## Scheme of Studies & Examinations

### M. Tech Programme in Renewable Energy (RE)

#### 1st YEAR (I - SEMESTER)

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Course No.</th>
<th>Course Name</th>
<th>L.</th>
<th>T</th>
<th>P</th>
<th>Total Credit</th>
<th>Class Work</th>
<th>Theory Marks</th>
<th>Practical Marks</th>
<th>Total</th>
<th>Duration of Exam (Hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RE/EEM-101</td>
<td>Renewable Energy Systems-I</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>25</td>
<td>75</td>
<td>-</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>RE-103</td>
<td>Heat Transfer and Process Integration</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>25</td>
<td>75</td>
<td>-</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>PE-1</td>
<td></td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>25</td>
<td>75</td>
<td>-</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>PE-2</td>
<td></td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>25</td>
<td>75</td>
<td>-</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>RE/EE M-117</td>
<td>Research Methodology and IPR</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>25</td>
<td>75</td>
<td>-</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>RE-105</td>
<td>Heat Transfer Lab</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td>25</td>
<td>-</td>
<td>75</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>RE-107</td>
<td>Energy Research Laboratory-I</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td>25</td>
<td>-</td>
<td>75</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>Audit-I</td>
<td></td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>25</td>
<td>75</td>
<td>-</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

**Grand Total**

| 18 | 800 |

### List of PE-1

1. RE/EEM-109 Solar Energy: Fundamentals, Devices and Systems
2. RE/EEM-111 Energy and Climate

### List of PE-2

1. RE-113 Direct Energy Conversion
2. RE-115 Nuclear Energy
Audit course 1 & 2

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills
## Scheme of Studies & Examinations

### M. Tech Programme in Renewable Energy (RE)

**1st Year (II - Semester)**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Course No.</th>
<th>Course Name</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>Total Credit</th>
<th>Class Work</th>
<th>Theory Marks</th>
<th>Practical Marks</th>
<th>Total</th>
<th>Duration of Exam (Hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RE/EEM-102</td>
<td>Renewable Energy Systems-II</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>25</td>
<td>75</td>
<td>-</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>RE-104</td>
<td>Materials and Devices for Energy Applications</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>25</td>
<td>75</td>
<td>-</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>PE-1</td>
<td></td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>25</td>
<td>75</td>
<td>-</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>PE-2</td>
<td></td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>25</td>
<td>75</td>
<td>-</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mini Project with seminar</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>25</td>
<td>75</td>
<td>-</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>RE-106</td>
<td>Energy Auditing and Simulation Laboratory</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td>25</td>
<td>-</td>
<td>75</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>RE-108</td>
<td>Energy Research Laboratory-II</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td>25</td>
<td>-</td>
<td>75</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>Audit-II</td>
<td>Audit-II</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>25</td>
<td>75</td>
<td>-</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**List of PE-3**

1. RE/EEM-110 Solar Photovoltaic Technology
2. RE-112 Energy Audit Procedures and Techniques

**List of PE-4**

1. RE/EEM-114 Solar passive heating and cooling
2. RE-116 Energy Conversion Systems
Audit course 1 & 2

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills
## M. Tech Programme in Renewable Energy (RE)

### IIInd YEAR (III - SEMESTER)

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Course No.</th>
<th>Course Name</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>Total</th>
<th>Class Work</th>
<th>Theory Marks</th>
<th>Practical Marks</th>
<th>Total</th>
<th>Duration of Exam (Hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PE-5</td>
<td></td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>25</td>
<td>75</td>
<td>-</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>OE</td>
<td></td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>25</td>
<td>75</td>
<td>-</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>RE-209</td>
<td>Phase-I Dissertation</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>10</td>
<td>25</td>
<td>__</td>
<td>75</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Grand Total</strong></td>
<td>16</td>
<td>75</td>
<td>150</td>
<td>75</td>
<td>300</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### List of PE-5

1. RE/EEM-201 Solar Energy Utilization
2. RE-203 Hydrogen Energy

### List of OE

1. RE/EEM-205 Waste to Energy
2. RE-207 Green Building Technology
## M. Tech Programme in Renewable Energy (RE)

### IIInd YEAR (IV - SEMESTER)

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Course No.</th>
<th>Course Name</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>Total</th>
<th>Class Work</th>
<th>Theory Marks</th>
<th>Practical Marks</th>
<th>Total</th>
<th>Duration of Exam (Hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RE-202</td>
<td>Phase-II Dissertation</td>
<td>0</td>
<td>0</td>
<td>32</td>
<td>16</td>
<td>25</td>
<td>-</td>
<td>75</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grand Total</td>
<td>16</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>75</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Total Credits: $18+18+16+16 = 68$
RE/EEM-101: Renewable Energy Systems-I
M. Tech. - Renewable Energy (RE) 1st Year (I – Semester)

L     T     P/D     Credits
3     --    --     3

Class Work : 25 Marks
Examination (Theory/Practical) : 75 Marks
Total : 100 Marks
Duration of Examination : 3 Hours

Course Objectives:
To provide knowledge, understanding and application oriented skills on all renewable energy sources and relevant technologies towards their effective utilization for meeting energy demand. To introduce the various renewable sources of energy and modern applications. It includes solar thermal power, power from wind, biomass power and fuel cell. To provide the concepts of Interrelationship between energy and utilization of various resources of energy. The course will include latest technologies related to different power resources.

Unit I:

Unit II:
Biomass: Origin of Biomass: Resources: Classification and characteristics; Techniques for biomass assessment; Biomass estimation, Thermochemical Conversion Different processes: Direct combustion, incineration, pyrolysis, gasification and liquefaction; Economics of thermochemical conversion.

Unit III:

Unit IV:
Fuel Cell: Thermodynamics of fuel cells; free energy change and cell potentials; effects of temperature and pressure on cell potential; energy conversion efficiency; factors affecting conversion efficiency; polarization losses; important types of fuel cells, Principle of working, construction, electrode types; electrolytes for fuel cells; applications.

