Syllabus

M.TECH. (Green Energy Technology)

2019
CENTRE FOR GREEN ENERGY TECHNOLOGY
PONDICHERRY UNIVERSITY, PONDICHERRY – 605 014, INDIA

M.TECH. IN GREEN ENERGY TECHNOLOGY

The field of Green Energy Technology (GET) encompasses a continuously evolving group of methods, materials and processes from environmentally benign techniques for generating energy to its minimal utilization for maximal production of end materials and utilization of waste products when generated. The goals of this rapidly growing highly interdisciplinary field include i) sustainability - meeting the needs of society in ways that without damaging or depleting natural resources, ii) innovation - developing alternatives to technologies to those that have been demonstrated to damage health and the environment and source reduction – and iii) reducing waste and pollution by changing patterns of production and consumption. Thus, Green Technology is a term used to describe production of knowledge-based products or provide services that improve operational performance, productivity or efficiency, while reducing costs, inputs, energy consumption, waste and pollution.

M.Tech. offered at Pondicherry University in Green Energy Technology is a cutting edge material based program designed to equip post-graduates with multi-disciplinary skills and knowledge in the areas of green energy generation, green processes in chemical and construction industries, applications of nanotechnology, waste management and environmental sustainability etc. The course will be taught by a team of specialists working in the fields of green energy technology, chemical science, biological science, project management, and environmental policy. This program is designed for two years spread into four semesters. First two semesters are for hard and soft core courses, third semester is entirely for soft-core (optional) courses and final semester is for project. Many soft-core courses are stand alone, so, they can be taken at any time offered by the Department. In addition there will be some bridge courses. Most of the first semester courses will be on energy and modelling. In the second and third semester courses will be based on energy, environment, chemistry, management and other GET related fields. Students will select courses suiting background and interest. Each theory course will have a project component which will be either individual or group based. Students will be required to earn at least 72 credits to qualify for the M.Tech. degree. Students with M.Sc in Material Science, Physical Sciences, Chemical Sciences, Biological Sciences or equivalent degree. B.E/B.Tech in Electronics, Electrical, Mechanical or equivalent degree, excepting M.Sc. IT and B.E/ B.Tech IT, with at least 55% marks or equivalent grade in qualifying examination are eligible to undergo this program.

The following are the thrust areas of our center currently focused for teaching and conducting research.

- Solar Thermal Energy Technology
- Solar Photovoltaic Technology
- Bio-energy Technology
- Energy Material Development
- Electrochemical Energy Conversion and Storage Technology
- Advanced Combustion Technology
Subject areas covered in M.Tech. Green Energy Technology program are:

1. **Energy Courses** on energy includes the development of alternative fuels, new means of generating energy, energy efficiency, storage and distribution, modelling and waste management.

2. **Energy, Environment, renewable energy and sustainable development**: This course focus on the fundamentals of energy, environment, renewable energy and sustainable development. This course will give overview of the energy scenario in national and global level.

3. **Modelling and simulation** allow engineers to reason about the expected behavior of a system without having to physically implement it. Simulation pervades much of engineering to build models of individual devices, circuit simulation, networks, and physical systems for control purposes. The course is intentionally designed to have a strong practical focus, with extensive laboratory work serving to develop key skills with the aim to enable students to use Modelling and Simulation in the design and verification of Renewable and Green Energy systems. Green Economics this subject involves the search for products whose contents and methods of production have the smallest possible impact on the environment.

4. **Processing energy harvesting materials** is an essential part of Green Energy Technology. Course indents to introduce the material selection criteria and material processing techniques to the M.Tech students.

5. **Solar Thermal Technology & Energy Conversion Systems** aims to provide understanding of the solar thermal energy conversion processes, storage and the utilization of solar thermal energy. Student will acquire knowledge on the various types of collectors, concentrators, thermal power plants design and thermal energy storage concepts.

6. **Wind Energy & Small Hydropower Systems**: student will get the understanding on the source of energy in the wind, its characterization and various methods of harnessing the same. Detail theoretical understanding on design and characterization of wind energy conversion system with particular reference to electrical machines & turbines is emphasized. In the other part of the course, fundamentals of energy generation from hydro power and small hydro power plant concepts are discussed. Students will also get exposure in terms of case studies on wind and hydrothermal power plant.

7. **Bio-energy and conversion systems** deal with biomass resource estimation and management, various energy conversion technologies and methods to generate energy from waste.

8. **Photovoltaic energy conversion** principles, required materials and device structures - characterization techniques and quality analysis. Installation and maintenance of SPV power systems – Knowledge on power systems components and economic aspects SPV power systems.
9. **Nanotechnology for energy harvesting** starts with the basic nano-electronics and elaborates to the size and shape depended properties of nanomaterial. Then it focuses towards the energy harvesting with nanomaterials and also explains how the nanomaterial properties can be tuned for energy storage and energy efficiency. Theoretical, computational and project based activities are included in the course.

10. **Electrochemical Energy Conversion and Storage:** From the basics to technologies on electrochemical energy conversion & storage will be taught which includes various types of batteries, supercapacitors and fuel cells.

11. **Research and Business Skills,** Project and Portfolio Management Development of research, communication and project management skills.

12. **Energy Laboratories:** Students will be taught green energy experiments which involve estimation of calorific values of a fuel, studying solar radiation, assembling solar still, and solar water hear, fuel cell performance and simulation/ modelling of few energy devices, etc. In semester I, II & III, energy laboratory course will be offered.

13. **Mini-project and Proposal Writing:** All students will do a mini-project which involves taking up a small green energy project within campus or outside and learning about how to communicate the data to scientific journals.

14. **Research Project and Dissertation** Specifically designed to give the student practical experience in technologies and principles appropriate to developing a green technology. The student will undertake a research based project at Pondicherry University or at an associated academic or industrial partner and thus receive practical training in chosen area from an expert.

