficiency (BEE), a statutory body under Ministry of Power, Government of India.,2015.
3. Handbook on Energy Efficiency, TERI, New Delhi, 2001
4. Barney L. Capehart, Wayne C. Turner, William J. Kennedy, Guide to energy management, eighth Edition. by The Fairmont Press, 2016
5. A Textbook of Electrical Technology: Vol 2 Ac and Dc Machines: L Theraja,1959
6. Energy Conservations in Buildings O. P. Jahkar Khanna publications, 2020

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	M	-	H	-	H	L	-	L	-	M	M	H	L
3	H	-	M	M	-	H	-	-	L	M	M	M	M	L
4	L	-	-	M	-	H	H	-	M	M	M	H	M	-
5	L	-	-	L	-	H	-	-	M	-	M	H	H	-

26UPEST1C09 NANOMATERIALS FOR ENERGY APPLICATIONS

L	T	P	C
5	0	0	5

COURSE OBJECTIVES

- To know Nanoscience and related fields.
- To make the students acquire the properties of nanomaterials
- To help them understand the broad outline of synthesis of nano materials.
- To understand the characterization of nanomaterials.
- To know the different application of nanomaterials.

UNIT – I : INTRODUCTION

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.

UNIT – II : PROPERTIES OF NANOMATERIALS ON EFFECT OF SIZE

Thermal Properties, Electrical Properties- Surface scattering, Change of electronic structure, Quantum transport, Effect of microstructure, Lattice Constant, Phase Transformation, Surface plasmon resonance, Quantum size effects Mechanical Properties, Optical Properties, Chemical Sensitivity, Dielectric Constant.

UNIT– III : SYNTHESIS OF NANOMATERIALS

Top-Down Approaches - Mechanical Alloying, Severe Plastic Deformation, Lithography. Bottom-Up Approaches-Physical Vapor Deposition (PVD), Molecular-Beam Epitaxy, Chemical Vapor Deposition, Colloidal or Wet Chemical Route, Reverse Micelle Method, Green Chemistry Route - Synthesis of Metallic NPs, Synthesis of Oxide NPs, Factors Affecting Size and Morphology of NPs. Sol-gel Method, Combustion Method, Atomic Layer Deposition.

UNIT- IV : CHARACTERIZATION TECHNIQUES

Structural Characterization -X-ray diffraction (XRD), Scanning electron microscopy (SEM), Transmission electron microscopy (TEM). Chemical Characterization -Optical spectroscopy (Raman Spectroscopy, UV–vis Spectroscopy, Photoluminescence Spectroscopy, Fourier Transform Infrared Spectroscopy), X-ray Photoelectron Spectroscopy, Thermal Analyzer, Zeta Potential.

UNIT – V : APPLICATIONS

Nanofluids - Automotive Applications, Coolants, Dynamic Seal. Hydrogen Storage, Solar Energy – Photo electrochemical Cells, Thermoelectric Devices. Automotive Sector - Solar Energy, Fuel Cell Vehicle Radiator, Diesel Particulate Filter, Other Applications. Catalysts and energy storage devices.

COURSE OUTCOME

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

CO1	Learn about the background on nanoscience.	K1-K6
CO2	Gain knowledge in properties of nanomaterials.	K1-K6
CO3	Understand the synthesis of nanomaterials and their application and the impact of nanomaterials on environment	K1-K6
CO4	Apply their learned knowledge to develop Nanomaterial’s by different characterization techniques	K1-K6
CO5	Design nanomaterials for various energy applications	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, USA, 2004, Vol. 1, 1st Edition.
2. Rajendra Kumar Goyal, *Nanomaterials and Nanocomposites: Synthesis, Properties, Characterization Techniques and Applications*, CRC Press, 2018, Vol. 1, 1st Edition.
3. Hari Singh Nalwa, *Nanostructured Materials and Nanotechnology*, Academic Press, 2008, Vol. 1, 1st Edition.
4. C. N. R. Rao, P. J. Thomas, and G. U. Kulkarni, *Nanocrystals: Synthesis, Properties and Applications*, Springer, 2007, Vol. 1, 1st Edition.
5. Arthur S. Edelstein and Richard C. Cammarata, *Nanomaterials: Synthesis, Properties and Applications*, Institute of Physics Publishing, 2001, Vol. 1, 1st Edition.

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

26UPEST1C10	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 know ethical issues and the Preparation of a research project thesis report.
- To understand significance, effective technical writing and report
- To know about the IPR
- To get the adequate knowledge on patent and 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 - statistical design of experiments - types and principles; data types & classification - constructing an instrument for data collection - selecting a sample - writing a research proposal - conducting a research study - collecting data - processing and displaying data - writing a research report

UNIT – II: LITERATURE REVIEW

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

UNIT– III: TECHNICAL WRITING /EVALUATION

Developing an outline - Writing about a variable - Writing a bibliography – evaluation - Types of evaluation

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

Concept of Property vis-à-vis 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 – Types of IPR – Patent, Design, Trademarks, Trade Secrets,Geographical Indications and Copyrights.

UNIT – V: PATENTS

Patents - Indian Patent Law - The Patents Act, 1970 - Patentable Subject Matter - Patentability Criteria - Duration of Patents- Law and Policy Consideration - Procedure for Filing of Patent Application and types of Applications - Procedure for Opposition - Ownership and Maintenance of Patents - Patent Agent- Qualification and Registration Procedure

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 the principles of ethics and ethical issues in science and engineering	K1-K6
CO3	Understand writing a research report as per format.	K1-K6
CO4	Familiarized about the Intellectual Property Rights	K1-K6
CO5	Understand about Patent and 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, Vol. 1, 3rd Edition.
2. The Institute of Company Secretaries of India, *Intellectual Property Rights: Law and Practice (Module 3)*, ICSI Publications, 2019, Vol. 1, Revised Edition.
3. Deborah E. Halbert, *Resisting Intellectual Property*, Taylor & Francis, Routledge, 2007, Vol. 1, 1st Edition.
4. Benjamin W. Niebel and Andris Freivalds, *Product Design*, McGraw-Hill Education, 1974, Vol. 1, 1st Edition.
5. W. H. Mayall, *Industrial Design for Engineers*, McGraw-Hill, 1992, Vol. 1, 4th Edition.

