# REGULATIONS AND SYLLABUS
# (University Department)

(For the candidates admitted from the academic year 2023-2024 onwards)

# MASTER OF SCIENCE IN
# ENERGY SCIENCE

(Under Choice Based Credit System)


## DEPARTMENT OF ENERGY SCIENCE AND TECHNOLOGY

## SCHOOL OF ENERGY AND ENVIRONMENTAL SCIENCES

## PERIYAR UNIVERSITY

**(NAAC A$^{++}$ Grade – State University - NIRF Rank 59 – NIRF Innovation Band of 11-50)**

## SALEM - 636011

## TAMIL NADU

# Regulations & Scheme

# M.Sc., Energy Science

Choice Based Credit System (CBCS) Regulation,
Scheme and Syllabus
(W.e.f. 2023 - 2024 onwards)

## 1. Eligibility for Admission

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

## 2. Mode of Selection

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

## 3. Duration of the Course

The duration of the M.Sc. degree shall be two years consist of four semesters. Each semester consists of 90 working days.

## 4. Distribution of Credit Points

The minimum credit requirement for M.Sc., degree shall be 92 Credits. The break-up of credits for the Programme is as follows;

- Core, Practical, Project Courses : 64 Credits
- Elective Courses : 18 Credits
- NME/SEC : 06 Credits
- Internship/Industrial Activity : 02 Credits
- Extension Activity : 01 Credit
- Fundamentals of Human Rights : 01 Credit

## 5. Course of Study

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

| **METHODS OF EVALUATION** | | |
|---|---|---|
| **Internal Evaluation** | Continuous Internal Assessment Test | **25 Marks** |
| | Assignments / Snap Test / Quiz | |
| | Seminars | |
| | Attendance and Class Participation | |
| **External Evaluation** | End Semester Examination | **75 Marks** |
| **Total** | | **100 Marks** |

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

### 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 |
| Total | 25 Marks |

### 5.2 Theory Papers

| | |
|---|---|
| External | 75 Marks |
| Internal | 25 Marks |
| Total | 100 Marks |

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

| **Internal (40 Marks)** | | **External (60 Marks)** | | |
|---|---|---|---|---|
| Internal Tests (Best 1 out of 2) | Model | Record Work | Experimental Work | Viva Voce |
| 20 | 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 (25 Marks)** | | | **External (75 Marks)** | | |
|---|---|---|---|---|---|
| Presentation I | Presentation II | Presentation III | Dissertation | Presentation | Viva Voce |
| 05 | 10 | 10 | 30 | 30 | 15 |

### 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 (Phase I & II)

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

| **Project work** | **Internal (80 Marks)** | | | | **External (120 marks)** | | | |
|---|---|---|---|---|---|---|---|---|
| Phase II (200 Marks) | Review I | Review II | Model Review | Conference Presentation/ Journal Article/ Book Chapter Publication /Patent | 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. Students may be permitted to carry out Phase II 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. Passing Minimum for External Examination shall be of 50% (Fifty Percentage) of the maximum marks prescribed for the paper.
2. In aggregate (External +Internal) the passing minimum shall be of 50% for each Paper/Practical/Project and Viva-voce.
3. Grading shall be based on overall marks obtained (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 |
|---|---|---|---|
| **90 – 100** | 9.0 – 10.0 | O | **Outstanding** |
| **80-89** | 8.0 – 8.9 | D+ | **Excellent** |
| **75-79** | 7.5 – 7.9 | D | **Distinction** |
| **70-74** | 7.0 – 7.4 | A+ | **Very Good** |
| **60-69** | 6.0 – 6.9 | A | **Good** |
| **50-59** | 5.0 – 5.9 | B | **Average** |
| **00-49** | 0.0 | U | **Re-Appear** |
| **Absent** | **0.0** | AAA | **Absent** |

## 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 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 one internal member from the Department.

**INTERNSHIP TRAINING (100 Marks)**

| Report | Presentation | | Viva Voce | | Total |
|---|---|---|---|---|---|
| **External** | **External** | **Internal** | **External** | **Internal** | |
| 40 | 15 | 15 | 15 | 15 | 100 |

## 12. Non-major elective (NME)

Non-major elective will be offered in Second and Third semester. Students are expected to opt Non-major elective offered by other departments.

## 13. Skill Enhancement Course (SEC)/ Professional Competency Skill

The aim of Skill Enhancement Course is to impart Practical knowledge to the students with hands-on training. A committee constituted by the Head of the Department will conduct the Viva-Voce Examination. The committee comprises of one Senior faculty and Subject In-charge from the Department.

| **Assessment of Skill Enhancement Course** | | |
|---|---|---|
| Sl. No. | Assessment Aspects | Assigned Marks |
| 01 | Field Work on theme | 20 |
| 02 | Technical Analysis of theme | 20 |
| 03 | Dissertation | 20 |
| 04 | Presentation | 20 |
| 05 | Viva Voce | 20 |

## 14. Extension Activity

The students may undergo industrial visit at industry for one or two days. After completion of industrial visit, the student shall submit a report. A committee constituted by the Head of the Department will conduct the Viva-Voce Examination. The committee comprises of one Senior faculty and industrial visit In-charge from the Department.

**Extension Activity (100 Marks)**

| Sl. No. | Assessment Aspects | Assigned Marks |
|---|---|---|
| 01 | Industrial Visit | 20 |
| 02 | Technical Analysis of Industry | 20 |
| 03 | Presentation | 20 |
| 04 | Dissertation | 20 |
| 05 | Viva Voce | 20 |

## 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:

| PO | Graduate Attribute | Programme Outcome |
|---|---|---|
| 1 | Knowledge | Apply knowledge of mathematics, basic science and engineering science. |
| 2 | Problem analysis | Identify, formulate and solve engineering problems. |
| 3 | Design/development of solutions | Design a system or process to improve its performance, satisfying its constraints. |
| 4 | Conduct investigations of complex problems | Conduct experiments & collect, analyze and interpret the data. |
| 5 | Modern tool usage | Apply various tools and techniques to improve the efficiency of the system. |
| 6 | The Scientist and society | Conduct them 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** |
| **I** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **II** | ✓ | ✓ | | | | | | | ✓ | | ✓ | ✓ |
| **III** | ✓ | ✓ | | | | ✓ | ✓ | | ✓ | | ✓ | ✓ |
| **IV** | ✓ | ✓ | ✓ | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | |
| **V** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

**Mapping of Course Outcome and Programme Outcome**

| | | Course Name | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I YEAR | Semester 1 | Energy Scenario, Audit and Management | ✓ | | ✓ | ✓ | | ✓ | ✓ | ✓ | | ✓ | | ✓ |
| | | Basics of Fluid Mechanics and Heat Transfer | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | ✓ |
| | | Energy Laboratory | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | ✓ |
| | | Elective –I | | | | | | | | | | | | |
| | | Elective –II | | | | | | | | | | | | |
| | Semester 2 | Thermal Energy Conservation | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | | | ✓ | ✓ |
| | | Basics of Computational Fluid Dynamics | ✓ | | | ✓ | | ✓ | ✓ | | | | | ✓ |
| | | Computer Aided Design and Simulation Laboratory | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | | ✓ | ✓ |
| | | Elective – III | | | | | | | | | | | | |
| | | Elective –IV | | | | | | | | | | | | |
| | | NME –I (Swayam/MOOC/NPTEL) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | Fundamentals of Human Rights | | | | | | | | | | | | |
| II YEAR | Semester 3 | Electrical Energy Conservation | ✓ | | ✓ | | ✓ | ✓ | ✓ | | ✓ | | ✓ | ✓ |
| | | Nanomaterials for Energy Applications | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ |
| | | Energy Storage Systems | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | ✓ |
| | | Project Phase – I | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | Elective V | | | | | | | | | | | | |
| | | Internship / Industrial Activity | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | NME-II | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Semester 4 | Hydrogen Storage System | ✓ | | ✓ | | ✓ | ✓ | ✓ | | ✓ | | ✓ | ✓ |
| | | Project Phase – II | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | Elective VI | | | | | | | | | | | | |
| | | SEC | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | Extension Activity | | | | | | | | | | | | |

**PERIYAR UNIVERSITY, SALEM**
**UNIVERSITY DEPARTMENT REGULATIONS – 2023**
**CHOICE BASED CREDIT SYSTEM**
**M.Sc., ENERGY SCIENCE**