In addition to above, courses will be added time to time based on developments in this fast emerging field.

Teaching and Learning Methods Lectures, tutorials and seminars form the main methods of course delivery enhanced by individual and group project work, laboratory work, computing workshops and industrial visits.

Assessment Methods Teaching and assessment will be by Choice Based Credit System (CBCS). Evaluation will be through session (laboratory reports, class tests, set assignments) or by continuous assessment (designing, computer practical, seminar papers, project reports etc.) and end-semester examinations. The pattern of end-semester examination shall be broadly as per the following:
End Semester Theory Examination  (Total Marks = 60)

Part A: Answer All the Questions. Five questions of 2 marks each (5 x 2 = 10).

Part B: Answer Any 5 questions out of 6. Each question carry 4 marks (5 x 4 = 20).

Part C: Descriptive. Answer any 5 questions out of 8. Each question carry 6 marks (5x6=30).
Each question may contain sub-divisions a, b, c etc.

End Semester-Practical Examination (Total Marks = 60)

Evaluation pattern:

Internal Examinations: Examinations are conducted in a semester for 40 Marks. Written Examination 30 Marks and Assignment /Seminar 10 Marks.

Employment: It is envisaged that the M.Tech. Graduates in Green Technology will gain employment in the Engineering Industry with many companies now seeking to exploit the benefits of Green Technology products and processes.

M.Tech. Green Energy Technology - Program Specific Outcome:

1. Trained man powers in the area of major renewable and clean energy technologies
2. Acquiring specialization on the chosen field of renewable energy through industrial training and/or research work.
3. Acquire knowledge on energy generation including design, fabrication, testing and modelling of process
4. Gaining specific understanding on fabrication and evaluation of solar cells, battery, supercapacitors and fuel cells.
5. Gaining specific understanding on design and installation of PV power plant, solar thermal devices.
6. Specific understanding on biodiesel, bioethanol and biogas production
7. Specific understanding on conversion of waste to energy and harnessing energy from the wind
8. Gained knowledge on energy audit and management
9. Trained man powers on building sustainability on society and environment
10. Gained knowledge on art of scientific writing, publishing and presenting

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M.Tech (Green Energy Technology)
Course Curriculum Effective from academic year: 2019-20

**SEMESTER-I**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Type</th>
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<tbody>
<tr>
<td>GETY511</td>
<td>Energy, Environment and Renewable Energy Technologies</td>
<td>H</td>
<td>3</td>
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<tr>
<td>GETY512</td>
<td>Modeling and Simulations</td>
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<tr>
<td>GETY513</td>
<td>Bio-energy &amp; Conversion Systems</td>
<td>H</td>
<td>3</td>
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<tr>
<td>GETY514</td>
<td>Fuels &amp; Combustion Technology</td>
<td>H</td>
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**Soft-Core Courses**

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<tr>
<td>GETY515</td>
<td>Nanomaterials: Properties, Synthesis, Characterization and Applications</td>
<td>S</td>
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<td>GETY516</td>
<td>Heat Transfer and Electrical Power - Generation, Transmission and Distribution</td>
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<tr>
<td>GETY519</td>
<td>Biomass Feedstock and Solid Biofuel Production</td>
<td>S</td>
<td>3</td>
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**Practical**

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<tr>
<td>GETY510</td>
<td>Energy Laboratory –I</td>
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**SEMESTER-II**

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<tbody>
<tr>
<td>GETY522</td>
<td>Solar Thermal Energy: Fundamentals, Devices and Systems</td>
<td>H</td>
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<tr>
<td>GETY523</td>
<td>Solar Photovoltaic Energy Conversion</td>
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<td>GETY525</td>
<td>Electrochemical Energy Conversion and Storage</td>
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**Soft-core courses**

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<tr>
<td>GETY524</td>
<td>Processing of Green Energy Materials</td>
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<td>GETY526</td>
<td>Waste to Energy Conversion</td>
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<tr>
<td>GETY541</td>
<td>Polymer and Composite Materials for Renewable Energy</td>
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<tr>
<td>GETY616</td>
<td>Algal Energy Technology</td>
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<td>GETY520</td>
<td>Energy Laboratory –II</td>
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<tr>
<td>GETY611</td>
<td>Project (Phase I): Research Methodology, Proposal Writing and Defense</td>
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<td>GETY612</td>
<td>Solar Photovoltaic Power Systems</td>
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<td>GETY631</td>
<td>Wind Energy and Small Hydro Power Systems</td>
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#### Soft-core Courses

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<tr>
<td>GETY613</td>
<td>Advanced Battery and Fuel Cell Technologies</td>
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<td>GETY614</td>
<td>Nanotechnology for Energy Systems</td>
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<td>GETY615</td>
<td>Energy Audit and Management</td>
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<td>GETY619</td>
<td>Biorefineries</td>
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#### Practical

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<tr>
<td>GETY610</td>
<td>Energy Laboratory – III (Virtual Instrumentation and Case Study on Sustainable Energy Systems)</td>
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**Minimum No. of Credits: 18**

### SEMESTER-IV

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<th>Course Code</th>
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<tbody>
<tr>
<td>GETY620</td>
<td>Project (Phase II) Green Energy Technology</td>
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<tr>
<td></td>
<td>Dissertation</td>
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<td>Viva-Voce</td>
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**Total No. of Credits**

|                  |                                    |               |   |   |   | 12|

H – Hard-core Course; S - Soft-core Course

L – Lecture; T – tutorial; P – Practical; C – No. of Credits

**Evaluation:**

All theory, practical and dissertation courses have Internal Assessment of 40 Marks and External Assessment of 60 Marks.
**OTHER SOFT-CORE COURSES**

These courses will be offered in any of first three semesters depending on the availability of the resource faculty.