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

26UPEST2I01 **INTERNSHIP**

L	T	P	C
0	0	0	2

COURSEOBJECTIVES

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)**

26UPEST1L03 ENERGY AUDITING LABORATORY

L	T	P	C
0	0	6	3

COURSE OBJECTIVES

- To 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), and 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 asound 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 a 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

26UPEST1P01 **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

Project work evaluation is based on Regulations of Credit system University Departments Post graduate programs of Periyar University

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

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

		L	T	P	C
26UPEST1E01	**POWER PLANT ENGINEERING**	4	0	0	4

COURSE OBJECTIVES

- To Understand the thermodynamic properties and cycles of power plants
- To obtain knowledge on the role of various components in Steam power plants
- To acquire knowledge on the working of gas turbine and diesel power plants
- To Learn the concept of nuclear power plants
- To Attain knowledge on economics of power generation

UNIT – I : POWER PLANT CYCLES

Introduction – classification of power plant cycles – carnot cycle, Rankine cycle, modified Rankine cycle, Reheat cycle, regenerative cycle, binary vapor cycle, Otto cycle, diesel cycle, Dual combustion cycle and gas turbine cycles

UNIT – II : STEAM POWER PLANT

Classification of steam power plant – layout of modern steam power plant - site selection for steam power plant – fuel Handling – combustion equipments for boilers – fluidized bed combustion – ash handling – dust collection – types of chimney draught- Boiler's- Classification of boilers.

UNIT–III : DIESEL AND GAS POWER PLANT

Operation of Diesel power plant – Types of engines – layout of diesel power plant – performance of diesel power plant – Gas Turbines – Site selection – Classification of Gas Turbine power plant – constant pressure Gas Turbine power plant – Constant Volume Gas Turbine power plant.

UNIT-IV: NUCLEAR POWER PLANT

General aspects of nuclear energy – Nuclear power systems – Nuclear reactors – Components of nuclear power plant – Pressurized water reactor – boiling water reactor – Canadian Deuterium uranium reactor – gas cooled Reactor – liquid metal cooled reactor – breeder reactor – Safety measures for Nuclear power plant

UNIT – V: ECONOMICS OF POWER GENERATION

Cost analysis – selection of power generation – Selection of Power plant equipment – Economics of plant selection - Economics of Hydro–Electric power plants – Tariff of electrical Energy.

COURSE OUTCOME

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

CO1	Suggest appropriate power generation technologies for mitigating the energy gap	K1-K6
CO2	Compute the steam rate, heat rate and cost for generating electricity from coal based thermal power plants	K1-K6
CO3	Analyse and suggest measures for improving the performance of gas turbine and diesel power plants	K1-K6
CO4	Identify a suitable type nuclear power plant commensurate with the prevailing conditions	K1-K6
CO5	Asses the economics of different power plants	K1-K6

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

TEXT AND REFERENCE BOOKS

1. P. K. Nag, *Power Plant Engineering*, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2002, Vol. 1, 2nd Edition.
2. R. K. Rajput, *A Textbook of Power Plant Engineering*, Laxmi Publications, New Delhi, 2016, Vol. 1, 5th Edition.
3. S. C. Arora and S. Domkundwar, *A Course in Power Plant Engineering*, Dhanpat Rai & Co. (P) Ltd., New Delhi, 2004, Vol. 1, 6th Edition.
4. R. W. Haywood, *Analysis of Engineering Cycles*, Pergamon Press, Oxford, 1991, Vol. 1, 4th Edition.
5. Allen J. Wood and Bruce F. Wollenberg, *Power Generation, Operation, and Control*, John Wiley & Sons, New York, 1984, Vol. 1, 1st Edition.

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

26UPEST1E02 BIO ENERGY CONVERSION

L	T	P	C
4	0	0	4

COURSE OBJECTIVES

- To provide an understanding of biomass resources, their properties, and conversion mechanisms for energy applications.
- To impart knowledge of biogas production processes, system design, and operational parameters.
- To develop understanding of combustion principles and systems used for biomass fuels.
- To introduce thermochemical conversion processes of biomass and their applications.
- To provide knowledge on production, properties, and applications of liquid biofuels.

UNIT – I: INTRODUCTION

Biomass: types – advantages and drawbacks – Indian scenario – characteristics – carbon neutrality – conversion mechanisms – fuel assessment studies – densification technologies – Comparison with coal – Proximate & Ultimate Analysis - Thermo Gravimetric Analysis

UNIT – II: BIOMETHANATION

Microbial systems – phases in biogas production – parameters affecting gas production – effect of additives on biogas yield – possible feed stocks. Biogas plants – types – design – constructional details and comparison – purification of Biogas - biogas appliances

UNIT– III: COMBUSTION

Perfect, complete and incomplete combustion - stoichiometric air requirement for biofuels - equivalence ratio – fixed Bed and fluid Bed combustion – fuel and ash handling system s – steam cost comparison with conventional fuels

UNIT- IV: GASIFICATION, PYROLYSIS AND CARBONISATION

Chemistry of gasification - types – comparison – application – performance evaluation – economics – dual fueling in IC engines – gas cooling and cleaning systems - Pyrolysis - Classification - process governing parameters – Typical yield rates. Carbonization Techniques – merits of carbonized fuels

UNIT – V: LIQUIFIED BIOFUELS

History of usage of Straight Vegetable Oil (SVO) as fuel - Biodiesel production from oil seeds, waste oils and algae - Process and chemistry – Alcoholic fuels (methanol and ethanol) from biomass - Biodiesel health effects / emissions / performance.

COURSE OUTCOME

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

CO1	Analyze biomass characteristics, conversion processes, and fuel assessment techniques for energy utilization.	K1-K6
CO2	Apply biomethanation principles to evaluate biogas production systems and their performance.	K1-K6
CO3	Analyze combustion processes, air requirements, and performance of biomass-based combustion systems.	K1-K6
CO4	Evaluate gasification, pyrolysis, and carbonization processes for efficient energy conversion and applications.	K1-K6
CO5	Analyze biodiesel production processes and assess performance, emissions, and environmental impacts.	K1-K6

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

TEXT AND REFERENCE BOOKS

1. Tom B. Reed, *Biomass Gasification: Principles and Technology*, Noyes Data Corporation, 1981, Vol. 1, 1st Edition.
2. David Boyles, *Bio Energy Technology: Thermodynamics and Costs*, Ellis Horwood Ltd., Chichester, 1984, Vol. 1, 1st Edition.
3. K. C. Khandelwal and S. S. Mahdi, *Biogas Technology: A Practical Handbook*, Tata McGraw-Hill Publishing Company Ltd., 1986, Vol. 1, 1st Edition.
4. R. C. Maheshwari, *Bio-Energy for Rural Energisation*, Concept Publishing Company, New Delhi, 1997, Vol. 1, 1st Edition.
5. Mahmoud M. El-Halwagi, *Biogas Technology: Transfer and Diffusion*, Elsevier Applied Science Publishers, New York, 1984, Vol. 1, 1st Edition.

