# REGULATIONS AND SYLLABUS
# (University Department)

(For the candidates admitted from the academic year 2021-2022 onwards)

# MASTER OF SCIENCE IN ENERGY SCIENCE

(Under Choice Based Credit System)


**DEPARTMENT OF ENERGY SCIENCE AND TECHNOLOGY**

**PERIYAR UNIVERSITY**

**SCHOOL OF ENERGY AND ENVIRONMENTAL SCIENCE**

**(NAAC A Grade -State University- NIRF Rank 83, ARIIA Rank 4)**

**SALEM– 636 011**

**TAMIL NADU**

# Regulations & Scheme

# M.Sc., Energy Science

Choice Based Credit System (CBCS) Regulation,

Scheme and Syllabus

(W.e.f.2021-2022onwards)

## 1. Eligibility for Admission

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

## 2. Mode of Selection

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

## 3. Duration of the Course

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

## 4. Distribution of Credit Points

The minimum credit requirement for M.Sc. degree shall be 90 Credits. The break-up of credits for the Programme is as follows;

- Core Courses : 69 credits
- Elective Courses : 16 credits
- Supportive Courses : 06 credits

## 5. Course of Study

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

### 5.1 Components of Internal Examination

The allotment of marks and scheme of examination as follows;

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

**5.2 Theory Core Paper**

| | |
|---|---|
| External | 75 Marks |
| Internal | 25 Marks |
| Total | 100 Marks |
| Duration of Examination | 3 Hours |

**5.3 Practical Internal &External**

| | |
|---|---|
| Model Practical | 30 Marks |
| Record | 05 Marks |
| Viva Voce | 05 Marks |
| Internal Total | 40 Marks |
| External | 60 Marks |
| Total | 100 Marks |

**5.4 Marks allotment for attendance as follows**

| % of attendance | Marks |
|---|---|
| 96% - 100% | 5 |
| 91% - 95% | 4 |
| 86%- 90% | 3 |
| 81% - 85% | 2 |
| 75% - 80% | 1 |
| Below 75% | No marks |

**6. Details of Project Marks**

| **Project work** | **Internal (40 Marks)** | | | **External (60 marks)** | | | |
|---|---|---|---|---|---|---|---|
| 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 |

| **Project work** | **Internal (80 Marks)** | | | **External (120 marks)** | | | |
|---|---|---|---|---|---|---|---|
| Phase II | Review I | Review II | Review III | Thesis Evaluation (External) | Viva –voice 90 Marks | | |
| | | | | | Supervisor | External | Internal |
| | 20 | 20 | 40 | 30 | 30 | 30 | 30 |

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

The Project work for Phase II shall be pursue for a minimum of 90 days during the final semester. Students may be permitted to carried out project work either internal or external mode i.e, Industrial / Research Organization, etc., on the recommendations of the Head of the Department. In case of external, the Project work shall be jointly guided by a supervisor of the department and an expert as joint supervisor from the organization and 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 Hrs** **Maximum Marks: 75**

**PART – A (20X1= 20 Marks)**

Objective Type Questions

**PART – B (3X5= 15 Marks)**

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

**PART – C (5X8= 40 Marks**)

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

**8. Passing Minimum**

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

## 9. Classification of Successful Candidate

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

Supportive paper should be offered in second and third semesters. Students are expected to opt Supportive Course (Non major elective) offered by other departments. Students can earn three credits from supportive course.

## 12. Swayam Course

SWAYAM is a Programme initiated by Government of India and designed to achieve the three cardinal principles of Education Policy namely access, equity, and quality. The objective of this effort is to take the best teaching learning resources to all, including the most disadvantaged. SWAYAM seeks to bridge the digital divide for students who have hitherto remained untouched by the digital revolution and have not been able to join the mainstream of the knowledge economy. The courses hosted on SWAYAM are in 4 quadrants – (1) video lecture, (2) specially prepared reading material

that can be downloaded/printed (3) self-assessment tests through tests and quizzes and (4) an online discussion forum for clearing the doubts. Steps have been taken to enrich the learning experience by using audio-video and multi-media and state of the art pedagogy / technology. In order to ensure best quality content are produced and delivered, nine National Coordinators have been appointed: They are AICTE for self-paced and international courses, NPTEL for engineering, UGC for non-technical post-graduation education, CEC for under-graduate education, NCERT and NIOS for school education, IGNOU for out-of-the school students, IIMB for management studies and NITTTR for Teacher Training Programme. Courses delivered through SWAYAM are available free of cost to the learners, however, students wanting certifications if they register will be offered a certificate on successful completion of the course, for a small fee. At the end of each course, there will be an assessment of the student through proctored examination and the marks/ grades secured in this exam could be transferred to the academic record of the students.

**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. Getting employment in public/private industrial energy sectors, Government energy agencies, consultancy energy services and educational institution dealing with energy.

II. Getting admission for higher studies /employment in research organization working on energy and environment.

III. Successfully carry out their profession as an entrepreneur and team player with innovative approach to provide economical and sustainable solutions to solve energy/ environmental problems for societal progress.

IV. Leading ethical life and continuous progressing in any profession through practicing lifelong learning attitude

V. Responsive to changing situations by continuously acquiring new knowledge and skills

**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 Engineer and society | Conduct themselves to uphold the professional and social obligations. |
| 7 | Environment and sustainability | Design the system with environment consciousness and sustainable development. |
| 8 | Ethics | Interact in industry, business and society in a professional and ethical manner. |
| 9 | Individual and team | Function in a multidisciplinary team. |
| 10 | Communication | Proficiency in oral and written Communication. |
| 11 | Project management and finance | Implement cost effective and improved system. |
| 12 | Life-long learning | Continue professional development and learning as a life-long activity. |

**PROGRAM SPECIFIC OUTCOMES (PSOs):**

1. Graduates will apply the knowledge of energy sourcing, generation, and distribution for the effective utilization of green energy to develop net zero emission society
2. Graduates will design economically feasible equipment's for the modernization of traditional energy source developing methods
3. Graduates will apply the knowledge of energy science and technology principles from the various aspects and related disciplines to solve practical and real-world problems

**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 | PO01 | PO02 | PO03 | PO04 | PO05 | PO06 | PO07 | PO08 | PO09 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I YEAR | Semester 1 | APPLIED MATHEMATICS FOR ENERGY | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | | | | |
| | | BASICS OF FLUID MECHANICS AND HEAT TRANSFER | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ | | | ✓ |
| | | ENERGY AUDIT AND MANAGEMENT | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | | ✓ |
| | | WIND ENERGY | ✓ | | | ✓ | ✓ | ✓ | ✓ | | ✓ | | ✓ | ✓ |
| | | ENERGY LABORATORY – I | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | | | ✓ |
| | | ELECTIVE – I | | | | | | | | | | | | |
| | Semester 2 | ENERGY ECONOMICS & POLICES | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ |
| | | BASICS OF THERMODYNAMICS | ✓ | ✓ | | ✓ | | | | | ✓ | | | ✓ |
| | | BASICS OF COMPUTATIONAL FLUID DYNAMICS | ✓ | ✓ | | ✓ | | | | | ✓ | | | ✓ |
| | | ENVIRONMENTAL SCIENCE AND | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | | ✓ |
| | | ANALYSIS AND SIMULATION LABORATORY | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | | | ✓ |
| | | ELECTIVE –II | | | | | | | | | | | | |
| | | SUPPORTIVE-I | | | | | | | | | | | | |
| II YEAR | Semester 3 | HYDROGEN & FUEL CELLS | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ |
| | | INTRODUCTION OF ENERGY MATERIALS | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | | | ✓ |
| | | MATERIAL CHARACTERIZATION | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | | ✓ |
| | | PROJECT WORK PHASE I | | | | | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ |
| | | ELECTIVE –III | | | | | | | | | | | | |
| | | SUPPORTIVE-II | | | | | | | | | | | | |
| | Semester 4 | BIOENERGY TECHNOLOGIES | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ |
| | | INDUSTRIAL INSTRUMENTATION | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | | | ✓ |
| | | PROJECT WORK PHASE II | | | | | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ |
| | | ELECTIVE –IV | | | | | | | | | | | | |

# PERIYAR UNIVERSITY, SALEM
# UNIVERSITY DEPARTMENT REGULATIONS – 2021
# CHOICE BASED CREDIT SYSTEM
# M.Sc. ENERGY SCIENCE

## CURRICULUM AND SYLLABUS

### SEMESTER I

| S. No | Course Code | Course Title | Category | Contact Periods | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| 1 | 21UPEST1C01 | APPLIED MATHEMATICS FOR ENERGY | PC | 5 | 4 | 1 | 0 | 4 |
| 2 | 21UPEST1C02 | BASICS OF FLUID MECHANICS AND HEAT TRANSFER | PC | 5 | 4 | 1 | 0 | 4 |
| 3 | 21UPEST1C03 | ENERGY AUDIT AND MANAGEMENT | PC | 5 | 4 | 1 | 0 | 4 |
| 4 | 21UPEST1C04 | WIND ENERGY | PC | 5 | 4 | 1 | 0 | 4 |
| 5 | - | ELECTIVE – I | PE | 4 | 4 | 0 | 0 | 4 |
| **PRACTICALS** | | | | | | | | |
| 6 | 21UPEST1C05 | ENERGY LABORATORY – I | PC | 3 | 0 | 0 | 3 | 2 |
| | | | **TOTAL** | **27** | **20** | **4** | **3** | **22** |