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<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>GETY517</td>
<td>Scientific Writing and Research Methodology</td>
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<td>GETY518</td>
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<td>GETY527</td>
<td>Green Management</td>
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<tr>
<td>GETY528</td>
<td>Green Chemistry</td>
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<tr>
<td>GETY529</td>
<td>Green Building Concept</td>
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<td>GETY531</td>
<td>Advance Heat Transfer for Energy Engineering</td>
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<td>GETY532</td>
<td>Electrical Power Generation and Power System Analysis</td>
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<tr>
<td>GETY618</td>
<td>Carbon Sequestration at Landscape Level</td>
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GETY 511 - Energy, Environment and Renewable Energy Technologies

(Hard-core Course)                                    L T P C
                                                     3 1 0 3  45L

**Course Outcome:**
- Understand the nexus between energy, environment and sustainable development
- Appreciate energy ecosystems and its impact on environment
- Learn basics of various types of renewable and clean energy technologies
- Serve as bridge to advanced courses in renewable energy

**Unit I. Energy** [8]
Introduction to the nexus between energy, environment and sustainable development, Energy sources overview and classification, sun as the source of energy, fossil fuel reserves and resources - overview of global/ India’s energy scenario. Energy consumption models – Specific Energy Consumption

**Unit II. Ecology and Environment** [9]
Concept and theories of ecosystems, - energy flow in major man-made ecosystems- agricultural, industrial and urban ecosystems - sources of pollution from energy technologies and its impact on atmosphere - air, water, soil, and environment - environmental laws on pollution control. The environmental protection act :Effluent standards and ambient air quality, innovation and sustainability, eco-restoration: phyto-remediation.

**Unit III. Renewable Sources of Energy** [10]
**Solar Energy:** Solar radiation: measurements and prediction. Indian’s solar energy potential and challenges, solar energy conversion principles and technologies: Photosynthesis, Photovoltaic conversion and Photo thermal energy conversion. **Wind Energy:** Atmospheric circulations, atmospheric boundary layers, classification, factors influencing wind, wind shear, turbulence, wind energy basics and power Content, wind speed monitoring, Betz limit, wind energy conversion system: classification, characteristics and applications. **Ocean Energy:** Ocean energy resources-ocean energy conversion principles and technologies: ocean thermal, ocean wave & ocean tide

**Unit IV. Bioenergy** [9]
Biomass as energy resources; bio-energy potential and challenges, Classification and estimation of biomass; Source and characteristics of biofuels: Biodiesel, Bioethanol, Biogas. Types of biomass energy conversion systems - waste to energy conversion technologies.

**Unit V. Other Energy Sources and Systems** [9]
Hydropower, Nuclear fission and fusion-Geothermal energy: Origin, types of geothermal energy sites, site selection, geothermal power plants; hydrogen energy, Magneto-hydro-dynamic (MHD) energy conversion – Radioisotope Thermoelectric Generator (RTG), Bio-solar cells, battery & super capacitor, energy transmission and conversions.
References

GETY 512: Modelling and Simulations

(Hard-core Course) \[ L \ T \ P \ C \]
\[ 3 \ 1 \ 0 \ 3 \ 45L \]

Course Outcome:
- Mathematical understanding of green energy systems
- Numerical calculations with advanced scientific software
- Programming skill development in research and engineering software

Unit I. [9]

Unit II. [9]

Unit III. [9]
Graphical Programming: Starting graphical programming (with the help of any one of graphical programming software, eg: Simulink, Femlab etc) t. Model files, Basic elements:- blocks and lines.-Running Simulation-Building Systems- Block Libraries: Sources, Sinks, Discrete, Linear. Nonlinear, Connections- - Interaction With other programmes (eg: Simulink with MatLab)- Defining Block Parameters Using Matlab, Variables-Exchanging Signals With other programmes Extracting Models (eg: Simulink into Matalb).
Unit IV. Lab exercises to develop simple Scripts and models related to building energy systems involving applications of data analysis, optimization, advanced graphics, diode model and simulation, simple photovoltaic models and simulation, DSSC model and simulation, FPC optimization model.


Reference Books

GETY 513: Bioenergy and Conversion Systems
(Hard-core Course) L T P C
3 1 0 3 45L

Course Outcome:
- Learn fundamentals of biochemistry and biological systems for energy application
- Realization of global bioenergy potential, and scenario of bioenergy in India.
- Understand various biofuel types and characteristics
- Understanding of various types of bioenergy conversion systems in practice
- Acquire basic knowledge on algal culture, biomass harvest and biofuel production
- Know the national and international biofuel Standards.

Unit I. Biological Systems 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 breakdown of carbohydrates- Lipids- proteins and nucleic acids TCA cycle - Glycolysis - Gluconeogenesis - Pentose phosphate shunt - Urea cycle - Interconnection of Pathways - Metabolic regulations.

Unit II. Biochemical Conversions Bio catalysis by enzymes and pathways - Fermentation and bioprocess engineering – Chemical kinetics – Mathematical modelling of biochemical reactions – Bioreactor designs; Biodegradation 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 III. Thermochemical & Chemical Conversions**

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

**Unit IV. Algae for Biofuel application**

Introduction to algal biomass; large scale culture and harvest methodologies - Open Raceway ponds & photo bioreactors; Biomass and Lipid optimization strategies; Algal biodiesel and bioethanol production process engineering – Concepts of Integrated bioprocess & bio refineries; Social and economic impact of algae as replacement petro fuel.

**Unit V. Biofuels Standards & Power Generation**

Physical and chemical characteristics of biofuels – Biomass, wood gas, bio methane; ethanol, biodiesel, 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; Biofuel roadmap of India - policy issues, regulatory issues and economic impact; Entrepreneurship in biofuel - Prospects & Challenges, Case studies.