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	-	-

26UPEST1E03	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 develop understanding of size reduction, separation technologies.
- To detail on the recent technologies of waste disposal
- To provide knowledge of physical, chemical, and biological transformation processes.
- To make the importance of healthy environment and safe disposal of e-waste and white goods.

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 and 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 – 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	Analyze and select suitable separation, densification, and processing methods.	K1-K6
CO3	convert waste into useful energy.	K1-K6
CO4	Evaluate separation, combustion, gasification, pyrolysis, composting, and energy recovery.	K1-K6
CO5	Analyze waste management techniques and disposal strategies for e-waste and white goods.	K1-K6

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

TEXT AND REFERENCE BOOKS

1. George Tchobanoglous, Hilary Theisen, and Samuel A. Vigil, *Integrated Solid Waste Management: Engineering Principles and Management Issues*, McGraw-Hill, New York, 1993, Vol. 1, 2nd Edition.
2. Howard S. Peavy, Donald R. Rowe, and George Tchobanoglous, *Environmental Engineering*, McGraw-Hill International Edition, 1985, Vol. 1, 1st Edition.
3. Michael D. LaGrega, Phillip L. Buckingham, and Jeffrey C. Evans, *Hazardous Waste Management*, McGraw-Hill, 2001, Vol. 1, 2nd Edition.
4. Stanley E. Manahan, *Hazardous Waste Chemistry, Toxicology, and Treatment*, Lewis Publishers, Chelsea, Michigan, 1990, Vol. 1, 1st Edition.
5. Colin Parker and Tom Roberts, *Energy from Waste: An Evaluation of Conversion Technologies*, Elsevier Applied Science Publishers, London, 1985, Vol. 1, 1st Edition.
6. Manoj Datta, *Waste Disposal in Engineered Landfills*, Narosa Publishing House, New Delhi, 1997, Vol. 1, 1st Edition.

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

26UPEST1E04 **HYDRO ENERGY SYSTEMS**

L	T	P	C
4	0	0	4

COURSE OBJECTIVES

- To understand the 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.
- To understand the recent developments and technologies in the wind & hydro energy
- To know about the operation and maintenance of civil engineering works

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

Governing of Water Turbines - Function of Turbine Governor - Condition for Governing stability - Surge Tank Oscillation and Speed Regulative Problem of Turbine Governing Future

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	Explain the principles of hydropower generation, energy extraction, and assess its potential.	K1-K6
CO2	Apply concepts of planning, design, and development in hydroelectric power plants.	K1-K6
CO3	Analyze aerodynamic principles involved in turbine blade design.	K1-K6
CO4	Evaluate recent technologies and advancements in wind and hydro energy systems.	K1-K6
CO5	Explain and apply operation and maintenance practices for civil engineering works in hydro energy systems.	K1-K6

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

TEXT AND REFERENCE BOOKS

1. M. M. Dandekar and K. N. Sharma, *Water Power Engineering*, Vikas Publishing House Pvt. Ltd., New Delhi, 2019, Vol. 1, 3rd Edition.
2. P. N. Modi and S. M. Seth, *Hydraulics and Fluid Mechanics including Hydraulic Machines*, Standard Book House, New Delhi, 2021, Vol. 1, 24th Edition.
3. R. K. Rajput, *A Textbook of Power Plant Engineering*, Laxmi Publications, New Delhi, 2016, Vol. 1, 5th Edition.
4. Dieter Bogen, *Hydroelectric Power Plants: Principles of Development and Operation*, Wiley-VCH Verlag GmbH, Germany, 2016, Vol. 1, 1st Edition.
5. J. Paul Guyer, *Introduction to Hydroelectric Power Plant Systems*, CreateSpace Independent Publishing Platform, 2018, Vol. 1, 1st Edition.

CO	**PO**											**PSO**		
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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	-	-

26UPEST1E05	SOLAR PHOTOVOLTAIC SCIENCE AND TECHNOLOGY	L	T	P	C
		4	0	0	4

COURSE OBJECTIVES

- To impart the knowledge on the basics of solar energy and laws related to it.
- To know in depth of its types and design of various PV-interconnected systems.
- To learn about the grid connected PV systems.
- To impart knowledge on need and type of Hybrid systems.
- To design the System Components for different PV Applications

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

UNIT – II: STAND ALONE PV SYSTEMS

Schematics and Components - Balance of system components for DC and/or AC Applications - Maximum power point tracking (MPPT) algorithms - Interfacing PV modules to loads – Direct connection of loads to PV modules - Connection of PV modules to a battery and load togetherTypical applications for lighting, water pumping etc

UNIT–III: GRID CONNECTED PV SYSTEM0053

Schematics and Components - Balance of system Components - Interface Components – Net metering - Feasible operating region of inverter at different power factor - Active power filtering with real power injection.

UNIT-IV: HYBRID SYSTEMS

Need for Hybrid Systems - Range and type of Hybrid systems - Case studies of Diesel-PV, WindPV, Microhydel-PV, Biomass-Diesel systems, Electric and hybrid electric vehicles - Comparison and selection criteria for a given application.

UNIT – V: DESIGN OF PV SYSTEMS

Design of System Components for different PV Applications - Sizing and Reliability – Modeling and simulation of stand-alone and grid-connected PV systems.

COURSE OUTCOME

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

CO1	Explain the fundamentals of solar energy and relevant laws governing solar radiation.	K1-K6
CO2	Analyze different types of photovoltaic (PV) systems and their design configurations.	K1-K6
CO3	Apply principles of grid-connected PV systems for energy generation and integration.	K1-K6
CO4	Evaluate the need and performance of hybrid energy systems.	K1-K6
CO5	Design system components for various photovoltaic applications.	K1-K6

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

TEXT AND REFERENCE BOOKS

1. Eduardo Lorenzo, *Solar Electricity: Engineering of Photovoltaic Systems*, Progensa, 1994, Vol. 1, 1st Edition.
2. Frank S. Barnes and Jonah G. Levine, *Large Energy Storage Systems Handbook*, CRC Press, 2011, Vol. 1, 1st Edition.
3. B. H. Khan, *Non-Conventional Energy Resources*, McGraw-Hill Education, New Delhi, 2017, Vol. 1, 3rd Edition.
4. Godfrey Boyle, *Renewable Energy: Power for a Sustainable Future*, Oxford University Press, 2019, Vol. 1, 5th Edition.
5. Antonio Luque and Steven Hegedus, *Handbook of Photovoltaic Science and Engineering*, John Wiley & Sons, 2011, Vol. 1, 2nd Edition.