Course Outcomes:
The Course will create awareness among students about Non-Conventional sources of energy technologies and provide adequate inputs on a variety of
issues. After completion of this course, the students will know about all renewable energy sources like solar thermal power, power from wind, biomass power and fuel cell and relevant technologies. Now they have the ability to plan and perform a short scientific study and present the results in writing and orally.

Reference Books:

3. Thermo chemical processing of Biomass, Bridgurater A V.

Note: Eight (8) questions are to be set selecting two from each unit. Students shall have to attempt any five (5) selecting at least one from each unit.
RE-103: HEAT TRANSFER AND PROCESS INTEGRATION

M. Tech. - Renewable Energy (RE) 1st Year (I – Semester)

<table>
<thead>
<tr>
<th>L</th>
<th>T</th>
<th>P/D</th>
<th>Credits</th>
<th>Class Work</th>
<th>Examination (Theory/Practical)</th>
<th>Total</th>
<th>Duration of Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>--</td>
<td>--</td>
<td>3</td>
<td></td>
<td>25 Marks</td>
<td>75 Marks</td>
<td>100 Marks</td>
</tr>
</tbody>
</table>

Course Objectives:

Heat Transfer is possible by conduction, convection, radiation. The subject has a wide application. It is gaining importance continuously. The present one is a fundamental course which provides adequate concepts and prepares the students for undertaking calculations of heat transfer rate through different mechanisms. This is a bridge course for non mechanical engineering background students for Energy programme. To introduce the fundamental of thermodynamics required in thermal process, heat transfer and fluid mechanics.

Unit I

Basic Heat Transfer Concept and Terminology:

Unit II

Convection:

Unit III

Boiling and Condensation

Heat Exchangers
Unit IV
Radiation

Course Outcomes:

After doing this course student will know about the basics of heat transfer i.e. conduction, convection and radiation. The subject has a wide application in the industries, energy auditing and ECBC compliance in buildings. This is a fundamental course, now the students are prepared for calculations of heat transfer rate through different mechanisms.

Reference Books:
5. J.P. Holman – Heat Transfer
6 Cengel, Heat transfer, Tata Mc Graw Hill

Note: Eight (8) questions are to be set selecting two from each unit. Students shall have to attempt any five (5) selecting at least one from each unit.
RE-105: HEAT TRANSFER LAB

M. Tech. - Renewable Energy (RE) 1st Year (I – Semester)

<table>
<thead>
<tr>
<th>L</th>
<th>T</th>
<th>P/D</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

Class Work : 25 Marks
Examination (Theory/Practical) : 75 Marks
Total : 100 Marks
Duration of Examination : 3 Hours

Course Objectives:

In order to supplement various topics related to energy aspects in class-room lectures, some laboratory experiments are needed as a part of curriculum development of energy studies programme for better understanding of the subjects. The experiments based on heat transfer principles are so designed so as to provide students enough stimulation for further investigation.

List of Experiments

1. Evaluation of UL, FR and $\eta$ in Thermosyphonic mode of flow with fixed input parameters and at different radiation level.
2. Evaluation of UL, FR, $\eta$ in Thermosyphonic mode of flow at different inlet water temperature and with fixed input parameters.
3. To determine and compare LMTD, Overall Heat transfer coefficient, efficiency and effectiveness of a heat exchanger in parallel flow and counter flow mode. (Water to water)
4. To determine and compare LMTD, Overall Heat transfer coefficient, efficiency and effectiveness of a heat exchanger in parallel flow and counter flow mode. (Water to air)
5. Evaluation of UL, FR, $\eta$ and drawing of different curves in forced mode of flow at different flow rate.
6. Evaluation of UL, FR, $\eta$ in forced mode of flow at different radiation level and at different inlet water temperature.
7. Evaluation of UL, FR, $\eta$ in forced mode of flow at different wind speed.
8. Evaluation of UL, FR, $\eta$ in forced mode of flow at different tilt angle and all other parameter as in forced mode experiment.

Course outcomes:

The students will be able to

1. Able to design and carry out a method of heat transfer analysis, including instrumental analysis.
2. Perform various heat transfer experiments through different modes like forced mode and thermosyphonic mode.
3. Now students easily understand the concept of heat transfer in their practical life also.
Course Objectives:

In order to supplement various topics related to energy aspects in class-room lectures, some laboratory experiments are needed as a part of curriculum development of energy studies programme for better understanding of the subjects. The experiments based on science/engineering principles are so designed so as to provide students enough stimulation for further investigation.

List of Experiments:

1. To demonstrate the I-V and P-V characteristics of PV module with varying radiation and temperature level.
2. To demonstrate the I-V and P-V characteristics of series and parallel combination of PV modules.
3. To show the effect of variation in tilt angle on PV module power.
4. To demonstrate the effect of shading on module output power.
5. To demonstrate the working of diode as Bypass diode and blocking diode.
6. To observe the open circuit voltage decay graph of a crystalline silicon solar cell.
7. To calculate the lifetime of the solar cell.
8. Understanding the concept of lifetime in solar cells.
9. Ability to calculate the lifetime of the solar cell.
10. To compare and analyse the performance of charge controllers.
11. To understand the different voltage rating applications.
12. Measurement of IV characteristics with change in illumination to analyse the deviation of operating points from Maximum power point.
13. To understand the PV system design and installation with tracking techniques and mechanisms.
14. Plot the Torque v/s Speed and Power v/s Speed characteristics of the turbine at different wind speed and load configuration.
15. Plot the torque v/s speed and power v/s speed characteristics of the turbine at different pitch angle and load configuration.
Course outcomes:
The students will be able to perform above mentioned experimental. The students are expected to learn the art and science of carrying out experimental research. At the end of the course a student should be able to design and carry out an experiment on his/her own. This is an important skill which anybody wanting to do experimental research is expected to possess.
Course Objectives:

This course has objectives to elaborate PG students regarding current trends in solar architecture and following key concepts: Solar Radiation, Sun Angles, and Importance of Sun Angles for Building Fenestration/day lighting, Solar Passive Architecture, heat transfer in buildings, Natural Heating/Cooling concepts for Building, Refrigeration systems.

