

# **REGULATIONS AND SYLLABUS**

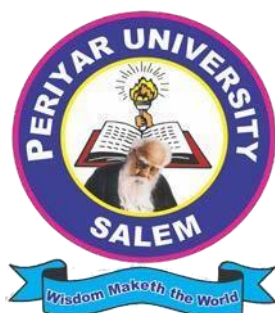
## **(University Department)**

(For the candidates admitted from the academic year 2022-2023 onwards)

# **MASTER OF SCIENCE IN**

## **ENERGY SCIENCE**

(Under Choice Based Credit System)



**DEPARTMENT OF ENERGY SCIENCE AND TECHNOLOGY**  
**SCHOOL OF ENERGY AND ENVIRONMENTAL SCIENCES**

**PERIYARUNIVERSITY**

(NAAC A<sup>++</sup> Grade –State University-NIRF Rank73, ARIIA Rank 10)

**SALEM-636011**

**TAMILNADU**

# **Regulations & Scheme**

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## **M.Sc., Energy Science**

Choice Based Credit System (CBCS) Regulation,  
Scheme and Syllabus  
(W.e.f.2022-2023 onwards)

### **1. Eligibility for Admission**

Candidate who has passed the B.Sc. degree in **Physics/ Chemistry/ Energy / Electronics/ Biotechnology/ Biochemistry/ Mathematics/ Nano Science** of this University or any other University shall be eligible for admission to M.Sc. Energy Science degree of this University

### **2. Mode of Selection**

The admission is subject to the prevailing rules and regulations for PG admission of this University and also 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. Each semester consists of 90 working days.

### **4. Distribution of Credit Points**

The minimum credit requirement for M.Sc., degree shall be 94 Credits. The break-up of credits for the Programme is as follows;

❖ Core Courses	: 69 credits
❖ Elective Courses	: 16 credits
❖ Supportive Courses	: 04 credits
❖ Human Rights	: 02 credits
❖ Technical Seminar	: 01 credit
❖ Swayam	: 02 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.

#### **5.1 Components of Internal Examination**

The allotment of marks and scheme of examination as follows;

Internal Tests (Best 1 out of 2)	05 Marks
Model Examination	05 Marks
Seminar	05 Marks
Assignment	05 Marks
Attendance	05 Marks
<b>Total</b>	<b>25 Marks</b>

**5.2 Theory Core Paper**

External	75 Marks
Internal	25 Marks
Total	100 Marks

**5.3 Practical Internal & External (100 Marks)**

Internal (40 Marks)			External (60 Marks)		
Internal Test I	Internal Test II	Model	Record Work	Experimental Work	Viva Voce
10	10	20	10	40	10

**5.4 Technical Seminar (100 Marks)**

Technical Seminar aims to help students acquire the employability skills necessary for the workplace through technical presentation. It also attempts to meet the expectations of the employers by giving special attention to presentation skills and soft skills. This will be attained through expert guidance and teaching activities focusing on the above listed skills and language skills.

Internal (40 Marks)			External (60 Marks)		
Presentation I	Presentation II	Presentation III	Dissertation	Presentation	Viva Voce
10	10	20	20	30	10

**5.5 Marks allotment for attendance as follows**

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 work	Internal (40 Marks)			External (60 marks)			
	Review I	Review II	Review III	Thesis Evaluation (External)	Viva –Voce 45 Marks		
Phase I (100 Marks)	10	10	20		15	Supervisor	External
					15	15	15

Project work	Internal (80 Marks)				External (120 marks)			
Phase II (200 Marks)	Review I	Review II	Review III	Conference Paper Presentation/ Journal Article/ Book Chapter Publication /Patent Filing	Thesis Evaluation (External)	Viva –Voce 90 Marks		
						Supervisor	External	Internal
	20	20	30	10	30	30	30	30

The project work is an important component of postgraduate programme. The Project work consists of Phase – I and Phase – II. The Phase – I is to be undertaken during III semester and Phase – II which is a continuation of Phase – I is to be undertaken during IV semester.

The Project work for Phase II shall be pursued for a minimum of 90 days during the final semester. Students may be permitted to carried out project work 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)**

Analytical Questions Any 3 out of 5 (One question from each Unit)

### **PART – C (5X8= 40 Marks)**

Either or Type descriptive questions (Two questions from each Unit)

## 8. Passing Minimum

1. There shall be no Passing Minimum Marks for Internal.
2. For External Examination, Passing Minimum shall be of 50% (Fifty Percentage) of the maximum marks prescribed for the paper.
3. In aggregate (External +Internal) the passing minimum shall be of 50% for each Paper/Practical/Project and Viva-voce.
4. Grading shall be based on overall marks obtained (Internal + External).

**9. 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

**10. Marks and Grades**

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

**11. 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.

Duration of Internship	Credits
2 Weeks to 4 weeks	2

At the end of internship, the student shall submit a report. A three-member committee constituted by the Head of the Department will conduct the Viva-Voce Examination. The committee comprises of one expert from an industry/institutions and two members (Coordinator and supervisor) from the Department.

**INTERNSHIP TRAINING (100 Marks)**

<b>Report</b>	<b>Presentation</b>		<b>Viva Voce</b>		<b>Total</b>
<b>External</b>	<b>External</b>	<b>Internal</b>	<b>External</b>	<b>Internal</b>	
40	15	15	15	15	100

**12. Supportive Paper**

Supportive paper should be offered in second semester. Students are expected to select one Supportive Course (Non-major elective) offered by other departments. Students can earn four credits from supportive course.

**13. Swayam Course**

The student must attend a SWAYAM course mandatorily in first semester with two credits. The student is eligible for the award of Degree only if he gets pass in Swayam course.

SWAYAM is a programme initiated by Government of India and designed to achieve the three cardinal principles of Education Policy viz., access, equity and quality. The objective of this effort is to take the best teaching learning resources to all, including the most disadvantaged. SWAYAM seeks to bridge the digital divide for students who have hitherto remained untouched by the digital revolution and have not been able to join the mainstream of the knowledge economy.

The courses hosted on SWAYAM are in 4 quadrants – (1) video lecture, (2) specially prepared reading material that can be downloaded/printed (3) self-assessment tests through tests and quizzes and (4) an online discussion forum for clearing the doubts. Steps have been taken to enrich the learning experience by using audio-video and multi-media and state of the art pedagogy / technology.

In order to ensure that best quality content is produced and delivered, nine National Coordinators conduct the exam. They are:

1. AICTE (All India Council for Technical Education) for self-paced and international courses
2. NPTEL (National Programme on Technology Enhanced Learning) for Engineering
3. UGC (University Grants Commission) for non-technical post-graduation education
4. CEC (Consortium for Educational Communication) for under-graduate education
5. NCERT (National Council of Educational Research and Training) for school education
6. NIOS (National Institute of Open Schooling) for school education
7. IGNOU (Indira Gandhi National Open University) for out-of-school students
8. IIMB (Indian Institute of Management, Bangalore) for management studies
9. NITTTR (National Institute of Technical Teachers Training and Research) for Teacher Training programme

Courses delivered through SWAYAM are available free of cost to the learners, however learners wanting a SWAYAM certificate should register for the final proctored exams that come at a fee and attend in-person at designated centres on specified dates.

Eligibility for the certificate will be announced on the course page and learners will get certificates only if this criterion is matched. Universities/colleges approving credit transfer for these courses can use the marks/certificate obtained in these courses for the same.

### **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 or manufacture 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:

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



**PROGRAM SPECIFIC OUTCOMES (PSOs):**

1. To create awareness on the energy sourcing, generation, distribution, consumption, and emission patterns of India Vs Globe, apart from computation of plant load factor, efficiency, quantification of emissions along with cost of power generation from various energy sources
2. To carry out energy audit in Industries by accounting its energy consumption pattern, determining its specific energy consumption, diagnosing the causes for deviation from the industry benchmarks and suggestions for improving the performance of the plant
3. To instill ability to use knowledge in various domains to identify research gaps and ideate innovations by simulation of energy systems using software such as MATLAB, ANSYS- CFD, Fluent, TRNSYS, PV-SYST

**PEO / PO Mapping**

Programme Educational Objectives	Programme Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
<b>I</b>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<b>II</b>	✓	✓							✓		✓	✓
<b>III</b>	✓	✓				✓	✓		✓		✓	✓
<b>IV</b>	✓	✓	✓		✓		✓	✓	✓	✓	✓	
<b>V</b>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

## Mapping of Course Outcome and Programme Outcome

		Course Name	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	
<b>I YEAR</b>	<b>Semester 1</b>	Energy Scenario, Audit and Management	✓		✓	✓		✓	✓	✓		✓		✓	
		Basics of Fluid Mechanics And Heat Transfer	✓	✓	✓	✓	✓	✓	✓					✓	✓
		Basics of Thermodynamics	✓	✓	✓	✓	✓	✓	✓					✓	✓
		Applied Mathematics for Energy	✓	✓	✓	✓	✓	✓	✓					✓	✓
		Professional Elective –I													
		Energy Laboratory	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Technical Seminar	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	<b>Semester 2</b>	Thermal Energy Conservation	✓	✓		✓	✓	✓	✓					✓	✓
		Electrical Systems - Electrical Energy Conservation	✓			✓		✓	✓						✓
		Basics of Computational Fluid Dynamics	✓	✓	✓	✓	✓	✓	✓					✓	✓
		Research Methodology and Intellectual Property Rights	✓		✓		✓				✓	✓	✓		✓
		Professional Elective –II													
		Supportive													
		Fundamentals of Human Rights													
Computer Aided Design and Simulation Laboratory	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓		
<b>II YEAR</b>	<b>Semester 3</b>	Hydrogen Storage System	✓		✓		✓	✓	✓		✓		✓	✓	
		Nanomaterial's for Energy Applications	✓	✓	✓		✓	✓	✓	✓			✓	✓	
		Energy Storage Systems	✓	✓	✓	✓	✓	✓	✓					✓	✓
		Professional Elective III													
		Professional Elective IV													
		Internship	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Project Work Phase I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
<b>Semester 4</b>	Project Work Phase II	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	

**PERIYAR UNIVERSITY, SALEM**  
**UNIVERSITY DEPARTMENT REGULATIONS – 2022**  
**CHOICE BASED CREDIT SYSTEM**  
**M.Sc., ENERGY SCIENCE**

**CURRICULUM AND SYLLABUS**

**SEMESTER I**

S.No	Course Code	Course Title	Category	L	T	P	C
1	22UPEST1C01	Energy Scenario, Audit and Management	PC	3	1	0	4
2	22UPEST1C02	Basics of Fluid Mechanics and Heat Transfer	PC	3	1	0	4
3	22UPEST1C03	Basics of Thermodynamics	PC	3	1	0	4
4	22UPEST1C04	Applied Mathematics for Energy	PC	3	1	0	4
5	-	Professional Elective –I	PE	4	0	0	4
6	-	Swayam Course	-	0	0	0	2
<b>PRACTICALS</b>							
7	22UPEST1C05	Energy Laboratory	PC	0	0	4	2
8	22UPEST1C06	Technical Seminar	-	0	0	2	1
<b>TOTAL</b>				<b>16</b>	<b>4</b>	<b>6</b>	<b>25</b>