CO	PO											PSO		
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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	-	-

26UPEST1E06	INDUSTRIAL INSTRUMENTATION	L	T	P	C
		4	0	0	4

COURSE OBJECTIVES

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

UNIT – I: MEASUREMENT SYSTEM: CHARACTERISTICS AND STATISTICAL ANALYSIS

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

UNIT – II: ELECTRICAL MEASUREMENTS AND SIGNAL CONDITIONING

Voltage, Current, Power, Energy, Time and Frequency measurement, Frequency Counter, Signal conditioning Circuits: Wheatstone bridge – Differential Amplifier – V to I Converter, I to V Converter, Integrator, Differentiator, Instrumentation Amplifier, Attenuators and Filters, DAC, ADC, PID Controller.

UNIT–III: DIGITAL MEASUREMENT OF PHYSICAL QUANTITIES

Digital measuring techniques of Displacement, Temperature, Pressure, Force, Torque, Vibration, Acceleration, Velocity, Level, Flow, Thermal and Nuclear Radiation. Solar instruments: Pyrheliometers – Pyranometers– Pyrheliometers – Albedometers – Pyrradiometers – Pyrgeometers – Net Pyrradiometers – Sun photometers

UNIT-IV: MEASUREMENT OF THERMO-PHYSICAL PROPERTIES AND AIR POLLUTANTS

Measurement of Thermal Conductivity – Solids, Liquids and Gas, Viscosity, Gas Diffusion. Calorimetry – Bomb Calorimeter – Continuous flow Calorimeter. Measurement of Heat Transfer, Humidity, Heat flux, pH, Air pollution Sampling and Measurement – Particulate Sampling techniques – Measurement of Sulphur Dioxide, Combustion products, Opacity and Odour

UNIT – V: CONTROL SYSTEMS

Introduction to Arduino and Raspberry Pi – Interfacing with I/O devices of system: Sensors, Display devices, Stepper and Servomotors. Measurement by Data Acquisition System. Introduction to Internet of Things (IoT) – Application of IoT with Raspberry Pi for Process monitoring and control – Energy management. Application of PID controller in PV and Energy systems. Application of Smart Sensors and Intelligent instrumentation and Control

COURSE OUTCOME

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

CO1	Analyze and evaluate the uncertainties in measurement data.	K1-K6
CO2	Identify appropriate sensors for measuring electrical quantities and signal conditioning circuits.	K1-K6
CO3	Explain the digital measurement techniques of physical quantities.	K1-K6
CO4	Implement the measurement of thermo-physical properties and air pollutants.	K1-K6
CO5	Design and develop the appropriate measurement and control system for an application.	K1-K6

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

TEXT AND REFERENCE BOOKS

1. Ernest O. Doebelin and Dhanesh N. Manik, *Doebelin's Measurement Systems: Application and Design*, McGraw-Hill Education, 2011, Vol. 1, 6th Edition.
2. J. P. Holman, *Experimental Methods for Engineers*, McGraw-Hill Education, 2012, Vol. 1, 8th Edition.
3. Barney G. C., *Intelligent Instrumentation: Microprocessor Applications in Measurement and Control*, Prentice Hall of India, 1988, Vol. 1, 1st Edition.
4. Charles Bell, *Beginning Sensor Networks with Arduino and Raspberry Pi*, Apress, 2013, Vol. 1, 1st Edition.
5. B. George, J. K. Roy, V. J. Kumar, and Subhas Chandra Mukhopadhyay, *Advanced Interfacing Techniques for Sensors*, Springer, 2017, Vol. 1, 1st Edition.
6. A. K. Sawhney and Puneet Sawhney, *A Course in Electrical and Electronic Measurements and Instrumentation*, Dhanpat Rai Publications, New Delhi, 2015, Vol. 1, 19th Edition.
7. Bela G. Liptak, *Instrument Engineers' Handbook: Process Measurement and Analysis*, CRC Press, 2016, Vol. 1, 5th Edition.
8. Ramon Pallás-Areny and John G. Webster, *Sensors and Signal Conditioning*, John Wiley & Sons, 2012, Vol. 1, 3rd Edition.
9. Krishna Kant, *Microprocessors and Microcontrollers: Architecture, Programming and System Design Using 8085, 8086, 8051 and ARM*, PHI Learning, 2018, Vol. 1, 1st Edition.

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

26UPEST1E07 **WIND ENERGY CONVERSION**

L	T	P	C
4	0	0	4

COURSE OBJECTIVES

- To understand the processes of generation of wind, its potential and energy extraction
- To understand the aerodynamic principles of turbine blade design
- To understand the design considerations and control strategies in wind turbine
- To understand the Economics and applications of wind energy.
- To analyze and evaluate the implication of wind energy

UNIT – I: WIND ENERGY CONVERSION

Wind Energy Basics, Wind Speeds and scales, Terrain, Roughness, Power Content, Site selection, Classification of wind turbines, Instrumentation for wind measurements, Wind data analysis, Wind resource estimation, Betz's Limit.

UNIT – II: AERODYNAMIC CHARACTERISTICS

Aerodynamic design principles; Aerodynamic theories; Axial momentum, blade element and combine theory; Rotor characteristics; Maximum power coefficient; Prandlt's tip loss Correction

UNIT– III: DESIGN OF WIND TURBINE

Wind turbine design considerations –influence of Reynolds number–load calculation –Stall control–Pitch control–Yaw control–Braking System–turbine blade design.