### SEMESTER II

| S. No | Course Code | Course Title | Category | Contact Periods | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| 1 | 21UPEST1C06 | ENERGY ECONOMICS & POLICES | PC | 4 | 4 | 0 | 0 | 4 |
| 2 | 21UPEST1C07 | BASICS OF THERMODYNAMICS | PC | 5 | 4 | 1 | 0 | 4 |
| 3 | 21UPEST1C08 | BASICS OF COMPUTATIONAL FLUID DYNAMICS | PC | 5 | 4 | 1 | 0 | 4 |
| 4 | 21UPEST1C09 | ENVIRONMENTAL SCIENCE AND POLLUTION CONTROL | PC | 4 | 4 | 0 | 0 | 4 |
| 5 | - | ELECTIVE II | PE | 4 | 4 | 0 | 0 | 4 |
| 6 | - | SUPPORTIVE | NM | 3 | 3 | 0 | 0 | 3 |
| 7 | 06PHR01 | HUMAN RIGHTS | - | 0 | 0 | 0 | 0 | 0 |
| **PRACTICALS** | | | | | | | | |
| 8 | 21UPEST1C10 | ANALYSIS AND SIMULATION LABORATORY | PC | 3 | 0 | 0 | 3 | 2 |
| | | | **TOTAL** | **28** | **23** | **2** | **3** | **25** |

## SEMESTER III

| S. No | Course Code | Course Title | Category | Contact Periods | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| **THEORY** | | | | | | | | |
| 1 | 21UPEST1C11 | HYDROGEN & FUEL CELLS | PC | 4 | 4 | 0 | 0 | 4 |
| 2 | 21UPEST1C12 | INTRODUCTION OF ENERGY MATERIALS | PC | 4 | 4 | 0 | 0 | 4 |
| 3 | 21UPEST1C13 | MATERIAL CHARACTERIZATION | PC | 4 | 4 | 0 | 0 | 4 |
| 4 | - | ELECTIVE III | PE | 4 | 4 | 0 | 0 | 4 |
| 5 | - | SUPPORTIVE | NM | 3 | 3 | 0 | 0 | 3 |
| **Project Work** | | | | | | | | |
| 6 | 21UPEST2C14 | PROJECT WORK PHASE I | PC | 8 | 0 | 0 | 8 | 4 |
| | | | **TOTAL** | **27** | **19** | **0** | **8** | **23** |

## SEMESTER IV

| S. No | Course Code | Course Title | Category | Contact Periods | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| **THEORY** | | | | | | | | |
| 1 | 21UPEST1C15 | BIOENERGY TECHNOLOGIES | PC | 4 | 4 | 0 | 0 | 4 |
| 2 | 21UPEST1C16 | INDUSTRIAL INSTRUMENTATION | PE | 4 | 4 | 0 | 0 | 4 |
| 3 | - | ELECTIVE IV | PE | 4 | 4 | 0 | 0 | 4 |
| **Project Work** | | | | | | | | |
| 4 | 21UPEST1C17 | PROJECT WORK PHASE II | PC | 18 | 0 | 0 | 18 | 9 |
| | | | **TOTAL** | **30** | **12** | **0** | **18** | **21** |

**TOTAL CREDITS TO BE EARNED FOR THE AWARD OF DEGREE = 90**

## Swayam Course Details

| S. No | Course Code | Course Title | Category | Contact Periods | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| 1 | SWAYAM Course – I (I Year) | | | | | | | |
| 2 | SWAYAM Course –II (II Year) | | | | | | | |

## PROFESSIONAL CORE (PC)

| S.No | Course Code | Course Title | Category | Contact Periods | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| 1. | 21UPEST1C01 | APPLIED MATHEMATICS FOR ENERGY | PC | 5 | 4 | 1 | 0 | 4 |
| 2. | 21UPEST1C02 | BASICS OF FLUID MECHANICS AND HEAT TRANSFER | PC | 5 | 4 | 1 | 0 | 4 |
| 3. | 21UPEST1C03 | ENERGY AUDIT AND MANAGEMENT | PC | 5 | 4 | 1 | 0 | 4 |
| 4. | 21UPEST1C04 | WIND ENERGY | PC | 5 | 4 | 1 | 0 | 4 |
| 5. | 21UPEST1C05 | ENERGY LABORATORY – I | PC | 3 | 0 | 0 | 3 | 2 |
| 6. | 21UPEST1C06 | ENERGY ECONOMICS & POLICES | PC | 4 | 4 | 0 | 0 | 4 |
| 7. | 21UPEST1C07 | BASICS OF THERMODYNAMICS | PC | 5 | 4 | 1 | 0 | 4 |
| 8. | 21UPEST1C08 | BASICS OF COMPUTATIONAL FLUID DYNAMICS | PC | 5 | 4 | 1 | 0 | 4 |
| 9. | 21UPEST1C09 | ENVIRONMENTAL SCIENCE AND POLLUTION CONTROL | PC | 4 | 4 | 0 | 0 | 4 |
| 10. | 21UPEST1C10 | ANALYSIS AND SIMULATION LABORATORY | PC | 3 | 0 | 0 | 3 | 2 |
| 11. | 21UPEST1C11 | HYDROGEN & FUEL CELLS | PC | 4 | 4 | 0 | 0 | 4 |
| 12. | 21UPEST1C12 | INTRODUCTION OF ENERGY MATERIALS | PC | 4 | 4 | 0 | 0 | 4 |
| 13. | 21UPEST1C13 | MATERIAL CHARACTERIZATION | PC | 4 | 4 | 0 | 0 | 4 |
| 14. | 21UPEST2C14 | PROJECT WORK PHASE I | PC | 8 | 0 | 0 | 8 | 4 |
| 15. | 21UPEST1C15 | BIOENERGY TECHNOLOGIES | PC | 4 | 4 | 0 | 0 | 4 |
| 16. | 21UPEST1C16 | INDUSTRIAL INSTRUMENTATION | PE | 4 | 4 | 0 | 0 | 4 |
| 17. | 21UPEST1C17 | PROJECT WORK PHASE II | PC | 18 | 0 | 0 | 18 | 9 |

**PROFESSIONAL ELECTIVE (PE)**

| S. No | Course Code | Course Title | Category | Contact Periods | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| **Semester-I (Elective – I)** | | | | | | | | |
| 1. | 21UPEST1E01 | Foundation of Energy Sources | PE | 4 | 4 | 0 | 0 | 4 |
| 2. | 21UPEST1E02 | Renewable Energy System | PE | 4 | 4 | 0 | 0 | 4 |
| 3. | 21UPEST1E03 | Cogeneration and Waste Heat Recovery Systems | PE | 4 | 4 | 0 | 0 | 4 |
| **Semester -II (Elective – II)** | | | | | | | | |
| 4. | 21UPEST1E04 | Rural Electrification Technologies and Economics | PE | 4 | 4 | 0 | 0 | 4 |
| 5. | 21UPEST1E05 | Basics of solar cell | PE | 4 | 4 | 0 | 0 | 4 |
| 6. | 21UPEST1E06 | Principles and Applications of Hydrogen Storage | PE | 4 | 4 | 0 | 0 | 4 |
| **Semester -III (Elective – III)** | | | | | | | | |
| 7. | 21UPEST1E07 | Bio –Energy Conversion | PE | 4 | 4 | 0 | 0 | 4 |
| 8. | 21UPEST1E08 | Energy Conservation, Energy Storage and Transportation | PE | 4 | 4 | 0 | 0 | 4 |
| 9. | 21UPEST1E09 | Modeling and Analysis of Energy Science based Systems | PE | 4 | 4 | 0 | 0 | 4 |
| **Semester -IV (Elective – IV)** | | | | | | | | |
| 10 | 21UPEST1E10 | Green Concepts in Buildings | PE | 4 | 4 | 0 | 0 | 4 |
| 11 | 21UPEST1E11 | Smart Grid Technologies | PE | 4 | 4 | 0 | 0 | 4 |
| 12 | 21UPEST1E12 | Energy Storage System | PE | 4 | 4 | 0 | 0 | 4 |

## NON-MAJOR ELECTIVE COURSES (NM)

| S. No | Course Code | Course title | Category | Contact Periods | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| 1 | 21UPESTS01 | Basic Concepts in Energy Sciences | NM | 3 | 3 | 0 | 0 | 3 |
| 2 | 21UPESTS02 | Climate Change and $CO_2$ Emission Assessment | NM | 3 | 3 | 0 | 0 | 3 |
| 3 | 21UPESTS03 | Energy and Environmental Impacts | NM | 3 | 3 | 0 | 0 | 3 |
| 4 | 21UPESTS04 | Erection and Maintenance of Refrigeration and Air-Conditioning Equipment | NM | 3 | 3 | 0 | 0 | 3 |
| 5 | 21UPESTS05 | Green Concepts in Building | NM | 3 | 3 | 0 | 0 | 3 |

## VALUE ADDED COURSE

| S. No | Course Code | Course title | Category | Contact Periods | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| 1 | 21UPESTVA01 | ALTERNATE FUELS AND EMISSIONS | **VA** | 30 | 30 | 0 | 0 | 0 |
| 2 | 21UPESTVA02 | BIOMASS AND ITS CONVERSION TECHNOLOGIES | **VA** | 30 | 30 | 0 | 0 | 0 |
| 3 | 21UPESTVA03 | MATERIALS FOR ENERGY APPLICATIONS | **VA** | 30 | 30 | 0 | 0 | 0 |
| 4 | 21UPESTVA04 | ELECTRIC VEHICLES | **VA** | 30 | 30 | 0 | 0 | 0 |
| 5 | 21UPESTVA05 | DESIGN THINKING | **VA** | 30 | 30 | 0 | 0 | 0 |

**21UPEST1C01 APPLIED MATHEMATICS FOR ENERGY**

**OBJECTIVES**

- Providing high quality education in pure and applied mathematics
- To understand partial equation concepts
- Imparting theoretical knowledge and to develop computing skill
- Students will gain deeper understanding of the Fourier series by mastering the theory of heat boundary value problems.
- Students will gain practical knowledge of conformal mapping.