**SEMESTER II**

S.No	Course Code	Course Title	Category	L	T	P	C
1	22UPEST1C07	Thermal Energy Conservation	PC	3	1	0	4
2	22UPEST1C08	Electrical Systems - Electrical Energy Conservation	PC	3	1	0	4
3	22UPEST1C09	Basics of Computational Fluid Dynamics	PC	3	1	0	4
4	22UPEST1C10	Research Methodology and Intellectual Property Rights	PC	4	0	0	4
5	-	Professional Elective –II	PE	4	0	0	4
6	-	Supportive	-	4	0	0	4
7	22UPSOC2H01	Fundamentals of Human Rights	-	2	0	0	2
<b>PRACTICALS</b>							
8	22UPEST1C11	Computer Aided Design and Simulation Laboratory	PC	0	0	4	2
<b>TOTAL</b>				<b>23</b>	<b>3</b>	<b>4</b>	<b>28</b>

**SEMESTER III**

S.No	Course Code	Course Title	Category	L	T	P	C
1	22UPEST1C12	Hydrogen Storage System	PC	4	0	0	4
2	22UPEST1C13	Nanomaterials for Energy Applications	PC	4	0	0	4
3	22UPEST1C14	Energy Storage Systems	PC	4	0	0	4
4	-	Professional Elective III	PE	4	0	0	4
5	-	Professional Elective IV	PE	4	0	0	4
6	22UPEST1C15	Internship	PC	0	0	0	2
<b>PRACTICALS</b>							
7	22UPEST1C16	Project Work Phase I	PC	0	0	10	5
<b>TOTAL</b>				<b>20</b>	<b>0</b>	<b>10</b>	<b>27</b>

**SEMESTER IV**

S.No	Course Code	Course Title	Category	L	T	P	C
<b>Project Work</b>							
1	21UPEST1C17	Project Work Phase II	PC	0	0	28	14
<b>TOTAL</b>				<b>0</b>	<b>0</b>	<b>28</b>	<b>14</b>

**TOTAL CREDITS TO BE EARNED FOR THE AWARD OF DEGREE = 94**

**PROFESSIONAL CORE (PC)**

S. No	Course Code	Course Title	Category	L	T	P	C
1.	22UPEST1C01	Energy Scenario, Audit and Management	PC	3	1	0	4
2.	22UPEST1C02	Basics of Fluid Mechanics and Heat Transfer	PC	3	1	0	4
3.	22UPEST1C03	Basics of Thermodynamics	PC	3	1	0	4
4.	22UPEST1C04	Applied Mathematics For Energy	PC	3	1	0	4
5.	22UPEST1C05	Energy Laboratory	PC	0	0	4	2
6.	22UPEST1C06	Technical Seminar	PC	0	0	2	1
7.	22UPEST1C07	Thermal Energy Conservation	PC	3	1	0	4
8.	22UPEST1C08	Electrical Energy Conservation	PC	3	1	0	4
9.	22UPEST1C09	Basics of Computational Fluid Dynamics	PC	3	1	0	4
10.	22UPEST1C10	Research Methodology and IPR	PC	4	0	0	4
11.	22UPEST1C11	Computer Aided Design and Simulation Laboratory	PC	0	0	4	2
12.	22UPEST1C12	Hydrogen Storage System	PC	4	0	0	4
13.	22UPEST1C13	Nanomaterial's For Energy Applications	PC	4	0	0	4
14.	22UPEST1C14	Energy Storage Systems	PC	4	0	0	4
15.	22UPEST1C15	Internship	PC	0	0	0	2
16.	22UPEST1C16	Project Work Phase I	PC	0	0	10	5
17.	22UPEST1C17	Project Work Phase II	PC	0	0	28	14

**PROFESSIONAL ELECTIVE (PE)**

S. No	Course Code	Course Title	Category	L	T	P	C
<b>PROFESSIONAL ELECTIVE - I</b>							
1	22UPEST1E01	Power Plant Engineering	PE	4	0	0	4
2	22UPEST1E02	Electrical Drives and Controls	PE	4	0	0	4
3	22UPEST1E03	Cogeneration and Waste Heat Recovery Systems	PE	4	0	0	4
4	22UPEST1E04	Industrial Instrumentation	PE	4	0	0	4
<b>PROFESSIONAL ELECTIVE - II</b>							
5	22UPEST1E05	Hydro Power Systems	PE	4	0	0	4
6	22UPEST1E06	Principles and Applications of Hydrogen Storage	PE	4	0	0	4
7	22UPEST1E07	Waste Management and Energy Recovery Techniques	PE	4	0	0	4
8	22UPEST1E08	Basics of Solar Energy Technologies	PE	4	0	0	4
<b>PROFESSIONAL ELECTIVE - III</b>							
9	22UPEST1E09	Nuclear Energy Technology	PE	4	0	0	4
10	22UPEST1E10	Energy Conservation, Energy Storage and Transportation	PE	4	0	0	4
11	22UPEST1E11	Wind Energy	PE	4	0	0	4
12	22UPEST1E12	Smart Grid Technologies	PE	4	0	0	4
<b>PROFESSIONAL ELECTIVE - IV</b>							
13	22UPEST1E13	Green Concepts in Building	PE	4	0	0	4
14	22UPEST1E14	Bio –Energy Conversion	PE	4	0	0	4
15	22UPEST1E15	Innovation and Entrepreneurship	PE	4	0	0	4
16	22UPEST1E16	Power Electronics for Renewable Energy Systems	PE	4	0	0	4

**NON-MAJOR ELECTIVE COURSES (NM)**

S.No	Course Code	Course title	Category	L	T	P	C
1	22UPESTS01	Renewable Energy	NM	4	0	0	4
2	22UPESTS02	Climate Change and CO <sub>2</sub> Emission Assessment	NM	4	0	0	4
3	22UPESTS03	Energy Scenario and Policy	NM	4	0	0	4
4	22UPESTS04	Erection and Maintenance of Refrigeration and Air-Conditioning Equipment	NM	4	0	0	4
5	22UPESTS05	Green Concepts in Building	NM	4	0	0	4

**VALUE ADDED COURSE**

S. No	Course Code	Course title	Category
1	22UPESTVA01	Alternate Fuels and Emissions	VA
2	22UPESTVA02	Biomass and its Conversion Technologies	VA
3	22UPESTVA03	Materials for Energy Applications	VA
4	22UPESTVA04	Electric Vehicles	VA
5	22UPESTVA05	Design Thinking	VA
6	22UPESTVA06	First Aid & Fire Fighting Safety Management	VA
7	22UPESTVA07	Refrigeration and Air Conditioning	VA
8	22UPESTVA08	Industrial Robotics	VA

22UPEST1C01	ENERGY SCENARIO, AUDIT AND MANAGEMENT	L	T	P	C
		3	1	0	4

### COURSE OBJECTIVES

- To know Global and Indian Energy Scenario and Energy Conservation Act
- To know the procedure of Energy Audit
- To understand the material and energy balance in the production
- To Know the demand side management analysis
- To know the planning and targeting of energy in industries

### 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 Conservation and its importance, Energy Conservation Act and related policies, Bureau of Energy Efficiency (BEE) Regulations. Need to Manage Energy, Definition and objectives of Energy Management, Components of Energy Management program and their explanation.

### UNIT – II: ENERGY AUDIT

Energy audit concepts, Scope of energy audit, types of energy audit, general procedure for a detailed 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– III: UTILITY RATE STRUCTURES AND FINANCIAL ANALYSIS

Understanding Energy Costs, Innovative rates – Time – of - Use rates, Real Time Pricing Rates, Financial Incentive Rates, Energy Purchase Rates. Basic concept of Economic Analysis – Interest rate, Inflation rate, Single Payment, Uniform – Series Payment. Economic Evaluation Methods – Net Present Worth, Rate of Return, Benefit – Cost Ratio, Payback period. Comparison of Various Economic Evaluation Methods

### UNIT- IV: DEMAND SIDE MANAGEMENT

Introduction to Demand Side Management, Integrated Resource Planning Concepts, Relation between Demand Side Management and Integrated Resource Planning, Demand Side Management Programs, Cost Benefit Analysis of Demand Side Management.

### 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

- Adopt energy standards based on various acts officially established for qualitative and quantitative improvement in energy utilization
- Familiarized about energy auditing and energy management methods.
- Find the production rate and energy consumption data
- Analyse the cost benefits of demand side management



- Involve in energy extraction and efficiency rate improvement

### REFERENCE BOOKS

1. Smith C. B. Energy Management Principles, Pergamon Press, New York. 2015
2. Wayne C. Turner, Steve Doty, Energy Management Handbook, Taylor and Francis Ltd., CRC Press. 2012
3. Frank Kreith, Goswami D. Yogi, Energy Management and Conservation Handbook, Taylor and Francis Ltd., CRC Press.2017
4. Albert Thumann, Terry Niehus, William J. Younger, Handbook of Energy Audits, Taylor and Francis Ltd., CRC Press.2012
5. Rajiv Shanker, Energy Auditing in Electrical Utilities, Viva Book Pvt. Limited, New Delhi.
6. Bureau of Energy Efficiency, General Aspects of Energy Management and Energy Audit. New Delhi.2015

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

22UPEST1C02	BASICS OF FLUID MECHANICS AND HEAT TRANSFER	L	T	P	C
		3	1	0	4

**COURSE OBJECTIVES**

- To introduce the students about properties of the fluids, behavior of fluids under static conditions
- To impart basic knowledge of the dynamics of fluids
- To explain the incompressible and compressible fluid flow concepts
- To understand the mechanisms of heat transfer under steady and transient conditions.
- To learn the thermal analysis and sizing of heat exchangers and to understand the basic concepts of mass transfer

**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 AND LOSSES**

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 –  $\epsilon$  – NTU - approach and design procedure – compact heat exchanger.

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

- Understand the difference between solid and fluid, its properties and behaviour in static conditions.
- Understand the concepts of flow governing equations
- Estimate losses in pipelines for both laminar and turbulent conditions and analysis of pipes connected in series and parallel.
- Explain basic laws for radiation and apply these principles to radiative heat transfer between different types of surfaces to solve problems
- Explain the phenomena and apply LMTD and NTU methods of thermal analysis to different types of heat exchanger configurations and solve problems

**REFERENCE BOOKS**

1. Yunus A. Çengel, John M. Cimbala, Fluid mechanics : Fundamentals and Applications, McGraw-Hill; 3rd edition, 2014
2. Bansal,R.K., Fluid Mechanics, Laxmi Publications Pvt Ltd; 2nd Edition. 2016
3. Yunus A. Cengel, Afshin J. Ghajar, Heat and Mass Transfer: Fundamentals & Applications

in SI Units, 6th Edition, McGraw-Hill Education, 2020

4. Streeter, V.L., Wylie, E.B., and Bedford, K.W., Fluid Mechanics, WCB McGraw Hill, Boston, 1998.
5. Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw Hill Co., 1985

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<b>22UPEST1C03</b>	<b>BASICS OF THERMODYNAMICS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		3	1	0	4

**COURSE OBJECTIVES**

- To apply concepts of thermodynamics and Zeroth Law in solving numerical problems with relevant units.
- To analyze and evaluate different forms work, heat and other properties by applying 2<sup>nd</sup> Law of thermodynamics.
- To understand entropy concepts in thermodynamics.
- To explain pure substance with various diagrams, explain with sketches different calorimeters and to solve numerical problems using steam tables or fundamental equations.
- To apply ideal and real gases laws in solving related numerical problems for various conditions.

**UNIT – I: INTRODUCTION AND BASIC CONCEPTS**

Thermodynamics and Energy - Importance of Dimensions and Units - Systems and Control Volumes - Properties of a System - Density and Specific Gravity - State and Equilibrium - Processes and Cycles - Temperature and the Zeroth Law of Thermodynamics – Pressure - The Manometer - The Barometer and Atmospheric Pressure.