Unit I

Earth & Sun Relationship:

Unit II

Thermal Energy Storage: Sensible Storage (Water, pebble bed and ground storage), Latent Heat Storage.
Thermal Energy Systems
Solar Water Heating System: Components, Natural Flow, Forced Flow and Load
Solar desalination system: Design and type, Solar still, performance analysis.

Unit III

Solar Refrigeration and Desiccant

Unit IV

Solar Power Generator
Course outcomes:

This will enable them to understand the solar architecture and following key concepts: Solar Radiation, Sun Angles, and Importance of Sun Angles for Building Fenestration/day lighting, thermal energy storage and devices, Solar Passive Architecture, Solar Refrigeration and Desiccant and Solar Power Generator.

Recommended Books:
9. Markvart, Solar Electricity, John Wiley

Note: Eight (8) questions are to be set selecting two from each unit. Students shall have to attempt any five (5) selecting at least one from each unit.
# RE-111: Energy and Climate

**M. Tech. - Renewable Energy (RE) Elective**

<table>
<thead>
<tr>
<th>L</th>
<th>T</th>
<th>P/D</th>
<th>Credits</th>
<th>Class Work</th>
<th>Examination (Theory/Practical)</th>
<th>Total</th>
<th>Duration of Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>--</td>
<td>--</td>
<td>3</td>
<td></td>
<td>25 Marks</td>
<td>75 Marks</td>
<td>100 Marks</td>
</tr>
</tbody>
</table>

## Course Objectives:

To provide knowledge, understanding and application oriented skills on energy – environment interaction, environmental emissions from various energy resource technology combinations and their impact on ecosystems as well as various measures and initiatives for emissions mitigation. The course also fosters an understanding of fundamental environmental issues with a focus on resource conservation and management for future use. To sensitize students towards environmental concerns and issues, and make them able to apply their knowledge for sustainable development.

### Unit I

Energy and us: Energy terms; Current energy scenario (World, US, India); Fossil energy Vs renewable sources; Electricity; Future projections; Externalities of energy use, Carbon Cycle: Natural systems, autotrophs, heterotrophs, energy flows, pre-industrial humanity; Photosynthesis- efficiency of natural ecosystems, forests and various crops; Respiration, combustion and other oxidation processes.

### Unit II

Climate Science Research: Climate history; Greenhouse gas effect; Anthropogenic climate change; Role of different gases; Global problem; Integrated assessment models; Impacts and adaptation; Uncertainties.

### Unit III

Carbon Sequestration: Biological pathways; Physico-chemical methods; CO₂ capture from large point sources; Pre-, post- and oxy-combustion technology; Transport, storage and monitoring; Feasibility, economics and public perceptions.

### Unit IV

Climate Policy: Kyoto protocol; UNFCCC; IPCC; Geopolitics of GHG control; Carbon market - CDM and other emission trading mechanisms; Non-CO₂ GHGs; Relevance for India.
**Course outcomes:**

Student will be able to explain the concepts of Interrelationship between energy, ecology and environment, environmental issues related to harnessing and utilization of various sources of energy and related environmental degradation. Understand the special engineering challenges of using each of these sources of energy efficiently and environmentally effectively. Students will be able to understand the problems related to environment at global level like GHG emissions, Kyoto protocol, CDM etc.

**Reference Books:**


**Note:** Eight (8) questions are to be set selecting two from each unit. Students shall have to attempt any five (5) selecting at least one from each unit.
Course Objectives:

To provide adequate inputs on a variety of issues relating to direct energy conversion systems. Introduction to principles and operation of devices that convert thermal, chemical, and electromagnetic energy directly into electricity. This course will also discuss about the basics of semiconductor materials and devices for photovoltaic applications.

Unit I
Survey of energy conversion problem. Basic science of energy conversion, Energy conversion process, indirect and direct energy conversion. Preview of semiconductor physics: Basic ideas of quantum physics, Fermi Energy, band diagram, Intrinsic and extrinsic semiconductors, p-n junction, Physics of semiconductor junctions for photovoltaic

Unit II
Fabrication and evaluation of various solar cells. Application of solar cells in photo voltaic power generation systems. Batteries: Thermodynamic analysis, design and analysis of batteries, Other modes of direct energy conversion.

Unit III
Technology and physics of thermo-electric generators. Thermo-electric materials and optimization studies, Basic concepts and design consideration of MHD generators. Cycle analysis of MHD systems. Thermionic power conversion and plasma.

Unit IV
Introduction to the principles and operation of fuel cells, stack configurations and fuel cell systems. Fuel cell system design, optimization and economics. Overview of fuel cell technology. Thermodynamics of fuel cells, introduction to electrochemical kinetics, transport-related phenomena and conservation equations for reacting multicomponent systems. Environmental effect.

Course outcomes:
After doing this course students will know about energy conversion problems, basic science of energy conversion, energy conversion process, indirect and direct energy conversion; fabrication and evaluation of various solar cells; design and analysis of batteries; technology and physics of thermo-electric and MHD generators and basic concept of other chemical to energy conversion devices.
Reference Books:

1. Direct Energy Conversion : W.R.Corliss
4. Energy conversion principles : Begamudre , Rakoshdas
7. Solar Cells by Martin Green, Pergamon press.
11. Non-Conventional Sources of Energy- G D Rai
12. Energy Technology- S. Rao (Khanna Publications)

Note: Eight (8) questions are to be set selecting two from each unit. Students shall have to attempt any five (5) selecting at least one from each unit.
Course Objectives:

Due to the rapidly growing energy needs of the country, India has made definite moves towards exercising the nuclear option for large-scale energy generation in the coming years. To further the needs of the country in this direction a National Fusion Program has also been set up within the country. In view of these developments, it is appropriate that a course on basic nuclear energy be available for students interested in large scale energy options both for India and globally. The course treats the basics of both nuclear fission and fusion, and energy generation using these methods; it is suitable for students from interdisciplinary background. To impart knowledge about nuclear deformations, properties and nuclear models for understanding of related reaction dynamics.