**UNIT-I EMPIRICAL LAWS AND CURVE FITTING**

Introduction - Linear law –method of group averages – law containing three constants –Principle of Least Squares – Fitting a Straight line – Fitting a parabola – Fitting an exponential curve – Methods of moments

**UNIT-II FINITE DIFFERENCES**

Finite Differences – Interpolation – Newton forward Interpolation formula – Methods: Forward difference, backward difference, central difference- Gaussion forward and backword formula – Operators – Forward ($\Delta$) , backward ($\ddot{\nabla}$)and central ($\delta$ ) , shifting (E) Average ($\mu$ ) and their interrelations

**UNIT- III PARTIAL DIFFERENTIAL EQUATIONS (PDES)**

Basic Concepts of PDEs - Modeling: Vibrating String, Wave Equation - Solution by Separating Variables. -Vibrating String if the Initial Deflection Is Triangular –Application's

**UNIT- IV MODELING: HEAT FLOW FROM A BODY IN SPACE HEAT EQUATION**

Heat Equation: Solution by Fourier Series. Steady Two-Dimensional Heat Problems. Dirichlet Problem-Sinusoidal Initial Temperature - "Triangular" Initial Temperature in a Bar -Bar with Insulated Ends. Eigenvalue zero- Steady Two-Dimensional Heat Problems. Laplace's Equation

**UNIT-V CONFORMAL MAPPING**

Geometry of Analytic Functions: Conformal Mapping - Use of Conformal Mapping. Modelling- - Potential Between Noncoaxial Cylinders- Potential Between Two Semicircular Plates- Heat Problems - Temperature Between Parallel Plates- Temperature Distribution Between a Wire and a Cylinder - Fluid Flow - Flow Around a Corner- Flow Around a Cylinder

**OUTCOMES**

Students successfully completing this module will be able to:

- To learn pure and applied mathematics
- Will understand partial equation concepts
- Students will gain deeper understanding of the Fourier series by mastering the theory of heat boundary value problems.
- Students will get modeling knowledge on the mathematical skills

- Students will gain practical knowledge of conformal mapping.

**REFERENCES**


1. Singaravelan, E (1999) Numerical Methods,Meenakshi Agency Chennai
2. Advanced Engineering Mathematics, Irvin Kreyszig, Wiley
3. Mathematical Methods, Dutta, D., New Age
4. Spiegel, M.R., Theory and Problems of Complex Variables and its Application (Schaum‟s Outline Series), McGraw Hill Book Co., Singapore (1981).
5. Jain M K., Iyengar S R K., Jain R K (1993); Numerical Methods for Scientific and Engineering Computation, New Age International (P) Ltd. New Delhi.
6. Andrews, L.C. and Shivamoggi, B.K., Integral Transforms for Engineers, Prentice Hall of India Pvt. Ltd., New Delhi (2003)


**Mapping of course outcomes with program specific outcomes**

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

**21UPEST1C02 BASICS OF FLUID MECHANICSAND HEAT TRANSFER**

**OBJECTIVES**

- To familiarize with the properties of fluids and the applications of fluid mechanics.
- To make students familiarize with the application of conservation equations
- To explain the incompressible and compressible fluid flow concepts
- To provide the details of turbulent forced convective heat transfer
- To understand the concept of fluid measurement, types of flows and dimensional analysis

**UNIT - I PROPERTIES OF FLUIDS**

Introduction–Density-SpecificWeight-SpecificVolume-SpecificGravity-Viscosity-KinematicViscosity -Dynamic Viscosity-Compressibility and Bulk Modulus-Surface Tension and Capillarity

**UNIT - II PRESSURE MEASURING DEVICES**

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

**UNIT–III FLUID FLOW AND LOSSES**

Types of flows- Rate of Flow (Or) Discharge- Continuity Equation- Euler‟s Equation of Motion-Bernoulli‟s Equation from Euler‟s Equation -ApplicationOfBernoulli‟sEquation-Venture-OrificeMeter-Pitot-Tube.

**UNIT-IV DIMENSIONAL AND MODEL ANALYSIS**

Introduction-DerivedQuantities-BuckinghamsΠTheoremMethodofSelectingRepeatingVariables-ProcedureforSolvingBuckinghamsΠTheorem-DimensionlessNumber

**UNIT-V HYDRAULIC MACHINES & APPLICATION**

Centrifugalpump-Construction-Working-ReciprocatingPump-Construction- Working –Hydraulic Press –Hydraulic Accumulator-Hydraulic Intensifier– Hydraulic Ram-Hydraulic-Lift-Hydraulic Crane.

**OUTCOMES**

Upon completion of this course, the students will be able

- To Identify and obtain the values of fluid properties and relationship
- Understand the principles of continuity, momentum, and energy as applied to fluid motions
- Learn the flow concepts of fluid flow and losses
- Solve the conduction and gas radiation heat transfer problems.
- Understand the dimensional and model analysis
- Design a hydraulic machines & application

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2. Fluid Mechanics, Spurk, Joseph, Aksel, Nuri, Springer Publications (2008).
3. Fluid Mechanics and Hydraulic Machines–Dr.R.K. Bansal Laxmi Publications (2010).

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**21UPEST1C03 ENERGY AUDIT AND MANAGEMENT**

**OBJECTIVES**

- Students able be understand the basic knowledge of energy auditing role in industry
- Students will be able to use the energy audit methods learnt to identify the areas deserving tighter control to save energy expenditure
- To understand the energy utilization pattern including wastage and its management.
- Students will be able to apply the knowledge of the subject to calculate the efficiency of various thermal utilities.
- Students will be able to understand complete study of Electrical Energy Management

**UNIT- I ENERGY MANAGEMENT AND AUDIT**

Need of Energy audit - Types of energy audit - Energy management (audit) approach - understanding energy costs - Bench marking - Energy performance - Matching energy use to requirements - Maximizing system efficiencies - Optimizing the input energy requirements - Duties and responsibilities of energy auditors - Energy audit instruments - Procedures and Techniques.

**UNIT II MATERIAL AND ENERGY BALANCE**

Introduction – Components of materials and energy balance – Basic Principles of Material and Energy Balance – Classification of Process – Material Balance – Energy Balance – Facilities as an Energy System – Energy analysis and the Sankey diagram

**UNIT III ENERGY ACTION PLANNING**

Top Management commitment and support – Assessing Energy Profile and Establishing Baseline – Energy Policy and Planning – Implementation – Evaluating Energy Performance – Recognize achievements – Management tools for Effective Implementation

**UNIT IV ENERGY MONITORING AND TARGETING**

Definition: Monitoring and targeting – Setting up Monitoring and Targeting – Key Elements – Data information Sources – Data information Analysis – EMIS

**UNIT V INDUSTRIAL SAFETY**

Evolution of modern safety concept- Safety policy - Safety Organization - line and staff functions for safety- Safety Committee- budgeting for safety

**OUTCOME**

After successful completion of the course, the students should be able to

- Perform energy auditing tasks in different fields & development of energy efficient systems
- Design and develop consumer products for the betterment of human kind
- Understand various aspects of energy audit such as planning, monitoring and implementation
- Manage electric and thermal energy in the industry.

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1. 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.2004.
2. W.C. turner, "Energy Management Hand book" Wiley, New York, 1982
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**21UPEST1C04 WIND ENERGY**

**OBJECTIVES**

- Understand the processes of generation of wind, its potential and energy extraction
- Identify and estimate wind resource potential of an area
- Understand the aerodynamic principles of turbine blade design
- Understand the Economics and applications of wind energy.
- 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 WECS DESIGN**

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

**OUTCOMES**

Students will

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

**REFERENCE**

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 Power Systems, John Wiles & Son Ltd.
4. Ray Hunter, (1997), Wind Energy Conversion: From Theory to Practice, John Wiley and

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5. Gary L.Johnson, (1985), Wind Energy Systems, Prentice-Hall Inc., New Jersey.

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**21UPEST1C05 ENERGY LABORATORY**

**OBJECTIVES**

- To learn the working of Solar Hot Water heater
- To obtain the knowledge on working of Solar PV devices and its characterization
- To acquire the information on biogas production
- To characterize the fuel properties
- To gain practical information on thermal Heat Storage system
- To expand practical knowledge on thermal Heat Storage system
- To analyze on solar cell efficiency through solar cell simulator
- To understand the methodology adopted for performance evaluation of various renewable energy systems

**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 & amp; 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 Abel flash point apparatus.
7. Study Experiment on Nano Floating Drum Biogas Plant.
8. Experimental analysis on the percentage of biogas formed for the given amount of organic waste using bio gas analyzer.
9. Experimental Evaluation of a Paraffin wax as Phase Change Material for Thermal Energy Storage in TES Training System.
10. Experimental Evaluation of a fatty acid as Phase Change Material for Thermal Energy Storage in TES Training System.
11. 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.
12. 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.
13. Determination the overall heat transfer coefficient in a plate type heat exchanger at different hot fluid flow rate.
14. Experimental analysis on efficiency of solar cell under varying light intensity using Solar Simulator- SS50 AAA.
15. 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).

**OUTCOME**

- Upon completion of this course, the students will be able to:
- Evaluate the performance of renewable energy gadgets
- To gain an understanding of how a solar hot water heater works.
- To gain knowledge about the operation of solar PV devices and their characterization.
- To gain practical knowledge about thermal Heat Storage systems
- To evaluate solar cell performance using solar cells
- Analyze the factors influencing the efficiency and suggest methods for improving the adaptability and efficiency of renewable energy gadgets

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**21UPEST1C06 ENERGY ECONOMICS & POLICES**

**OBJECTIVES**

- To explain the energy conservation Laws using a different law
- To understand Indian energy scenario in different aspects
- To understand world energy scenario with different aspects
- To understand Indian energy policy systems through in different aspects.
- To understand world energy policy systems through in different aspects.