**UNIT – II: ENERGY CONVERSION AND GENERAL ENERGY ANALYSIS**

Forms of Energy - Energy Transfer by Heat - Energy Transfer by Work - Energy Transfer by Work - The First Law of Thermodynamics - Energy Conversion Efficiencies - Energy and Environment- Energy Analysis of Steady-Flow Systems - Some Steady - Flow Engineering Devices - The Second Law of Thermodynamics

**UNIT–III: ENTROPY**

Entropy - The Increase of Entropy Principle - Entropy Change of Pure Substance - Isentropic Processes - Property Diagrams Involving Entropy - Entropy Change of Liquids and Solids - The Entropy Change of Ideal Gases - Reversible Steady-Flow Work- Minimizing the Compressor Work - Entropy Balance.

**UNIT – IV: EXERGY**

Exergy: Work Potential of Energy - Reversible Work and Irreversibility - Second-Law Efficiency - Exergy Change of a System - Exergy Transfer by Heat, Work, and Mass - The Decrease of Exergy Principle and Exergy Destruction Exergy Destruction - Exergy Balance: Closed Systems- Exergy Balance: Control Volumes.

**UNIT – V: THERMODYNAMIC PROPERTY RELATIONS**

The Maxwell Relations - The Clapeyron Equation - General Relation - The Joule-Thomson Coefficient- Enthalpy Changes of Real Gases - Internal Energy Changes of Real Gases - Entropy Changes of Real Gases.

**COURSE OUTCOME**

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

- Know the thermodynamics laws and their applications.
- Apply concepts of thermodynamics and Zeroth Law in solving numerical problems with relevant units.
- Analyze of a system's thermal energy per unit temperature that is unavailable for doing useful work.
- Illustrate problem solving procedure related to pure substances using PT, PV, TH diagrams.
- Apply ideal and real gases laws in solving related numerical problems for various conditions.

**REFERENCE BOOKS**

1. Yunus A Cengel, Thermodynamics, McGraw-Hill, An Engineering Approach, 2007
2. Sachdeva R C, "Fundamentals of Engineering Heat and Mass Transfer" New Age International, 1995.
3. Holman.J.P., "Thermodynamics", 3d Ed. McGraw-Hill, 1995.
4. Arora C.P, "Thermodynamics", Tata McGraw-Hill, New Delhi, 2003.
5. Kothandaraman C.P "Fundamentals of Heat and Mass Transfer" New Age International, New Delhi, 1998.

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<b>22UPEST1C04</b>	<b>APPLIED MATHEMATICS FOR ENERGY</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		3	1	0	4

**COURSE OBJECTIVES**

- To make students understand with the first-order ODES
- To solving of homogeneous and non-homogeneous linear ODE problem with applications
- To explain the numerical analysis of solving of a partial differential equation
- To provide the details of dimensional and model analysis with applications
- To impart the knowledge of about conformal mapping with different applications

**UNIT – I: FIRST- ORDER ODES**

First-Order ODEs – Basic Concepts- Modeling -Concept of Solution -Separable ODEs. Modeling- Examples -Heating an Office Building -Leaking Tank. Outflow of Water Through a Hole -Extended Method: Reduction to Separable Form.

**UNIT – II: LINEAR ODES**

Linear ODEs. Bernoulli Equation. - Homogeneous Linear ODE.-Non-Homogeneous Linear ODE.-First-Order ODE, General Solution, Initial Value Problem-Electric Circuit-Reduction to Linear Form. Bernoulli Equation.

**UNIT–III: A PARTIAL DIFFERENTIAL EQUATION (PDE)**

Basic Concepts of PDEs- -Important Second-Order PDEs-Physical Assumptions-Modeling: Vibrating String, Wave Equation - Solution by Separating Variables. Two ODEs from the Wave Equation- Satisfying the Boundary Conditions -Solution of the Entire Problem Fourier Series-D’Alembert’s Solution of the Wave Equation. Characteristics

**UNIT – IV: DIMENSIONAL AND MODEL ANALYSIS**

Heat Flow from a Body in Space -Physical Assumptions -Heat Equation -Solution by Fourier series. Steady Two-Dimensional Heat Problems. Dirichlet Problem -Sinusoidal Initial Temperature -“Triangular” Initial Temperature in a Bar-Modeling Very Long Bars. Solution by Fourier Integrals and Transforms

**UNIT – V: CONFORMAL MAPPING AND POTENTIAL THEORY**

Conformal Mapping- Geometry of Analytic Functions: Conformal Mapping- Complex Analysis and Potential Theory- Electrostatic Fields-Use of Conformal Mapping. Modeling- Heat Problems- Temperature Between Parallel Plates-Temperature Distribution Between a Wire and a Cylinder-A Mixed Boundary Value Problem-Fluid Flow-Flow Around a Corner-Flow Around a Cylinder.

**COURSE OUTCOME**

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

- Providing knowledge about basics of first-order ODES
- To understand Linear ODEs and nonlinear equation
- Imparting theoretical knowledge about boundary problem
- Students will gain deeper understanding of the Fourier series by mastering the theory of heat boundary value problems with various applications.
- Students will gain practical knowledge of conformal mapping with fluid and heat problem

**REFERENCE BOOKS**

1. Irvin Kreyszig, Advanced Engineering Mathematics, Wiley Publisher, 2017.
2. Dutta. D, Mathematical Methods, New Age International (P) Ltd. New Delhi, 2007.

3. Jain M K., Iyengar S R K., Jain R K; Numerical Methods for Scientific and Engineering Computation, New Age International (P) Ltd. New Delhi, 1993.
4. Versteeg and Malalasekera, N, “An Introduction to computational Fluid Dynamics Finite Volume Method,” Pearson Education, Ltd., Second Edition, 2014.

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**22UPEST1C05****ENERGY LABORATORY**

L	T	P	C
0	0	4	2

**COURSE OBJECTIVES**

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

**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).

**COURSE OUTCOME**

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

- Understand the working of solar hot water heater and calculate the thermal efficiency of the system.
- Operate solar PV devices under different operating parameter and evaluate their performance



- Investigate the performance of Wind Energy Generator
- Evaluate the thermal properties of various fuel
- Examine thermal heat storage systems and determine the performance of various PCM materials
- Handle solar simulator and assess solar cell performance
- Analyze the factors influencing the efficiency and suggest methods for improving the adaptability and efficiency of renewable energy gadgets

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22UPEST1C06

TECHNICAL SEMINAR

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
0	0	2	1

**COURSE OBJECTIVES**

This course aims to help students acquire the employability skills necessary for the workplace through technical presentation. It also attempts to meet the expectations of the employers by giving special attention to presentation skills and soft skills. This aim will be achieved through expert guidance and teaching activities focusing on the above listed skills and language skills.

**SEMINAR EVALUATION**

Internal (40 Marks)			External (60 Marks)		
Presentation I	Presentation II	Presentation III	Dissertation	Presentation	Viva Voce
10	10	20	20	30	10

	L	T	P	C
<b>22UPEST1C07</b>				
<b>THERMAL ENERGY CONSERVATION</b>	3	1	0	4

## COURSE OBJECTIVES

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

### UNIT – I: ENERGY CLASSIFICATION

Energy Classification, Principle fuels for energy conversion: Fossil fuels, nuclear fuels, conventional & Non-conventional energy sources : prospecting, extraction and resource assessment and their peculiar characteristics. Direct use of primary energy sources, conversion of primary into secondary energy sources such as Electricity, Hydrogen, And Nuclear energy etc. Energy conversion through fission and fusion, Nuclear power generation

### UNIT – II: THERMAL AND MECHANICAL ENERGY

Production of Thermal energy using fossil fuels, Bio-mass and solar energy Production of Mechanical energy using thermal energy, electric energy (electric motors) Turbines: Steam turbines, Hydraulic turbines and wind turbines.

### UNIT–III: THERMAL ENERGY UTILITY SYSTEMS

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. 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-IV: COGENERATION

Cogeneration: Definition, need, application, advantages, classification, saving potentials Waste heat recovery: Concept of conversion efficiency, energy waste, waste heat recovery classification, advantages and applications, commercially viable waste heat recovery devices

### 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**

- To know the classification of energy from different sources
- Evaluate the performance of fuel and biomass under different operating conditions
- Know the Boiler, Steam and energy efficiency opportunities in steam systems
- Know the classification and working of different cogeneration system
- Know the design of different waste heat recovery and heat exchangers.

**REFERENCE BOOKS**

1. Direct energy conversion : W.R. Corliss, 2021
2. Energy conversion principles : Begamudre , Rakoshdas, 2005
3. Energy Manager Training Manual (4Volumes) available at [www.energymanagertraining.com](http://www.energymanagertraining.com), a website administered by Bureau of Energy Efficiency (BEE), a statutory body under Ministry of Power, Government of India,2015.
4. Yunus A. Cengel, Afshin J. Ghajar, Heat and Mass Transfer: Fundamentals & Applications in SI Units, 6th Edition, McGraw-Hill Education, 2020
5. Fuels & Combustion by Sharma S.P. &Chander Mohan, Tata McGraw Hill Publishing Co. Ltd.,1987
6. Cohen, H., Rogers, G F C and Saravanmotto, H I H, Gas Turbine Theory, John Wiley, 5th Edition, 2001.
7. Stoecker, W.F., Design of Thermal Systems, McGraw Hill, 2011.

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22UPEST1C08

**ELECTRICAL SYSTEMS - ENERGY  
CONSERVATION**

L	T	P	C
3	1	0	4

**COURSE OBJECTIVES**

- To learn the basics of electrical energy conversion
- To learn electrical transmission and distribution system and Electrical motors
- 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**

Importance of Electrical energy in modern industrial society - Electricity generation using renewable energy sources : Basic principles and applications. (Conversion of electromagnetic energy and natural energy sources like solar radiation, wind, ocean waves solid waste to electricity) Conversion of chemical energy into electric energy (fuel cell) Thermal power plant, nuclear power plants and hydroelectric power plant, Transmission and distribution of electricity

**UNIT – II: ELECTRIC ENERGY SYSTEMS**

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 – III: PUMPING SYSTEM**

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**

- To know the electrical energy generation process
- Evaluate the efficiency and losses in electrical system
- Determine the performance fans, blowers and pumping system and understand the parameters and terminologies used
- Adopt the compressed air system based on application with energy conservation
- Familiarized about the use of HVAC and refrigeration system
- Know the energy conservative measures and efficient in lighting systems

**REFERENCE BOOKS**

1. Direct energy conversion : M.A. Kettani, 2008
2. Energy Manager Training Manual (4Volumes) available at [www.energymanager training.com](http://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

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22UPEST1C09

**BASICS OF COMPUTATIONAL FLUID DYNAMICS**

L	T	P	C
3	1	0	4

**COURSE OBJECTIVES**

- Developing mathematical models for Boundary Value Problems and their numerical solution.
- Applying concepts of Finite Element Analysis to solve one dimensional problem.
- Determining field variables for two dimensional scalar variable problems.
- Determining field variables for two dimensional vector variable problems.
- Applying the need for isoparametric transformation and the use of numerical integration

**UNIT – I: INTRODUCTION**

Historical Background – Mathematical Modeling of field problems in Engineering – Governing Equations – Discrete and continuous models – Boundary, Initial and Eigen Value problems– Weighted Residual Methods – Variational Formulation of Boundary Value Problems – Ritz Technique – Basic concepts of the Finite Element Method.

**UNIT – II: ONE-DIMENSIONAL PROBLEMS**

One Dimensional Second Order Equations – Discretization – Element types- Linear and Higher order Elements – Derivation of Shape functions and Stiffness matrices and force vectors-Assembly of Matrices - Solution of problems from solid mechanics including thermal stresses-heat transfer. Natural frequencies of longitudinal vibration and mode shapes. Fourth Order Beam Equation Transverse deflections and Transverse Natural frequencies of beams.