**References:**

8. Renewable Bioreources - Scope and Modification for Non-Food Applications Edited by Stevens, Christian and Verhe, Roland, Wiley June 2004
GETY 514: Fuels & Combustion Technology

(Hard-core Course) L T P C 3 1 0 3 45L

Course Outcome:
- Acquire knowledge on fundamentals of solid, liquid and gases fuels.
- Acquire insight about combustion stoichiometry theory and enable them to assess the environmental impact of conventional fuels.
- Develop understanding on burner design, industrial furnaces and its applications.
- Learn the concept of industrial waste energy recovery & combustion energy efficiency process.

Unit I. Solid Fuels [9]
Coal; Family, origin, classification of coal; Analysis and properties; Action of heat on coal; Gasification; Oxidation; Hydrogenation and liquefaction of coal- Efficient use of solid fuels- Manufactured fuels-Agro fuels- Solid fuel handling- Properties related to combustion - handling and storage

Unit II. Liquid and Gaseous Fuels [9]
Origin and classification of petroleum; Refining; Properties & testing of petroleum products; various petroleum products; Petroleum refining in India; Liquid fuels from other sources; Storage and handling of liquid fuels. Types of gaseous fuels: natural gases, methane from coal mines, manufactured gases, producer gas, water gas, biogas, refinery gas, LPG; Cleaning and purification of gaseous fuels.

Unit III. Theory of Combustion Process [9]
Ignition: Concept, auto ignition, ignition temperature; Burners: Stoichiometry and thermodynamics; Combustion stoichiometry: Methods of combustion - Combustion thermodynamics.

Unit IV. Fuel stoichiometry and analysis [9]
Fuel stoichiometry relations; Estimation of air required for complete combustion; Estimation of minimum amount of air required for a fuel of known composition; Estimation of dry flue gases for known fuel composition; Calculation of the composition of fuel & excess air supplied, from exhaust gas analysis; Dew point of products; Flue gas analysis (O2, CO2, CO, NOx, SOx).

Unit V. Burner Design and Furnaces [9]
Fluidized bed combustion process; Burners: Propagation, various methods of flame stabilization; Basic features and design of burners for solid, liquid, and gaseous fuels; Furnaces: Industrial furnaces, process furnaces, batch & continuous furnaces; Advantages of ceramic coating; Heat source; Distributions of heat source in furnaces; Blast furnace; Open hearth furnace, Kilns; Pot & crucible furnaces; Waste heat recovery in furnaces: Recuperates and regenerators; Furnace insulation; Furnace heat balance computations; Efficiency considerations.
GETY515: Nanomaterials: Properties, Synthesis, Characterization and Applications

(Soft Core Course)  

Course Outcome:  
The aim of this course is to expose the students to nanomaterial’s basics, synthesis, characterization and broad application of them. Knowledge of the societal impact of nanomaterial will also be taught.

Unit I. Properties at Nanoscale  

Unit II. Nanomaterials by Physical and Chemical Methods  

Unit III. Green Synthesis of Nanomaterials  
General approach for green synthesis – principles - Green synthesis of metals and alloys – use of natural resources and biosynthesis of nanomaterials. Microwave synthesis of nanomaterials.

Unit IV. Structural and Morphological Characterization  

References:
5. J. D. Gilchrist , Fuels, Furnaces & Refractories, Pergamom Press.
Unit V. Applications of Nanomaterials and Societal Implications

Nanomaterials and Nanotechnology General Applications – green technology and green energy applications - Industrial manufacturing, materials and products, medicine and clean environment - implications for philosophy, ethics and society.

References:

GETY516: Heat Transfer and Electrical Power -Generation, Transmission and Distribution

(Soft Core Course)

Course Outcome:
• Learn various modes of heat and mass transfer analysis of applied to different thermal systems.
• Learn in detail generation, transmission and distribution aspects of electric power.
• Carry out cost analysis of electrical power and comprehend parameters associated with electric power generation and load management.

Unit I.

Laws of Thermodynamics, Sterling Engine: Principle, working and efficiency, Basic Heat Transfer Concept and Terminology: Basic concepts terminology; Heat transfer coefficients; Thermal resistance; Overall heat transfer coefficient.
Conduction: Conduction equation; Steady state conduction in simple geometries; Thermal contact Resistance; Critical thickness of insulation; Multidimensional steady state heat conduction (Shaper Factor); Extended surfaces; Types of fins; Effectiveness and efficiencies of fins; Transient heat conduction; Lumped heat capacity analysis; Hailer’s charts for semi-Infinite medium; Slab cylinder and sphere; Periodic heat conduction.

Unit II. Convection

Principle of similarity; Mechanism of convection; Concept of velocity boundary layer; Concept of thermal boundary layer; Evaluation of dimensionless parameters; Forced flow convection (Laminar, Turbulent & Mixed); Boundary layer thickness; Convective heat transfer coefficient; Drag coefficient for flat plate, Inside tube, cylinder, sphere and banks of tubes, Free convection
(Laminar, Turbulent & Mixed) on horizontal, vertical and Inclined plates, cylinder and sphere; forced convection inside tubes and ducts; Forced convection over exterior surfaces.

**Unit III. Radiation**

Blackbody radiation; View factor algebra; Enclosures with black surfaces and grey surfaces; Radiosity; Heat exchangers and its types; Effectiveness, LMTD and NTU methods.

**Unit IV. Electrical System**

Introduction to electric power supply systems: Power generation plant, Transmission and distribution lines, Cascade efficiency; Electrical billing; Electrical load management and maximum demand control; Power factor improvement and benefits; Transformers; Distribution losses in industrial system; Assessment of Transmission and Distribution (T&D) losses in power systems; Estimation of technical losses in distribution system; Demand side management; Harmonics.