Unit I
Basics of Nuclear Fission and Fusion processes, Advantages and Disadvantages, Fuels for Nuclear energy, Nuclear Energy in relevance India. Current status

Unit II
Nuclear Fusion reactions, Difficulties in the fusion reactions, Fuel Ignition temperature, Lawson criterion, confinement problems.

Unit III
Laser-driven fusion, magnetic confinement, equilibrium and stability, cross-field transport, Important heating schemes. Tokamak and magnetic mirror, reactor concepts.

Unit IV

Course outcomes:

Student will familiarize with the basic possibilities for energy production by fission and fusion reactions. Students will know the necessary technological elements of fusion reactors and areas of current problems in their development. Student will develop the understanding of the energy conversion systems for nuclear power plants, the advantages/disadvantages (including overall environmental effects) of each type of present plants, and those of the new Generation IV concepts. After doing this course the students are expected to have basic understanding of nuclear fusion process and the schemes to achieve this.
Reference/Text books:

1. Energy Technology-S. Rao (Khanna Publications)
2. Nuclear Energy Now: - Alan M. Herbst and George W. Hopley
7. Plasma Physics and Fusion Energy by Jeffrey P. Freidberg

Note: Eight (8) questions are to be set selecting two from each unit. Students shall have to attempt any five (5) selecting at least one from each unit.
RE/EEM-117: RESEARCH METHODOLOGY AND IPR

M. Tech. - Renewable Energy (RE) 1st Year (I – Semester)

<table>
<thead>
<tr>
<th>L</th>
<th>T</th>
<th>P/D</th>
<th>Credits</th>
<th>Class Work : 25 Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>--</td>
<td>--</td>
<td>3</td>
<td>Examination (Theory/Practical) : 75 Marks</td>
</tr>
</tbody>
</table>

**Total : 100 Marks**

**Duration of Examination : 3 Hours**

---

**Course Objectives:**

1. To understand some basic concepts of research and its methodologies
2. To identify appropriate research topics
3. To select and define appropriate research problem and parameters
4. To prepare a project proposal (to undertake a project)
5. To organize and conduct research (advanced project) in a more appropriate manner
6. To write a research report and thesis
7. To write a research proposal (grants)
8. The main objective of the IPR is to make the students aware of their rights for the protection of their invention done in their project work.
9. To get registration in our country and foreign countries of their invention, designs and thesis or theory written by the students during their project work and for this they must have knowledge of patents, copyright, trademarks, designs and information Technology Act.
10. Further teacher will have to demonstrate with products and ask the student to identify the different types of IPR’s.

**Unit 1:**

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**Unit 2:**

Effective literature studies approaches, analysis, Plagiarism, Research ethics, Effective technical writing, how to write report, Paper, Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee
Unit 3:


Unit 4:


Course Outcomes:

At the end of this course, students will be able to:

1. Understand research problem formulation.
2. Analyze research related information
3. Follow research ethics
4. Understand that today’s world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
5. Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
6. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Reference Books :

2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
Note: Eight (8) questions are to be set selecting two from each unit. Students shall have to attempt any five (5) selecting at least one from each unit.
RE/EEM-102: Renewable Energy Systems-II
M. Tech. - Renewable Energy(RE) 1st Year (II – Semester)

L       T      P/D      Credits
3       --     --       3

Class Work : 25 Marks
Examination (Theory/Practical) : 75 Marks
Total : 100 Marks
Duration of Examination : 3 Hours

Course Objectives:
To provide knowledge, understanding and application oriented skills on all renewable energy sources and relevant technologies towards their effective utilization for meeting energy demand. The Course will create awareness among students about Non-Conventional sources of energy technologies and provide adequate inputs on a variety of issues. The objective of this course is to study the potential of power generation from renewable and quantify its impact on carbon dioxide mitigation. It includes geothermal, tidal Energy, hydrogen energy, hydel energy and nuclear power. Some of the advanced countries around the world are harnessing this power. The course will include latest technologies related to different power resources.

Unit I:

Unit II:

Unit III:

Unit IV:
Course Outcomes:
The Course will create awareness among students about Non-Conventional sources of energy technologies and provide adequate inputs on a variety of issues. After completion of this course, the students will know about all renewable energy sources like geothermal, tidal Energy, hydrogen energy, hydel energy and nuclear power and relevant technologies. Now they have the ability to plan and perform a short scientific study and present the results in writing and orally.

Reference Books:

4. Solar Cell : Marteen A. Green

Note: Eight (8) questions are to be set selecting two from each unit. Students shall have to attempt any five (5) selecting at least one from each unit.
RE-104: Materials and Devices for Energy Applications

M. Tech. - Renewable Energy (RE) 1st Year (II – Semester)

<table>
<thead>
<tr>
<th>L</th>
<th>T</th>
<th>P/D</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>--</td>
<td>--</td>
<td>3</td>
</tr>
</tbody>
</table>

Class Work : 25 Marks
Examination (Theory/Practical) : 75 Marks
Total : 100 Marks
Duration of Examination : 3 Hours

Course Objectives:

The development of novel materials and processes requires deep knowledge of physical foundations of materials. The central objective of the course is to provide basic understanding of physics and technology behind thin film growth. Possible applications demonstrating novel material designs and case studies in technological areas of current interest will be discussed. The aim of this course is to provide the knowledge on the physics of nanostructure materials, materials growth aspects important for size control and size selection and application of nanoscale materials for energy harvesting. The aim of this course is to provide the knowledge on the Experimental methods used by researchers to understand the properties of materials.