**UNIT- I ENERGY CONSERVATION**

Energy Conservation Act-2001 and its features - Electricity Act – 2003 and its features - Framework of Central Electricity Authority (CEA), Central & States Electricity Regulatory Commissions (CERC & ERCs)-Role of MoP(Ministry of Power)-BEE (Bureau of Energy Efficiency).

**UNIT-II INDIAN ENERGY SCENARIO**

Energy resources & Consumption-Commercial and noncommercial forms of energy- Fossil fuels-Renewable sources in India- Sector wise energy Consumption - Impact of energy on economy – 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

**UNIT-III GLOBAL ENERGY SCENARIO**

Role of energy in economic development and social transformation - Energy and GDP - GNP and its dynamics - Energy sources, overall Energy demand and availability - Energy consumption in various sectors and its changing pattern - Depletion of energy sources and impact economics on international relations.

**UNIT-IV INDIAN ENERGY POLICY**

Global Energy Issues-National & State Level Energy Issues-National & State Energy Policy-Industrial Energy Policy- Energy Security-Energy Vision- Energy Pricing and Impact of Global Variations-Energy Productivity (National & Sector wise productivity).

**UNIT-V GLOBAL ENERGY POLICY**

International Energy Polices of G-8 Countries - G-20 Countries - OPEC Countries - EU Countries - International Energy Treaties (Rio, Montreal and Kyoto) - INDO-US Nuclear Deal- Future Energy Options-Sustainable Development-Energy Crisis-Role of International Energy Agency.

**OUTCOMES**

Students will have

- An exposure energy conservation with different policies and laws
- Understand the Indian Policy Issues

- Describe the key policies that will facilitate the transition and explain the economics of how the policies will introduce incentives that will support the transition
- Describe and explain the effects of TAE resources and technologies on economic growth and economic development including transition effects and those associated with moving the economy along the sustainable path
- Identify the key economic development consequences of the development of local indigenous alternative energy resources

**REFRENCES**


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2. Charles E.Brown, World Energy Resources,Springer2002.
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4. Principles of Energy Conversion: A.W.Culp (McGrawHillInternationaledition) BEE Referencebook:no.1/2/3/4
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**21UPEST1C07 BASICS OF THERMODYNAMICS**

**OBJECTIVES**

- To apply concepts of TD 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 TD.
- To evaluate COP, EER, Efficiency and entropy by applying second law of TD and its corollaries.
- 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

**OUTCOMES**

- Understand thermodynamics laws and their applications
- Apply concepts of TD and Zeroth Law in solving numerical problems with relevant units.
- Analyze and evaluate different forms work, heat and other properties by applying 1st Law of TD. Evaluate COP, EER, Efficiency, temperature and entropy by applying second law of TD and its corollaries.
- Illustrate problem solving procedure related to pure substances using PT, PV, TH diagrams.
- Apply ideal and real gases laws in solving related numerical problems for various conditions.

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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).
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**21UPEST1C08 BASICS OF COMPUTATIONAL FLUID DYNAMICS**

**OBJECTIVES**

- To make students familiarize with the computational analysis
- To explain the numerical analysis of solving of steady and unsteady diffusion heat transfer
- To explain the numerical analysis of solving of convection-diffusion heat transfer
- To provide the details of discretization of incompressible flow governing equations
- To impart the knowledge of turbulence modelling

**UNIT I GOVERNING DIFFERENTIAL EQUATIONS AND DISCRETISATION TECHNIQUES**

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

**UNIT II DIFFUSION PROCESSES: FINITE VOLUME METHOD**

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

**UNIT IIICONVECTION - DIFFUSION PROCESSES: FINITE VOLUME METHOD**

One dimensional convection – diffusion problem, Central difference scheme, upwind scheme – Hybrid and power law discretization techniques – QUICK scheme.

**UNIT IV FLOW PROCESSES: FINITE VOLUME METHOD**

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

**UNIT V MODELLING OF COMBUSTION AND TURBULENCE**

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

**OUTCOMES**

Upon completion of this course, the students will be able to
- Know the differences between various discretization techniques.
- Learn the finite volume based numerical method for solving diffusion heat transfer problems.
- Learn the finite volume based numerical method for solving convection-diffusion heat transfer problems.

- Understand the discretization of incompressible flow governing equations
- Recognize the impact of various turbulence modelling

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1. Versteeg and Malalasekera, N, "An Introduction to computational Fluid Dynamics Finite Volume Method," Pearson Education, Ltd., Second Edition, 2014.
2. Ghoshdastidar, P.S., "Computer Simulation of Flow and Heat Transfer", Tata McGraw Hill Publishing Company Limited, New Delhi, 1998.
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**21UPEST1C09 ENVIRONMENTAL SCIENCE AND POLLUTION CONTROL**

**OBJECTIVES**

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

**UNIT I INTRODUCTION**

Man & Environment – Types of Pollution – Global Environmental issues – Environmental Impact Assessment – Global Warming Issues –CO2 Mitigation – Basic definition of Pollution Indicators – Noise Pollution

**UNIT II WATER POLLUTION**

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

**UNIT III AIR POLLUTION**

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

**UNIT IV SOLID & HAZARDOUS WASTE MANAGEMENT**

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

**UNIT V GLOBAL WARMING & CLIMATE CHANGE**

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

**OUTCOMES**

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

- Types and effects of each type of pollution on man – earth will be made known.

- Technical aspects of Global Warming will make them understand the impact they have on climate
- Technologies that are available for reduction of pollutants dumped into the atmosphere
- Cursory / superficial formation - the students – had in Hazardous waste, waste disposal hitherto will be deep & sensible enough after studying this subject
- Comprehend the different techniques available for safe disposal of hazardous waste

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**21UPEST1C10 ANALYSIS AND SIMULATION LABORATORY**

**OBJECTIVES**

- 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

**LIST OF EXPERIMENTS**

1. Heat exchanger analysis – NTU method
2. Heat exchanger analysis – LMTD method
3. Convection heat transfer analysis – Velocity boundary layer
4. Convection heat transfer analysis – Internal flow
5. Radiation heat transfer analysis – Emissivity
6. Lumped heat transfer analysis
7. Conduction heat transfer analysis

**OUTCOMES**

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

- Use modern engineering software tools to analyze the flow with heat transfer related problems
- Analyse the various parameters influencing the performance of thermodynamic systems

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**21UPEST1C11 HYDROGEN & FUEL CELLS**

**OBJECTIVES**

- To understand hydrogen generation techniques and hydrogen economy.
- To provide comprehensive and logical knowledge of hydrogen production, storage and utilization.
- To address the underlying concepts, methods and application of fuel cell technology.
- To discuss the fundamentals of various types of fuel cell system.

**UNIT I HYDROGEN ENERGY**

Introduction to hydrogen economy, hydrogen from fossil fuels, electrolysis of water, thermo chemical cycles, transmission and infrastructure requirements, safety and environmental impacts, economics of transition to hydrogen systems.

**UNIT II HYDROGEN PRODUCTION AND STORAGE SYSTEMS**

Hydrogen Production: fossil fuels, electrolysis, thermal decomposition, nuclear, photochemical, photo catalytic, hybrid; Hydrogen Storage: Metal hydrides, chemical hydrides, carbon nano-tubes; sea as the source of Deuterium, methane hydrate, etc. Hydrogen fuel for transport.

**UNIT III FUEL CELL TECHNOLOGY**

Introduction–working and types of fuel cell - low, medium and high temperature fuel cell, liquid and methanol types Proton Exchange Membrane Fuel Cells, alkaline fuel cells, phosphoric acid, solid oxide, molten carbonate, direct methanol fuel cells – thermodynamics and electrochemical kinetics of fuel cells.

**UNIT IV FUELS FOR FUEL CELLS**

Hydrogen, methane, methanol - Sources and preparation, reformation processes for hydrogen – clean up and storage of the fuels – use in cells, advantages and disadvantages of using hydrogen as fuel. Membranes for fuel cells: Nafion – Polymer blends and composite membranes; assessment of performance – recent developments.

**UNIT V APPLICATION OF FUEL CELLS**

Fuel Cell usage for domestic power systems, large scale power generation, Automobile, environmental analysis. Future trends in fuel cells, portable fuel cells, laptops, mobiles, submarines.

**OUTCOME**

Upon successful completion of the course, the student will be able to

- To understand and demonstrate the hydrogen production technologies, storage methods and strategies for transition to hydrogen economy.

- Minimize environmental hazards associated with the use of hydrogen storage and fuel cell technology.
- Select and defend appropriate fuel cell technology for a given application.
- Can find the applications of all the areas in day to day life.

**REFERENCE**

1. Alexander Gavrilyuk (2014); Hydrogen Energy for Beginner, Pan Stanford.
2. Gupta R. B. (2008); Hydrogen Fuel: Production, Transport and Storage, CRC Press.
3. Larminie J., Dicks A. and McDonald M. S. (2003); Fuel cell systems explained second Edition. Wiley.
4. Fuel Cells: From Fundamentals to Applications by S Srinivasan, Springer.

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**21UPEST1C12 WIND ENERGY**

**OBJECTIVES**

- To understand the fundamentals and basics of materials for solar energy.
- To provide the knowledge of the synthesis of materials.
- To understand about the characterization of materials.
- To provide an understanding of energy harvesting materials.
- To provide an understanding of the energy storage materials.