**Unit V. Material and Energy Balance**

Energy intensity on purchasing power parity (PPP); Energy pricing in India; Energy units and conversation; Purpose of material and energy balance; Components of material and Energy balance; Basic principles of material and energy balance; Classification of processes: steady-state process, unsteady state process; Material balance: levels of material balance; Material balance procedure; Energy balance; Efficiency and losses; Facility as an energy system; Energy balance in power plant cycle; Energy analysis; Energy action planning.

**References:**


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**GETY519 Biomass Feedstock and Processing of Solid Biofuel**

(L T P C)

3 0 0 3 45L

**Course Outcome:**

- Student shall able to assess regional biomass potential for energy conversion.
- Learn the processes and technology to develop solid biofuel from available biomass.
- Learn various solid biofuel processing processes and their commercial potential.
Unit I. **Biomass Resources:**
Biomass Resources: Agricultural produce and waste biomass, Biomass from forest produce and energy plantation. Biomass yield, availability, energy potential. Industrial biomass, Biomass from urban and municipal wastes.

Unit II. **Resource Assessment of Biomass:**

Unit III. **Processing of Biomass:**

Unit IV. **Solid Biofuel Production Processes:**

Unit V. **Energy Economy of solid biofuel:**

Reference:
A. Course Outline:
☐ Basic concepts: Terminology used in experimental methods i.e. sensitivity, accuracy, uncertainty, calibration and standards; experimental system design and arrangement.
☐ Analysis of experimental data: Analysis of causes and types of experimental errors, uncertainty and statistical analysis of experimental data.
☐ Data acquisition and processing: Data acquisition methods, data storage and display, examples of application in typical energy system.
☐ Apparatus design and construction: Conceptual, substantive and detail designs of experiments; illustration of thermal energy equipment/devices and their accessories.
☐ Experiment plan and execution: Preparatory work for carrying out experiments; range of experimental study, choice of measuring instruments, measurement system calibration, data sheets and log books, experimental procedure, etc; applications.
☐ Technical Communication: Report preparation of experimental work, use of graphs, figures, tables, software and hardware aids for technical communication.

B. Laboratory:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>List of Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Solar irradiation measurement using Optical Pyranometer</td>
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<tr>
<td>2.</td>
<td>To study the IV curves and calculate efficiency, fill factor, Pmax of solar cell at varied irradiance</td>
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<tr>
<td>3.</td>
<td>Study of SPV module assembly process</td>
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<tr>
<td>4.</td>
<td>Installation of Solar Panel and study of influencing parameters</td>
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<tr>
<td>5.</td>
<td>Structure, Electrical and Optical characterization of energy materials</td>
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<tr>
<td>6.</td>
<td>Determination of the viscosity, flash point, fire point and pour point of liquid fuels</td>
</tr>
<tr>
<td>7.</td>
<td>Experimental study of down draft gasifier and analysis of flue gas</td>
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<tr>
<td>8.</td>
<td>Biogas production by anaerobic digestion and analysis</td>
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<tr>
<td>9.</td>
<td>Synthesis of gold nanoparticles–green synthesis</td>
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<tr>
<td>10.</td>
<td>Characterization of Phase Change materials</td>
</tr>
<tr>
<td>11.</td>
<td>Proximate and ultimate analysis and calorific value solid fuels</td>
</tr>
<tr>
<td>12.</td>
<td>Biomass Briquetting and their Characterization</td>
</tr>
<tr>
<td>13.</td>
<td>Extraction and characterization of photosystem complex</td>
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</table>

Manuals

References:
SEMESTER-II

GETY522: Solar Thermal Energy: Fundamentals, Devices and Systems

(Hard Core Course)

Course Outcome: This paper aims to impart knowledge on design and development of various types of solar thermal collectors. Students shall be trained to quantify the solar radiation received on the collector, carry out detailed thermal analysis of different types of solar collectors, decide on material selection for various components such as absorber plate, glazing, insulation, etc. Get thorough understanding on the working principle of various types of solar gadgets like solar water heater, solar air heater, solar still, solar drier, solar air conditioning system, solar thermal power generation, etc. Also, carry out techno-economic analysis of solar thermal projects.

Unit I. Solar Radiation Geometry
Solar angles; the earth and solar constant; day length; angle of incidence on tilted surface; variation of extraterrestrial radiation; solar radiation at the earth’s surface; solar radiation data; sunrise, sunset and day length; local apparent time; instruments for measuring solar radiation and sunshine; solar radiation on tilted surfaces; analysis of Indian solar radiation data and applications.

Unit II. Solar Collectors: Thermal Analysis
Flat plate collectors: Effective energy losses; thermal analysis; heat capacity effect; overall loss coefficient; collector efficiency factor; collector heat removal factor; efficiency of flat plate collectors; testing methods. Evacuated tube collectors: Types; thermal analysis; testing methods. Concentrating collectors: Designing and types; acceptance angle; geometric concentration ratio; optical efficiency; thermal efficiency; testing methods. Selective surfaces.

Unit III. Solar Thermal Energy Storage
Low, Medium and High temperature thermal energy storage. Sensible heat storage: Types of sensible heat storage; energy analysis in a liquid stratified tank; design aspects; materials for latent heat storage.
Latent heat storage: Phase change material (PCM) for latent heat storage; inorganic and organic PCM’s; calculation of quantity of material required for latent heat thermal energy storage; design of a solar thermal device with the provision of thermal storage. Thermo-chemical storage: Materials; merits and demerits of thermo-chemical storage; potential of thermo-chemical storage materials for high temperature applications.

Unit IV. Solar Thermal Energy Systems
Solar water heating systems: Materials and components; Natural flow; Forced flow; applications
Solar air heating systems: Description and classifications; porous and non-porous type; testing of solar air heater, applications. Solar concentrating systems: Materials for concentrators; types of

Unit V. Economic analysis for solar thermal engineering projects

Annualized cost method: annualized cost; annualized capital cost; salvage value; capital recovery factor; salvage fund factor; annualized maintenance cost; Life cycle savings: savings per day; present worth of annual savings; present worth of cumulative savings. Payback period.