**UNIT-III: TWO DIMENSIONAL SCALAR VARIABLE PROBLEMS**

Second Order 2D Equations involving Scalar Variable Functions – Variational formulation – Finite Element formulation – Triangular elements and Quadrilateral elements- Shape functions and element matrices and vectors. Application to Field Problems - Thermal problems – Torsion of Non circular shafts.

**UNIT-IV: TWO DIMENSIONAL VECTOR VARIABLE PROBLEMS**

Equations of elasticity – Plane stress, plane strain and axisymmetric problems – Constitutive matrices and Strain displacement matrices – Stiffness matrix – Stress calculations - Plate and shell elements.

**UNIT – V: ISOPARAMETRIC FORMULATION AND ADVANCED TOPICS**

Natural co-ordinate systems – Isoparametric elements – Shape functions for isoparametric elements – One and two dimensions – Serendipity elements – Numerical integration - Matrix solution techniques – Solutions Techniques to Dynamic problems – Introduction to Analysis Software- Introduction to Non Linearity.

**COURSE OUTCOME**

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

- Build up mathematical models for Boundary Value Problems and their numerical solution
- Relate concepts of Finite Element Analysis to resolve one dimensional problems
- Conclude field variables for two dimensional scalar variable problems
- Establish field variables for two dimensional vector variable problems
- Appropriate the need for Isoparametric transformation and the use of numerical integration

**REFERENCE BOOKS**

1. David Hutton, “Fundamentals of Finite Element Analysis”, Tata McGrawHill, 2005
2. Dhanaraj. R and Prabhakaran Nair. K, “Finite Element Analysis”, Oxford Publications, 2015.
3. Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt, “Concepts and Applications of Finite Element Analysis”, 4th Edition, Wiley Student Edition, 2004
4. Seshu.P, “Text Book of Finite Element Analysis”, PHI Learning Pvt. Ltd., NewDelhi, 2012.
5. TirupathiR.Chandrupatla and Ashok D.Belegundu, “Introduction to Finite Elements in Engineering”, International Edition, Pearson Education Limited, 2014

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22UPEST1C10

**RESEARCH METHODOLOGY AND  
INTELLECTUAL PROPERTY RIGHTS**

L	T	P	C
4	0	0	4

**COURSE OBJECTIVES**

- Identify an appropriate research problem in their interesting domain
- Understand ethical issues and the Preparation of a research project thesis report.
- Understand significance, effective technical writing and report
- Understand the law of patent and copyrights
- Understand 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 - 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 about a variable - Writing a bibliography – evaluation - Types of 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 – Copyrights – Trademarks

**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**

- Understand the characteristics, objects of a good research problem
- Understand the principles of ethics and ethical issues in science and engineering
- Understand writing a research report as per format.
- Ability to understand that today’s world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity
- Ability to understand about IPR and filing patents in R & D

**REFERENCE BOOKS**

1. Ranjit Kumar, “Research Methodology: A Step by Step Guide for beginners” 3rd Edition 2011, Sage Publication
2. Intellectual Property Rights-Law and Practice, Module 3, The Institute of Company



Secretaries of India

3. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
4. Niebel, "Product Design", McGraw Hill, 1974.
5. Mayall, "Industrial Design", McGraw Hill, 1992.

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3	H	-	L	-	H	-	-	H	H	H	-	H	-	-	H
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5	H	-	-	-	H	-	-	H	H	H	-	H	-	-	H

<b>22UPSOC2H01</b>	<b>FUNDAMENTALS OF HUMAN RIGHTS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		4	0	0	4

**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.

**REFERENCE BOOKS**

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

<b>22UPEST1C11</b>	<b>COMPUTER AIDED DESIGN AND SIMULATION LABORATORY</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		0	0	4	2

**COURSE OBJECTIVES**

- To know the basics of drawing
- To gain practical experience in handling 2D design and drafting.
- To provide a platform to learn and get familiar with computational analysis
- To learn the simulation and analysis software for solving of flow with heat transfer related problems
- To understand the boundary conditions for various 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. Isometric views creation of cone
4. Isometric views creation of cylinder
5. Isometric views creation of hexagonal prism
6. Isometric views creation of pentagonal prism
7. Isometric views creation of title block
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**

- Understand the different types of views projection views
- Two dimensional surface creation with isometric views.
- Use modern engineering software tools to analyze the flow with heat transfer related problems
- Analyze the various parameters influencing the performance of thermodynamic systems
- Learn modelling and measurement tools to solve flow problems related to heat transfer

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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	-	-

<b>22UPEST1C12</b>	<b>HYDROGEN STORAGE SYSTEM</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		4	0	0	4

**COURSE OBJECTIVES**

- To foundational knowledge of properties energy and related fields.
- To make the students acquire an understanding the power fuel cells automobiles
- 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-POWERED FUEL CELL AND HYBRID AUTOMOBILES**

Introduction-Fuel Cells-Hydrogen Fuel Cell Applications -Near-Future Hydrogen-Driven Cars and Industry Milestones-European Hydrogen and Fuel Cell Projects- Hydrogen Transportation Concepts by Geographic Region- 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 - Pipelines and Underground Hydrogen Storage -Materials-Based Hydrogen Storage - Technical Targets and Status -Industrial Application of Hydrogen Energy - Electrical Energy Storage-Characteristics of Electricity -Electricity and the Roles of Electrical Energy Storage-Strategic Asset Management of Power Networks-Orchestrating Infrastructure for Sustainable Smart Cities -Smart Technology Solutions Create Value-New

**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-7.8 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**

- Learn about the background on hydrogen and their properties.
- Gain knowledge about power fuel cells automobiles
- Understand the hydrogen energy and driving renewable energy and the impact on environment
- Apply their learned knowledge to develop hydrogen storage processes and technologies
- Design hydrogen production for various energy applications

**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.

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

<b>22UPEST1C13</b>	<b>NANOMATERIALS FOR ENERGY APPLICATIONS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		4	0	0	4

**COURSE OBJECTIVES**

- To foundational knowledge of Nanoscience and related fields.
- To make the students acquire an understanding 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, Magnetic Properties, Optical Properties, Wear Resistance, 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), Scanning probe microscopy (SPM), Gas adsorption. Chemical Characterization -Optical spectroscopy (Raman Spectroscopy, UV–vis Spectroscopy, Photoluminescence Spectroscopy, Fourier Transform Infrared Spectroscopy), Electron spectroscopy, Ionic spectrometry, Light Scattering Method, X-ray Photoelectron Spectroscopy, Thermal Analyzer, Zeta Potential.

**UNIT – V : APPLICATIONS**

Nanofluids - Automotive Applications, Coolants, Dynamic Seal. Hydrogen Storage, Solar Energy - Photoelectrochemical 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**

- Learn about the background on nanoscience.
- Gain knowledge in properties of nanomaterials.
- Understand the synthesis of nanomaterials and their application and the impact of nanomaterials on environment
- Apply their learned knowledge to develop Nanomaterial's by different characterization techniques
- Design nanomaterials for various energy applications

**REFERENCE BOOKS**

1. Nanostructures and nanomaterials, synthesis, properties and applications, Guozhong Cao, USA, Imperial college Press, 2004.
2. Nanomaterials and nanocomposites, synthesis, properties, characterization techniques and applications, Rajendra Kumar Goyal, CRC press, 2018.
3. Nanostructured Materials and Nanotechnology, Hari Singh Nalwa, Academic Press, 2008
4. Nanocrystals: Synthesis, Properties and Applications, C. N. R. Rao, P. J. Thomas and G.U. Kulkarni, Springer, 2007.
5. A. S. Edelstein and R. C. Cammarata, "Nanomaterials: Synthesis, Properties and Applications", Institute of Physics Pub., 2001.

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

<b>22UPEST1C14</b>	<b>ENERGY STORAGE SYSTEMS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		4	0	0	4

**COURSE OBJECTIVES**

- To understand the concept lead acid battery
- To study the various applications and working of lithium-ion battery
- To acquire the knowledge of various types of metal- air battery
- To understand the fundamental theories that explain design of fuel cells
- To comprehend the concepts of hybrid energy storage systems

**UNIT – I : LEAD ACID BATTERY**

Advantages and disadvantages of lead acid batteries - Electrochemical reactions - Physical and chemical properties of active materials - Characteristics and properties of sulphuric acid - Constructional features - Materials and manufacturing methods - SLI (Automotive) batteries - Charge and discharge properties of lead acid batteries - Sealed lead acid or maintenance free batteries fabrication technology and testing - Lead acid battery for PV and automotive applications.

**UNIT – II : LITHIUM-ION BATTERY**

Advanced anodes and cathodes – Theoretical capacity – Merits and demerits Nanomaterials for anodes - Carbon nanotubes - SnO<sub>2</sub> – NiO - TiO<sub>2</sub>& LiTiO<sub>4</sub> Battery fabrication technology and testing - Batteries for electric vehicles - Hybrid vehicles and solar photovoltaic applications.

**UNIT– III : METAL-AIR BATTERIES**

Lithium-Air - Sodium-Air – Zinc - Air batteries - Principle – Components – anodes – Cathodes- Fabrication – Evaluation – Merits - Demerits and Applications.

**UNIT- IV : FUEL CELLS**

Membrane electrode assemblies – Fabrication - Catalyst layer - Fuel cell supports – Gas diffusion layer - Bipolar plates - Fuel cell catalysts – Precious and non-precious metal catalysts - Bi-functional catalysts – Nanomaterials for low temperature fuel cells – Reversible fuel cells - Fuel cell stacks and systems - Fuel cells for vehicles and grid connected applications.

**UNIT – V : HYBRID ENERGY SYSTEMS**

Concept of hybrid energy systems - Supercapacitors – Fundamentals and types - Battery/supercapacitors hybrid systems – Example – Applications - Hybrid fuel cell/battery systems – Example – Applications.

**COURSE OUTCOME**

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

- Gain knowledge in lead acid batteries.
- Acquire knowledge in Industrial and usage of Li-Ion batteries
- Advance technologies used in Metal air batteries
- Recent trends of technology used fuel cells.
- Advancement of hybrid storage systems

**REFERENCE BOOKS**

1. Linden's Handbook Of Batteries, Thomas B. Reddy , David Linden, 4<sup>th</sup> Edition, McGraw Hill, 2011.
2. Electrochemical power sources, Batteries, Fuel Cells, and Supercapacitors, Vladimir S. Bagotsky, Alexander M. Skundin, Yuriy M. Volkovich, Wiley, Canada, 2015.
3. Energy Storage Fundamentals, Materials and Applications Second Edition, Robert A. Huggins,



USA, Springer, 2016.

4. Fuel Cells, Solar Panels and Storage Devices Materials and Methods, Johannes Karl Fink, John Wiley & Sons, USA, 2018.
5. Metal–Air Batteries Fundamentals and Applications, Xin-bo Zhang, Wiley VCH, Germany, 2018.
6. Modern electric, hybrid electric and fuel cells vehicles: fundamentals, theory and design, 2<sup>nd</sup> edition, Mehrdad Ehsani, Ali Emadi, YiminGao, USA, CRC press, 2010.

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

**22UPEST1C15****INTERNSHIP**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
0	0	0	2

**COURSE OBJECTIVES**

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.

<b>Duration of Internship</b>	<b>Credits</b>
2 Weeks to 4 weeks	2

At the end of internship, the student shall submit a report. A Two-member committee constituted by the Head of the Department will conduct the Viva-Voce Examination. The committee comprises of one expert member from an industry/institutions and One member (Coordinator) from the Department.