**UNIT- I MATERIALS FOR PHOTOVOLTAICS**

First generation and Second-generation solar cell materials for applications in photovoltaics, Materials for thin film solar cells. Third generation solar cell materials; Quantum Dots, Organic materials, Composites, Dyes, Perovskites and their synthesis, characterization and properties, Interface energetics, photoactive layers and their materials, role of electron transport, hole transport, electron blocking and hole blocking materials and their processing. Contact materials and processing of contact layers

**UNIT II MATERIALS SYNTHESIS PHYSICAL METHODS**

Vacuum Evaporation, Electron beam evaporation Sputtering, Cathodic Arc Deposition, Chemical Vapor Deposition, Atomic Layer Deposition, Pulsed Laser Deposition, Molecular Beam Epitaxy, Lithography and their types,

**UNIT III MATERIALS SYNTHESIS CHEMICAL METHODS**

Sol-Gel technique, self-assembly, colloidal method, hydro-thermal method, co-precipitation method, solid state synthesis, microwave method, micro-emulsion method.

**UNIT IV MATERIALS FOR ENERGY HARVESTING**

Piezoelectric, Pyro electric and Thermo-electrics materials, Electrostatic (capacitive) Energy Harvesting and materials, energy from Magnetic Induction, Metamaterial, energy from atmospheric pressure changes, electro active polymers (EAPs), Nano generators, Ambient radiation sources and Nano antenna, energy from noise.

**UNIT V MATERIAL FOR ENERGY STORAGE**

Electrochemistry and electro-chemical Battery materials, Hydrogen Storage materials for fuel cells: Metal hybrids, Nanostructured metal hydrides, Non-metal hydrides, Carbohydrates, Synthesis of hydrocarbons, Aluminum, Liquid organic hydrogen carriers (LOHC), Ammonia, Amine borane complexes, Nano borohydrides and nano catalyst doping, imidazolium ionic liquids, phosphonium borate, Carbonite substances, Metal Organic frameworks, Activated Carbons, Carbon nanotubes, Clathrate hydrates, Glass capillary arrays.

**OUTCOMES**

Students will

- Aware about different types of solar energy observed materials.

- Understand importance and analysis of properties of nanomaterials.
- Understand the nanomaterials and classification of technology.
- Identify the energy storage materials for suitable applications.

**REFERENCE**


1. Materials for Sustainable Energy Applications Conversion, Storage, Transmission and consumption (2016),Xavier Moya, David Munoz- Rojas, Pan Stanford Publishing.
2. Advanced Energy Materials, Ashutosh Tiwari & Sergiy Valyukh, J. Wiley & Sons.
3. Principle of materials Science (2016), S.Mohan, Sujin P. Jose, V. Arjunan, MJP.
4. Eco-and Renewable Energy Materials, Young Zho, Springer
5. Materials and Energy (Book Series), Leonard C Feldman (Ed. In Chief), World Scientific


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**21UPEST1C13 MATERIAL CHARACTERIZATION**

**OBJECTIVES**

- To introduce the materials characterization techniques to the students
- Help the students to understand the instrumentation aspects
- To provide a detailed understanding of data interpretation
- To provide hands on experience of the characterization techniques

**UNIT- I- X-RAY TECHNIQUES**

X-ray diffraction- Generation and characteristics of x-ray- Lattice planes and Bragg's law-Theory of diffraction- Determination of particle size and micro/macro strains- Reciprocal Lattice, Electron Diffraction, Energy Loss Spectroscopy- SAXS, XRF, insitu methods in XRD

**UNIT II SPECTROSCOPIC METHODS**

UV-visible spectroscopy- Beer's law, Instrumentation, Quantitative analysis; Vibrational spectroscopy- Raman and Infrared, Principles of vibrational spectroscopy, Infrared and Raman activity, Fourier transform infrared spectroscopy, Instrumentation, Raman spectroscopy, MicroRaman, Applications

**UNIT III OPTICAL MICROSCOPY**

Image formation, Resolution, Aberrations, Imaging modes, Specimen preparation, Confocal microscopy Electron microscopy: Scanning electron microscopy SEM), Instrumentation, Electron beam-specimen interaction, Specimen preparation, Energy dispersive spectroscopy (EDS) in electron microscopes; Transmission electron microscopy (TEM) - Basics of TEM, Electron sources, Specimen preparation,

**UNIT IV THERMAL ANALYSIS**

Thermo gravimetric analysis (TGA), Differential thermal analysis (DTA), Differential scanning calorimetry (DSC), Dynamic mechanical analysis (DMA), Thermomechanical analysis (TMA) and Dynamic mechanical thermal analysis (DMTA), Basic theory, Instrumentation and applications

**UNIT V MATERIALS CHARACTERIZATION BY ELECTROCHEMICAL METHODS**

Cyclic voltammetry, Electrochemical Impedance spectroscopy: experiment and its applications

**OUTCOME**

- Students will learn the sample preparation methods and sample handling
- Students will acquire the ability to analyze the data obtained from the techniques
- The student will be able to identify the ideal method of analysis to draw the required information
- The students will get on experience of the characterization techniques

**REFERENCE**


1. T. Pradeep, "A Textbook of Nanoscience and Nanotechnology", Tata McGraw Hill Education Pvt. Ltd.2012
2. Hari Singh Nalwa, "Nanostructured Materials and Nanotechnology", Academic Press, 2008
3. A.Nabok, "Organic and Inorganic Nanostructures", Artech House, 2009
4. C.Dupas, P.Houdy, M.Lahmani, "Nanoscience: Nanotechnologies and Nanophysics", Springer-Verlag Berlin Heidelberg, 2007
5. "Nanocrystals: Synthesis, Properties and Applications", C. N. R. Rao, P. J. Thomas and G. U. Kulkarni, Springer (2007).


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**21UPEST1C14 PROJECT WORK PHASE I**

**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

**OUTCOME**

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

**21UPEST1C15 BIOENERGY TECHNOLOGIES**

**OBJECTIVES**

- Introduce fundamentals of biological systems necessary to grasp bioenergy concepts
- Understand global bioenergy scenario and relate to bioenergy resources in India.
- Learn various biofuel types and its characteristics
- 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 TO BIOMOLECULES**

Classification of amino acids, carbohydrates and nucleotides; Structure and properties of carbohydrate polymers, proteins and nucleic acids; Classification and utility of lipids and fatty acids; Functional roles of biomolecules – energy carriers, enzyme cofactors and biochemical regulation. Biosynthesis and Metabolism.

**UNIT II BIOMASS**

Biomass resources; classification and characteristics; Techniques for biomass assessment; Application of remote sensing in forest assessment; Biomass estimation; Biomass to biofuel; Source and classification of biofuels and their characteristics.

**UNIT III BIOCHEMICAL CONVERSIONS**

Bio-catalysis by enzymes and pathways - Fermentation and bioprocess engineering – Chemical kinetics – Mathematical modelling of biochemical reactions – Bioreactor designs; iodegradation and biodegradability of substrate; anaerobic digestion - Bioconversion of lignocellulosic feedstock to sugars - Bioconversion of sugars and starches to fuels – Difference of the technologies of starch ethanol and cellulosic ethanol.

**UNIT IV THERMOCHEMICAL & CHEMICAL CONVERSIONS**

Thermochemical Conversion: Direct combustion, incineration, pyrolysis, gasification and liquefaction; economics of thermochemical conversion. Bio-gasification: Bio-methanation process, biogas digester types, biogas utilization; Waste to energy. Chemical Conversion: Hydrolysis & hydrogenation; solvent extraction of hydrocarbons; solvolysis of wood, biocrude, biodiesel production via chemical process; catalytic distillation; transesterification methods; Fischer-Tropsch diesel: chemicals from biomass.

**UNIT V BIOFUELS STANDARDS & POWER GENERATION**

Physical and chemical characteristics of biofuels – Biomass, wood gas, biomethane; ethanol, biodisel, Wood oil; Bio-blends - Indian and International standard specifications. Bio-blends; Adaptation of biofuel in various applications – biomass integrated gasification/combined cycles systems - Sustainable co-firing of biomass with coal; Biofuel economy; Case studies.

**OUTCOMES**

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

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

**REFERENCE**


1. Lehninger's Principles of Biochemistry by David L. Nelson and Michael M. Cox, Macmillan Worth publisher, 2009.
2. Biochemistry 6th edition by Jeremy M Berg, LubertStryer, John L. Tymoczko, 2008.
3. Voet and Voet's Biochemistry, D. Voet and J. Voet 3rd Edition, John Wiley and Sons Inc., 2005.
4. Biochemistry, 5th Ed by Eric E Conn, Paul K Stumpf, George Bruening and Roy H Doi, 2009.
5. Biofuels - Securing the Planet's Future Energy Needs, Edited by ADemirbas Springer 2009.
6. Biomass Assessment Handbook - Bioenergy for a sustainable environment Edited by Frank Rosillo-Calle, Sarah Hemstock, Peter de Groot and Jeremy Woods, Earthscan November 2006.
7. Dictionary of Renewable Resources - 2nd Edition, Revised and Enlarged, Zoebelein, Hans, Wiley-VCH, 2001.


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**21UPEST1C16 INDUSTRIAL INSTRUMENTATION**

**OBJECTIVES**

- To familiarize with the characteristics of instruments.
- To familiarize with the thermal and pressure flow measurements systems.
- To understand the flow visualization techniques.
- To understand the pollution and energy measurement.
- To understand the applications of electrical energy measurement.

**UNIT-I GENERALIZED INSTRUMENTATION SYSTEM**

Error theory – Calibration of instruments – Range – resolution – Span – Linearity, Sensitivity- Signal conditioning systems.

**UNIT-II PRESSURE AND TEMPERATURE MEASUREMENT**

Bimaterials, Pressure thermometers, Thermocouples, RTD, Thermisters, and Pyrometry, pyrometers- Calibration of Pressure measuring equipment, principles and operation of various vacuum pumps and gauges.

**UNIT-III FLOW MEASUREMENT**

Variable head flow meters- Rota meters, Electromagnetic flow meters, Hot wire anemometers, Hot film transducers, Ultrasonic flow meters, impellers turbine system, corollas meters, vortex-shed meters

**UNIT-IV AIR POLLUTION AND ENERGY MEASUREMENTS**

Particulate sampling techniques, SO2, Combustion Products, Opacity, odour measurements - Measurement of liquid level, Humidity, O2, CO2 in flue gases- pH measurement, moisture analyzer.