Text Books

GETY 523: Solar Photovoltaic Energy Conversion

(Hard Core Course)

Course Objective: This course highlights about the solar energy, solar energy conversion principles, fundamentals about semiconductors and their application for solar cell fabrication and solar characterization

Expected Outcome: Students will have complete understanding about the solar energy and their conversion principles – solar cell fundamentals – solar cell fabrication and characterization techniques.

Unit I. Properties of Semiconductor

Unit II. Semiconductors for Solar Cell
Silicon: preparation of metallurgical, electronic and solar grade Silicon - Production of single crystal Silicon: Czokralski (CZ) and Float Zone (FZ) method – imperfections – carrier doping and lifetime - Germanium - compound semiconductors: growth & characterization - amorphous materials – Transparent conducting oxides-Anti-reflection principles and coatings – organic materials

Unit III. Device fabrication
Semiconductor junctions: Schottky barriers, MIS, P-N junction, p-i-n junction and its properties Homo & hetero junction solar cells, multijunction solar cells- Fabrication techniques: Diffusion, thin film technology- physical vapour deposition (PVD)- Electro-deposition-Molecular beam epitaxy (MBE)- Metal organic chemical vapour deposition (MOCVD)- Plasma enhanced chemical vapour deposition (PECVD)- Organic and Nano tech solar cells – contact & grid metalization.

Unit IV. Characterization and Analysis
Device isolation & analysis - Ideal cell under illumination- solar cell parameters short circuit current, open circuit voltage, fill factor, efficiency; optical losses; electrical losses, surface recombination velocity, quantum efficiency - measurements of solar cell parameters; I-V curve & L-I-V characteristics, internal Quantum yield measurements – Effects of series and parallel resistance and Temperature - Loss analysis.

Unit V. Thermo-photovoltaics
Thermo photovoltaic principles - thermophotovoltaic materials and device fabrication – thermophotovoltaic device characterization and analysis – Thermophotovoltaic power systems

References:
GETY 524: Processing of Green Energy Materials

Course Outcome:
- Practical knowledge of materials embodied energy emission and toxicity
- Survey and analysis skill
- Hands on experience in making materials

Unit I. [9]

Unit II. [9]
Silicon processing, source material, refining, Czochralski method, Float Zone method, wafer processing, diffusion, screen printing, buried contacts, rear contacts. Cell characterization and modelling.

Unit III. [9]
Thin-film fabrication techniques: vacuum technology, sputter coating technique, Epitaxial technology-Molecular Beam Epitaxy, Chemical beam Epitaxy, MOCVD, GaAs & CdTe material properties and processing. Electrochemical fabrication of thin film materials.

Unit IV. [9]

Unit V. [9]
Energy Efficient devices and material processing: material selection criteria for LEDs, OLEDs, Dye-sensitized solar cells (DSSCs), polymer solar cells, fabrication/assembling, testing methods and its specific application.

Text Books
The aim of this course is to give a broad view of electrochemical energy conversion and storage devices. The basics of these devices and their merits and demerits will be taught. At the end of this course, the students will have a thorough knowledge on what are primary and secondary batteries, important of supercapacitors and fuel cells.

**Unit I. Introduction**

Electrochemical cell, electro motive force, free energy changes and emf, concentration of the reactants on EMF, effect of cell temperature, derivation of number of electrons involved in a cell reactions, thermodynamic calculations, electrochemical series-equilibrium potential, Nernst equation-Battery types – primary and secondary batteries and examples - theoretical voltage, capacity, energy & specific energy, power & specific power.

**Unit II. Primary batteries**

Dry cells-zinc/carbon battery, alkaline primary batteries, Zn/air, Lithium batteries, reserve batteries: principle, components, construction, characteristics, applications, and problems associated with the systems.

**Unit III. Secondary Batteries**

Principle, construction, components, merits and demerits of lead acid, nickel-cadmium, nickel-metal hydride, lithium-ion batteries-Possible applications.

**Unit IV. Supercapacitors**

Introduction to supercapacitors, types of supercapacitors, Reagone plot, similarities and differences between supercapacitors and batteries, electrode interface & double layer capacitors-redox capacitors-construction and performance evaluation, materials for supercapacitors and technology development – typical examples.

**Unit V. Fuel Cells**

Introduction to fuel cells, merits and demerits, comparison to batteries & internal engines, types of fuel cells, EMF of fuel cells, Nernst equation, efficiency, current versus potential issues, fuel cell reaction kinetics, ORR, MOR, selection of fuel, electrode, electrolyte and membranes-fuel cell charge transport, fuel cell mass transport, fuel cell characterization, fuel cell losses, hydrogen - oxygen fuel cell, PEMFCs, DMFCs, PAFCs, molten carbonate fuel cells, SOFCs and Biofuel cells.
GETY 526: Waste to Energy Conversion

(L T P C)

3 0 0 3 45L

Course Outcome:
1. Learn fundamentals of solid waste generation and its management techniques.
2. Acquire knowledge on various waste treatments and disposal processes.
3. Student shall learn to appreciate importance of waste-to-energy and waste management hierarchy for all kinds of wastes materials.
4. Learn to assess environmental and health impacts of various waste-to-energy conversion technologies with case studies.

Unit I. [9]
Introduction to Waste & Waste processing: Definitions, sources, types and composition of various types of wastes; Characterization of Municipal Solid Waste (MSW), Industrial waste and Biomedical Waste (BMW), waste collection and transportation; waste processing-size reduction, separation; waste management hierarchy, waste minimization and recycling of MSW; Life Cycle Analysis (LCA), Material Recovery Facilities (MRF), recycling processes of solid waste.