**CURRICULUM AND SYLLABUS**

**SEMESTER I**

| S.No | Course Code | Course Title | Category | L | T | P | C | Int. Mark | Ext. Mark | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 23UPEST1C01 | Energy Scenario, Audit and Management | C | 5 | 0 | 0 | 5 | 25 | 75 | 100 |
| 2 | 23UPEST1C02 | Basics of Fluid Mechanics and Heat Transfer | C | 5 | 0 | 0 | 5 | 25 | 75 | 100 |
| 3 | 23UPEST1L01 | Energy Laboratory | L | 0 | 0 | 6 | 4 | 40 | 60 | 100 |
| 4 | - | Elective –I | E | 5 | 0 | 0 | 3 | 25 | 75 | 100 |
| 5 | - | Elective –II | E | 5 | 0 | 0 | 3 | 25 | 75 | 100 |
| | | | **TOTAL** | **20** | **0** | **6** | **20** | | | |

**SEMESTER II**

| S.No | Course Code | Course Title | Category | L | T | P | C | Int. Mark | Ext. Mark | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 23UPEST1C03 | Thermal Energy Conservation | C | 5 | 0 | 0 | 5 | 25 | 75 | 100 |
| 2 | 23UPEST1C04 | Basics of Computational Fluid Dynamics | C | 5 | 0 | 0 | 5 | 25 | 75 | 100 |
| 3 | 23UPEST1L02 | Computer Aided Design and Simulation Laboratory | L | 0 | 0 | 6 | 4 | 40 | 60 | 100 |
| 4 | - | Elective –III | E | 4 | 0 | 0 | 3 | 25 | 75 | 100 |
| 5 | - | Elective –IV | E | 4 | 0 | 0 | 3 | 25 | 75 | 100 |
| 6 | - | NME –I (Swayam/MOOC/NPTEL) | N | 2 | 0 | 0 | 2 | - | 100 | 100 |
| 7 | 23UPPGC1H01 | Fundamentals of Human Rights | H | 2 | 0 | 0 | 1 | 25 | 75 | 100 |
| | | | **TOTAL** | **22** | **0** | **6** | **23** | | | |

## SEMESTER III

| S.No | Course Code | Course Title | Category | L | T | P | C | Int. Mark | Ext. Mark | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 23UPEST1C05 | Electrical Energy Conservation | C | 5 | 0 | 0 | 5 | 25 | 75 | 100 |
| 2 | 23UPEST1C06 | Nanomaterials for Energy Applications | C | 5 | 0 | 0 | 5 | 25 | 75 | 100 |
| 3 | 23UPEST1C07 | Energy Storage Systems | C | 5 | 0 | 0 | 5 | 25 | 75 | 100 |
| 4 | 23UPEST1P01 | Project Phase I | P | 0 | 0 | 6 | 4 | 40 | 60 | 100 |
| 5 | - | Elective –V | E | 4 | 0 | 0 | 3 | 25 | 75 | 100 |
| 6 | - | NME-II | N | 2 | 0 | 0 | 2 | 25 | 75 | 100 |
| 7 | 23UPEST1I01 | Internship / Industrial Activity | I | 0 | 0 | 0 | 2 | - | 100 | 100 |
| | | | **TOTAL** | **21** | **0** | **6** | **26** | | | |

## SEMESTER IV

| S.No | Course Code | Course Title | Category | L | T | P | C | Int. Mark | Ext. Mark | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 23UPEST1C08 | Hydrogen Storage System | C | 5 | 0 | 0 | 5 | 25 | 75 | 100 |
| 2 | 23UPEST1P02 | Project Phase II | P | 0 | 0 | 18 | 12 | 80 | 120 | 200 |
| 3 | - | Elective –VI | E | 4 | 0 | 0 | 3 | 25 | 75 | 100 |
| 4 | - | NME-III/SEC | N/S | 2 | 0 | 0 | 2 | - | 100 | 100 |
| 5 | 23UPEST1X01 | Extension Activity | X | 0 | 0 | 0 | 1 | - | 100 | 100 |
| | | | **TOTAL** | **11** | **0** | **18** | **23** | | | |

**TOTAL CREDITS TO BE EARNED FOR THE AWARD OF DEGREE = 92**

## Core (C), Practical (L) & Project (P)

| S. No | CourseCode | Course Title | Category | L | T | P | C | Int. Mark | Ext. Mark | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 23UPEST1C01 | Energy Scenario, Audit and Management | C | 5 | 0 | 0 | 5 | 25 | 75 | 100 |
| 2 | 23UPEST1C02 | Basics of Fluid Mechanics and Heat | C | 5 | 0 | 0 | 5 | 25 | 75 | 100 |
| 3 | 23UPEST1L01 | Energy Laboratory | L | 0 | 0 | 6 | 4 | 40 | 60 | 100 |
| 4 | 23UPEST1C03 | Thermal Energy Conservation | C | 5 | 0 | 0 | 5 | 25 | 75 | 100 |
| 5 | 23UPEST1C04 | Basics of Computational Fluid | C | 5 | 0 | 0 | 5 | 25 | 75 | 100 |
| 6 | 23UPEST1CL02 | Computer Aided Design and Simulation | L | 0 | 0 | 6 | 4 | 40 | 60 | 100 |
| 7 | 23UPEST1C05 | Electrical Energy Conservation | C | 5 | 0 | 0 | 5 | 25 | 75 | 100 |
| 8 | 23UPEST1C06 | Nanomaterials For Energy Applications | C | 5 | 0 | 0 | 5 | 25 | 75 | 100 |
| 9 | 23UPEST1C07 | Energy Storage Systems | C | 5 | 0 | 0 | 5 | 25 | 75 | 100 |
| 10 | 23UPEST1P01 | Project Phase I | P | 0 | 0 | 6 | 4 | 40 | 60 | 100 |
| 11 | 23UPEST1C08 | Hydrogen Storage System | C | 5 | 0 | 0 | 5 | 25 | 75 | 100 |
| 12 | 23UPEST1P02 | Project Phase II | P | 0 | 0 | 18 | 12 | 80 | 120 | 200 |

**ELECTIVE (E)**

| S. No | Course Code | Course Title | Category | L | T | P | C | Int. Mark | Ext. Mark | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| **ELECTIVE - I** | | | | | | | | | | |
| 1 | 23UPEST1E01 | Applied Mathematics for Energy | E | 5 | 0 | 0 | 3 | 25 | 75 | 100 |
| 2 | 23UPEST1E02 | Industrial Instrumentation | E | 5 | 0 | 0 | 3 | 25 | 75 | 100 |
| 3 | 23UPEST1E03 | Renewable Energy Systems | E | 5 | 0 | 0 | 3 | 25 | 75 | 100 |
| 4 | 23UPEST1E04 | Energy and Environmental Science | E | 5 | 0 | 0 | 3 | 25 | 75 | 100 |
| **ELECTIVE - II** | | | | | | | | | | |
| 5 | 23UPEST1E05 | Basics of Thermodynamics | E | 5 | 0 | 0 | 3 | 25 | 75 | 100 |
| 6 | 23UPEST1E06 | Waste Management and Energy Recovery Techniques | E | 5 | 0 | 0 | 3 | 25 | 75 | 100 |
| 7 | 23UPEST1E07 | Energy Conservation, Storage and Transportation | E | 5 | 0 | 0 | 3 | 25 | 75 | 100 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 23UPEST1E08 | Bio Energy Conversion | E | 5 | 0 | 0 | 3 | 25 | 75 | 100 |
| **ELECTIVE - III** | | | | | | | | | | |
| 9 | 23UPEST1E09 | Research Methodology and Intellectual Property Rights | E | 4 | 0 | 0 | 3 | 25 | 75 | 100 |
| 10 | 23UPEST1E10 | Wind Energy conversion | E | 4 | 0 | 0 | 3 | 25 | 75 | 100 |
| 11 | 23UPEST1E11 | Electric Vehicle System | E | 4 | 0 | 0 | 3 | 25 | 75 | 100 |
| 12 | 23UPEST1E12 | Energy and Water Management in High Performance Building | E | 4 | 0 | 0 | 3 | 25 | 75 | 100 |
| **ELECTIVE - IV** | | | | | | | | | | |
| 13 | 23UPEST1E13 | Power Plant Engineering | E | 4 | 0 | 0 | 3 | 25 | 75 | 100 |
| 14 | 23UPEST1E14 | Power Electronics for Renewable Energy Systems | E | 4 | 0 | 0 | 3 | 25 | 75 | 100 |
| 15 | 23UPEST1E15 | Solar Photovoltaic Science and Technology | E | 4 | 0 | 0 | 3 | 25 | 75 | 100 |
| **ELECTIVE - V** | | | | | | | | | | |
| 16 | 23UPEST1E16 | Technical Seminar - I | E | 4 | 0 | 0 | 3 | 25 | 75 | 100 |
| **ELECTIVE - VI** | | | | | | | | | | |
| 17 | 23UPEST1E17 | Technical Seminar - II | E | 4 | 0 | 0 | 3 | 25 | 75 | 100 |