**INTERNSHIP TRAINING EVALUATION**

<b>Report</b>	<b>Presentation</b>		<b>Viva Voce</b>		<b>Total</b>
<b>External</b>	<b>External</b>	<b>Internal</b>	<b>External</b>	<b>Internal</b>	
40	15	15	15	15	100

**22UPEST1C16****PROJECT WORK PHASE I**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
0	0	10	5

**COURSE OBJECTIVES**

A research project topic may be selected either from published lists or from the creative ideas of the students themselves in consultation with their project supervisor

**EVALUATION**

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

<b>Project work</b>	<b>Internal (40 Marks)</b>			<b>External (60 marks)</b>			
Phase I	Review I	Review II	Review III	Thesis Evaluation (External)	Viva –voice 45 Marks		
	10	10	20		15	Supervisor	External
					15	15	15

**OUTCOME**

The students would apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to the students to be creative, well planned, organized, coordinated in their project work phase – II.

22UPEST1C17

**PROJECT WORK PHASE II**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
0	0	28	14

**COURSE OBJECTIVES**

The objective of the research project work is to produce factual results of their applied research idea in the energy science, from phase – I.

**EVALUATION**

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

Project work	Internal (80 Marks)				External (120 marks)			
	Phase II	Review I	Review II	Review III	Conference Presentation/ Journal Article/ Book Chapter Publication/Patent	Thesis Evaluation (External)	Viva –voice 90 Marks	
Supervisor							External	Internal
20		20	30	10	30	30	30	30

**OUTCOME**

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

**PROFESSIONAL ELECTIVES****22UPEST1E01****POWER PLANT ENGINEERING**

L	T	P	C
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:**

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

**REFERENCE BOOKS**

1. Nag, P.K., Power Plant Engineering, Tata McGraw Hill Publishing Co Ltd, New Delhi, 2002.
2. R.K. Rajput., “A Textbook of Power Plant Engineering” 5th edition-2016.
3. Arora and Domkundwar, A course in power Plant Engineering, Dhanpat Rai and CO, 2004.
4. Haywood, R.W., Analysis of Engineering Cycles, 4th Edition, Pergamon Press, Oxford, 1991.

5. Wood, A.J., Wollenberg, B.F., Power Generation, operation and control, John Wiley, New York,1984.

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

22UPEST1E02	ELECTRICAL DRIVES AND CONTROLS	L	T	P	C
		4	0	0	4

### COURSE OBJECTIVES

- To expose students to the operation, application and control of power conversion systems employing electric drive to cater to industrial needs.
- To familiarize the operation principles, and design of starting, braking, and speed control arrangements for electric motors and their applications
- To provide strong foundation to assess performance of different industrial drives
- To Design new control and power conversion schemes
- To justify and implementing alternative solutions considering the critical and contemporary issues

### UNIT – I : REVIEW OF CONVENTIONAL MOTOR DRIVES

Characteristics of DC and AC motors for various applications - starting and speed control -methods of breaking.

### UNIT – II : PHYSICAL PHENOMENA IN ELECTRICAL MACHINES

Various losses in motors - Saturation and Eddy current effects -mmf harmonics and their influence of leakage - stray losses -vibration and noise.

### UNIT– III : INTRODUCTION TO SOLID STATE POWER CONTROLLERS

Power devices - Triggering Circuits - Rectifiers - Choppers. Invertors - AC Controllers

### UNIT- IV : SUPERCONDUCTIVITY

Super conducting generators - motors and magnets -Super conducting magnetic energy storage (SMES).

### UNIT – V : SOLID STATE MOTOR CONTROLLERS

Single and Three Phase fed DC motor drives -AC motor drives -Voltage Control -Rotor resistance control Frequency control - Slip Power Recovery scheme

### COURSE OUTCOME

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

- Examine various applications in industrial and domestic areas where use of electric drives are essential.
- Classify types of electric drives systems based on nature of loads, control objectives, performance and reliability.
- Combine concepts of previously learnt courses such as, electrical machines, Control and power electronics to cater to the need of automations in industries.
- Select most suitable type and specification of motor drive combination for efficient conversion and control of electric power.
- Identify the critical areas in application levels, and derive typical solutions.

### REFERENCE BOOKS

1. Electrical drives concept and application, Vedham Subramaniam, Tata McGraw Hill publications, (2011)
2. Fundamental of Electrical Drives, G.K. Dubey, New Age International Publication
3. Electric motor drives, R. Krishnan, PHI
4. Modern Power Electronics & Ac drives, B.K. Bose, Pearson Education.
5. Electric Motor & Drives. Austin Hughes, Newnes.

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

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>22UPEST1E03</b>				
<b>COGENERATION AND WASTE HEAT RECOVERY</b>				
	4	0	0	4

**COURSE OBJECTIVES**

- To gain fundamental knowledge in energy generation, heat transfer in thermal engineering.
- To reduce the impact global warming for betterment of living things to serve healthy life.
- To knowledge on recovery of waste heat recovery
- To know the impact on environmental of waste heat recovery
- To identify the techniques on waste heat recovery

**UNIT – I: COGENERATION**

Introduction - Principles of Thermodynamics - Combined Cycles - Topping – Bottoming - Organic Rankine Cycles - Advantages of Cogeneration Technology

**UNIT – II: APPLICATION & TECHNO ECONOMICS OF COGENERATION**

Cogeneration Application in various Industries like Cement, Sugar Mill, Paper Mill etc. Sizing of Waste Heat Boilers - Performance Calculations - Part Load Characteristics. Selection of Cogeneration Technologies - Financial Considerations-Operating and Investments - Costs of Cogeneration.

**UNIT–III: WASTE HEAT RECOVERY**

Introduction - Principles of Thermodynamics and Second Law - Sources of Waste Heat Recovery - Diesel Engines and Power Plant etc.

**UNIT-IV: WASTE HEAT RECOVERY SYSTEMS, APPLICATIONS & TECHNO ECONOMICS**

Recuperators - Regenerators - Economizers - Plate Heat Exchangers - Waste Heat Boilers - Classification, Location, Service Conditions, Design Considerations, Unfired Combined Cycle - Supplementary Fired Combined Cycle - Fired Combined Cycle. Applications in Industries - Fluidized Bed Heat Exchangers - Heat Pipe Exchangers - Heat Pumps - Thermic Fluid Heaters Selection of Waste Heat Recovery Technologies - Financial Considerations - Operations and Investment Costs of Waste Heat Recovery

**UNIT – V: ENVIRONMENTAL CONSIDERATIONS**

Environmental considerations for Cogeneration and Waste Heat Recovery – Pollution

**COURSE OUTCOME**

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

- The students will acquire fundamental knowledge in energy generation,
- Understand heat transfer in thermal engineering.
- Students will get the ability solve problems using mathematical concepts and to use modern engineering tools, software and equipment
- To analyze and solve complex engineering problems.
- The students will be able to solve real world problems and reduce the impact global warming for betterment of living things to serve healthy life.

**REFERENCE BOOKS**

1. Charles H Butler, Cogeneration, McGraw Hill Book Co., 1984.
2. Horlock JH, Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford, 1987.



3. Institute of Fuel, London, Waste Heat Recovery, Chapman & Hall Publishers, London, 1963.
4. Nag P. K, Power Plant Engineering, 4e, Tata McGraw Hill, 2001.
5. Sengupta Subrata, Lee SS EDS, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.
6. De Nevers, Noel., Air Pollution Control Engineering, Mcgraw Hill, New York, 1995.

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<b>22UPEST1E04</b>	<b>INDUSTRIAL INSTRUMENTATION</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		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 – Pyrrometers – Pyrgeometers – Net Pyrrometers – 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 Servo motors. Measurement by Data Acquisition System. Introduction to Internet of Things (IoT) – Application of IoT with Raspberry Pi for Process monitoring and control – Energy management. 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**

- Analyze and evaluate the uncertainties in measurement data.
- Identify appropriate sensors for measuring electrical quantities and signal conditioning circuits.
- Explain the digital measurement techniques of physical quantities.

- Implement the measurement of thermo-physical properties and air pollutants.
- Design and develop the appropriate measurement and control system for an application.

**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.

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22UPEST1E05

**HYDRO POWER SYSTEMS**

L	T	P	C
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**COURSE OBJECTIVES**

- To understand the process of generation of hydropower, its potential & energy extraction.
- To provide knowledge of planning, design and development of hydroelectric power plants
- To understand the aerodynamic principle of turbine blade design.
- 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**

- Understand the hydrodynamics of open-channel flows.
- Understand the hydraulic design/sizing of the main components of a Hydro power Plant
- Compute steady-state profiles of open-channel flows with variable geometry and discharge.
- Carry out the main hydrological analyses necessary for the design of hydroelectric systems and simulation of their productivity
- Estimate the hydrological alterations induced by the presence of hydroelectric power stations.

**REFERENCE BOOKS**

1. Monition, L., M. Lenir and J. Roux, (1984) Micro Hydro Electric Power Station
2. Alen R. Inversin, (1986) Micro Hydro Power Source Book
3. Tyler G. Hicks (1988), Power Plant Evaluation and Design

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<b>22UPEST1E06</b>	<b>PRINCIPLES AND APPLICATIONS OF HYDROGEN STORAGE</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		4	0	0	4

**COURSE OBJECTIVES**

- To impart knowledge on use of hydrogen for achieving sustainable growth
- To facilitate analysis of the challenges in transition to hydrogen economy
- To understand and demonstrate the hydrogen production technologies, storage methods and strategies for transition to hydrogen economy
- To know the concepts and characteristics of various types of fuel
- To know the application of fuel cells with economic and environment analysis

**UNIT – I: INTRODUCTION**

History of hydrogen – origin of hydrogen emission – molecular hydrogen – hydrogen in engineering – hydrogen bond – photosynthesis – bio hydrogen

**UNIT – II: THERMODYNAMICS**

Gibbs Phase Rule; Pressure-Composition-Temperature plots; Van't Hoff plots for absorption desorption enthalpies; Gravimetric capacities; Hysteresis in cycling; Joule-Thomson Effect, Non- ideal treatment of hydrogen gas

**UNIT–III: HYDROGEN PRODUCTION**

Semiconductor catalyst – water splitting and nano technology – steam reforming – partial oxidation - electrolysis – thermolysis

**UNIT-IV: DESIGN AND APPLICATIONS OF STORAGE SYSTEMS**

Conventional methods of hydrogen storage – solid state; metal organic – Zeolites – carbons – interstitial hydrides – AB<sub>5</sub> & AB<sub>2</sub> compound

**UNIT – V: HYDROGEN FUEL CELL**

Hydrogen fuel cell design – proton exchange membrane fuel cells – preparation of nafion membrane - catalyst

**COURSE OUTCOME**

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

- Upon successful completion of the course, the student will be able to
- Evaluate the performance of fuel cells under different operating conditions.
- Select and defend appropriate fuel cell technology for a given application.
- Design and develop suitable hydrogen storage system to be used along with fuel cell system.
- Minimize environmental hazards associated with the use of hydrogen storage and fuel cell

**REFERENCE BOOKS**

1. Alexander Gavriluk, Hydrogen energy for Beginners, Pan Stanford, publishing Pvt, Ltd, 2014
2. Angelo Basile, Adolfo Iulianelli, Advances in Hydrogen Production, Storage and Distribution, 1st Edition, Woodhead Publishers, Cambridge (UK), 2014.
3. Gavriluk, Hydrogen Energy for Beginners, Pan Sanford Publication private ltd. UK
4. Michael Hirscher, Hand Book of Hydrogen Storage, 1st Edition, Wiley-VCN Verlag GmbH, 2010.
5. Gavin Walker, Solid State Hydrogen Storage: Materials and Chemistry, 1st Edition, Woodhead Publishers, Cambridge (UK), 2008.
6. Rober A. Varin, Tomasz Czujko, Zbigniew S. Wronski, Fuel Cells and Hydrogen Energy Series: Nanomaterials for Solid State Hydrogen storage, 1st Edition, Springer, 2009.