**UNIT-V ELECTRICAL ENERGY MEASUREMENT AND ADVANCE MEASUREMENT TECHNIQUES**

Power factor, load factor, harmonic analyzer, lighting: Shadowgraph, Schlieren, Interferometer, Laser Doppler Anemometer, Hot wire, Anemometer, heat flux sensors, Telemetry in measurement.

**OUTCOMES**

After successful completion of this course, the students will be able to

- Illustrate the various types of transducers and measurement systems
- Demonstrate the temperature measuring devices
- Understand the operation of pressure and level measuring devices
- Summarize the various parameter measuring devices
- Distinguish various measurement devices in different application
- Apply basic knowledge of measuring devices in various real time applications

**REFERENCE**

1. Bechwith, Marangoni and Lienhard, "Mechanical Measurements" Addison-Wesley, 2000.
2. Holman J P, "Experimental methods for engineer"s", McGraw-Hill, 1994.
3. Rangan C S, Sharma G R and Mani V S V, "Instrumentation Devices and Systems", Tata McGraw-Hill, 1983.

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**21UPEST1C17 PROJECT WORK PHASE II**

**OBJECTIVES**

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

**EVALUATION**

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

**OUTCOME**

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

**PROFESSIONAL ELECTIVE**

**21UPEST1E01 FOUNDATION OF ENERGY SOURCES**

**OBJECTIVES**

- To understand the fundamental concepts of Energy technology.
- To provide the knowledge of the basics of energy conversion.
- To learn the energy conversion techniques and its benefits
- To provide an understanding of energy demand and utilization.
- To study impact of energy on environment

**UNIT I RENEWABLE ENERGY RESOURCES**

Renewable Energy potential, Basic concepts and working principals of : Solar Energy, Wind Energy, Bioenergy, Hydro, Tidal energy, Ocean energy, Nuclear Energy, Geothermal Energy, Magneto-hydro-dynamic(MHD) energy conversion, Fuel Cells, Waste to Energy Conversion, Hydrogen energy

**UNIT II NON-RENEWABLE ENERGY RESOURCES**

Fossil and Mineral Energy Resources, Details of Coal, Peat, Oil, Natural Gas and Nuclear Resources, Recovery of Fossil Fuels, Classification and Characterization of Fossil fuels. Working principles of power generation through conventional fuels.

**UNIT III HEAT TRANSFER**

Conduction, Convection, radiation heat transfer, overall heat transfer coefficient, heat exchangers.

**UNIT IV ELECTRICAL MACHINES**

Transformer, Induction motor and generators, Synchronous generators, characteristics and applications; DC machines: characteristics and Applications

**UNIT V POWER SYSTEMS**

Load and load duration curves, selection of generating units, Introduction to power generation, trans mission and distribution, power systems losses and compensation, High voltage AC (HVAC) a nd Highvoltage DC (HVDC) transmission; Interconnected grid system

**OUTCOMES**

- Identify the working principle of different resources of energy
- Apply energy conversion device principle and evaluate their operation and performance
- Prepare AC and DC distribution networks from energy source
- Analyze the various aspects of waste from energy affects the environment.
- Understating the power system based solar cell

**REFERENCES**


1. Energy Thermodynamics by P.K. Nag, Tata McGraw-Hill.
2. Non-conventional energy sources, GD Rai, Khanna Publishers, Delhi, 1998
3. Basic Electrical Engineering by Kothari D. P. and Nagrath I., McGraw Hill, India
4. Solar Energy- Principles of thermal collection and storage by SP Sukhatme, Tata McGraw-Hill, New Delhi
5. Theraja B. L. and Theraja A. K. (1998); A Text Book in Electrical Technology, S. Chand and Co
6. Wakil M, Power Plant Engineering, McGraw Hill, 2004


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**21UPEST1E02 RENEWABLE ENERGY SYSTEM**

**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**

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 SOLAR RADIATION ANALYSIS**

Introduction, Structure of the sun-fusion energy-characteristics of the sun, Solar constant, Electromagnetic energy spectrum, Extra Terrestrial radiation, Terrestrial radiation-beam radiation-diffuse radiation-sun at zenith-Air mass, Attenuation of Beam Radiation-absorption, Scattering, Solar radiation Geometry, Basic of Earth and Sun Angles-Latitude-Hour angle-Sun declination, Solar Time, Solar angles derivation, Sunrise, Sunset, and Day length.

**UNIT III SOLAR RADIATION MEASUREMENT AND DATA ESTIMATION**

Solar energy measuring equipments-classification, Pyrheliometers, Pyranometers, Sun-shine recorder, Solar radiation data, Estimation of average solar radiation, Estimation of Direct and Diffused radiation-during no cloudy days-during cloudy days, Ratio of Beam radiation on tilted surface to horizontal surface, Ratio of eam radiation on tilted surface to horizontal surface, Ratio of total radiation on tilted surface to a horizontal surface.

**UNIT-IV PHOTOVOLTAIC FUNDAMENTALS**

Place of PV in energy supply – PV Cells - Modules and arrays & costs - Review of semiconductor physics and Operating principle – Introduction to P-N and P-I-N junctions - Equilibrium and non-equilibrium conditions - Design of solar cells - Cell parameters limits-Losses in solar cells-Solar cell design for high Isc,, Voc and FF.

**UNIT V HYBRID RENEWABLE ENERGY SYSTEMS**

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

**OUTCOMES**

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

- Analyze the various conversion techniques in renewable energy technologies.
- Apply the various mechanisms for the conversion of renewable energy sources.

- Identify the appropriate power converters for renewable energy systems.
- Implement the different conversion mechanisms for wind and solar systems.
- Recognize the importance of various hybrid renewable energy systems.

**REFERENCE**


1. Solar photovoltaics-Fundamentals, technologies and Applications/Chetan Singh
2. Solanki/PHI Learning private Ltd. New Delhi
3. Leon Freris, David Infield, "Renewable energy in power systems", John Wiley & Sons, 2008.
4. Rai. G.D, "Non-conventional energy sources", Khanna publishes,2010.
5. Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, John Wiley & Sons,2011.
6. Wind Electric Systems: S.N. Bhadra, D. Kastha, OXFORD university press,2005.


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**21UPEST1E03 COGENERATION AND WASTE HEAT RECOVERY SYSTEMS**

**OBJECTIVES**

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

**UNIT I COGENERATION**

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

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

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

**UNIT III WASTE HEAT RECOVERY**

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

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

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

**UNIT V ENVIRONMENTAL CONSIDERATIONS**

Environmental considerations for Cogeneration and Waste Heat Recovery – Pollution

**OUTCOMES**

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

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

**REFERENCES**


1. Charles H Butler, Cogeneration, McGraw Hill Book Co., 1984.
2. Horlock JH, Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford, 1987.
3. Institute of Fuel, London, Waste Heat Recovery, Chapman & Hall Publishers, London, 1963.
4. Nag P. K, Power Plant Engineering, 4e, Tata McGraw Hill, 2001.
5. Sengupta Subrata, Lee SS EDS, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.
6. De Nevers, Noel., Air Pollution Control Engineering, Mcgraw Hill, New York, 1995.


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**21UPEST1E04 RURAL ELECTRIFICATION TECHNOLOGIES AND ECONOMICS**

**OBJECTIVES**

- To provide knowledge about urban and rural environment and its energy demand
- To understand financial analysis for Electrification Technologies
- To learn about various power generation
- To provide information about bio gas in rural electrification
- To introduce the concept of smart grid

**UNIT –I GENERATION TECHNOLOGIES**

Decentralized generation technologies; Costs and choice of technology, Demand and benefits forecasting and program development, Principles of cost-benefit calculations

**UNIT- II FINANCIAL ANALYSIS**

Economic and financial analysis of stand-alone electrification projects, Decentralized versus central station generation, Traditional power systems, Load curves and load curve analysis

**UNIT- III GAS TURBINE GENERATOR**

Basic gas turbine generator concepts; Utility system turbine generators; Mini and micro gas turbine generators; Solar thermal power generation, utility scale photovoltaic (USPV) generation; Wind powered generation

**UNIT –IV BIOMASS BASED GENERATION**

Biomass based generation; DG Evaluation: Cost from past, present, and future, basic DG cost analysis, cost Evaluation and schedule of demand.

**UNIT- V POWER GRID**

The power grid; DG-Grid interconnection issues, Mini and Micro Grids – Economics – Environmental Factors – Transmission and Regulations

**OUTCOMES**

Students will have

- The principle of direct technologies used in rural areas
- The structure, materials and operation of bio gas process in rural areas
- knowledge about socio-economic and environmental merits of rural electrification
- The prospects of rural technology for sustainable power generation
- knowledge in concept of smart grids, environmental factor and economic issues

**REFERENCE**


1. H.Lee Willisand W.G.Scott: Distributed Power Generation : Planning and Evaluation, Marcel Dekker,(2000).
2. J.J.Burke: Power Distribution Engineering, Fundamentals and Applications, Marcel Dekker,(1994).
3. T.Gonen: Electric Power Distribution System Engineering, McGraw Hill(1986).
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**21UPEST1E05 BASICS OF SOLAR CELL**

**OBJECTIVES**

- To learn and study the basics of basics of electricity
- To study the various solar photovoltaic energy and their applications
- To learn about various solar PV cell materials and conversion techniques
- To learn various and designs solar pv cell and requirement
- To know about various solar pv modules and arrays applications

**UNIT-I BASICS OF ELECTRICITY**

Introduction to Electricity – Voltage – Current – Resistance –Electric Power –Electrical Energy-Types of Power - Measurement of Electrical Quantities – Millimeter - Measurement of DC Voltage -AC Voltage - DC Current - AC Current – Resistance - Electrical Power and Energy

**UNIT-II INTRODUCTION TO SOLAR PHOTOVOLTAIC ENERGY**

Photovoltaic effect – Solar Cell –Parameters of Solar Cells –Solar Cell Technology -Effect of Conversion Efficiency - Input Light- Solar Cell Area – Angle of Light Falling on Solar Cell – Solar Cell Operating Temperature.