UNIT- IV: WIND ENERGY ECONOMICS AND APPLICATION

Wind energy in India –Annual average output–Time value of money–depreciation –life cycle costing-Stand alone, grid connected and hybrid applications of WECS -Wind pumps; Case studies

UNIT – V: ENVIRONMENTAL IMPACTS

Environmental Analysis and social costs –Biological impacts –visual impacts –sound impacts –Electromagnetic interface

COURSE OUTCOME

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

CO1	Explain the processes of wind energy generation, its potential, and energy extraction methods.	K1-K6
CO2	Examine aerodynamic principles involved in wind turbine blade design.	K1-K6
CO3	Gain Knowledge of construction characteristics and performance of wind turbine	K1-K6
CO4	Study economics of harnessing energy from wind energy	K1-K6
CO5	Analyse environmental impacts in installing wind turbine	K1-K6

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

TEXT AND REFERENCE BOOKS

1. S. M. Ahmed, *Wind Energy: Theory and Practice*, PHI Learning Pvt. Ltd., New Delhi, 2016, Vol. 1, 3rd Edition.
2. D. P. Kothari and S. Umashankar, *Wind Energy Systems and Applications*, Narosa Publishing House, New Delhi, 2014, Vol. 1, 1st Edition.
3. Thomas Ackermann, *Wind Power in Power Systems*, John Wiley & Sons Ltd., 2005, Vol. 1, 1st Edition.
4. Ray Hunter and George Elliot, *Wind Energy Conversion: From Theory to Practice*, John Wiley & Sons Ltd., 1997, Vol. 1, 1st Edition.
5. Gary L. Johnson, *Wind Energy Systems*, Prentice-Hall Inc., New Jersey, 1985, Vol. 1, 1st Edition.

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

		L	T	P	C
26UPEST1E08	**MATERIAL SCIENCE**	4	0	0	4

COURSE OBJECTIVES

- To understand the crystal structure, growth methods and X-ray scattering.
- To study the synthesis, classification and applications of nanomaterials.
- To explain the optical, dielectric and diffusion properties of crystals.
- To recognize the basis of semiconductors, superconductivity materials and magnets.
- To learn about the importance of materials used for renewable energy conversion

UNIT – I: CRYSTALLOGRAPHY

Symmetry - Unit cell and Miller indices - crystal systems - Bravais lattices - Point groups and space groups - X-ray diffraction-Laue equations-Bragg's law-Reciprocal lattice and its application to geometrical crystallography. Crystal structure–powder and single crystal applications. Electron charge density maps, Neutron diffraction-method and applications.

UNIT – II: CRYSTAL GROWTH METHODS

Nucleation–Equilibrium stability and metastable state. Single crystal–Low and high temperature, solution growth–Gel and sol-gel. Crystal growth methods-nucleation–equilibrium stability and metastable state. Melt growth - Bridgeman-Stock barger and Czochralski methods. Flux technique, physical and chemical vapour transport. Lorentz and polarization factors - Primary and secondary extinctions.

UNIT–III: PROPERTIES OF MATERIALS

Optical studies – Electromagnetic spectrum (qualitative) Refractive index, reflectance, transparency, translucency and opacity. Types of luminescence – photo-, electro-, and injection luminescence, LEDs – organic, inorganic and polymer LED materials - Applications. Dielectric studies- Polarisation - electronic, ionic, orientation, and space charge polarisation. Effect of temperature. Dielectric constant and dielectric loss. Types of dielectric breakdown– intrinsic, thermal, discharge, electrochemical and defect breakdown.

UNIT-IV: SPECIAL MATERIALS

Superconductivity: Meissner effect, Critical temperature and critical magnetic field, Type I and II superconductors, BCS theory-Cooper pair - Applications. Soft and hard magnets – Domain theory hysteresis loop-Applications. Magneto and giant magneto resistance. Ferro, ferri and antiferromagnetic materials-Application: Magnetic parameters for recording applications. Ferro-, Piezo-, and pyro electric materials – properties and applications. Shape memory alloys-characteristics and applications, Non-linear Optics-Second harmonic generators, mixing of Laser wavelengths by quartz, ruby and LiNbO3. Nano crystalline materials- Applications.

UNIT – V: MATERIALS FOR RENEWABLE ENERGY CONVERSION

Solar Cells: Organic, bilayer, bulk heterojunction, polymer and perovskite based solar energy conversion: Lamellar solids and thin films, dye-sensitized photo voltaic cells. Coordination compounds anchored onto semiconductor surfaces – Ru(II) and Os(II) polypyridyl complexes. Photochemical activation and splitting of water, CO2 and N2. Manganese based photo systems for water-splitting. Complexes of Rh, Ru, Pd and Pt - photochemical generation of hydrogen from

alcohol.

COURSE OUTCOME

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

CO1	Explain crystal structures, growth methods, and X-ray scattering techniques.	K1-K6
CO2	Describe the synthesis, classification, and applications of nanomaterials.	K1-K6
CO3	Explain the optical, dielectric, and diffusion properties of crystalline materials.	K1-K6
CO4	Recognize and explain the fundamental principles of semiconductors, superconducting materials, and magnetic materials.	K1-K6
CO5	Identify and explain the significance of advanced materials used in renewable energy conversion.	K1-K6

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

TEXT AND REFERENCE BOOKS

1. S. Mohan and V. Arjunan, Principles of Materials Science, MJP Publishers, 2016.
2. Arumugam, Materials Science, Anuradha Publications, 2007.
3. Giacavazzo et. al., Fundamentals of Crystallography, International Union of Crystallography. Oxford Science Publications, 2010.
4. Woolfson, An Introduction to Crystallography, Cambridge University Press, 2012.
5. James F. Shackelford and Madanapalli K. Muralidhara, Introduction to Materials Science for Engineers. 6thEdition, PEARSON Press, 2007.
6. M.G. Arora, Solid State Chemistry, Anmol Publications, New Delhi, 2001.
7. R.K. Puri and V.K. Babbar, Solid State Physics, S Chand and Company Ltd, 2001.
8. C. Kittel, Solid State Physics, John-Wiley and sons, NY, 1966.
9. H.P. Meyers, Introductory Solid-State Physics, Viva Books Private Limited, 1998.
10. A.R. West, Solid-State Chemistry and Applications, John-Wiley and sons, 1987.

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

26UPEST1E09	INNOVATION AND ENTREPRENEURSHIP DEVELOPMENT	L	T	P	C
		4	0	0	4

COURSE OBJECTIVES

- To introduce the fundamentals of entrepreneurship, entrepreneurial traits, and the entrepreneurial ecosystem in India.
- To provide knowledge on innovation processes, design thinking, and intellectual property rights in business development.
- To develop skills in identifying and analyzing business opportunities in the energy sector.
- To enable students to understand and prepare structured business plans for start-ups and entrepreneurial ventures.
- To provide knowledge on financial management, government policies, and marketing strategies in the energy business sector.