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<b>22UPEST1E07</b>	<b>WASTE MANAGEMENT AND ENERGY RECOVERY TECHNIQUES</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		4	0	0	4

**COURSE OBJECTIVES**

- To provide information on various methods of waste management
- To familiarize students with recent energy generation techniques
- To detail on the recent technologies of waste disposal
- To know about the disposal of hazardous wastes.
- To make student realize on the importance of healthy environment

**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**

- Waste characterization, Segregation, Disposal will be made known
- Technologies that are available for effective waste disposal along with pros / cons will become clearer to students
- Able to convert waste into useful energy.
- First-hand information on present day waste related problems (Hazardous Waste, Pharma Waste, Biomedical Waste etc)
- Get awareness on the healthy environment.

**REFERENCE BOOKS**

1. Tchobanoglous, Theisen and Vigil, Integrated Solid Waste Management, 2d Ed. McGraw Hill, New York, 1993.
2. Howard S. Peavy et al, Environmental Engineering, McGraw Hill International Edition, 1985
3. La Grega, M., et al., Hazardous Waste Management, McGraw Hill, c. 1200 pp., 2nd ed., 2001.
4. Stanley E. Manahan. Hazardous Waste Chemistry, Toxicology and Treatment, Lewis Publishers,



Chelsea, Michigan, 1990

5. Parker, Colin and Roberts, Energy from Waste – An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985.
6. Manoj Datta, Waste Disposal in Engineered Landfills, Narosa Publishing House, 1997.

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<b>22UPEST1E08</b>	<b>BASICS OF SOLAR ENERGY TECHNOLOGIES</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		4	0	0	4

**COURSE OBJECTIVES**

- To impart the knowledge on the basics of solar energy and laws related to it.
- To understand the physics of sun, angles and solar time.
- To study the principle operations, types and applications of solar cells.
- To provide insights of solar thermal collectors and basic solar cycles.
- To understand the concepts of various energy storage technologies

**UNIT – I: INTRODUCTION**

Solar Radiation and Measurement, Solar angles, day length, angle of incidence on tilted surface; Sun-path diagrams; Extra-terrestrial characteristic, Analysis of Indian solar radiation data and applications, pyranometer, pyrheliometer

**UNIT – II: HEAT TRANSFER AND RADIATION CHARACTERISTICS**

Planck's Law and Wien's Displacement Law - Stefan-Boltzmann Equation - Radiation Intensity and Flux - Radiation Heat Transfer Coefficient - Wind Convection Coefficients - Absorptance and Emittance - Kirchhoff's Law

**UNIT-III: SOLAR COLLECTORS**

Flat-Plate Collectors - Basic Flat-Plate Energy Balance - Effects of Dust and Shading - Concentrating Collectors - Collector Configurations - Concentration Ratio - Thermal Performance of Concentrating Collectors - Paraboloidal Concentrators - Central-Receiver Collectors

**UNIT-IV: SOLAR PHOTOVOLTAICS**

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

**UNIT – V: ENERGY STORAGE**

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

**COURSE OUTCOME**

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

- Enumerate the basic laws related to the solar radiation.
- Predict the solar time due to the motion of the earth with respect to sun
- Provide accurate diagrams of solar cells and be able to classify solar cells
- Formulate scientific questions about the imaging type concentrating collectors.
- Identify and classify the different energy storage techniques

**REFERENCE BOOKS**

1. Sukhatme.S.P., "Solar Energy: Principles of Thermal Collection and Storage", Tata McGraw, 2008
2. Sukhatme S.P. J K Nayak, Solar Energy, Tata McGraw Hills P Co., ISBN: 9789352607112, 4th Edition, , pp. 568, 2017
3. M. Stix, The Sun, An Introduction, Second Edition, Springer, 2002
4. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications , 2nd edition, PHI Publications, pp. 512, 2011
5. Joshwa Earnest., Wind Power Technologies, Second Edition, Eastern Economy Edition, 2014

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22UPEST1E09

NUCLEAR ENERGY TECHNOLOGY

L	T	P	C
4	0	0	4

**COURSE OBJECTIVES**

- To understand the main aspects of Nuclear Engineering and history of nuclear energy
- Describes the interaction of radiation with matter and nuclear reactions
- To familiarize in nuclear fission and the chain reaction
- Introduction to nuclear reactor theory and heat removal from nuclear reactors
- To impart the knowledge of waste disposal and radiation protection

**UNIT – I : BASIC NUCLEAR CONCEPTS**

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

**UNIT – II : NUCLEAR FUELS**

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

**UNIT-III : NUCLEAR REACTORS**

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

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

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

**UNIT – V: NUCLEAR RADIATION APPLICATIONS**

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

**COURSE OUTCOME**

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

- At the end of the module the students are able to understand: how nuclear energy is produced today
- The physical principles in which the production of nuclear energy is based how nuclear power systems work
- Basic concepts of radiation and radiation protection
- The basis of nuclear safety, The economic, issues and prospects of nuclear power to day

**REFERENCE BOOKS**

1. Fundamentals of Nuclear Engineering by TJ Cannoly, John Wiley, 1978
2. Introduction to Nuclear Reactor Theory by JR Lamarsh, Wesley, 1972
3. Introduction to Nuclear Power by JG Collier and GF Hewitt, Hemisphere Publishing, New York, 1987
4. Nuclear Reactor Engineering by S Glasstone and A Sesonske, Von Nostrand, 1981.

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<b>22UPEST1E10</b>	<b>ENERGY CONSERVATION, ENERGY STORAGE AND TRANSPORTATION</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		4	0	0	4

**COURSE OBJECTIVES**

- To Introduce to emerging technologies like production and storage of Energy
- To determine conservation of basic techniques and available technologies
- To provide a comprehensive understanding on industrial waste heat recovery and storage systems
- To understand the basic necessities of energy transportation
- The course covers the physical understanding of application of batteries and hydrogen fuel cells

**UNIT – I : ENERGY CONSERVATION**

Introduction - approaches to energy conservation-energy conservation in the united states- energy conservation in India – cogeneration - smart grid - energy conservation in the community-LED street lights.

**UNIT – II : HOME HEATING COOLING AND TRANSPORTATION**

Furnace efficiency - heat pumps - air conditioning-integrated HVAC systems - minimizing heat loss-insulation, windows, and air leaks-residential lighting - transportation - FUEL Economy - hybrid vehicles

**UNIT-III : ENERGY STORAGE**

Introduction - pumped hydroelectric power - bath country pumped hydroelectric facility - compressed air energy storage - implementation of compressed air energy storage-fly wheels-superconducting magnetic energy storage (SMES).

**UNIT-IV: BATTERY ELECTRIC VEHICLES (BEVs)**

Introduction - battery types - the cost of electricity-BEV requirements and design-flow batteries-history of BEVs-rechargeable sodium batteries-super capacitors.

**UNIT – V: HYDROGEN FUELS**

Introduction-properties of hydrogen-hydrogen production methods – electrolysis-Thermal Decomposition of Water-Chemical Reactions-Storage And Transportation of Hydrogen-Hydrogen Internal Combustion Vehicles- Fuel Cells-Fuel Vehicles-Hydrogen Present And Future-Efficiency of Different Transportation Technologies

**COURSE OUTCOME**

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

- Exposure Students will be Able to analyses various types of energy storage devices and perform the selection based on techno economic view point
- Ideas in energy conservation
- Conception of home heating and transportation
- Detail practical knowledge in energy storage systems
- Conversion process of battery electric vehicles
- Types and usage of hydrogen fuel cells

**REFERENCE BOOKS**

1. Richarda.Dbunlap sustainable energy,CengageLearning;1edition(2014)
2. Jochen Fricke, Walter L. Borst, Essentials of Energy Technology:Sources,Transport,Storage,Conservation1st Edition, Wiley,(2014)

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22UPEST1E11

**WIND ENERGY**

L	T	P	C
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**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 conversion principles; General introduction; Types and classification of WECS; Power, torque and speed characteristics.

**UNIT – II : AERODYNAMIC CHARACTERISTICS**

Aerodynamic design principles; Aerodynamic theories; Axial momentum, blade element and combine theory; Rotor characteristics; Maximum power coefficient; Prandtl'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**

- Prepare and evaluate detailed project reports for establishing a wind farm
- Understand the operation of a wind farm and economics of power generation
- Gain Knowledge of construction characteristics and performance of wind turbine
- Study economics of harnessing energy from wind energy
- Analyse environmental impacts in installing wind turbine

**REFERENCE BOOKS**

1. Wind Energy Theory and Practice, Siarj Ahmed PHI learning Pvt Ltd, 2016
2. Wind Energy Systems and Applications, D.P Kothari, S.Umashankar, Narosa Publishing,2014
3. Thomas Ackermann, (2005), Wind Power in PowerSystems, John Wiles& Son Ltd.
4. Ray Hunter, (1997), Wind Energy Conversion: FromTheory to Practice, John Wiley and Son Ltd.
5. Gary L.Johnson, (1985), Wind Energy Systems, Prentice-Hall Inc., New Jersey.



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

22UPEST1E12

**SMART GRID TECHNOLOGIES**

L	T	P	C
4	0	0	4

**COURSE OBJECTIVES**

- To understand concept of smart grid and developments on smart grid.
- To understand smart grid technologies and application of smart grid concept in hybrid electric vehicles etc.
- To have Knowledge on smart substations, feeder automation and application for monitoring and protection.
- To have knowledge on micro grids and distributed energy systems.
- To know power quality aspects in smart grid.

**UNIT – I : INTRODUCTION TO SMART GRID**

Evolution of electric grid- Concept of smart grid - Definitions – Need of smart grid- Functions of smart grid – Opportunities & barrier of smart grid- Difference between conventional & smart grid- Concept of resilient & self-healing grid present development & international policies on smart grid – case study of smart grid..

**UNIT – II : SMART GRID TECHNOLOGIES**

Introduction to smart meters- Real time pricing – Smart appliances- Automatic meter reading (AMR)- Outage management systems (OMS)- plug in hybrid electric vehicles (PHEV)-Vehicle to grid- Smart sensors- Home & building automation.

**UNIT–III : SMART GRID TECHNOLOGIES**

Smart Substations – Substation automation – Feeder automation – Intelligent electronic devices (IED) & their application for monitoring protection – Smart storage like battery – SMES- Pumped hydro – Compressed air energy storage – Wide area measurement system (WAMS)-Phasor measurement unit (PMU).

**UNIT-IV: MICRO GRIDS AND DISTRIBUTED ENERGY RESOURCES**

Concept of micro grid- Need & applications of micro grid- Formation of micro grid- Issues of interconnection – Protection & control of micro grid- Plastic & organic solar cells- Thin film solar cells – Variable speed wind generators- Fuel cells- Micro turbines- Captive power plants- Integration of renewable energy sources.

**UNIT – V: INFORMATION AND COMMUNICATION TECHNOLOGY FOR SMART GRID**

Advanced metering infrastructure (AMI)- Home area network (HAN)- Neighborhood area Network (NAN)-Wide area network (WAN).