## NON-MAJOR ELECTIVE COURSES (NM)

| S.No | Course Code | Course title | Category | L | T | P | C | Int. Mark | Ext. Mark | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 23UPESTN01 | Renewable Energy | N | 2 | 0 | 0 | 2 | 25 | 75 | 100 |
| 2 | 23UPESTN02 | Climate Change and $CO_2$ Emission Assessment | N | 2 | 0 | 0 | 2 | 25 | 75 | 100 |
| 3 | 23UPESTN03 | Energy Scenario and Policy | N | 2 | 0 | 0 | 2 | 25 | 75 | 100 |
| 4 | 23UPESTN04 | Erection and Maintenance of Refrigeration and Air-Conditioning Equipment | N | 2 | 0 | 0 | 2 | 25 | 75 | 100 |

## SKILL ENHANCEMENT COURSE (SEC)

| S.No | Course Code | Course title | Category | L | T | P | C | Int. Mark | Ext. Mark | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 23UPESTS01 | PV Installation and Operation | S | 2 | 0 | 0 | 2 | - | 100 | 100 |
| 2 | 23UPESTS02 | Practical Implementation of Energy Audit | S | 2 | 0 | 0 | 2 | - | 100 | 100 |
| 3 | 23UPESTS03 | Innovation and Entrepreneurship | S | 2 | 0 | 0 | 2 | - | 100 | 100 |

## VALUE ADDED COURSE

| S.No | Course Code | Course title | Category |
|---|---|---|---|
| 1 | 23UPESTVA01 | Alternate Fuels and Emissions | **VA** |
| 2 | 23UPESTVA02 | Biomass and its Conversion Technologies | **VA** |
| 3 | 23UPESTVA03 | Materials for Energy Applications | **VA** |
| 4 | 23UPESTVA04 | Hybrid Vehicles | **VA** |
| 5 | 23UPESTVA05 | Design Thinking | **VA** |
| 6 | 23UPESTVA06 | First Aid & Fire Fighting Safety Management | **VA** |
| 7 | 23UPESTVA07 | Refrigeration and Air Conditioning | **VA** |
| 8 | 23UPESTVA08 | Industrial Robotics | **VA** |
| 9 | 23UPESTVA09 | Energy Forecasting, Modeling and Project Management | **VA** |
| 10 | 23UPESTVA10 | Economics And Planning of Energy Systems | **VA** |

| | | L | T | P | C |
|---|---|---|---|---|---|
| **23UPEST1C01** | **ENERGY SCENARIO, AUDIT AND MANAGEMENT** | 5 | 0 | 0 | 5 |

**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 Intensity on Purchasing Power Parity (PPP) - Energy Security, Energy Conservation Act and related policies, Bureau of Energy Efficiency (BEE) Regulations.

**UNIT – II: BASICS OF ENERGY AND ITS VARIOUS FORMS**

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

**UNIT– III: ENERGY AUDIT**

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

**UNIT- IV: UTILITY RATE STRUCTURES AND FINANCIAL ANALYSIS**

Introduction to Material and Energy Balance - Classification of Processes - Energy Analysis and the Sankey Diagram - Financial Analysis Techniques - Economic Evaluation Methods - Energy Performance Contracting and Role of ESCOs - Energy Efficiency in Building through ESCO

**UNIT- V: PROJECT MANAGEMENT, ENERGY MONITORING AND TARGETING**

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

**COURSE OUTCOME**

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

| | | |
|---|---|---|
| CO1 | Adopt energy standards based on various acts officially established for qualitative and quantitative improvement in energy utilization | K1-K6 |
| CO2 | Familiarized about energy auditing and energy management methods. | K1-K6 |
| CO3 | Find the production rate and energy consumption data | K1-K6 |
| CO4 | Analyse the cost benefits of demand side management | K1-K6 |
| CO5 | Involve in energy extraction and efficiency rate improvement | K1-K6 |

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

**TEXT AND REFERENCE BOOKS**


1. 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


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

| 23UPEST1C02 | BASICS OF FLUID MECHANICS AND HEAT TRANSFER | L | T | P | C |
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**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**

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 –$\mathcal{E}$ – NTU - approach and design procedure – compact heat exchanger.

**COURSE OUTCOME**

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

| | | |
|---|---|---|
| CO1 | Understand the difference between solid and fluid, its properties and behavior in static conditions. | K1-K6 |
| CO2 | Understand the concepts of flow governing equations | K1-K6 |
| CO3 | Estimate losses in pipelines for both laminar and turbulent conditions and analysis of pipes connected in series and parallel. | K1-K6 |
| CO4 | Explain basic laws for radiation and apply these principles to radiative heat transfer between different types of surfaces to solve problems | K1-K6 |
| CO5 | Explain the phenomena and apply LMTD and NTU methods of thermal analysis to different types of heat exchanger configurations and solve problems | K1-K6 |

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

**TEXT AND 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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**23UPEST1L01 ENERGY LABORATORY- I**

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**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).
15. Experimental investigation of solar dryer using various food sources
16. Experimental analysis of a Solar Thermal Desalination using impure water

**COURSE OUTCOME**

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

| | | |
|---|---|---|
| CO1 | Understand the working of solar hot water heater and calculate the thermal efficiency of the system. | K1-K6 |

| | | |
|---|---|---|
| CO2 | Operate solar PV devices under different operating parameter and evaluate their performance | K1-K6 |
| CO3 | Investigate the performance of Wind Energy Generator | K1-K6 |
| CO4 | Evaluate the thermal properties of various fuel | K1-K6 |
| CO5 | Examine thermal heat storage systems and determine the performance of various PCM materials | K1-K6 |
| CO6 | Handle solar simulator and assess solar cell performance | K1-K6 |

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

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| **23UPEST1C03** | **THERMAL ENERGY CONSERVATION** | 5 | 0 | 0 | 5 |

**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: FUEL CLASSIFICATION**

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

**UNIT – II: THERMAL ENERGY UTILITY SYSTEMS**

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

**UNIT–III: FURNACES**

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

**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**

| | | |
|---|---|---|
| CO1 | Identify the classification of energy from different sources | K1-K6 |
| CO2 | Evaluate the performance of fuel and biomass under different operating conditions | K1-K6 |
| CO3 | Know the Boiler, Steam and energy efficiency opportunities in steam systems | K1-K6 |
| CO4 | Know the classification and working of different cogeneration system | K1-K6 |
| CO5 | Know the design of different waste heat recovery and heat exchangers. | K1-K6 |

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

**TEXT AND REFERENCE BOOKS**

1. Direct energy conversion : W.R. Corliss, 2021 8.

2. Energy conversion principles : Begamudre , Rakoshdas, 2005
3. Energy Manager Training Manual (4Volumes) available at www.energymanager training.com, a website administered by Bureau of Energy Efficiency (BEE), a statutory body under Ministry of Power, Government of India,2015.
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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**23UPEST1C04 BASICS OF COMPUTATIONAL FLUID DYNAMICS**

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**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**

| | | |
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| CO1 | Build up mathematical models for Boundary Value Problems and their numerical solution | K1-K6 |
| CO2 | Relate concepts of Finite Element Analysis to resolve one dimensional problems | K1-K6 |
| CO3 | Conclude field variables for two dimensional scalar variable problems | K1-K6 |
| CO4 | Establish field variables for two dimensional vector variable problems | K1-K6 |
| CO5 | Appropriate the need for Isoparametric transformation and the use of numerical integration | K1-K6 |

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

**TEXT AND 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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| **23UPEST1L02** | **COMPUTER AIDED DESIGN AND SIMULATION LABORATORY** | 0 | 0 | 6 | 4 |

**COURSE OBJECTIVES**

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

**COURSE OUTCOME**

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

| | | |
|---|---|---|
| CO1 | Understand the different types of views projection views | K1-K6 |
| CO2 | Know 2D surface creation and 3D part Modeling | K1-K6 |
| CO3 | Use modern engineering software tools to analyze the flow with heat transfer | K1-K6 |
| CO4 | Analyze the various parameters influencing the performance of thermodynamic systems | K1-K6 |
| CO5 | Learn modelling and measurement tools to solve flow problems related to heat transfer | K1-K6 |

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

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| **23UPEST1C05** | **ELECTRICAL ENERGY CONSERVATION** | 5 | 0 | 0 | 5 |