UNIT – I: INTRODUCTION

The Entrepreneur – Definition – Characteristics of Successful entrepreneur. Entrepreneurial scene in India; MSME; Analysis of entrepreneurial growth in different communities – Case histories of successful entrepreneurs. Similarities and Distinguish between Entrepreneur and Intrapreneur.

UNIT – II: INNOVATION IN BUSINESS

Types of Innovation – Creating and Identifying Opportunities for Innovation – Design Thinking- The Technological Innovation Process – Creating New Technological Innovation and Intrapreneurship – Licensing – Patent Rights – Innovation in Indian Firms.

UNIT–III BUSINESS OPPORTUNITY IDENTIFICATION IN ENERGY

Idea generation techniques and opportunity analysis, Market survey and demand analysis in energy sector, Renewable energy business models (solar rooftop, micro grids, EV charging), Feasibility study: technical, economic, environmental aspects, Case studies of successful energy startups.

UNIT-IV: BUSINESS PLAN PREPARATION

Benefits of a Business Plan – Elements of the Business Plan – Developing a Business Plan – Guidelines for preparing a Business Plan – Start-ups and e-commerce Start-ups.

UNIT – V: FINANCE, POLICY & SUSTAINABILITY

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.

COURSE OUTCOME

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

CO1	Explain entrepreneurship, intrapreneurship, and MSMEs.	K1-K6
CO2	Analyze innovation, patents, and technological advancements.	K1-K6
CO3	Identify energy business opportunities through market and feasibility analysis.	K1-K6
CO4	Develop business plans for energy start-ups.	K1-K6
CO5	Apply finance, policy, and marketing strategies for energy ventures.	K1-K6

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

TEXT AND REFERENCE BOOKS

1. Vasant Desai, *Dynamics of Entrepreneurial Development and Management*, Himalaya Publishing House, Mumbai, 2021, Vol. 1, 7th Edition.
2. Robert D. Hisrich, Michael P. Peters, and Dean A. Shepherd, *Entrepreneurship*, McGraw-Hill Education, 2020, Vol. 1, 11th Edition.
3. Donald F. Kuratko, *Entrepreneurship: Theory, Process, and Practice*, Cengage Learning, 2021, Vol. 1, 11th Edition.
4. Peter F. Drucker, *Innovation and Entrepreneurship*, Harper Business, 2014, Vol. 1, Revised Edition.
5. David H. Holt, *Entrepreneurship: New Venture Creation*, Prentice Hall of India, New Delhi, 2016, Vol. 1, 2nd Edition.
6. B. H. Khan, *Non-Conventional Energy Resources*, McGraw-Hill Education, New Delhi, 2017, Vol. 1, 3rd Edition.
7. Chetan Singh Solanki, *Solar Photovoltaics: Fundamentals, Technologies and Applications*, PHI Learning Pvt. Ltd., New Delhi, 2015, Vol. 1, 3rd Edition.
8. Rajeev Roy, *Entrepreneurship*, Oxford University Press, New Delhi, 2019, Vol. 1, 3rd Edition.

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

26UPEST1E10 HYDROGEN ENERGY TECHNOLOGIES

L	T	P	C
4	0	0	4

COURSE OBJECTIVES

- To foundational knowledge of properties energy and related fields.
- To make the students acquire an understanding the Hydrogen fuel cells
- To help them understand the broad outline of hydrogen energy and driving renewable energy.
- To understand the large-scale hydrogen production.
- To understand the hydrogen storage processes and technologies

UNIT – I: INTRODUCTION OF HYDROGEN ENERGY

Introduction -History of Hydrogen- Summary-Hydrogen Sources - Hydrogen Isotopes- Uses for Hydrogen- Zeppelins and Airships- Hydrogen Energy - Pros and Cons of Hydrogen Energy - Manufacture of Hydrogen

UNIT – II: HYDROGEN FUEL CELL

Introduction-Fuel Cells-Hydrogen Fuel Cell Applications -Near-Future Hydrogen-Driven Cars and Industry Milestones-Hydrogen Energy and Global Warming -Hydrogen for the Future - A High Price- Looking Ahead -The Dawn of Hydrogen as the Future of Fuel Cells.

UNIT– III: HYDROGEN: DRIVING RENEWABLE ENERGY

Introduction -Hydrogen as an Energy Carrier-Hydrogen Energy Storage- Hydrogen Production - Hydrogen Re-Electrification - Solar and Wind-based Hydrogen Production, Emerging Hydrogen Generation Technologies. Industrial Application of Hydrogen Energy.

UNIT- IV: LARGE-SCALE HYDROGEN PRODUCTION

Large-Scale Hydrogen Production- Introduction -Hydrogen Production by Steam Reforming of Hydrocarbons- Steam Reforming Technologies -Heat of Combustion -Reforming Reactions Introduction to Combustion- Chemical Combustion -Combustion Equations -Mass and Mole Fractions -Enthalpy of Formation- Enthalpy of Combustion -Adiabatic Flame Temperature.

UNIT – V: HYDROGEN STORAGE PROCESSES AND TECHNOLOGIES

Introduction -Hydrogen Storage Technologies -How Does Hydrogen Storage Work? -Physical Hydrogen Storage -Research and Development Goals -Materials-Based Hydrogen Storage - Technical Targets and Status -Onboard Hydrogen Storage for Light-Duty Vehicles-Material Handling Equipment-Portable Power Equipment-High-Density Hydrogen Storage Challenges.

COURSE OUTCOME

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

CO1	Learn about the background on hydrogen and their properties.	K1-K6
CO2	Gain knowledge about Hydrogen fuel cells	K1-K6
CO3	Understand the hydrogen energy and driving renewable energy and the impact on environment	K1-K6
CO4	Apply their learned knowledge to develop hydrogen storage processes and technologies	K1-K6
CO5	Design hydrogen production for various energy applications	K1-K6

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

TEXT AND REFERENCE BOOKS

1. Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma, 2005
2. Bent Sorensen (Sørensen), Hydrogen and Fuel Cells: Emerging Technologies and Applications, Elsevier, UK, 2005
3. Kordesch, K and G.Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany (1996).
4. Hart, A.B and G.J.Womack, Fuel Cells: Theory and Application, Prentice Hall, NewYork Ltd., London, 1989
5. Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA, 2002.
6. Viswanathan, B and M AuliceScibioh, Fuel Cells – Principles and Applications, Universities Press, 2006.