**COURSE OUTCOME**

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

- Understand smart grids and analyze grid policies and development in smart grids.
- Develop concepts of smart grid technologies in hybrid electrical vehicles etc.
- Understand smart substation, feeder automation, GIS etc.
- Analyze micro grids and distributed generation systems.
- Analyze the effect of power quality in smart grid and to understand latest developments in ICT for smart grid

**REFERENCE BOOKS**

1. Sudip Misra, Samaresh Bera Smart Grid Technology: A Cloud Computing and Data Management Approach Cambridge University Press 2018
2. “Integration of Green and Renewable Energy in Electric Power Systems”, Ali Keyhani,
3. Mohammad N. Marwail, Min Dai Wiley.
4. “The Smart Grid: Enabling Energy Efficiency and Demand Response “, Clark W. Gellings, CRC Press.
5. “Smart Grid: Technology and Applications”, JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, Wiley.
6. “Smart Grids”, Jean Clude Sabonnadiere, Nouredine Hadjsaid, Wiley Blackwell.
7. “Smart Power: Climate Changes the Smart Grid, and the Future of Electric Utilities”, Peter
8. S. Fox Penner, Island Press; 1 edition 8 Jun 2010
9. “Microgrids and Active Distribution Networks.” S. Chowdhury, S.P. Chowdhury, P.Crossley , Institution of Engineering and Technology, 30 Jun 2009

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22UPEST1E13

**GREEN CONCEPTS IN BUILDINGS**

L	T	P	C
4	0	0	4

**COURSE OBJECTIVES**

- To understand and apply the concept of availability and to calculate the behavior of real gases
- To predict the condition of systems and analyze them by the criteria of equilibrium
- impart knowledge on different ways of energy building
- to develop capability in the students to design solar energy building systems and make students aware with the challenges of the field,
- to give students in depth understanding of green composite building, related technical and environmental challenges

**UNIT – I : INTRODUCTION TO SMART GRID**

Environmental implications of buildings energy, carbon emissions, water use, waste disposal; Building materials: sources, methods of production and environmental Implications. Embodied Energy in Building Materials: Transportation Energy for Building Materials; Maintenance Energy for Buildings.

**UNIT – II : SMART GRID TECHNOLOGIES**

Implications of Building Technologies Embodied Energy of Buildings: Framed Construction, Masonry Construction. Resources for Building Materials, Alternative concepts. Recycling of Industrial and Buildings Wastes. Biomass Resources for buildings.

**UNIT-III : SMART GRID TECHNOLOGIES**

Comforts in Building: Thermal Comfort in Buildings- Issues; Heat Transfer Characteristic of Building Materials and Building Techniques. Incidence of Solar Heaton Buildings - Implications of Geographical Locations.

**UNIT-IV: MICRO GRIDS AND DISTRIBUTED ENERGY RESOURCES**

Utility of Solar energy in buildings concepts of Solar Passive Cooling and Heating of Buildings. Low Energy Cooling - Case studies of Solar Passive Cooled and Heated Buildings.

**UNIT – V: INFORMATION AND COMMUNICATION TECHNOLOGY FOR SMART GRID**

Green Composites for buildings: Concepts of Green Composites - Water Utilization in Buildings, Low Energy Approaches to Water Management. Management of Solid Wastes - Management of Sullage Water and Sewage - Urban Environment and Green Buildings – Green Cover and Built Environment.

**COURSE OUTCOME**

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

- To calculate the availability of the systems and cycles
- Analyze the engineering systems to improve and optimize its performance
- Elaborate knowledge on the building technologies
- Able to apply solar energy in green buildings.
- Familiar in the concept of green composites for buildings.

**REFERENCE BOOKS**

1. K.S.Jagadish, B.U.Venkataramareddy and K.S.Nanjundarao. Alternative Building Materials and Technologies. New Age International, (2007).
2. Low Energy Cooling For Sustainable Buildings. John Wiley and SonsLtd,(2009).
3. Green My Home:10 Steps to Lowering Energy Costs and Reducing Your Carbon Footprint, by Dennis C. (2008).
4. B.Givoni, Man, Climate and Architecture Elsevier,(1969).

5. T. A. Markus and E. N. Morris Buildings Climate and Energy. Pitman, London,(1980).

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4	M	L	M	M	H	L	L	-	-	-	H	-	-	-	M
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22UPEST1E14

BIO ENERGY CONVERSATION

L	T	P	C
4	0	0	4

**COURSE OBJECTIVES**

- To detail on the types of biomass, its surplus availability and characteristics.
- To create awareness on the technologies available for conversion of biomass to energy in terms of its technical competence and economic implications.
- To impart knowledge on stoichiometry and combustion of bio fuels
- To elucidate on the influence of equivalence ratio on thermochemical conversion of biomass
- To provide insight to the possibilities of producing liquid fuels form biomass

**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 – 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 - Biodiesel health effects / emissions / performance.

**COURSE OUTCOME**

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

- Estimate the surplus biomass availability of any given area
- Design a biogas plant for a variety of biofuels
- Determine and compare the cost of steam generation from biofuels with that of coal and petroleum fuels
- Analyze the influence of process governing parameters in thermochemical conversion of biomass
- Synthesize liquid biofuels for power generation from biomass

**REFERENCE BOOKS**

1. Tom B Reed, Biomass Gasification – Principles and Technology, Noyce Data Corporation, 1981
2. David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis Hoknood Chichester, 1984.
3. Khandelwal KC, Mahdi SS, Biogas Technology – A Practical Handbook, Tata McGraw Hill, 1986
4. Mahaeswari, R.C. Bio Energy for Rural Energisation, Concepts Publication,1997

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<b>22UPEST1E15</b>	<b>INNOVATION AND ENTREPRENEURSHIP</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		4	0	0	4

**COURSE OBJECTIVES**

- To understand the Entrepreneurial Opportunities in current scenario
- To learn various Entrepreneurial Process and Decision Making
- Acquire Knowledge in Crafting business models and Lean Start-ups
- To inculcate ideas in Organizing Business and Entrepreneurial Finance
- To develop and explore business opportunities

**UNIT – I : INTRODUCTION TO ENTREPRENEURSHIP**

Entrepreneurs; entrepreneurial personality and intentions - characteristics, traits and behavioral; entrepreneurial challenges.

**UNIT – II : ENTREPRENEURIAL OPPORTUNITIES**

Opportunities. Discovery / creation, Pattern identification and recognition for venture creation: prototype and exemplar model, reverse engineering.

**UNIT-III : ENTREPRENEURIAL PROCESS AND DECISION MAKING**

Entrepreneurial ecosystem, Ideation, development and exploitation of opportunities; Negotiation, decision making process and approaches, Effectuation and Causation.

**UNIT-IV: CRAFTING BUSINESS MODELS AND LEAN START-UPS**

Introduction to business models; Creating value propositions-conventional industry logic, value innovation logic; customer focused innovation; building and analyzing business models; Business model canvas, Introduction to lean startups, Business Pitching.

**UNIT – V: ORGANIZING BUSINESS AND ENTREPRENEURIAL FINANCE**

Forms of business organizations; organizational structures; Evolution of Organization, sources and selection of venture finance options and its managerial implications. Policy Initiatives and focus; role of institutions in promoting entrepreneurship

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

- To calculate the availability of the systems and cycles
- Analyze the engineering systems to improve and optimize its performance
- Elaborate knowledge on the building technologies
- Able to apply solar energy in green buildings.
- Familiar in the concept of green composites for buildings.

**REFERENCE BOOKS**

1. Ries, Eric (2011), The lean Start-up: How constant innovation creates radically successful businesses, Penguin Books Limited.
2. Blank, Steve (2013), The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company, K&S Ranch.
3. S. Carter and D. Jones-Evans, Enterprise and small business- Principal Practice and Policy, Pearson Education (2006)
4. T. H. Byers, R. C. Dorf, A. Nelson, Technology Ventures: From Idea to Enterprise, McGraw Hill (2013)
5. Osterwalder, Alexander and Pigneur, Yves (2010) Business Model Generation.
6. Kachru, Upendra, India Land of a Billion Entrepreneurs, Pearson
7. Bagchi, Subroto, (2008), Go Kiss the World: Life Lessons for the Young



Professional,PortfolioPenguin

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<b>22UPEST1E16</b>	<b>POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEM</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		4	0	0	4

**COURSE OBJECTIVES**

- To impart knowledge on conversion techniques and renewable energy technologies.
- To study the mechanisms of machines for the conversion of renewable energy sources.
- To learn the power converters and its applications in renewable energy systems.
- To understand the different conversion mechanisms of wind and solar systems.
- To understand the various hybrid systems of renewable energy conversion techniques

**UNIT – I : INTRODUCTION TO ENTREPRENEURSHIP**

Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems

**UNIT – II : ENTREPRENEURIAL OPPORTUNITIES**

Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG

**UNIT-III : ENTREPRENEURIALPROCESSANDDECISIONMAKING**

Solar: Block diagram of solar photo voltaic system -Principle of operation: line commutated converters (inversion-mode) - Boost and buck-boost converters- selection Of inverter, battery sizing, array sizing Wind: three phase AC voltage controllers- AC-DC-AC converters:uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters. Power Quality Measurements.

**UNIT-IV: CRAFTINGBUSINESSMODELSANDLEANSTART-UPS**

Stand-alone operation of fixed and variable speed wind energy conversion systems and solar system- Grid connection Issues -Grid integrated PMSG and SCIG Based WECS Grid Integrated solar system

**UNIT – V: ORGANIZINGBUSINESSANDENTREPRENEURIALFINANCE**

Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PV Maximum Power Point Tracking (MPPT).

**COURSE OUTCOME**

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

- Analyze the various conversion techniques in renewable energy technologies.
- Apply the various mechanisms for the conversion of renewable energy sources.
- Identify the appropriate power converters for renewable energy systems.
- Implement the different conversion mechanisms for wind and solar systems.
- Recognize the importance of various hybrid renewable energy systems.

**REFERENCE BOOKS**

1. Rashid.M. H “power electronics Hand book”, Academic press, 2007.
2. Leon Freris, David Infield, “Renewable energy in power systems”, John Wiley & Sons, 2008.
3. Rai. G.D, “Non-conventional energy sources”, Khanna publishes, 2010.
4. Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, John Wiley & Sons, 2011.
5. Wind Electric Systems: S.N. Bhadra, D. Kastha, OXFORD university press, 2005.

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## SUPPORTIVE COURSES

<b>22UPESTS01</b>	<b>RENEWABLE ENERGY</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		4	0	0	4

### 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**

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

### REFERENCE BOOKS

1. Twidell, J.W. & Weir A., “Renewable Energy Resources”, EFN Spon Ltd., UK, 2015
2. Godfrey Boyle, “Renewable Energy: Power for a Sustainable Future”, Oxford University Press, U.K., 2012.
3. Sukhatme.S.P., “Solar Energy: Principles of Thermal Collection and Storage”, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2012
4. Sukhatme, S.P., Solar Energy, Tata McGraw Hill, 2017

5. Tiwari G.N., “Solar Energy – Fundamentals Design, Modelling and applications”, Alpha Science Intl Ltd, 2015

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4	H	H	H	M	H	M	M	-	-	-	-	-	-	H	H
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<b>22UPESTS02</b>	<b>CLIMATE CHANGE AND CO<sub>2</sub> EMISSION ASSESSMENT</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		4	0	0	4

**COURSE OBJECTIVES**

- To study the global climate change
- To analysis emission assessment
- To familiarize about impact of climate changes on the environment.
- To know the carbon dioxide conversion and carbon footprint
- 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<sub>2</sub>) EMISSIONS AND CONVERSION/CONSUMPTION**

Carbon dioxide (CO<sub>2</sub>) emissions in relation to energy conversion/consumption: theory of CO<sub>2</sub> emission in relation to energy conversion processes.