Unit I

Device fabrication technologies: diffusion, oxidation, photolithography, sputtering, physical vapor deposition, chemical vapor deposition (CVD), plasma enhanced CVD (PECVD), hot wire CVD (HWCVD), etc.

Unit II

Introduction to material characterization: Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), X-ray diffraction (XRD), Raman spectroscopy, Atomic force microscopy (AFM), Spectral response of solar cells, quantum efficiency analysis, dark conductivity, I-V characterization.

Unit III


Unit IV

Materials and devices for energy storage; Batteries, Carbon Nano-Tubes (CNT), fabrication of CNTs, CNTs for hydrogen storage, CNT-polymer composites etc. Polymer membranes for fuel cells, PEM fuel cell, Acid/alkaline fuel cells.
Course outcomes:

This course will discuss some of the important concepts, which are key to understand and modify the properties of different types of materials. The course lays foundation for advanced courses in engineering aspects of materials and their applications. This course will provide the knowledge on the Experimental methods used by researchers to understand the properties of materials.

Texts/Reference Books:


Note: Eight (8) questions are to be set selecting two from each unit. Students shall have to attempt any five (5) selecting at least one from each unit.
RE-106: Energy Auditing and Simulation Laboratory

M. Tech. - Renewable Energy(RE)1" Year (II – Semester)

<table>
<thead>
<tr>
<th>L</th>
<th>T</th>
<th>P/D</th>
<th>Credits</th>
<th>Class Work</th>
<th>Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>--</td>
<td>4</td>
<td>2</td>
<td>20 Marks</td>
<td>30 Marks</td>
</tr>
</tbody>
</table>

(Theory/Practical)

Total: 50 Marks

Duration of Examination: 3 Hours

Objectives of the Laboratory:
- Attract more M.Tech/ Ph.D Students to carry out their experiments in the field of energy use analysis and Thesis work and to publish high quality research papers in the National /International Journals.
- Provide facility for conducting the energy conservation, quality and auditing of Residential,Commercial,Official Buildings and Industries etc.
- Develop more and more Socio-economic / Industrial /Public relationship.
- Improve teaching, training and learning facilities of Engineers from industry and other Technical Institutes.
- Promote demand driven R&D with suitable added facilities

List of experiments

1. Introduction to energy simulation tools.
2. Modelling techniques, validation of simulation model.
3. Use of application software (TRANSYS, PVSyst, RETSCREEN, HOMER etc.) For energy system analysis.
4. Simulation for energy efficiency of buildings.
5. Simulation of major energy experiments using real time data acquired through data acquisition system.
6. Modeling of energy systems and investigation of dynamic behaviour: concept of input, parameters, output, errors, tools for validation.
7. Solar Radiation Data Monitoring and Analysis.
8. To study various renewable energy source options (Solar PV) installed in the DCRUST campus and write report.
9. Software - Modelling software like ProE, Gambit, ANSYS etc Analysis software like ANSYS, Fluent, CFX, etc Equation solving software like MATLAB, Engg equation solver.
10. Energy audit of a small scale industry/institute and submit report with recommendation.
11. Energy audit of HVAC or Compressed air or Boiler and steam system and submit report with recommendations.
12. Carry out the Energy audit of Electrical system.
13. Electrical tariff calculations
Outcomes: Learner will be able to…
1. Simulation and Modelling of typical energy system.
2. Summarize and explain need for energy management, economics and auditing.
3. Describe importance of and analyze efficiency in thermal and electrical utilities.
RE-108: Energy Research Laboratory -II

M. Tech. - Renewable Energy(RE)1st Year (II – Semester)

<table>
<thead>
<tr>
<th>L</th>
<th>T</th>
<th>P/D</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>--</td>
<td>--</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

Class Work : 20 Marks
Examination (Theory/Practical) : 30 Marks
Total : 50 Marks
Duration of Examination : 3 Hours

Objectives:
In order to supplement various topics related to energy aspects in class-room lectures, some laboratory experiments are needed as a part of curriculum development of energy studies programme for better understanding of the subjects. The experiments based on science/engineering principles are so designed so as to provide students enough stimulation for further investigation. Acquainting the students on the SOP adopted for quantification of various parameters. To inculcate the habit of analyzing the numbers resulting from experimentation. To create awareness on actual performance limits of renewable energy gadgets/ industrial utilities

List of experiments

1. To draw the charging and discharging characteristics of battery.
2. Workout power flow calculations of standalone PV system of DC load with battery.
3. Workout power flow calculations of standalone PV system of AC load with battery.
4. Workout power flow calculations of standalone PV system of DC and AC load with battery.
5. Performance analysis of PWM and MPPT type charge controllers.
   (a) Change in operating point of modules with and without MPPT with variation in load.
   (b) Comparison between charging points of battery with and without MPPT.
6. To convert and observe various DC voltages 17.5, 35, 70 V to 24, 48 & 96 V respectively using DC step up converters.
7. To convert and observe various DC voltages 17.5, 35, 70 V to 6, 12, 24 V respectively using DC step down converters.
8. To convert various DC voltages to 230 V single phase AC.
9. To analyse the efficiency of step up and step down converter and DC to AC converter at different power.
10. Measurement of IV characteristics at different temperature levels to extract temperature parameters of the modules(without fans)
11. Measurement of IV characteristics with change in illumination to analyse the deviation of operating points from Maximum power point.