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	H	M	L	-	L	-	H	M	-	-	-	H	M	L	-
2	H	M	M	-	M	L	H	M	-	-	-	H	-	-	M
3	H	M	L	-	M	-	H	M	-	-	-	H	-	L	-
4	H	H	M	-	-	M	H	M	-	-	-	H	L	-	M
5	M	L	H	-	M	M	H	H	-	-	-	H	L	L	M

26UPEST1E11	ENERGY AND WATER MANAGEMENT IN HIGH PERFORMANCE BUILDING	L	T	P	C
		4	0	0	4

COURSE OBJECTIVES

- To understand demand requirement and reduction strategies
- To be familiar with basic terminologies related to buildings
- To learn the building (air) conditioning techniques and their performance measurement
- To provide knowledge of efficient water use in indoor/outdoor water management systems.
- To understand energy and water monitoring, retrofit strategies, and operational control in buildings.

UNIT – I: ENERGY DEMAND REDUCTION MANAGEMENT

Building Physics (Orientation, Envelope etc.) – Occupants - Zone Separation – Passive heating and cooling - Thermal performance – Shading – Lighting Energy consumption - Energy efficient equipment's – Renewable source of Energy

UNIT – II: ENERGY EFFICIENT SYSTEMS

Air Conditioning System Performance- Heating and Cooling – AHU & FCUs, Lighting system- Pumps and Motors – Household appliances – ASHRAE – ECBC – Life Cycle Cost Analysis.

UNIT– III: REFRIGERANT MANAGEMENT AND COMMISSIONING

Ozone depletion - Natural Refrigerants - ODP and GWP of different refrigerants - Environmentally preferable Refrigerants - Fundamental Refrigerant Management – Commissioning – Scope and Responsibility, Systems to be commissioned.

UNIT- IV: INDOOR & OUTDOOR WATER USE

Efficient sanitary fixtures – Efficient appliances – FTE – Sensors – Water reuse – Rain water and storm water collection – Water Conservation Policies - Regional plants species - Effective landscape management – Grey water system –Submeters – Water monitoring.

UNIT – V: OPERATION AND MAINTENANCE

Energy and Water Monitoring and Management in Existing buildings, Energy and Water Retrofit for Existing buildings. Energy and Water Use Intensity. Operation & Control Philosophy

COURSE OUTCOME

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

CO1	Analyze Energy Demand Reduction Management	K1-K6
CO2	Understand Energy Efficient systems of buildings	K1-K6
CO3	Elaborate Refrigerant Management their performance measurement	K1-K6
CO4	Understand the Indoor & Outdoor Water Use.	K1-K6
CO5	Incorporate Renewable energy systems in buildings.	K1-K6

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

TEXT AND REFERENCE BOOKS

1. LEED Green Associate Made Easy study guide, K.M. Bazeeth Ahamed. Energy Conservation Building Code User Guide, ASHRAE 90.1 2013 Standard.
2. Uniform Plumbing Code 2009. LEED Reference Guide for Building Design and Construction, USGBC.
3. K.S.Jagadish, B.U.Venkataramareddy and K.S.Nanjundarao. Alternative Building Materials and Technologies. New Age International, (2007).
4. Low Energy Cooling For Sustainable Buildings. John Wiley and SonsLtd,(2009).
5. Green My Home:10 Steps to Lowering Energy Costs and Reducing Your Carbon Footprint, by Dennis C. (2008).
6. B.Givoni, Man, Climate and Architecture Elsevier,(1969).
7. T. A. Markus and E. N. Morris Buildings Climate and Energy. Pitman, London,(1980).

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

		L	T	P	C
26UPEST1E12	**ELECTRIC VEHICLE SYSTEM**	4	0	0	4

COURSE OBJECTIVES

- To present a comprehensive overview of Electric and Hybrid Electric Vehicle
- To obtain knowledge on storage techniques on electrical vehicles
- To provide knowledge on hybrid electric vehicle systems.
- To learn about the propulsion system used in electrical vehicle
- To understand the drive system and characteristics of electrical vehicle

UNIT – I: INTRODUCTION

The Electric Vehicle Debate, Primary Energy Sources and Alternative Fuels for Transportation, History of electric Vehicles, Electrochemical Power Sources –Secondary Batteries and Fuel Cells

UNIT – II: BATTERIES

Aqueous Electrolyte Batteries –Lead Acid, Nickel – Iron, Nickel – Zinc, Metal – Air Zinc – Halogen - Non-Aqueous Electrolyte Batteries- High Temperature Batteries, Organo Electrolyte and Solid-State Batteries

UNIT–III: HYBRID ELECTRIC VEHICLES

Combustion Engine Hybrid Electric Vehicles, Laboratory Test of Electric Vehicle Batteries, Vehicle tests with Electric Vehicle Batteries, Future of Electric Vehicles

UNIT-IV: EV PROPULSION

Choice of electric propulsion system, block diagram of EV propulsion system, concept of EV Motors, single motor and multi-motor configurations, fixed & variable geared transmission, In wheel motor configuration, classification of EV motors, Electric motors used in current vehicle applications

UNIT – V: EV MOTOR DRIVES

DC Motor: Type of wound-field DC Motor, Torque speed characteristics DC-DC Converter, Two quadrant DC Chopper, two quadrant zero voltage transition converter-fed dc motor drive, speed control of DC Motor Induction Motor Drive: Three Phase Inverter Based Induction Motor Drive, Speed Control of Induction Motor, FOC, Adaptive Control, Model Reference Adaptive Control (MARS), Sliding mode Control

COURSE OUTCOME

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

CO1	Choose a suitable drive scheme for developing an electric of hybrid vehicle depending on resources	K1-K6
CO2	Different energy storage techniques used in electric vehicles.	K1-K6
CO3	Explain hybrid electric vehicle concepts	K1-K6
CO4	Explain the working principles of propulsion systems in electric vehicles.	K1-K6
CO5	Interpret the drive systems and performance characteristics of electric vehicles.	K1-K6

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

TEXT AND REFERENCE BOOKS

1. C. C. Chan and K. T. Chau, *Modern Electric Vehicle Technology*, Oxford University Press Inc., New York, 2001, Vol. 1, 1st Edition.
2. Iqbal Husain, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2003, Vol. 1, 1st Edition.
3. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, and Ali Emadi, *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design*, CRC Press, 2004, Vol. 1, 1st Edition.
4. James Larminie and John Lowry, *Electric Vehicle Technology Explained*, John Wiley & Sons, 2003, Vol. 1, 1st Edition.
5. David Linden and Thomas B. Reddy (Eds.), *Handbook of Batteries*, McGraw-Hill Book Company, New York, 2002, Vol. 1, 3rd Edition.
6. B. Viswanathan and M. Aulice Scibioh, *Fuel Cells: Principles and Applications*, Universities Press, Hyderabad, 2006, Vol. 1, 1st Edition.
7. Nick Yost, *The Essential Hybrid Car Handbook: A Buyer's Guide*, The Lyons Press, New York, 2006, Vol. 1, 1st Edition.