**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**

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

**UNIT – II: HVAC AND REFRIGERATION SYSTEM**

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

**UNIT – III: PUMPING SYSTEM AND COOLING TOWERS**

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

**UNIT– IV: COMPRESSED AIR SYSTEM, FANS AND BLOWERS**

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

**UNIT- V: LIGHTING SYSTEM**

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

**COURSE OUTCOME**

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

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

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

**TEXT AND REFERENCE BOOKS**


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


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| 4 | L | - | - | M | - | H | H | H | - | M | M | M | H | M | - |
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**23UPEST1C06 NANOMATERIALS FOR ENERGY APPLICATIONS**

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**COURSE OBJECTIVES**

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

**UNIT – I : INTRODUCTION**

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

**UNIT – II : PROPERTIES OF NANOMATERIALS ON EFFECT OF SIZE**

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

**UNIT– III : SYNTHESIS OF NANOMATERIALS**

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

**UNIT- IV : CHARACTERIZATION TECHNIQUES**

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

**UNIT – V : APPLICATIONS**

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

**COURSE OUTCOME**

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

| | | |
|---|---|---|
| CO1 | Learn about the background on nanoscience. | K1-K6 |
| CO2 | Gain knowledge in properties of nanomaterials. | K1-K6 |
| CO3 | Understand the synthesis of nanomaterials and their application and the impact of nanomaterials on environment | K1-K6 |
| CO4 | Apply their learned knowledge to develop Nanomaterial's by different characterization techniques | K1-K6 |
| CO5 | Design nanomaterials for various energy applications | K1-K6 |

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

**TEXT AND REFERENCE BOOKS**


1. Nanostructures and nanomaterials, synthesis, properites and applciations, Guozhong Cao,USA, Imperial college Press, 2004.
2. Nanomaterials and nanocomposites, synthesis, properites, characterization techniques and applciations, 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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| 3 | H | M | L | - | M | - | H | M | - | - | - | H | - | L | - |
| 4 | H | H | M | - | - | M | H | M | - | - | - | H | L | - | M |
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**23UPEST1C07 ENERGY STORAGE SYSTEMS**

| L | T | P | C |
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**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 : BASIC CONCEPTS**

Components of Cells and Batteries- Classification of Cells and Batteries- Operation of a Cell / Theoretical Cell Voltage, Capacity, and Energy - Specific Energy and Energy Density of Practical Batteries - Upper Limits of Specific Energy and Energy Density.

**UNIT – II : ELECTROCHEMICAL PRINCIPLES AND REACTIONS**

Introduction- Thermodynamic Background - Electrode Processes- Electrical Double-Layer Capacity and Ionic Adsorption- Mass Transport to the Electrode Surface -Electroanalytical Techniques

**UNIT– III : BATTERY DESIGN**

Designing to Eliminate Potential Safety Problems-Battery Safeguards when Using Discrete Batteries - Battery Construction- Design of Rechargeable Batteries- Electronic Energy Management and control systems.

**UNIT- IV : FUEL CELLS**

Conventional Fuel Cells: Sealing Material for Solid Polymer Fuel Cell Separator; Water Management in a Polymer Electrolyte Fuel Cell; Alkaline Fuel Cells: Alkaline Direct Alcohol Fuel Cells; Vanadium Redox Flow Battery; Miniaturisation of a Polymer-Type Fuel Cell; Polymer Fuel Cell Structure Direct Methanol Fuel Cells Modelling Liquid Feed Direct Methanol Fuel Cells and Vapour Feed Direct Methanol Fuel Cells: Types of Fuel Cells and Their Applications

**UNIT – V : HYBRID ENERGY SYSTEMS**

Introduction to Hybrid Energy System-Hybrid System as Source of Renewable Energy - Energy Storage Systems- Compressed Air Energy Storage -Compressed Air Energy Storage (CAES). - Advanced Adiabatic Compressed Air Energy Storage (AA-CAES). Introduction- The Electric Grid - Power Generation -Transmission and Distribution -Load Management - Types of Storage Technology -Kinetic Energy Storage or Flywheel Concept.

**COURSE OUTCOME**

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

| | | |
|---|---|---|
| CO1 | Gain knowledge in lead acid batteries. | K1-K6 |
| CO2 | Acquire knowledge in Industrial and usage of Li-Ion batteries | K1-K6 |
| CO3 | Advance technologies used in Metal air batteries | K1-K6 |
| CO4 | Recent trends of technology used fuel cells. | K1-K6 |
| CO5 | Advancement of hybrid storage systems | K1-K6 |

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

**TEXT AND REFERENCE BOOKS**


1. Linden's Handbook Of Batteries, Thomas B. Reddy , David Linden,4th Edition, McGraw Hill, 2011.
2. Fuel Cells, Solar Panels and Storage Devices Materials and Methods, Johannes Karl Fink, John Wiley & Sons, USA, 2018.
3. Hybrid Energy Systems Driving Reliable Renewable Sources of Energy Storage, Bahman Zohuri , springer, 2018
4. Energy Storage Fundamentals, Materials and Applications Second Edition, Robert A. Huggins, USA, Springer, 2016.
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, 2nd edition, Mehrdad Ehsani, Ali Emadi, YiminGao, USA, CRC press, 2010.
7. Electrochemical power sources, Batteries, Fuel Cells, and Supercapacitors, Vladimir S. Bagotsky, Alexander M. Skundin, Yurij M. Volfkovich, Wiley, Canada, 2015.


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| **2** | H | M | H | M | H | L | H | M | L | - | L | H | H | L | M |
| **3** | H | M | M | M | H | - | H | M | L | - | - | H | H | H | - |
| **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 |

**23UPEST1P01** **PROJECT PHASE I**

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## 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

| **Project work** | **Internal (40 Marks)** | | | **External (60 marks)** | | | |
|---|---|---|---|---|---|---|---|
| Phase I | Review I | Review II | Review III | Thesis Evaluation (External) | Viva –voice 45 Marks | | |
| | | | | | Supervisor | External | Internal |
| | 10 | 10 | 20 | 15 | 15 | 15 | 15 |

## OUTCOME

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

**23UPEST1C08 HYDROGEN STORAGE SYSTEM**

| L | T | P | C |
|---|---|---|---|
| 5 | 0 | 0 | 5 |

**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**

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

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

**TEXT AND REFERENCE BOOKS**


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


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| **3** | H | M | L | - | M | - | H | M | - | - | - | H | - | L | - |
| **4** | H | H | M | - | - | M | H | M | - | - | - | H | L | - | M |
| **5** | M | L | H | - | M | M | H | H | - | - | - | H | L | L | M |

**23UPEST1P02** **PROJECT PHASE II**

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## 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, to give confidence to the students to be creative, well-planned, organized, coordinated project outcome of the aimed work.

## ELECTIVES

**23UPEST1E01 APPLIED MATHEMATICS FOR ENERGY**

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**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**

| | | |
|---|---|---|
| CO1 | Providing knowledge about basics of first-order ODES | K1-K6 |
| CO2 | Exemplify in Linear ODEs and nonlinear equation | K1-K6 |
| CO3 | Imparting theoretical knowledge about boundary problem | K1-K6 |
| CO4 | Students will gain deeper understanding of the Fourier series by mastering the theory of heat boundary value problems with various applications. | K1-K6 |
| CO5 | Students will gain practical knowledge of conformal mapping with fluid and heat problem | K1-K6 |

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

**TEXT AND 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, 2003.
4. Versteeg and Malalasekera, N, "An Introduction to computational Fluid Dynamics Finite Volume Method," Pearson Education, Ltd., Second Edition, 2014.
5. Patankar, S.V. Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation, 2018.