Unit II. Waste treatment and disposal [9]
Aerobic composting, incineration, different type of incineration; medical and pharmaceutical waste incinerations- land fill classification, types, methods and sitting consideration, layout and preliminary design of landfills; composition, characteristics, generation, movement and control of landfill leachate and gases, environmental monitoring system for land fill gases.

Unit III. Energy from waste- thermo chemical conversion [9]
Sources of energy generation, incineration, pyrolysis, gasification of waste using gasifiers, briquetting, utilization and advantages of briquetting--environmental and health impacts of incineration; strategies for reducing environmental impacts.

Unit IV. Energy from waste- Bio-chemical conversion [9]
Anaerobic digestion of sewage and municipal wastes, direct combustion of MSW-refuse derived solid fuel, industrial waste, agro residues, anaerobic digestion- biogas production, land fill gas.

References
generation and utilization, present status of technologies for conversion of waste into energy, design of waste to energy plants for cities, small townships and villages.

**Unit V. Environmental and health impacts-case studies**

Environmental and health impacts of waste to energy conversion, case studies of commercial waste to energy plants, waste to energy- potentials and constraints in India, eco-technological alternatives for waste to energy conversions - Rules related to the handling, treatment and disposal of MSW and BMW in India.

**References:**


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**GETY541: Polymer and Composite Materials for Renewable Energy Systems**

**L T P C**

3 0 0 3 45L

(Soft Core Course)

**Course Outcome:**

- Acquire understanding on the basics of polymers and composites synthesis, analysis, and testing its properties.
- Develop ability to synthesis various types of polymeric and composite materials for specific applications such as solar PV, solar thermal, wind turbines, batteries, fuel cells, and related renewable energy technologies.
- Acquire state of the art in polymeric and hybrid composite materials in the field of renewable energy.

**Unit I. Fundamentals of Polymers and Composites**

Unit II. Polymers and Composites for Solar Energy


Unit III. Polymers and Composites for Wind and Biomass Energy


Unit IV. Polymers and Composites for Fuel Cells

Polymer electrolyte membrane synthesis and characterization for fuel cells: Structure–property relationships, membrane electrode, organic-inorganic membranes-composites for bipolar plates. Design and development of proton exchange membranes fuel cell (PEMFC) based on Nafion, sulfonated poly(ether-ether ketone)s, sulfonated poly(aryl ether) for PEMFC and direct methanol fuel cell (DMFCs). Polymer composite membrane role (cation/anion/proton-exchange membranes) in bioelectrochemical systems (MFCs) –construction and performance of MFCs.

Unit V. Polymers and Composites for Miscellaneous Renewable Energy Systems

Polymer electrolytes in battery, lithium polymer composite and carbon based composites in batteries. Flexible organic light-emitting diodes: introduction, roll-to-roll printing and characteristics of OLEDs. Polymer/composite-based thermoelectric materials synthesis and fabrication. Natural materials for sustainable energy systems.

References:
GETY616: Algal Energy Technology

(Soft Core Course)

Course Outcome:
Student will be in a position to assess the energy potential from culture of algae. Basic understanding on growth, characterization and lipid extraction for biofuel production shall be arrived. Various methodologies and instrumentation for large scale algal biomass production and fuel conversion will be learned. Will be become familiar with various standards of biodiesel and bioethanol.

Unit I.

Unit II.
Characterization of photosystems in microalgae – energy conversion efficiencies - optical characteristics of photoactive proteins in algae – recent development in artificial leaves and biosolar cells.

Unit III.
Cultivation of Algae for biodiesel and high value chemicals: Laboratory culture, Open raceways ponds, closed photobioreactors, design and illumination concepts - continuous culture and biomass recovery – Process engineering.

Unit IV.

Unit V.
References:

GETY 520: ENERGY LABORATORY – II

(Hard Core Course)

List of Experiments
1. Micro-controller based solar tracking system (simulation)
2. Micro-controller based solar tracking system (fabrication)
3. Impedance analysis of solar cell
4. Simulation of multi crystalline and amorphous solar modules
5. Solar panel installation
6. Fabrication of DSSC
7. I-V Characterization of DSSC
8. Thermal Performance evaluation of solar still without load
9. Performance evaluation of solar still with load
10. Solar air heater-Performance evaluation by natural convection
11. Solar air heater-performance evaluation by forced convection
12. Solar drier-Thermal performance evaluation by natural flow
13. Solar drier-Forced circulation analysis with different flow rates
14. Solar drier-evaluation of drying curve
15. Determination of thermal efficiency and heat loss factor of FPC based solar water heater
16. Determination of thermal efficiency and heat loss factor of ETC based solar water heater
17. Thermal testing of box type solar cooker: Determination of first and second figure of merits
18. To study the thermal performance of a paraboloid concentrating solar cooker
19. Performance evaluation of a single basin solar still
20. Solar air heater-Performance evaluation by natural convection
21. Solar air heater-performance evaluation by forced convection
22. Thermal performance and drying characteristic study on solar drier

Manuals

References
SEMESTER – III

GETY611: Project (Phase I): Research Methodology, Proposal Writing and Defense

(Hard Core Course)                             L T P C
                                                   0 2 4 3 90L

Course Outcome:
Through this course project work student shall get acquaintance in the selection of research problem, its analysis, carrying out relevant literature survey and reviewing. Also, they will learn how to analyse data and write a technical report.

Objective:
It is expected that the student will develop skills in Selection of research theme/problem, scientific approach, defining specific objectives, design of experiment, estimation of budget, estimation of time duration, execution and data collection, analysis and presentation.