14. Determine the Performance (UL, FR, η) of the Parabolic Trough collector with varying flow rate of fluid (Water).

15. Determine the Performance (UL, FR, η) of the Parabolic Trough collector with different inlet water temperature.

**Outcomes:** Learners will be able to ……

1. Understand the behavioral effect of battery under AC & DC loading.
2. Draw the V-I characteristics of PV modules and to analyse the effect of MPPT and PMW on the output of PV modules.
3. Draw the performance curves for various solar thermal system and can understand the impact of various parameters on the performance of the systems.
4. Develop new systems.
5. Ability to use the techniques, skills and modern engineering tools necessary for engineering practice.
RE/EEM-110: Solar Photovoltaic Technology
M. Tech. - Renewable Energy(RE) Elective

<table>
<thead>
<tr>
<th>L</th>
<th>T</th>
<th>P/D</th>
<th>Credits</th>
<th>Class Work</th>
<th>Examination (Theory/Practical)</th>
<th>Total</th>
<th>Duration of Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>--</td>
<td>--</td>
<td>3</td>
<td>25 Marks</td>
<td>75 Marks</td>
<td>100</td>
<td>3 Hours</td>
</tr>
</tbody>
</table>

Course Objectives:

The Course will be introducing the students to all the aspects of PV technology. To develop basic understanding related to fabrication and characterization of different types of solar cells. To know state of art in the field of solar cells materials and solar cells. To provide the introduction of solar photovoltaic system design and solar photovoltaic system testing.

Unit I
Solar Cells
Conversion of Solar energy into Electricity - Photovoltaic Effect, Equivalent Circuit of the Solar Cell, Analysis of PV Cells: Dark and illumination characteristics, Figure of merits of solar cell, Efficiency limits, Variation of efficiency with band-gap and temperature, Efficiency measurements, Effect of temperature on Cell performance, Thermo photovoltaic effect, Types of solar cells, Recent developments in Solar Cells.

Unit II
Fabrication Technology for Solar Cells
Si solar cells, CdTe solar cells, Cu(In,Ga)Se2, GaAs solar cells, Organic solar Cells, Perovskite solar cells, High efficiency multi-junction solar cell. Technologies for the fabrication of thin film cells: Thermal evaporation, CVD, CSS etc.

Unit III
Solar Photovoltaic System Design
Solar cell array system analysis and performance prediction, Shadow analysis: Reliability, Solar cell array design concepts, PV system design, Design process and optimization: Detailed array design, Voltage regulation, Maximum tracking, Quick sizing method, Array protection.

Unit IV
Solar Photo Voltaic System Testing
Course outcome:

This course will enable student to understand solar cells, fabrication technologies for solar cells, solar photovoltaic system design and solar photovoltaic system testing. This will enable students to understand the requirements for PV materials and PV systems for different applications. After completing this course student will have theoretical knowledge about fabrication of solar cells, device physics of solar cells, design and development of PV modules, arrays etc.

Text Books/ References:
3. RH Bube, Photovoltaic Materials, Imperial College Press, 1998

Note: Eight (8) questions are to be set selecting two from each unit. Students shall have to attempt any five (5) selecting at least one from each unit.
RE 112: Energy Audit Procedures and Techniques
M. Tech. - Renewable Energy(RE)Elective

<table>
<thead>
<tr>
<th>L</th>
<th>T</th>
<th>P/D</th>
<th>Credits</th>
<th>Class Work</th>
<th>25 Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>--</td>
<td>--</td>
<td>3</td>
<td>Examination</td>
<td>75 Marks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Theory/Practical)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total</td>
<td>100 Marks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Duration of Examination</td>
<td>3 Hours</td>
</tr>
</tbody>
</table>

Course Objectives:

1. To introduce to students the global energy management in building, energy efficient technology.
2. To develop student the ability to do simple energy audit
3. Study the working of various thermal systems and energy saving opportunities
4. Study electrical energy management, cogeneration and waste heat recovery

Unit I
Energy Audit Methodology & Recent Trends: Current Practices, Integration of two or more systems, Switching of Energy Sources, Economics of implementation of energy optimisation projects, it’s constraints, barriers and limitations, Report-writing, preparations and presentations of energy audit reports, Post monitoring of energy conservation projects, MIS, Case-studies / Report studies of Energy Audits. Guidelines for writing energy audit report, data presentation in report, findings recommendations, impact of renewable energy on energy audit recommendations. Case studies of implemented energy cost optimization projects in electrical utilities as well as thermal utilities.

Unit II

Unit III
Unit IV

Cogeneration: Integrated analysis of steam base co-gen system, Gas turbine combine cycle operation, IC engine base co-generation and tri-generation, extraction turbines and steam cycle of co-generation.

Course Outcomes:
1. Enhance professional practice to meet the global standards with ethical and social responsibility.
2. Solve industrial, social and environmental problems with modern engineering tools
3. Develop skills to work in teams, think intellectually and pursue life long learning.

Reference Books:
1. Energy Management: W.R.Murphy, G.Mckay (Butterworths).
4. Energy Economics A.V.Desai (Wieley Eastern)

Note: Eight (8) questions are to be set selecting two from each unit. Students shall have to attempt any five (5) selecting at least one from each unit.
RE/EEM-114: Solar Passive Heating and Cooling
M. Tech. - Renewable Energy(RE) Elective

<table>
<thead>
<tr>
<th>L</th>
<th>T</th>
<th>P/D</th>
<th>Credits</th>
<th>Class Work</th>
<th>Examination (Theory/Practical)</th>
<th>Total</th>
<th>Duration of Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>--</td>
<td>--</td>
<td>3</td>
<td></td>
<td>25 Marks</td>
<td>75 Marks</td>
<td>100 Marks</td>
</tr>
</tbody>
</table>

Course Objectives:

This course has objectives to elaborate PG students regarding current trends in solar architecture and following key concepts: Solar Radiation, Sun Angles, and Importance of Sun Angles for Building Fenestration/day lighting, Solar Passive Architecture, Natural Heating/Cooling concepts for Building, Earth to Air Heat Exchanger, passive heating, passive cooling and solar ventilation.

Unit I
Heating and cooling load of buildings: elements of heating and cooling load, load reduction approaches, building energy codes, thermal mass.