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

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| **23UPEST1E02** | **INDUSTRIAL INSTRUMENTATION** | 5 | 0 | 0 | 3 |

**COURSE OBJECTIVES**

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

**UNIT – I: MEASUREMENT SYSTEM: CHARACTERISTICS AND STATISTICAL ANALYSIS**

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

**UNIT – II: ELECTRICAL MEASUREMENTS AND SIGNAL CONDITIONING**

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

**UNIT–III: DIGITAL MEASUREMENT OF PHYSICAL QUANTITIES**

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

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

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

**UNIT – V: CONTROL SYSTEMS**

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

**COURSE OUTCOME**

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

| | | |
|---|---|---|
| CO1 | Analyze and evaluate the uncertainties in measurement data. | K1-K6 |
| CO2 | Identify appropriate sensors for measuring electrical quantities and signal conditioning circuits. | K1-K6 |
| CO3 | Explain the digital measurement techniques of physical quantities. | K1-K6 |

| | | |
|---|---|---|
| CO4 | Implement the measurement of thermo-physical properties and air pollutants. | K1-K6 |
| CO5 | Design and develop the appropriate measurement and control system for an application. | K1-K6 |

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

**TEXT AND REFERENCE BOOKS**


1. 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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| 3 | H | - | H | - | - | - | - | - | - | - | - | - | H | H | - |
| 4 | H | - | H | - | - | - | H | - | H | - | - | - | H | H | - |
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**23UPEST1E03 RENEWABLE ENERGY SYSTEMS**

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## COURSE OBJECTIVES

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

## UNIT – I: RENEWABLE ENERGY RESOURCES

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

## UNIT – II: WIND ENERGY

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

## UNIT–III: SOLAR PV AND THERMAL SYSTEMS

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

## UNIT-IV: BIOMASS ENERGY

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

## UNIT – V: OTHER ENERGY SOURCES

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

## COURSE OUTCOME

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

| | | |
|---|---|---|
| CO1 | Illustrate the Indian and global energy scenario. | K1-K6 |
| CO2 | Compare various solar energy technologies and identify its applications | K1-K6 |
| CO3 | Infer wind data and compare various wind energy systems. | K1-K6 |
| CO4 | Examine various bio-energy technologies and identify their application | K1-K6 |
| CO5 | Interpret ocean and geothermal energy conversion technologies | K1-K6 |

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

## TEXT AND REFERENCE BOOKS

1. David M. Buchla., “Renewable Energy Systems”, pearson education publication, Hard

cover/Paperback-2017.
2. Mehmet Kanoglu “Fundamentals and Applications of Renewable Energy”, Indian edition McGraw Hill Publication, Hard cover/Paperback-2020
3. TiwariG.N.,“Solar Energy–Fundamentals Design, Modelling and applications”, Alpha Science Intl Ltd, 2015
4. Sukhatme.S.P., “Solar Energy: Principles of Thermal Collection and Storage”,Tata McGraw Hill Publishing Company Ltd., New Delhi,2009.
5. Twidell,J.W.&WeirA.,“Renewable Energy Resources”, EFN Spon Ltd., UK, 2015.

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| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **1** | **2** | **3** |
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| 3 | H | - | H | - | - | - | - | - | - | - | - | - | H | H | - |
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| **23UPEST1E04** | **ENERGY AND ENVIRONMENTAL SCIENCE** | 5 | 0 | 0 | 3 |

**COURSE OBJECTIVES**

- To understand the fundamentals of energy sources, energy use, energy efficiency, and resulting environmental implications of various energy supplies.
- To introduce various aspects of environmental
- To understand the causes and remedies related to social issues like global warming, ozone layer depletion, climate change etc.
- To introduce various acts related to prevention and control of pollution of water and air, forest protection act, wild life protection act etc.
- To study the climate change quantification and mitigating adverse climate change impacts.

**UNIT – I: INTRODUCTION TO ENERGY**

Energy and power, forms of energy, primary energy sources, energy flows, world energy production and consumption, Key energy trends in India: Demand, Electricity, Access to modern energy, Energy production and trade, Factors affecting India's energy development: Economy and demographics Policy and institutional framework, Energy prices and affordability, Social and environmental aspects, Investment

**UNIT – II: ENVIRONMENT**

Introduction, Multidisciplinary nature of environmental studies- Definition, scope and importance, Need for public awareness. Ecosystem: Concept, Energy flow, Structure and function of an ecosystem. Food chains, food webs and ecological pyramids, Forest ecosystem, Grassland ecosystem, Desert ecosystem and Aquatic ecosystems, Ecological succession.

**UNIT–III: ENVIRONMENTAL POLLUTION**

Definition, Cause, effects and control measures of - Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution and Nuclear hazards, Solid waste Management, Disaster management Role of an individual in prevention of pollution, Pollution case studies.

**UNIT-IV: SOCIAL ISSUES AND THE ENVIRONMENT**

Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case Studies. Wasteland reclamation, Consumerism and waste products, Environment Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act, Issues involved in enforcement of environmental legislation.

**UNIT – V: CLIMATE CHANGE AND SAFEGUARDING**

Photosynthetic mechanism and global climate change; various impacts of global warming; prediction of future climate changes; global climate models; The role of international bodies. Kyoto and Montreal protocols and Kigali agreement. Intergovernmental panel on climate change (IPCC). Moral problems and responses

**COURSE OUTCOME**

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

| | | |
|---|---|---|
| CO1 | Understand energy scenario and their utilization | K1-K6 |
| CO2 | Analyse the awareness about the environment and ecosystem. | K1-K6 |

| | | |
|---|---|---|
| CO3 | Identify different types of pollutions and control measures. | K1-K6 |
| CO4 | Understand the environmental pollution along with social issues and acts | K1-K6 |
| CO5 | Demonstrate the concepts of sustainability on environment | K1-K6 |

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

**TEXT AND REFERENCE BOOKS**


1. Cherian A., Energy and global climate change: Bridging the sustainable development divide, Wiley Publisher, 2015.
2. Fouquet R., Handbook on energy and climate change, Edward Elgar Publishing, U.K., 2015.
3. Textbook of Environmental Studies for Undergraduate Courses by Erach Bharucha Second edition,2013 Publisher: Universities Press (India) Private Ltd, Hyderabad.
4. Energy Management Hand book Turner, W. C., Doty, S. and Truner, W. C Fairmont Press 7th Edition 2009
5. Energy Management Principles Smith, C. B Pergamum 2007


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**23UPEST1E05 BASICS OF THERMODYNAMICS**

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**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 2nd 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**

| | | |
|---|---|---|
| CO1 | Know the thermodynamics laws and their applications. | K1-K6 |
| CO2 | Apply concepts of thermodynamics and Zeroth Law in solving numerical problems with relevant units. | K1-K6 |
| CO3 | Analyze of a system's thermal energy per unit temperature that is unavailable for doing useful work. | K1-K6 |

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| CO4 | Illustrate problem solving procedure related to pure substances using PT, PV, TH diagrams. | K1-K6 |
| CO5 | Apply ideal and real gases laws in solving related numerical problems for various conditions. | K1-K6 |

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

**TEXT AND 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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| 3 | M | H | H | - | M | M | M | M | H | - | L | M | L | - | L |
| 4 | H | H | H | - | M | M | M | M | H | - | L | M | L | - | L |
| 5 | H | H | H | - | M | M | M | M | H | - | L | M | L | - | L |

| 23UPEST1E06 | WASTE MANAGEMENT AND ENERGY RECOVERY TECHNIQUES | L | T | P | C |
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**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**

| | | |
|---|---|---|
| CO1 | Waste characterization, Segregation, Disposal will be made known | K1-K6 |
| CO2 | Technologies that are available for effective waste disposal along with pros / cons will become cleaner to students | K1-K6 |
| CO3 | Able to convert waste into useful energy. | K1-K6 |
| CO4 | First-hand information on present day waste related problems (Hazardous Waste, Pharma Waste, Biomedical Waste etc) | K1-K6 |
| CO5 | Get awareness on the healthy environment | K1-K6 |

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

**TEXT AND 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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| **3** | M | H | H | - | H | L | H | M | - | - | L | L | M | - | L |
| **4** | - | M | L | - | M | M | M | M | M | - | L | - | M | - | L |
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| 23UPEST1E07 | **ENERGY CONSERVATION, STORAGE AND TRANSPORTATION** | **L** | **T** | **P** | **C** |
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**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**

| | | |
|---|---|---|
| CO1 | Exposure Students will be Able to analyses various types of energy storage devices and perform the selection based on techno economic view point | K1-K6 |
| CO2 | Ideas in energy conservation, Conception of home heating and transportation | K1-K6 |
| CO3 | Detail practical knowledge in energy storage systems | K1-K6 |
| CO4 | Conversion process of battery electric vehicles | K1-K6 |
| CO5 | Types and usage of hydrogen fuel cells | K1-K6 |

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

**TEXT AND REFERENCE BOOKS**

1. Richarda.D bunlap sustainable energy, Cengage Learning; 1$^{ST}$ edition(2014)
2. Jochen Fricke, Walter L. Borst, Essentials of Energy Technology: Sources, Transport, Storage,

Conservation 1st Edition, Wiley,(2014)
3. Karl Kordesch & Gunter Simader, Fuel Cells and Their Applications, VCH Publishers, NY, 2001.
4. Electric and Hybrid Vehicles Power Sources, Models, Sustainability, Infrastructure and the Market Gianfranco Pistoia Consultant, Rome, Italy, Elsevier Publications, 2017.
5. S. P. Sukhatme, Solar Energy - Principles of thermal collection and storage, Tata McGraw-Hil, New Delhi, 2018

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**23UPEST1E08** **BIO ENERGY CONVERSION**