**UNIT-III SOLAR CELL MATERIALS**

Semiconductors – Intrinsic Semiconductor – Extrinsic Semiconductor –P Type and N Type Semiconductors – Generation of Carriers – Recombination of Carriers - P-N Junction –Energy Band Diagram of P-N Junction – Carrier Movements and Current Densities.

**UNIT-IV CONCENTRATED PV CELLS**

Light concentration - Concentration Ratio Optics for Concentrator PV- V Trough Concentrator – Compound Parabolic Concentrator - Parabolic Trough Concentrator – Parabolic Reflector –Fresnel's Lenses Concentrator – Tracking Requirement of CPV-Cooling Requirements.

**UNIT-V PV MODULES AND ARRAYS**

Definition of PV module - Module Ratings - PV Module Parameters - IV and PV characteristics of PV module- Number of cells in a module-designing wattage of PV module – Definition of array – connection of modules in series – parallel and mixed combination - mismatch effect

**OUTCOMES**

Students will have

- Learn and study the solar radiation and various solar Cells
- Know the various solar energy technologies and their applications
- Aware about various solar PV cell materials and conversion techniques
- Learn various Solar SPV systems designs and their applications
- Understanding the solar cell theory to improve and optimize its performance of Solar cell device

**REFERENCE**

1. Chetan singh Solanki, solar photovoltaic technology and systems PHI learning private limited (2015)
2. H.P.Garg Solar Energy: Fundamentals And Applications, McGraw Higher Ed Publication (2000)
3. Suneel Deambi, From Sunlight to Electricity: A practical handbook on solar photovoltaic applications, The Energy And Resources Institute (2009).

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**21UPEST1E06 PRINCIPLES AND APPLICATIONS OF HYDROGEN STORAGE**

**OBJECTIVES**

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

**UNITI INTRODUCTION**

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

**UNIT II THERMODYNAMICS**

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

**UNIT III HYDROGEN PRODUCTION**

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

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

Conventional methods of hydrogen storage – solid state; metal organic – Zeolites – carbons – interstitial hydrides – AB5 & AB2 compound -

**UNITV HYDROGEN FUEL CELL**

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

**OUTCOMES**

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

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

**REFERENCES**


1. Angelo Basile, Adolfo Iulianelli, Advances in Hydrogen Production, Storage and Distribution, 1st Edition, Woodhead Publishers, Cambridge (UK), 2014.
2. Gavrilyuk, Hydrogen Energy for Beginners, Pan Sanford Publication private ltd. UK
3. 
4. Michael Hirscher, Hand Book of Hydrogen Storage, 1st Edition, Wiley-VCN Verlag GmbH, 2010.
5. Gavin Walker, Solid State Hydrogen Storage: Materials and Chemistry, 1st Edition, Woodhead Publishers, Cambridge (UK), 2008.
6. Rober A. Varin, Tomasz Czujko, Zbigniew S. Wronski, Fuel Cells and Hydrogen Energy Series: Nanomaterials for Solid State Hydrogen storage, 1st Edition, Springer, 2009.
7. LennieKlebanoff, Hydrogen Storage Technology: Materials and Applications, 1st Edition, CRC Press, 2012.


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**21UPEST1E07 BIO –ENERGY CONVERSION**

**OBJECTIVES**

- Acquiring the knowledge of bio-methanation
- Understanding Biomass through combustion and its importance with respect to environment protection
- To design gasification systems.
- Analyze the technologies available for conversion of biomass to energy in terms of its technical competence and economic implications.
- To provide general features of geothermal energy

**UNIT-I 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 & comparison – Biogas appliances – Burner, Illumination & Power Generation – Effect on Engine Performance.

**UNIT-II COMBUSTION**

Perfect, Complete & Incomplete – Equivalence ratio – Fixed Bed, Fluid Bed – Fuel & Ash handling – Steam Cost comparison with conventional fuels. Briquetting: Types of Briquetting – Merits & Demerits – Feed requirements & Preprocessing – Advantages - Drawbacks

**UNIT-III GASIFICATION**

Types – Comparison – Application – Performance Evaluation – Economics – Dual fuel engines –100 % Gas Engines – Engine characteristics on gas mode – Gas Cooling & cleaning train.

**UNIT-IV IMPORTANT ASPECTS OF GEOTHERMAL ENERGY**

Important aspects of Geothermal Energy (GTE), Applications, Geothermal Energy Resources, Origin of Geothermal Thermal Resources, Geothermal Thermal Gradients, Non-uniform Geothermal Thermal Gradients, Hydro- Geothermal Resources

**UNIT- V GEOTHERMAL ELECTRIC POWER (GTEP) PLANTS**

Introduction, Classification and Types, Historical Background, Vapor dominated GTEP Plant (Steam), Liquid dominated GTEP Plant (Hot Water), Liquid dominated Flashed Steam GTEP Plant, Scope for Geothermal Energy systems in India.

**OUTCOMES**

After successful completion of this course, the students will be able to

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

- Discuss the organic compounds will provide a strong platform to understand the concepts on Bio Gas these subjects for further learning.
- Develop knowledge on historical background and scope of geothermal

**REFERENCE**


1. GD Rai, Non Conventional Energy Sources,Khanna Publishers,NewDelhi(1988)
2. David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis Hoknood, Chichester,(1984)
3. Khandelwal KC, Mahdi SS, Biogas Technology – A Practical Handbook, TataMcGraw Hill, (1986)
4. R.C. Mahaeswari, Bio Energy for Rural Energisation, Concepts Publication,(1997)


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**21UPEST1E08 ENERGY CONSERVATION, ENERGY STORAGE AND TRANSPORTATION**

**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.

**OUTCOME**

Students will have

- Exposure Students will be Able to analyses various types of energy storage devices and perform the selection based on techno economic view point
- Ideas in energy conservation
- Conception of home heating and transportation
- Detail practical knowledge in energy storage systems

- Conversion process of battery electric vehicles
- Types and usage of hydrogen fuel cells

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

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**21UPEST1E09 MODELING AND ANALYSIS OF ENERGY SCIENCE BASED SYSTEMS**

**OBJECTIVES**

- To learn to apply mass and energy balances for the energy systems
- To learn the modeling and simulation techniques for energy systems.
- To learn the optimization techniques to optimize the energy system.
- To learn to use the energy-economy models.
- To understand the application of case studies.

**UNITI INTRODUCTION**

Primary energy analysis - energy balance for closed and control volume systems - applications of energy analysis for selected energy system design - modelling overview - levels and steps in model development - Examples of models – curve fitting and regression analysis

**UNITII MODELLING AND SYSTEMSSIMULATION**

Modelling of energy systems – heat exchanger - solar collectors – distillation -rectification turbo machinery components - refrigeration systems - information flow diagram - solution of set of non- linear algebraic equations - successive substitution - Newton Raphson method- examples of energy systems simulation

**UNITIII OPTIMISATIONTECHNIQUES**

Objectives - constraints, problem formulation - unconstrained problems - necessary and sufficiency conditions. Constrained optimization - Lagrange multipliers, constrained variations, Linear Programming

**UNIT IV ENERGY- ECONOMY MODELS**

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

**UNIT V APPLICATIONS AND CASE STUDIES**

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

**OUTCOMES**

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

- Apply mass and energy balances for the energy systems
- Do Simulation and Modeling of typical energy system
- Use the optimization techniques to optimize the energy system.
- Perform Energy-Economic Analysis for the typical applications
- Have knowledge in optimization of Energy systems problems

**REFERENCE BOOKS**


1. Reddy, T. Agami. Applied data analysis and modeling for energy engineers and scientists. Springer Science & Business Media,2011.
2. Bejan, A, Tsatsaronis, G and Moran, M., Thermal Design and Optimization, John Wiley & Sons1996
3. Stoecker, W.F., Design of Thermal Systems, McGraw Hill,2011.
4. Huang, J. P., K. L. Poh, and B. W. Ang. "Decision analysis in energy and environmental modeling." Energy 20, no. 9 (1995):843-855.
5. YogeshJaluria, Design and Optimization of Thermal Systems, CRC Press INC,2008
6. C. Balaji, Essentials of Thermal System Design and Optimization, Ane Books,2011


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**21UPEST1E10 GREEN CONCEPTS IN BUILDINGS**

**OBJECTIVES**

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

**UNIT–I ENVIRONMENTAL IMPLICATIONS OF BUILDINGS**

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

**UNIT-II IMPLICATIONS OF BUILDING TECHNOLOGIES**

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

**UNIT–III COMFORTS IN BUILDING**

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

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

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

**UNIT-V GREEN COMPOSITES FOR BUILDINGS**

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

**OUTCOMES**

Students will have

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

**REFRENCE**


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


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**21UPEST1E11 SMART GRID TECHNOLOGIES**

**OBJECTIVES**

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

**UNIT-I INTRODUCTION TO SMART GRID**

Evolution of electric grid- Concept of smart grid Definitions – Need of smart grid- Functions of smart grid – Opportunities & barrier of smart grid- Difference between conventional & smart grid

**UNIT-II SMART GRID TECHNOLOGIES**

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

**UNIT – III SMART GRID TECHNOLOGIES**

Smart Substations – Substation automation – Feeder automation – Intelligent electronic devices (IED) & their application for monitoring protection – Smart storage like battery – SMES-

**UNIT –IV MICRO GRIDS AND DISTRIBUTED ENERGY RESOURCES**

Concept of micro grid- Need & applications of micro grid- Formation of micro grid- Issues of interconnection – Protection & control of micro grid- Plastic & organic solar cells- Thin film solar cells –

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

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

**OUTCOMES**

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

- Understand smart grids and analyze grid policies and development in smart grids.
- Develop concepts of smart grid technologies in hybrid electrical vehicles etc.