**UNIT- IV: METHODOLOGY FOR CO<sub>2</sub> ASSESSMENT/CARBON FOOT PRINT**

Methodology for CO<sub>2</sub> 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**

- Depth knowledge in global climate change and the impact of climate change on the living things.
- Able to analysis emission characteristics and its impact on the globe.
- Obtained elaborate knowledge about impact of climate changes on the environment.
- Knowledge on carbon dioxide conversion and carbon footprint
- Knowledge on concept of carbon credit and their importance.

**REFERENCE BOOKS**

1. Franchetti M. J. and Apul D. S., Carbon Footprint Analysis: concepts, methods, implementation and case studies, CRC Press, (2013).
2. Clean Development Mechanism, UNFCCC Website; <http://cdm.unfccc.int/>
3. Stern N., The Economics of Climate Change. The Stern Review. Cambridge University Press, (2007).
4. Barrett S. Why Cooperate? The Incentive to Supply Global Public Goods. Oxford University Press, (2007).

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22UPESTS03

ENERGY SCENARIO AND POLICY

L	T	P	C
4	0	0	4

**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

- Familiar knowledge in energy scenario globally and locally.
- Gain knowledge on Indian Energy Conservation Act
- Acquire information on government energy policies
- Understand the Energy efficiency and climate change policies.
- Know about the effects of energy demand on environment

**REFERENCE AND TEXT BOOKS**

1. General Aspects of Energy Management and Energy Audit, Fourth Edition, Bureau of Energy Efficiency, New Delhi, India 2015
2. S.P. Sukhatme, Solar Energy: principles of Thermal Collection and Storage, Tata McGraw- Hill (2017).
3. Loulou, Richard, Waaub, Jean-Philippe; Zaccour, Georges, Energy and Environment Set: Mathematics of Decision Making, (Eds.), (2005), XVIII, 282 p. ISBN: 978-0-387- 25351- 0.



4. Ristinen, Robert A. Kraushaar, Jack J. AKraushaar, Jack P. Ristinen, Robert A, Energy and the Environment, 2nd Edition, John Wiley, 2006, ISBN:9780471172482, Pub Wiley, New York, (2006).

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<b>22UPESTS04</b>	<b>ERECTION AND MAINTENANCE OF REFRIGERATION AND AIR- CONDITIONING EQUIPMENT</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		4	0	0	4

**COURSE OBJECTIVES**

- To teach the principal of energy and environmental issues
- To explore the environmental impact of various energy sources and also the effects of different types of pollutants.
- To know the solar energy and conversion technologies.
- To understand the biomass and geothermal energy systems and conversion techniques.
- To get an elaborate knowledge on pollution control methods.

**UNIT – I: INTRODUCTION**

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

**UNIT – II: ERECTION OF R&AC SYSTEMS**

Erection methodology, foundation, padding, network analysis, critical path, interconnections; safety precautions, air handling equipment's. Maintenance procedures.

**UNIT– III: CARBON DIOXIDE (CO<sub>2</sub>) EMISSIONS AND CONVERSION/CONSUMPTION**

Carbon dioxide (CO<sub>2</sub>) emissions in relation to energy conversion/consumption: theory of CO<sub>2</sub> emission in relation to energy conversion processes.

**UNIT- IV: TOTAL PREVENTIVE MAINTENANCE**

TPM Principles, Corrective and preventive measures and Reliability analysis.

**UNIT – V: MAINTENANCE SCHEDULES**

Studies on different maintenance schedules followed by various industries

**COURSE OUTCOME**

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

- Awareness on the existence of various instrument objective and their merits, constraints and drawbacks
- Knowledge on various kinds of R & AC systems.
- Able to measure and design an appropriate AC system.
- Good knowledge on maintenance.

**REFERENCE BOOKS**

1. Arora C.P., Refrigeration and Air conditioning II Ed. McGraw-Hill, Pub., (2000).
2. ASHRAE Hand book on Refrigeration & Air conditioning, Published by ISHRAE, Bangalore, (1998).

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<b>22UPESTS05</b>	<b>GREEN CONCEPTS IN BUILDING</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
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**COURSE OBJECTIVES**

- To understand and apply the concept of availability and to calculate the behavior of real gases
- To predict the condition of systems and analyze them by the criteria of equilibrium
- To know the building technologies
- To get a knowledge on use of solar energy in green buildings.
- To know the concept of green composites for buildings.

**UNIT – I: ENVIRONMENTAL IMPLICATIONS OF BUILDINGS**

Environmental implications of buildings energy, carbon emissions, water use, waste disposal; Building materials: sources, methods of production and environmental Implications. Embodied Energy in Building Materials: transportation Energy for Building Materials; Maintenance Energy for Buildings.

**UNIT – II: IMPLICATIONS OF BUILDING TECHNOLOGIES**

Implications of Building Technologies Embodied Energy of Buildings: Framed Construction, Masonry Construction. Resources for Building Materials, Alternative concepts. Recycling of Industrial and Buildings Wastes. Biomass Resources for buildings.

**UNIT– III: COMFORTS IN BUILDING**

Comforts in Building: Thermal Comfort in Buildings- Issues; Heat Transfer Characteristic of Building Materials and Building Techniques. Incidence of Solar Heat on Buildings- Implications of Geographical Locations.

**UNIT- IV: UTILITY OF SOLAR ENERGY IN BUILDINGS**

Utility of Solar energy in buildings concepts of Solar Passive Cooling and Heating of Buildings. Low Energy Cooling. Case studies of Solar Passive Cooled and Heated Buildings.

**UNIT – V: GREEN COMPOSITES FOR BUILDINGS**

Green Composites for buildings: Concepts of Green Composites. Water Utilization in Buildings, Low Energy Approaches to Water Management. Management of Solid Wastes. Management of Sullage Water and Sewage. Urban Environment and Green Buildings. Green Cover and Built Environment.

**COURSE OUTCOME**

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

- To calculate the availability of the systems and cycles
- Analyze the engineering systems to improve and optimize its performance
- Elaborate knowledge on the building technologies
- Able to apply solar energy in green buildings.
- Familiar in the concept of green composites for buildings.

**REFERENCE BOOKS**

1. Low Energy Cooling for Sustainable Buildings. John Wiley and Sons Ltd, (2009).
2. K.S.Jagadish, B. U. Venkataramareddy and K. S. Nanjundarao. Alternative Building Materials and Technologies. New Age International, (2007).

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5	M	M	L	-	-	L	H	L	-	-	M	H	M	-	M

## VALUE ADDED COURSE

**22UPESTVA01**

### **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 basics 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**

CNG, LPG, H<sub>2</sub>, Hythane, Di-Methyl Ether, Ethanol, Biodiesel.

#### **UNIT– III: NOVEL TECHNOLOGIES AND STRATEGIES TO CURB EMISSIONS**

Homogeneous charge CI (HCCI) engines, Premixed Charge Compression Ignition (PCCI), Emission control technologies (EGR, SCR, DOC, DPF etc.) (To be updated periodically with new technologies and strategies).

#### **COURSE OUTCOME**

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

- The student can identify different areas of alternate fuels and energy system.
- Can find the applications of all the areas in day-to-day life.
- Will understand the emission norms

#### **REFERENCE BOOKS**

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

22UPESTVA02

## 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.

### 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.

**22UPESTVA03**

**MATERIALS FOR ENERGY APPLICATIONS**

**COURSE OBJECTIVES**

- To understand the concept of energy materials for energy generation.
- To analyze the material design, related to photovoltaic cell and energy storage
- To acquire information on phase change materials

**UNIT – I: INTRODUCTION**

Materials Glazing materials, Properties and Characteristics of Materials, Reflection from surfaces, Selective Surfaces: Ideal coating characteristics, Types and applications, Anti-reflective coating, Preparation and characterization. Reflecting Surfaces and transparent materials, Types of Insulation and properties

**UNIT – II: MATERIALS FOR PHOTOVOLTAIC'S CONVERSION**

Si and Non-Si materials, crystalline, semi-crystalline, Polycrystalline and Amorphous materials, p- n junction: homo and hetero junctions, Metal-semiconductor interface

**UNIT– III: PHASE CHANGE MATERIALS**

Phase Change Materials Selection criteria of Phase change, Materials use in Solar heating or cooling, Research Status

**COURSE OUTCOME**

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

- Apply the concept of materials required for energy storage and energy generation.
- Detailed study on properties of various energy-oriented materials for energy applications

**REFERENCE BOOKS**

1. Solar Thermal Energy Storage by HP Garg, D Reidel Publishing Company, 1985.
2. Mathematical Modeling of Melting and Freezing process by V Alexiades and AD Solomon, Hemisphere Publishing Corporation, Washington,1993.
3. Chemical and Electrochemical Energy System by R Narayan, B Viswanathan, Universities Press.
4. Energy Storage Systems by B Kilic and S Kakac (Ed), KAP, London

## 22UPESTVA04

## ELECTRIC VEHICLES

### COURSE OBJECTIVES

- To present a comprehensive overview of Electric and Hybrid Electric Vehicle
- To know about the sources of energy for electrical vehicles
- To obtain knowledge on storage techniques on electrical vehicles

### 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: SOURCES

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: OVERVIEW OF HYBRID ELECTRIC VEHICLES

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

### COURSE OUTCOME

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

- Choose a suitable drive scheme for developing an electric or hybrid vehicle depending on resources
- Design and develop basic schemes of electric vehicles and hybrid electric vehicles.
- Understanding electric car energy resources
- Experience of electric car storage technology.

### REFERENCE BOOKS

1. Hand Book of Batteries and Fuel cells, 3rd Edition, Edited by David Linden and Thomas. B. Reddy, McGraw Hill Book Company, N.Y. 2002.
2. Fuel Cells, Principles and Applications, Viswanathan, B. and Scibioh, Aulice M, Universities Press, 2006.
3. The Essential Hybrid Car Handbook: A Buyer's Guide (Paperback)by Nick Yost, The Lyons Press, N.Y. 2006.



**22UPESTVA05**

**DESIGN THINKING**

**COURSE OBJECTIVES**

- To introduce the idea of design thinking in product development
- To understand the practice of design thinking
- To leverage use of tools for the design process

**UNIT – I: INTRODUCTION**

Understanding Design thinking – Shared model in team-based design – Theory and practice in Design thinking – Exploring work of Designers across globe – Minimum Viable Products (MVP) or Prototyping

**UNIT – II: TOOLS FOR DESIGN THINKING**

Real-Time design interaction captures and analysis – Enabling efficient collaboration in digital space – Empathy for design – Collaboration in distributed Design

**UNIT– III: DESIGN THINKING IN IT**

Design Thinking to Business Process modeling – Agile in Virtual collaboration environment – Scenario based Prototyping

**COURSE OUTCOME**

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

- Apply design thinking for product development
- Use design thinking tools
- Identify need for products and disruption

**REFERENCE BOOKS**

1. Roger Martin, "The Design of Business: Why Design Thinking is the Next Competitive Advantage", Harvard Business Press, 2009.
2. Hasso Plattner, Christoph Meinel and Larry Leifer (eds), "Design Thinking: Understand – Improve – Apply", Springer, 2011 (Unit III).
3. Idris Mootee, "Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School", John Wiley & Sons 2013. (Unit IV).

## **22UPESTVA06      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

### **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.

## 22UPESTVA07 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

### 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

## **22UPESTVA08 INDUSTRIAL ROBOTICS**

### **COURSE OBJECTIVES**

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

### **UNIT – I: FUNDAMENTALS OF ROBOT**

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

### **UNIT – II: SENSORS AND MACHINE VISION**

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

### **UNIT– III: IMPLEMENTATION AND ROBOT ECONOMIC**

RGV, AGV; Implementation of Robots in Industries-Variou 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

### **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 AI Robotics” PHI Learning Private Limited, 2000