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**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**

| | | |
|---|---|---|
| CO1 | Estimate the surplus biomass availability of any given area | K1-K6 |
| CO2 | Design a biogas plant for a variety of biofuels | K1-K6 |
| CO3 | Determine and compare the cost of steam generation from biofuels with that of coal and petroleum fuels | K1-K6 |
| CO4 | Analyze the influence of process governing parameters in thermochemical conversion of biomass | K1-K6 |
| CO5 | Synthesize liquid biofuels for power generation from biomass | K1-K6 |

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

**TEXT AND REFERENCE BOOKS**

1. Tom B Reed, Biomass Gasification – Principles and Technology, 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
5. M.M. EL-Halwagi, Biogas Technology- Transfer and diffusion, Elsevier Applied science Publisher, New York, 1984

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| 23UPEST1E09 | RESEARCH METHODOLOGY AND INTELLECTUAL PROPERTY RIGHTS | L | T | P | C |
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**COURSE OBJECTIVES**

- To Identify an appropriate research problem in their interesting domain
- To know ethical issues and the Preparation of a research project thesis report.
- To understand significance, effective technical writing and report
- To know the law of patent and copyrights
- To get the adequate knowledge on patent and rights

**UNIT – I: RESEARCH: A WAY OF THINKING**

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

**UNIT – II: LITERATURE REVIEW**

Bringing clarity and focus to your research problem – Searching for the existing literature - Reviewing the selected literature - Developing a theoretical framework - Developing a conceptual framework

**UNIT– III: TECHNICAL WRITING /EVALUATION**

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

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

Concept of Property vis-à-vis Intellectual Property - Meaning, Relevance, Business Impact, Protection of Intellectual Property - Intellectual Property as an Instrument of Development; Need for Protecting - Intellectual Property – Policy Consideration – National and International - intellectual Property Rights as Human Right – 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**

| | | |
|---|---|---|
| CO1 | Understand the characteristics, objects of a good research problem | K1-K6 |
| CO2 | Understand the principles of ethics and ethical issues in science and engineering | K1-K6 |
| CO3 | Understand writing a research report as per format. | K1-K6 |
| CO4 | Ability to understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity | K1-K6 |
| CO5 | Ability to understand about IPR and filing patents in R &D | K1-K6 |

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

**TEXT AND REFERENCE BOOKS**

1. Ranjit Kumar, "Research Methodology: A Step by Step Guide for beginners" 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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**23UPEST1E10** **WIND ENERGY CONVERSION**

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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; Prandlt's tip loss Correction

**UNIT– III : DESIGN OF WIND TURBINE**

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

**UNIT- IV : WIND ENERGY ECONOMICS AND APPLICATION**

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

**UNIT – V : ENVIRONMENTAL IMPACTS**

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

**COURSE OUTCOME**

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

| | | |
|---|---|---|
| CO1 | Prepare and evaluate detailed project reports for establishing a wind farm | K1-K6 |
| CO2 | Understand the operation of a wind farm and economics of power generation | K1-K6 |
| CO3 | Gain Knowledge of construction characteristics and performance of wind turbine | K1-K6 |
| CO4 | Study economics of harnessing energy from wind energy | K1-K6 |
| CO5 | Analyse environmental impacts in installing wind turbine | K1-K6 |

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

**TEXT AND REFERENCE BOOKS**

1. 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 | - |

**23UPEST1E11 ELECTRIC VEHICLE SYSTEM**

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**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
- To learn about the propulsion system used in electrical vehicle
- To understand the drive system and characteristics of electrical vehicle

**UNIT – I: INTRODUCTION**

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

**UNIT – II: BATTERIES**

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

**UNIT–III: HYBRID ELECTRIC VEHICLES**

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

**UNIT-IV: EV PROPULSION**

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

**UNIT – V: EV MOTOR DRIVES**

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

**COURSE OUTCOME**

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

| | | |
|---|---|---|
| CO1 | Choose a suitable drive scheme for developing an electric of hybrid vehicle depending on resources | K1-K6 |
| CO2 | Design and develop basic schemes of electric vehicles and hybrid electric vehicles. | K1-K6 |
| CO3 | Understanding electric car energy resources | K1-K6 |
| CO4 | Experience of electric car storage technology | K1-K6 |
| CO5 | Learn the electrical vehicle motors and controls | K1-K6 |

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

**TEXT AND REFERENCE BOOKS**

1. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.

3. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
4. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
5. Hand Book of Batteries and Fuel cells, 3rd Edition, Edited by David Linden and Thomas. B. Reddy, McGraw Hill Book Company, N.Y. 2002.
6. Fuel Cells, Principles and Applications, Viswanathan, B. and Scibioh, Aulice M, Universities Press, 2006.
7. The Essential Hybrid Car Handbook: A Buyer's Guide (Paperback)by Nick Yost, The Lyons Press, N.Y. 2006

| 23UPEST1E12 | ENERGY AND WATER MANAGEMENT IN HIGH PERFORMANCE BUILDING | L | T | P | C |
|---|---|---|---|---|---|
| | | 4 | 0 | 0 | 3 |

**COURSE OBJECTIVES**

- To understand demand requirement and reduction strategies
- To be familiar with basic terminologies related to buildings
- To learn the building (air) conditioning techniques and their performance measurement
- To know the methods to evaluate the performance of buildings
- To incorporate Renewable energy systems in buildings

**UNIT – I: ENERGY DEMAND REDUCTION MANAGEMENT**

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

**UNIT – II: ENERGY EFFICIENT SYSTEMS**

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

**UNIT– III: REFRIGERANT MANAGEMENT AND COMMISSIONING**

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

**UNIT- IV: INDOOR & OUTDOOR WATER USE**

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

**UNIT – V: OPERATION AND MAINTENANCE**

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

**COURSE OUTCOME**

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

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

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

**TEXT AND REFERENCE BOOKS**

1. LEED Green Associate Made Easy study guide, K.M. Bazeeth Ahamed. Energy Conservation Building Code User Guide, ASHRAE 90.1 2013 Standard.
2. Uniform Plumbing Code 2009. LEED Reference Guide for Building Design and Construction, USGBC.

3. K.S.Jagadish, B.U.Venkataramareddy and K.S.Nanjundarao. Alternative Building Materials and Technologies. New Age International, (2007).
4. Low Energy Cooling For Sustainable Buildings. John Wiley and SonsLtd,(2009).
5. Green My Home:10 Steps to Lowering Energy Costs and Reducing Your Carbon Footprint, by Dennis C. (2008).
6. B.Givoni, Man, Climate and Architecture Elsevier,(1969).
7. T. A. Markus and E. N. Morris Buildings Climate and Energy. Pitman, London,(1980).

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

**23UPEST1E13** **POWER PLANT ENGINEERING**

| L | T | P | C |
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| 4 | 0 | 0 | 3 |

**COURSE OBJECTIVES**

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

**UNIT – I : POWER PLANT CYCLES**

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

**UNIT – II : STEAM POWER PLANT**

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

**UNIT–III : DIESEL AND GAS POWER PLANT**

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

**UNIT-IV: NUCLEAR POWER PLANT**

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

**UNIT – V: ECONOMICS OF POWER GENERATION**

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

**COURSE OUTCOME**

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

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

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

**TEXT AND REFERENCE BOOKS**


1. 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.


| CO | PO | | | | | | | | | | | | PSO | | |
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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 | - |

| 23UPEST1E14 | POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEM | L | T | P | C |
|---|---|---|---|---|---|
| | | 4 | 0 | 0 | 3 |

**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:**

| | | |
|---|---|---|
| CO1 | Analyze the various conversion techniques in renewable energy technologies. | K1-K6 |
| CO2 | Apply the various mechanisms for the conversion of renewable energy sources. | K1-K6 |
| CO3 | Identify the appropriate power converters for renewable energy systems. | K1-K6 |
| CO4 | Implement the different conversion mechanisms for wind and solar systems. | K1-K6 |
| CO5 | Recognize the importance of various hybrid renewable energy systems | K1-K6 |

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

**TEXT AND 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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| **1** | H | H | L | L | M | L | M | - | - | - | - | L | M | L | L |
| **2** | M | H | L | L | M | L | M | - | - | - | - | L | M | L | L |
| **3** | H | H | H | M | H | L | H | - | - | - | - | L | M | L | L |
| **4** | L | M | L | L | M | L | M | - | - | - | - | - | M | L | L |
| **5** | L | L | L | L | - | L | L | - | - | - | - | - | L | M | L |

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| **23UPEST1E15** | **SOLAR PHOTOVOLTAIC SCIENCE AND TECHNOLOGY** | 4 | 0 | 0 | 3 |

**COURSE OBJECTIVES**

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

**UNIT – I: INTRODUCTION**

Structure and working of Solar Cells - Types, Electrical properties and Behaviour of Solar Cells – Cell properties and design - PV Cell Interconnection and Module Fabrication – Electrical characteristics of the solar cell - equivalent circuit - Effects of temperature, irradiation and series/shunt resistances on the open-circuit voltage and short-circuit current - PV generators, shadow effects – Blocking and bypass diodes - hot spot problem in a PV module.