- Understand smart substation, feeder automation, GIS etc.
- Analyze micro grids and distributed generation systems.
- Analyze the effect of power quality in smart grid and to understand latest developments in ICT for smart grid

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1. "Integration of Green and Renewable Enegry in Electric Power Systems", Ali Keyhani, Mohammad N. Marwail, Min Dai Wiley.
2. "The Smart Grid: Enabling Energy Efficiency and Demand Response ", Clark W. Gellings, CRC Press.
3. "Smart Grid: Technology and Applications", Janaka E kanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, Wiley.
4. "Smart Grids", Jean Clude Sabonnadiere, Nouredine Hadjsaid, Wiley Blackwell.
5. "Smart Power : Climate Changes the Smart Grid ,and the Future of Electric Utilities", Peter S. Fox Penner ,Island Press; 1 edition 8 Jun 2010


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**21UPEST1E12 ENERGY STORAGE SYSTEMS**

**OBJECTIVES**

- To understand the concept of understand / analyses the various types of energy storage.
- To study the various applications of energy storage systems
- To acquire the knowledge of various types of energy storage materials
- To understand the fundamental theories that explain design of energy storage systems
- To comprehend the concepts of energy storage applications.

**UNIT-I LEAD ACID BATTERY**

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

**UNIT-II LITHIUM-ION BATTERY**

Advanced anodes and cathodes – Theoretical capacity – Merits and demerits Nanomaterials for anodes - Carbon nanotubes - $SnO_2$ – NiO - $TiO_2$& $LiTiO_4$ Battery fabrication technology and testing - Batteries for electric vehicles - Hybrid vehicles and solar photovoltaic applications.

**UNIT-III METAL-AIR BATTERIES**

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

**UNIT-IV FUEL CELLS**

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

**UNIT-V HYBRID ENERGY SYSTEMS**

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

**OUTCOME**

Students will have

- Students will be Able to analyses various types of energy storage devices and perform the selection based on techno economic view point
- Knowledge in Industrial and usage of lead acid batteries

- Advance technologies used in lithium-ion batteries
- Recent trends of technology used metal air batteries.
- Advancement of hybrid storage systems

**REFERENCE**

1. Subramanian Srinivasan, Fuel Cells from fundamentals to applications, Springer, (2006).
2. Modern Batteries, Colin A Vincent and Bruno Scrosati, (1997) Pub Arnold ISBN 0-340-66278-6.
3. Electric Vehicle Battery Systems Sandeep Dhameja, October (2001),
4. Pub Newnes, ISBN 0750699167.
5. T. R. Crompton, Battery Reference Book, SAE International, (1996). Edition: 2EV/Hybrid Batteries & Battery Material Suppliers: An Automotive Market Review.
6. David Linden, Hand Book of Batteries, McGraw-Hill, Inc), 4th edition, (2010) New York

**SUPPORTIVE COURSES**

**21UPEST2S01 BASIC CONCEPTS IN ENERGY SCIENCES**

**OBJECTIVES**

- To get a knowledge about the energy sources
- To analyze the working principle, pros and cons of Conventional energy conversion techniques
- To know the impact of non-renewable energy systems on the environment.
- To know the importance and methods of conversion of bio based waste into useful form of energy.
- Direct energy conversion systems Need and necessity of energy storage systems and their desirable characteristics & Fuel cells

**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

**OUTCOMES**

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

- Awareness on the energy status in India as well as globe and familiarized in the different form of energy sources and energy conversion techniques.
- Able to select the suitable energy source based on the working principle, pros and cons of energy conversion systems.

- The knowledge about importance of energy conservation and the impact of non- renewable energy sources.
- To understand the concept of conversion of bio based waste into useful form of energy.
- Awareness on the existence of various mechanisms for conversion and storage of energy, their merits, constraints and drawbacks

**REFERENCES:**

1. D. A. Spera, Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, ASME Press.
2. S.P. Sukhatme, Solar Energy: principles of Thermal Collection and Storage, Tata McGraw-Hill (1984).
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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**21UPEST2S02 CLIMATE CHANGE AND CO2 EMISSION ASSESSMENT**

**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 (CO2) EMISSIONS AND CONVERSION/CONSUMPTION**

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

**UNIT- IV METHODOLOGY FOR CO2 ASSESSMENT/CARBON FOOT PRINT**

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

**UNIT-V CARBON CREDIT**

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

**OUTCOMES**

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

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

**REFERENCES**

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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**21UPEST2S03 ENERGY AND ENVIRONMENTAL IMPACTS**

**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 ENERGY SOURCES**

Present Energy resources in India and its sustainability - Different type of conventional Power Plant--Energy Demand Scenario in India-Advantage and Disadvantage of conventional Power Plants – Conventional vs Non-conventional power generation

**UNIT-II SOLAR ENERGY**

Basics of Solar Energy- Solar Thermal Energy- Solar Photovoltaic- Advantages and Disadvantages-Environmental impacts and safety.

**UNIT-III BIOMASS AND GEO THERMAL ENERGY**

Biomass resources-Biomass conversion Technologies- Feedstock preprocessing and treatment methods- Bioenergy program in India-Environmental benefits and impacts. Geothermal Energy resources –Ocean Thermal Energy Conversion – Tidal.

**UNIT-IV POLLUTION CONTROL**

Air pollution- Sources, effects, control, air quality standards, air pollution act, air pollution measurement. Water pollution-Sources and impacts, Soil Pollution-Sources and impacts, disposal of solid waste.

**UNIT-V ENVIRONMENTAL AFFECT FACTORS**

Greenhouse gases – effect, acid rain. Noise pollution. Pollution aspects of various power plants. Fossil fuels and impacts, Industrial and transport emissions- impacts.

**OUTCOMES**

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

- Learned challenges and opportunities related to energy use and conversion. Learn how to evaluate the sustainability of energy systems.
- Able to analyses environmental impact of various energy sources and also the effects of different types of pollutants.
- Familiar knowledge on solar energy and conversion technologies.
- Good knowledge on biomass and geothermal energy systems and conversion techniques.
- Elaborate knowledge on pollution control methods.

**REFERENCES:**

1. B H Khan, 'Non Conventional Energy Resources'-The McGraw –Hill Second edition.
2. Boyle, G.. Renewable energy: Power for a sustainable future'. Oxford University press, (2004).

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**21UPEST2S04 ERECTION AND MAINTENANCE OF REFRIGERATION AND AIR-CONDITIONING EQUIPMENT'S**

**OBJECTIVES**

- To analyse the working principle, pros and cons of Conventional energy conversion techniques.
- To know about energy-based testing measurement
- To know about energy-based measurement & maintenance system
- To get good knowledge in R & AC systems.
- To get a knowledge in maintenance.

**UNIT-I INTRODUCTION**

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

**UNIT-II ERECTION OF R&AC SYSTEMS**

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

**UNIT-III TESTING OF EQUIPMENTS**

Testing of compressors, condensers, evaporators, cooling towers, motors, controls, test rings, ISI standards. Testing of control systems, circuitry and troubleshooting, condition monitoring

**UNIT-IV TOTAL PREVENTIVE MAINTENANCE**

TPM Principles, Corrective and preventive measures and Reliability analysis.

**UNIT-V MAINTENANCE SCHEDULES**

Studies on different maintenance schedules followed by various industries

**OUTCOMES**

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

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

**REFERENCES**

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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**21UPEST2S05 GREEN CONCEPTS IN BUILDINGS**

**OBJECTIVES**

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

**UNIT –I ENVIRONMENTAL IMPLICATIONS OF BUILDINGS**

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

**UNIT- II IMPLICATIONS OF BUILDING TECHNOLOGIES**

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

**UNIT –III COMFORTS IN BUILDING**

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

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

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

**UNIT- V GREEN COMPOSITES FOR BUILDINGS**

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

**OUTCOMES**

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

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

- Familiar in the concept of green composites for buildings.

**REFERENCES:**

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

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**VALUE ADDED COURSE**

**21UPESTVA01 IC ENGINE, ALTERNATE FUELS AND EMISSIONS**

**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)

**OUTCOMES**

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

**REFERENCES**

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

**21UPESTVA02 BIOMASS AND ITS CONVERSION TECHNOLOGIES**

**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
- Determine potential solutions for energy needs and problems by incorporating the bioenergy technologies being explored.

**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.

**OUTCOMES**

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

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

**REFERENCES**

1. Fuel Cells by Bockris and Srinivasan; McGraw Hill.
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.

**21UPESTVA03 MATERIALS FOR ENERGY APPLICATIONS**

**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

**OUTCOMES**

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

**REFERENCES**

1. Solar Thermal Energy Storage by HP Garg, D Reidel Publishing Co.
2. Mathematical Modeling of Melting and Freezing process by V Alexiades and AD Solomon, Hemisphere Publishing Corporation, Washington.
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

**21UPESTVA04 POWER SOURCES FOR ELECTRIC VEHICLES**

**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

**OUTCOMES**

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.

**REFERENCES**

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.

**21UPESTVA05 DESIGN THINKING**

**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
- To learn the application of design thinking for the IT industry
- To design using the methodology

**UNIT I INTRODUCTION**

Understanding Design thinking – Shared model in team-based design – Theory and practice in Design thinking – Exploring work of Designers across globe – 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

**OUTCOMES**

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

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

**REFERENCES**

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).