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

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 and J. Prakash, *Solar Energy: Fundamentals and Applications*, McGraw-Hill Education (India), New Delhi, 2015, Vol. 1, 22nd Reprint Edition.
2. S. P. Sukhatme and J. K. Nayak, *Solar Energy: Principles of Thermal Collection and Storage*, McGraw-Hill Education (India), New Delhi, 2015, Vol. 1, 4th Edition (19th Reprint).
3. G. N. Tiwari, *Solar Energy: Fundamentals, Design, Modelling and Applications*, Narosa Publishing House, New Delhi, 2013, Vol. 1, Revised Edition.
4. D. Yogi Goswami, Frank Kreith, and Jan F. Kreider, *Principles of Solar Engineering*, CRC Press, Taylor & Francis Group, 2015, Vol. 1, 3rd Edition.
5. Michael E. Mackay, *Solar Energy: An Introduction*, Oxford University Press, Oxford, 2015, Vol. 1, 1st 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	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

26UPESTN01 ALTERNATIVE ENERGY SOURCES

L	T	P	C
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. John Twidell, Tony Weir, *Renewable Energy Resources*, Taylor & Francis, 2015, Vol. 1, 3rd Ed.
2. Godfrey Boyle, *Renewable Energy: Power for a Sustainable Future*, Oxford University Press, 2012, Vol. 1, 3rd Ed.
3. S. P. Sukhatme, J. K. Nayak, *Solar Energy*, McGraw-Hill Education (India), 2017, Vol. 1, 4th Ed.
4. G. N. Tiwari, *Solar Energy: Fundamentals, Design, Modelling and Applications*, Alpha Science, 2015, Vol. 1, Revised Ed.

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

26UPESTN02	CLIMATE CHANGE AND CO2 EMISSION ASSESSMENT	L	T	P	C
		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 CO2 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 (CO_2) emissions in relation to energy conversion/consumption: theory of CO_2 emission in relation to energy conversion processes.

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

Methodology for CO_2 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. Michael J. Franchetti, Defne S. Apul, *Carbon Footprint Analysis: Concepts, Methods, Implementation, and Case Studies*, CRC Press, Taylor & Francis Group, 2013, Vol. 1, 1st Ed.
2. Nicholas Stern, *The Economics of Climate Change: The Stern Review*, Cambridge University Press, 2007, Vol. 1, 1st Ed.
3. Scott Barrett, *Why Cooperate? The Incentive to Supply Global Public Goods*, Oxford University Press, 2007, Vol. 1, 1st Ed.
4. United Nations Framework Convention on Climate Change, *Clean Development Mechanism (CDM) Guidelines and Reports*, UNFCCC, 2026, —, Updated Ed.
5. Intergovernmental Panel on Climate Change, *Climate Change Assessment Reports*, IPCC, 2023, Vol. 1, Latest Ed.

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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	Know about the effects of energy demand on environment	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, New Delhi, India, 2015, Vol. 1, 4th Ed.
2. Energy and the Environment, John Wiley & Sons, New York, 2006, Vol. 1, 2nd Ed.
3. Renewable Energy Power for a Sustainable Future, Oxford University Press, 2012, Vol. 1, 3rd Ed.
4. Bureau of Energy Efficiency, *Energy Conservation Act, 2001 and Related Policies*, Government of India, New Delhi, 2020, —, Updated Ed.
5. Intergovernmental Panel on Climate Change, *Climate Change Assessment Reports*, IPCC, 2023, Vol. 1, Latest Ed.
6. Richard Loulou, Jean-Philippe Waaub, Georges Zaccour (Eds.), *Energy and Environment: Mathematics of Decision Making*, Springer, 2005, Vol. 1, 1st Ed.

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 OBJECTIVES

- 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- multipressure system-low temperature refrigeration - Cascade systems – problems. Equipments: 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. Refrigeration and Air Conditioning, Tata McGraw-Hill Education, New Delhi, 2010, Vol. 1, 3rd Ed.
2. Refrigeration and Air Conditioning, Dhanpat Rai & Co., New Delhi, 2012, Vol. 1, 1st Ed.
3. Refrigeration and Air Conditioning, S. Chand Publishing, New Delhi, 2013, Vol. 1, 9th Ed.
4. Principles of Refrigeration, Pearson Education, 2001, Vol. 1, 4th Ed.
5. Fundamentals of Refrigeration and Air Conditioning, McGraw-Hill Education, New Delhi, 2013, Vol. 1, 1st Ed.

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

26UPESTN05 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. Environmental Pollution Control Engineering – C. S. Rao, New Age International Publishers, New Delhi, 2006.
2. Environmental Engineering – H. S. Peavy, D. R. Row, and G. Tchobanoglous, McGraw-Hill Book Company, New York, 1985.
3. Introduction to Environmental Engineering and Science – G. M. Masters, Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
4. Manual of Environmental Technology in Developing Countries – H. W. Ludwig and W. E. Evans, International Book Company, Absecon Highlands, New Jersey, 1991.
5. Environmental Engineering A Design Approach – A. P. Sincero and G. A. Sincero, 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

26UPGEN1V01 PEACE EDUCATION

a. On successful Completion of Course, the student will 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

1. https://www.un.org/en/
2. https://www.youtube.com/watch?v=18LhBZc6Sn4
3. https://www.hwpl.kr/language/en/home-hwpl_en/
4. Heavenly Culture World Peace Restoration of Light, (2022), Road to Peace
5. 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

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

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 the 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

- Study EV charging architectures
- Analyze power converter topologies
- 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, Grid connected 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

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

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

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.
5. Robin R. Murphy “Introduction to AIRobotics” PHI Learning Private Limited, 2000

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, Cambridge, Int. Science Publishing, 2008.

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.
- To impart knowledge on various modeling concepts and forecasting methods.

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

26UPESTCPO2 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.