**UNIT – II: STAND ALONE PV SYSTEMS**

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

**UNIT–III: GRID CONNECTED PV SYSTEMS**

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

**UNIT-IV: HYBRID SYSTEMS**

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

**UNIT – V: DESIGN OF PV SYSTEMS**

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

**COURSE OUTCOME**

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

| | | |
|---|---|---|
| CO1 | Apply principle of evidence-based photovoltaic technology | K1-K6 |
| CO2 | Provide accurate schematic of stand-alone PV systems | K1-K6 |
| CO3 | Provide accurate schematic of grid-connected PV systems | K1-K6 |
| CO4 | Select appropriate hybrid system for different applications | K1-K6 |
| CO5 | Design and simulate the stand-alone and grid connected system | K1-K6 |

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

**TEXT AND 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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| 2 | H | H | H | M | M | M | L | - | - | - | - | L | - | L | L |
| 3 | H | H | H | H | H | M | M | - | - | - | - | L | - | M | M |
| 4 | H | H | H | H | H | M | M | - | - | - | - | - | - | H | H |
| 5 | M | M | H | H | L | M | M | - | - | - | - | - | - | H | H |

**23UPEST1E16** **TECHNICAL SEMINAR - I**

| L | T | P | C |
|---|---|---|---|
| 4 | 0 | 0 | 3 |

**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 (25 Marks)** | | | **External (75 Marks)** | | |
|---|---|---|---|---|---|
| Presentation I | Presentation II | Presentation III | Dissertation | Presentation | Viva Voce |
| 5 | 10 | 10 | 30 | 30 | 15 |

**23UPEST1E17** **TECHNICAL SEMINAR - II**

| L | T | P | C |
|---|---|---|---|
| 4 | 0 | 0 | 3 |

**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 (25 Marks)** | | | **External (75 Marks)** | | |
|---|---|---|---|---|---|
| Presentation I | Presentation II | Presentation III | Dissertation | Presentation | Viva Voce |
| 05 | 10 | 10 | 30 | 30 | 15 |

**23UPPGC1H01 FUNDAMENTALS OF HUMAN RIGHTS**

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 0 | 2 |

**UNIT – I: INTRODUCTION**

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

**UNIT – II: HUMAN RIGHTS IN INDIA**

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

**UNIT–III: RIGHTS OF MARGINALIZED AND OTHER DISADVANTAGED PEOPLE**

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

**UNIT-IV: HUMAN RIGHTS MOVEMENTS**

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

**UNIT – V: REDRESSAL MECHANISMS**

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

**TEXT AND REFERENCE BOOKS**

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

# NON-MAJOR ELECTIVES

**23UPESTN01 RENEWABLE ENERGY**

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 0 | 2 |

**COURSE OBJECTIVES**

- To acquire knowledge about the conventional and non-conventional energy sources
- To analyze the working of Solar Thermal and PV systems
- To gain knowledge on Wind energy conversion
- To know the importance and methods of conversion of bio-based waste into useful form of energy.
- To obtain information on the source and utilization of geothermal energy

**UNIT – I: ENERGY SOURCES**

Environment and sustainable development - Energy sources - sun as the source of energy – photosynthesis - classification of energy sources - fossil fuel reserves and resources - overview of global/ India's energy scenario.

**UNIT – II: SOLAR ENERGY**

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

**UNIT–III: WIND ENERGY**

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

**UNIT-IV: BIOENERGY**

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

**UNIT – V: GEOTHERMAL ENERGY**

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

**COURSE OUTCOME**

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

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

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

**TEXT AND REFERENCE BOOKS**

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

| 23UPESTN02 | **CLIMATE CHANGE AND $CO_2$ EMISSION ASSESSMENT** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | 2 | 0 | 0 | 2 |

**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 ($CO_2$) EMISSIONS AND CONVERSION/CONSUMPTION**

Carbon dioxide ($CO_2$) emissions in relation to energy conversion/consumption: theory of CO2 emission in relation to energy conversion processes.

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

Methodology for $CO_2$ assessment/carbon foot print: estimation of emission from fossil fuel combustion (Fuels and their composition - fuel to energy conversion - concept of emission factor) - emission from major sectors (industry – transport – agriculture – domestic - service)

**UNIT – V: CARBON CREDIT**

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

**COURSE OUTCOME**

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

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

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

**TEXT AND REFERENCE BOOKS**

1. Franchetti M. J. and Apul D. S., Carbon Footprint Analysis: concepts, methods, implementation and case studies, CRC Press, (2013).
2. Clean Development Mechanism, UNFCC 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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| 3 | - | - | L | M | H | M | H | M | - | - | L | - | M | L | - |
| 4 | - | - | L | M | M | L | H | M | - | - | L | - | M | L | - |
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**23UPESTN03 ENERGY SCENARIO AND POLICY**

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**COURSE OBJECTIVE**

- To know the Energy Scenario in India and Global
- To know Indian Energy Conservation Act
- To understand the details on government policies in energy.
- To know the energy efficiency and climate change policies
- To know measures the impact of energy savings on environment

**UNIT – I: ENERGY SCENARIO**

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

**UNIT – II: ENERGY CONSERVATION ACT**

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

**UNIT–III: ENERGY POLICY**

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

**UNIT-IV: ENERGY EFFICIENCY AND CLIMATE CHANGE**

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

**UNIT – V: IMPACT OF ENERGY ON ECONOMY AND DEVELOPMENT**

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

**COURSE OUTCOME**

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

| | | |
|---|---|---|
| CO1 | Familiar knowledge in energy scenario globally and locally. | K1-K6 |
| CO2 | Gain knowledge on Indian Energy Conservation Act | K1-K6 |
| CO3 | Acquire information on government energy policies | K1-K6 |
| CO4 | Understand the Energy efficiency and climate change policies. | K1-K6 |
| CO5 | Know about the effects of energy demand on environment | K1-K6 |

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

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

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| **23UPESTN04** | **ERECTION AND MAINTENANCE OF REFRIGERATION AND AIR- CONDITIONING EQUIPMENT** | 2 | 0 | 0 | 2 |

**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: VAPOUR COMPRESSION REFRIGERATION SYSTEM**

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

**UNIT– III: OTHER REFRIGERATION SYSTEMS**

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

**UNIT- IV: PSYCHROMETRIC PROPERTIES AND PROCESSES**

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

**UNIT – V: LOAD ESTIMATION**

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

**COURSE OUTCOME**

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

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

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

**TEXT AND REFERENCE BOOKS**

1. 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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| 3 | - | - | L | L | M | M | H | M | - | - | M | M | M | L | L |
| 4 | - | - | L | L | M | M | H | M | - | - | M | M | M | L | L |
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# SKILL ENHANCEMENT COURSE (SEC)

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| **23UPESTS01** | **PV INSTALLATION AND OPERATION** | 2 | 0 | 0 | 2 |

**COURSE OBJECTIVES**

- To Carry out the site survey for installation of Solar PV system
- To Identify and Use the Tools & tackles used for Solar PV system installation
- To Install the Electrical components of a Solar PV system
- To Test and Commission Solar PV system
- To Maintain personal Health & Safety at project site

**UNIT – I: BASICS OF SOLAR PHOTOVOLTAIC SYSTEMS AND ITS COMPONENTS**

Solar PV system - understand the working and operations - different types of Solar PV systems - Specifications of Modules, Solar Inverters, Charge Controllers, Cables, Conduits, Junction Boxes, Solar Batteries and allied accessories - specifications of foundations/ footings

**UNIT – II: BASICS OF ELECTRICAL SYSTEMS AND DESIGN OF SOLAR PV**

Electrical circuit components - Electrical test equipment - Utility systems, generation, transmission, distribution & electrical service - Observe Sun path diagram and shading analysis - assess the site conditions - Identify the load to be connected to the Solar PV system - Prepare load profile - Customer specific requirement and budget constraints - Calculate system size - Calculate size of the system with basic mathematical tools

**UNIT–III: INSTALLATION OF ELECTRICAL COMPONENTS OF SOLAR PV SYSTEMS**

Single Line Diagram, Layouts and drawings - installing the electrical components including inverter, batteries, junction boxes, energy meters and other electrical components along with performing pre installation checks - installation of cables and conduits - types of Earthing and its installation - interpret the Bill of Material - Testing of all the solar components of the Solar PV system including fault finding and analysis including continuity checks, polarity check and other commissioning activities