Unit II
Solar geometry and exposure: sun path diagram, shading analysis, graphical design tools, solar control issues.

Unit III
Passive heating: Direct and indirect solar passive heating systems; solarium, trombe wall, trans-wall.
Passive cooling systems: thermal mass, courtyard effect, wind tower design, earth air tunnel system, evaporative cooling, radiative cooling.

Unit IV
Solar ventilation: stack effect, solar chimney for ventilation, absorber design, stack design, issues in opening design.

Course outcomes:

This will enable them to understand the solar architecture and following key concepts: Solar geometry, sun path diagram, heat transfer in buildings, Solar Passive Architecture, Flat plate collectors, Earth to Air Heat Exchanger, passive heating, passive cooling and green buildings.
Recommended Books:


Note: Eight (8) questions are to be set selecting two from each unit. Students shall have to attempt any five (5) selecting at least one from each unit.
Course Objectives:

The purpose of this course is to critically examine the technology of energy systems that will be acceptable in a world faced with global warming, local pollution. The focus is on thermal systems and devices used in various industries for power generations, production cooling and transportation. Both the devices and the overall systems are analyzed.

Unit I

Conventional & Renewable Energy Sources: prospecting, extraction and resource assessment and their peculiar characteristics. Direct use of primary energy sources, Conversion of primary into secondary energy sources such as Electricity, Hydrogen, Nuclear energy etc. Energy Conversion through fission and fusion, Nuclear power generation etc.

Unit II


Unit III

Boilers Types, combustion in boilers, performance evaluation, analysis of losses, feed water treatment, blow down. FBC Boilers: Introduction, mechanism of fluidized bed combustion, advantages, types of FBC boilers, operational features, retrofitting FBC system to conventional boilers. HVAC, Refrigeration and Air Conditioning: Vapor compressor refrigeration cycle, refrigerants, coefficient of performance, capacity, factors affecting refrigeration and air conditioning system performance, Vapor absorption refrigeration systems: Working principle, type and comparison with vapor compressor system.

Unit IV

Sterling Engines, Steam Engine, Internal Combustion systems and external combustion system, Overview of different types of turbines.

Mechanical Engineering and Overview: Basic Engineering concepts and design considerations, Governing regulations and codes and standards, Strength of Materials, mechanical properties of materials, mechanics of materials Torque and Power: Basic theory,

Course Outcomes:

1. The student will become adept in the comparative analysis of various energy conversion systems. The comparisons will include cost, social acceptability as well as environmental consequences.

2. The student will be able to apply engineering analysis techniques to the emerging energy technologies of the 21st century (e.g. wind turbines, combined cycle power plants), and to understand the context in which the design of energy systems takes place.

Reference Books:

1. Direct Energy Conversion : W.R.Corliss
4. Energy conversion principles : Begamudre, Rakoshdas
5. Fuel Economy Handbook, NIFES,
6. Industrial Furnaces (Vol I & II) and M.H. Mawhinney, (John Wiley Publications)
10. The storage and handling of Petroleum liquid (John R. Hughes, Charles Griffin & Co. Ltd.)
11. Fuels and fuel TechnologyWilfred Francis, (Pergamon press)
13. The efficient use of steam – Oliver Lyle, (HMSO London)
15. The Efficient use of steam generation – General editor – P.M.Goodall

Note: Eight (8) questions are to be set – uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.
RE-209: Phase-I Dissertation

M. Tech. - Renewable Energy (RE) 1st Year (I – Semester)

<table>
<thead>
<tr>
<th>L</th>
<th>T</th>
<th>P/D</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>--</td>
<td>--</td>
<td>3</td>
</tr>
</tbody>
</table>

| Class Work | : 25 Marks |
| Examination (Theory/Practical) | : 75 Marks |
| Total | : 100 Marks |

**Course Objectives:**


2. To make familiar with basic concepts of research and its methodologies

**Outcome of Course:**

After completion of the Phase-I Dissertation student will be able to:

1. To identify appropriate research topics

2. To understand research problem and parameters

3. To understand a project proposal

4. To understand how to conduct research

5. To understand basics of research report
RE/EEM-201: Solar Energy Utilization

M. Tech. - Renewable Energy(RE) Elective

<table>
<thead>
<tr>
<th>L</th>
<th>T</th>
<th>P/D</th>
<th>Credits</th>
<th>Class Work</th>
<th>Examination (Theory/Practical)</th>
<th>Total</th>
<th>Duration of Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>--</td>
<td>--</td>
<td>3</td>
<td>25 Marks</td>
<td>75 Marks</td>
<td>100 Marks</td>
<td>3 Hours</td>
</tr>
</tbody>
</table>

**Course Objectives:**

This course has objectives to elaborate PG students regarding current trends in solar architecture and following key concepts: Solar Radiation, Sun Angles, and Importance of Sun Angles for Building Fenestration/day lighting, heat transfer in buildings, Solar Passive Architecture, Flat plate collectors, Earth to Air Heat Exchanger, passive heating, passive cooling and green buildings.

**Unit I**
Thermal comfort, Sun’s motion, Building orientation and design, Thumb rules.

**Unit II**
Heat transfer in buildings, Thermal storage, Conversion of heat into mechanical energy, Active heating and cooling of buildings, Passive heating and cooling of buildings.

**Unit III**
Flat plate collectors: liquid and air type. Theory of flat plate collectors, advanced collectors, Solar water heating, solar dryers, solar stills, solar cooling and refrigeration.