**COURSE OUTCOME**

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

| | | |
|---|---|---|
| CO1 | Understand various Product-Oriented Solar Business Opportunities | K1-K6 |
| CO2 | Understand new technologies and the evolving market landscape | K1-K6 |
| CO3 | Understand new technologies and the evolving market landscape | K1-K6 |
| CO4 | Know the Commissioning process for the Solar PV System | K1-K6 |
| CO5 | Understand Terminology used in the Solar Industry | K1-K6 |

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

**TEXT AND 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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| **23UPESTS02** | **PRACTICAL IMPLEMENTATION OF ENERGY AUDIT** | 2 | 0 | 0 | 2 |

**COURSE OBJECTIVES**

- To Understanding the fundamentals of energy audit and management
- To Know about the auditing process and the complete data to be collected
- To how to analyze energy consumption in a facility and establish energy balance
- To know assessment of different electrical and thermal utilities
- To Understand the characteristics of energy consuming systems and the energy savings opportunities

**UNIT – I: INTRODUCTION**

General Information - facility overview - Scope of Work, Methodology and Approach of energy audit - Forming energy audit team

**UNIT – II: STUDY OF CONNECTED LOAD**

Details of Energy consuming Equipment's Installed - Lighting Fixtures - Fans at various locations - UPS - Air Conditioning - Use & occupancy of the building - Details of systems/equipment's/appliance

**UNIT–III: ANALYSIS OF PRESENT ENERGY CONSUMPTION & CARBON FOOT PRINTING**

Electrical Bill Analysis - Sanctioned Demand - Monthly Unit Consumption & Variation - Monthly Variation in Maximum Demand - Monthly Variation in Power Factor - Carbon Foot print - Basis for computation of CO2 Emissions - Month wise Consumption of Electrical Energy & CO2 Emissions - General Energy Conservation potential in Motors, Fans, Blowers, Pumps, HVAC (Heating / Ventilation / Air Conditioning), Lighting, DG sets, Buildings, Water & Wastewater - investment required - Cost analysis - Executive Summary

**COURSE OUTCOME**

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

| | | |
|---|---|---|
| CO1 | Adopt energy standards based on various acts officially established for qualitative and quantitative improvement in energy utilization | K1-K6 |
| CO2 | Familiarized about energy auditing and energy management methods. | K1-K6 |
| CO3 | Find the production rate and energy consumption data | K1-K6 |
| CO4 | Analyse the cost benefits of demand side management | K1-K6 |
| CO5 | Involve in energy extraction and efficiency rate improvement | K1-K6 |

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

**TEXT AND REFERENCE BOOKS**

1. Smith C. B. Energy Management Principles, Pergamon Press, New York. 2015 7.
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

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| 4 | H | H | - | M | - | H | H | H | - | M | H | M | H | M | - |
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| **23UPESTS03** | **INNOVATION AND ENTREPRENEURSHIP** | 2 | 0 | 0 | 2 |

**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 DECISIONMAKING**

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

**COURSE OUTCOME**

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

| | | |
|---|---|---|
| CO1 | The learners will gain entrepreneurial competence to run the business efficiently | K1-K6 |
| CO2 | The learners are able to undertake businesses in the entrepreneurial environment | K1-K6 |
| CO3 | The learners are capable of preparing business plans and undertake feasible projects | K1-K6 |
| CO4 | The learners are efficient in launching and develop their business ventures successfully | K1-K6 |
| CO5 | The learners shall monitor the business effectively towards growth and development | K1-K6 |

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

**TEXT AND 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.Carterand D.Jones-Evans, Enterprise and small business- Principal Practice and Policy, Pearson Education (2006)

**VALUE ADDED COURSE**

## 23UPESTVA01 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, H2, 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

### TEXT AND REFERENCE BOOKS

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

## 23UPESTVA02 BIOMASS AND ITS CONVERSION TECHNOLOGIES

### COURSE OBJECTIVES

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

### UNIT – I: INTRODUCTION

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

### UNIT – II: THERMO-CHEMICAL CONVERSION

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

### UNIT– III: BIOMASS PRODUCTIVITY

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

### COURSE OUTCOME

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

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

### TEXT AND REFERENCE BOOKS

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

**23UPESTVA03 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

**TEXT AND 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 Kilkis and S Kakac (Ed), KAP, London

**23UPESTVA04 HYBRID 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 of 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.

**TEXT AND 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.

**23UPESTVA05 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

**TEXT AND 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).

## 23UPESTVA06 FIRST AID & FIRE FIGHTING SAFETY MANAGEMENT

### COURSE OBJECTIVES

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

### UNIT – I: FIRST AID

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

### UNIT – II: INDUSTRIAL SAFETY

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

### UNIT– III: FIRE FIGHTING

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

### COURSE OUTCOME

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

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

### TEXT AND REFERENCE BOOKS

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

## 23UPESTVA07 REFRIGERATION AND AIR CONDITIONING

### COURSE OBJECTIVES

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

### UNIT – I: INTRODUCTION, REFRIGERANTS AND THEIR ENVIRONMENTAL ISSUE

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

### UNIT – II: AIR CONDITIONING SYSTEM TYPES AND AIR DISTRIBUTION

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

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

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

### COURSE OUTCOME

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

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

### TEXT AND REFERENCE BOOKS

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

**23UPESTVA08 INDUSTRIAL ROBOTICS**

**COURSE OBJECTIVES**

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

**UNIT – I: FUNDAMENTALS OF ROBOT**

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

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

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

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

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

**COURSE OUTCOME**

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

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

**TEXT AND REFERENCE BOOKS**

1. Craig J.J., “Introduction to Robotics Mechanics and Control”, Pearson Education, 2009.
2. Deb S.R., “Robotics Technology and Flexible Automation” Tata McGraw Hill Book Co., 2013.
3. Koren Y., “Robotics for Engineers", McGraw Hill Book Co., 1992
4. Maja J Mataric, “The Robotics Primer “Universities Press. 2013.
5. Robin R. Murphy “ Introduction to AI Robotics” PHI Learning Private Limited, 2000

**23UPESTVA09** **ENERGY FORECASTING, MODELING AND PROJECT MANAGEMENT**

## COURSE OBJECTIVES

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

## UNIT – I: ENERGY SCENARIO

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

## UNIT – II: FORECASTING AND OPTIMIZATION MODEL

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

## UNIT– III: PROJECT MANAGEMENT AND ENERGY POLICY

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

## COURSE OUTCOME

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

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

## TEXT AND REFERENCE BOOKS

1. Armstrong J.Scott (ed.), Principles of forecasting: a hand book for researchers and practitioners, Norwell, Massachusetts: Kluwer Academic Publishers.2001
2. DhandapaniAlagiri, Energy Security in India Current Scenario, The ICFAI University Press, 2006.
3. Fred Luthans, Brett C. Luthan, Kyle W. Luthans, Organisational Behaviour: An Evidence- Based Approach, Information Age Publishing; 13 edition, 2015.
4. Spyros G. Makridakis, Steven C. Wheelwright, Rob J. Hyndman, Forecasting: Methods and Applications, 4th Edition, ISBN: 978-0-471-53233-0,2003.
5. Yang X.S., Introduction to mathematical optimization: From linear programming to Metaheuristics, Cambridge, Int. Science Publishing, 2008.

## 23UPESTVA10 ECONOMICS AND PLANNING OF ENERGY SYSTEMS

### COURSE OBJECTIVES

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

### UNIT – I: INTRODUCTION AND BASIC CONCEPTS OF ENERGY ECONOMICS

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

### UNIT – II: SOCIO-ECONOMIC EVALUATION OF ENERGY CONSERVATION PROGRAMMES

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

### UNIT– III: OVERVIEW OF ENERGY POLICIES AND FORECASTING

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

### COURSE OUTCOME

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

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

### TEXT AND REFERENCE BOOKS

1. EA Diulio, Macroeconomic Theory, Schaum's Outline Series, 2nd Ed, McGraw-Hill Publishing Company (1990)
2. R Loulou, P R Shukla and A Kanudia, Energy and Environment Policies for a sustainable Future, Allied Publishers Ltd, New Delhi, 1997
3. J Parikh, Energy Models for 2000 and Beyond, Tata McGraw-Hill Publishing Company Ltd, New Delhi,1997.
4. Energy Economics -A.V.Desai (Wiley Eastern) Energy Economics - Simple Payback Period, Time Value of Money, IRR, NPV, Life Cycle Costing, Cost of Saved Energy, Cost of Energy generated, Examples from energy generation and conservation.