**Unit IV**

**Course outcomes:**

After doing this course students will be familiar with state of art and up to date knowledge in the field of solar architecture and following key concepts: Solar Radiation, Sun Angles, and Importance of Sun Angles for Building Fenestration/day lighting. Students will be familiar with sustainable aspects related to green building technology.
Recommended References:


Note: Eight (8) questions are to be set – uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.
RE-203: Hydrogen Energy

M. Tech. - Renewable Energy(RE) Elective

L T P/D Credits
3  -- -- 3

Class Work : 25 Marks
Examination (Theory/Practical) : 75 Marks
Total : 100 Marks
Duration of Examination : 3 Hours

Course Objectives:

To teach fundamentals of hydrogen energy as energy systems, production processes, storage, utilization, and safety that is necessary for taking some important elective subjects as well as to increase the potential for job opportunities in automotive industries and hydrogen production & its infrastructure development related sectors as about 40% energy is being consumed by automotive sectors.

Unit I
Hydrogen Energy: Need and Relevance in relation to depletion of fossil fuels and environmental considerations.

Unit II
Hydrogen Storage technologies: compressed storage, liquid state storage, solid state storage, different materials for storage – metal hydrides, high surface area materials, complex and chemical hydrides, hydrogen storage system – design and materials aspects. Advantages and disadvantage of different storage methods.
Metal Hydrides: Benefits, PC isotherms, Hydrogen storage methods.

Unit III
Fundamentals of Hydrogen storage in different materials: Carbon nanostructures, Magnesium hydrides, Intermetallics and other materials.

Unit IV

Course outcome:

After doing this course students will familiar with state of art and up to date knowledge in the field of hydrogen energy and its all aspects like production, storage, transportation and utilizations. Students will be familiar with safety aspects related to use of hydrogen energy as future energy carrier.
**Books/References:**

1. Energy Technology- S. Rao (Khanna Publications)
2. Renewable Energy Sources and Emerging Technologies- D. P. Kothari (PHI Publisher)
3. Metal Hydrides-MVC Sastri (Narosa Publisher)
7. Solid State Hydrogen Storage- Edited by Gavin Walker(CRC Publication)

**Note:** Eight (8) questions are to be set – uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.
RE-205: Waste to Energy

M. Tech. - Renewable Energy(RE) Open Elective

<table>
<thead>
<tr>
<th>L</th>
<th>T</th>
<th>P/D</th>
<th>Credits</th>
<th>Class Work</th>
<th>Examination (Theory/Practical)</th>
<th>Total</th>
<th>Duration of Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>--</td>
<td>--</td>
<td>3</td>
<td>25 Marks</td>
<td>75 Marks</td>
<td>100 Marks</td>
<td>3 Hours</td>
</tr>
</tbody>
</table>

Course Objectives:

To give an idea about different biomass and other solid waste materials as energy source and their processing and utilization for recovery of energy and other valuable products. A comprehensive knowledge of how wastes are utilized for recovery of value would be immensely useful for the students from all fields.

Unit I


Unit-II

Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste, MSW

Unit-III: Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification, Biomass conversion processes, Thermo chemical conversion, Direct combustion, Types of biogas Plants, Applications.

Unit-IV


Course Outcomes:

In these days of energy crisis and environmental deterioration, students will understand the concept of energy by waste products. It is being used globally to generate electricity and provide industrial and domestic applications. Students will also enable to understand the environmental issues related to harnessing and utilization of various sources of energy and related environmental degradation.
References:

Note: Eight (8) questions are to be set selecting two from each unit. Students shall have to attempt any five (5) selecting at least one from each unit.
RE-207: Green Building Technology
M. Tech. - Renewable Energy(RE) Elective

L T P/D Credits
3 -- -- 3

<table>
<thead>
<tr>
<th></th>
<th>Class Work</th>
<th>Examination (Theory/Practical)</th>
<th>Total</th>
<th>Duration of Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25 Marks</td>
<td>75 Marks</td>
<td>100</td>
<td>3 Hours</td>
</tr>
</tbody>
</table>

Course Objectives:

There is very good scope for saving energy, by using it judiciously. During these days of saving the environment, energy conservation plays a vital role. The government of India has passed Energy Conservation Act-2003 and Energy Conservation Building Code (ECBC-2007), in this regard. This course has objectives to elaborate PG students regarding current trends in solar architecture and following key concepts: Thermal comfort, Typical Designs of Selected Buildings in various Climatic Zones, LEED, GRIHA, Concept of Net zero energy building, net zero community.

Unit I
Energy use in Buildings, Factors effecting Energy use, Energy Conservation options. External Factors – Climate, Building Orientation, Shading, types of shading devices, Sustainable site, water, energy, material and indoor environment issues for green buildings

Unit II
Thermal Comfort, Criteria and various Parameters, Psychometric Chart, Thermal Indices, Requirements of Different use Buildings, Air Quality control Equipments, Typical Designs of Selected Buildings in various Climatic Zones.

Unit III
Thumb Rules for Design of Building systems, Concept of green buildings features of green building rating systems in India: LEED, GRIHA, Concept of Net zero energy building, net zero community.

Unit IV
Course Outcomes:

After doing this course student will know about the basics of saving energy. They will also understand the Energy Conservation Act-2003 and Energy Conservation Building Code (ECBC-2007), in this regard. This course also enable them to understand the current trends in solar architecture and following key concepts: Thermal comfort, Typical Designs of Selected Buildings in various Climatic Zones, LEED, GRIHA, Concept of Net zero energy building, net zero community.

Recommended Books:


Note: Eight (8) questions are to be set selecting two from each unit. Students shall have to attempt any five (5) selecting at least one from each unit.
Course Objectives:
1. To provide specialized training on IC Engines, Thermal Engineering, Solar Energy, Hydrogen Energy, Gas Sensing and Photo catalytic Activity, Renewable Energy etc.
2. To understand some basic concepts of research and its methodologies

Outcome of Course:
After completion of the Phase-II Dissertation student will be able to:
1. To identify appropriate research topics.
2. To select and define appropriate research problem and parameters.
3. To prepare a project proposal (to undertake a project).
4. To organize and conduct research (advanced project) in a more appropriate manner.
5. To write a research report and thesis.
6. To write a research proposal (grants).