A scientific or research article published in a peer reviewed journal is a technical document that describes a significant experimental, theoretical or observational extension of current knowledge, or advances in the practical application of known principles. A research article should report on research findings that are not only verifiable, reproducible and previously unpublished and should add to new understanding of the concerned subject. Unlike a novel, newspaper article or an essay, a research article should adhere to a structure and style, which is internationally acceptable. It should have an introduction, methods used, results obtained and discussion on the results and conclusions drawn. However, a RA is not only a technically rigid document, but also a subjective intellectual product that unavoidably reflects personal opinions and beliefs. Therefore, it requires good skills in both structuring and phrasing the discoveries and thoughts. These skills are acquired through experience, but can also be taught through instructional course like the one proposed now. Thus, above bridge course offered by English Department will help students to learn how to write research articles to be published in a scientific journal. In addition to scientific article writing this course will also cover principles of research methodology and scientific ethics.

All the students of the GET program are expected to take this course and pass. However, students with appropriate background may be exempted from taking this course provided enough evidence exists in the form of clearance of a screening test.

Impact: Student is expected to gain knowledge on the importance of research - research outcome - Contemporary technological approach - demand and supply - profitability, social impact etc.,

Expectation: Ethical considerations – respect of policy, formulation and implementation

References:
1. Scifinder,
2. Scopus
3. Scirus.com
4. ISI web of science
GET 612: Solar Photovoltaic Power Systems

(Hard-core Course)

Course Objective: This course teaches about the solar photovoltaic power system from module assembly process to establishment and commissioning of solar photovoltaic power plant

Expected Outcome: Students are expected to understand the technologies involved in the establishment and maintenance of solar photovoltaic power plant

Unit I. Solar PV Module

Unit II. SPV Systems & Components
Introduction to PV systems - system components: module and array – Charge controllers – Inverters – Batteries – power conditioning and Regulation – Mechanical assemblies – Balance of System Components

Unit III. SPV Power Systems

Unit IV. Power System Design and Installation
Power considerations and system design – Array integration: mechanical integration – electrical integration – utility integration – Inspection and commissioning - SPV power system maintenance: cleaning, shadowing, stability etc., and troubleshooting – Economics

Unit V. Space Power Systems

References
GETY 631: Wind Energy & Small Hydropower Systems

(Hard-core Course)

Course Outcome:
Student will learn to assess the wind energy potential of a place, understand the various components of wind energy conversion system, get introduced to design and engineering aspects of wind turbine and control systems. Familiarize with different types of wind electric power generators. Learn basics of costing wind power generation. Also get to know basics of small hydropower plant classification, installation detail and its impact on clean energy generation.

Unit I. Wind Energy Potential [9]

Unit II. Wind Energy Conversion [9]
Aerodynamic design principles; Aerodynamic theories; Axial momentum, blade element and strip theory; Maximum power coefficient; Prandl’s tip loss correction; Rotor design and characteristics; Power, torque and speed characteristics – Wind turbine performance measurement – Loading analysis.

Unit III. WECS Design Considerations [9]
Design of WECS components – Stall, pitch & yaw control mechanisms – Brake control mechanisms; Theoretical simulation of wind turbine characteristics; Test methods.

Unit IV. Wind Energy Application [9]
Wind pumps: Performance analysis, design concept and testing; Principle of Wind Energy Generators; Stand alone, grid connected and hybrid applications of WECS; Economics of wind energy utilization; Wind energy in India; Case studies.

Unit V. Small Hydropower Systems [9]
Overview of micro, mini and small hydro systems; Hydrology; Elements of pumps and turbine; Selection and design criteria of pumps and turbines; Site selection and civil works; Speed and voltage regulation; Investment issues load management and tariff collection; Distribution and marketing issues: case studies; Potential of small hydro power in India.
References

GET613: Advanced Battery and Fuel Cell Technologies

Course Outcome:
- Gain knowledge on lead-acid and lithium-ion batteries components
- Acquired know-how about fabrication and evaluation of lithium-ion battery
- Get awareness about the market for electric vehicle in India and elsewhere
- Gain knowledge on hybrid energy systems
- Acquire knowledge on fabrication and evaluation of PEMFC fuel cell

Unit I. Lead Acid Battery
Advantages and disadvantages of lead acid batteries, electrochemical reactions, physical and chemical properties of active materials, characteristics and properties of sulphuric acid, constructional features, materials and manufacturing methods, SLI (Automotive) batteries, charge and discharge properties of lead acid batteries, sealed lead acid or maintenance free batteries fabrication technology and testing. Lead acid battery for PV and automotive applications.

Unit II. Lithium-ion Battery
Advanced anodes and cathodes – theoretical capacity – merits and demerits - Nanomaterials for anodes: carbon nanotubes, graphene, Sn, Al, Si, SnO2, NiO, TiO2 & LiTiO4. Nanomaterials for cathodes: LiCoO2, LiMn2O4, LiFePO4, and doped cathodes. Fabrication of nanostructured LiCoO2, LiMn2O4, LiFePO4, Si, Sn and CNTs. Battery fabrication technology and testing, batteries for electric vehicles, hybrid vehicles and solar photovoltaic applications.

Unit III. Metal-Air Batteries
Unit IV. Fuel Cell Technology

Unit V. Hybrid Energy Systems
Concept of hybrid energy systems, development of battery and supercapacitors systems – Batteries and Fuel cells power systems – Recent developments and application areas.

References
9. Energy conversion and storage scientific journals.

GETY614: Nanotechnology for Energy Systems
(Soft Core Course)

Course Outcome:
- Computational skill (nanomaterial properties)
- Practical skill in making nanomaterials and characterizing it

Unit I. Nano-electronics
Concept of wave-matter duality, phase and group velocities, electron state in solids, uncertainty principle, operators, quantum mechanical postulates, Schrödinger’s Wave Equation, free electron gas, spherical, electron in spherical potential (hydrogen atom), Hydrogen molecule, Atom by Atom arrangements, band structure formation, E-k diagram, electronic states of 2-D, 1-D, 0-D nanosystems.

Unit II. Physical Properties of Nanosystems
Light absorption in Nano systems, size dependence and material dependence of absorption, band gap engineering, Fermi-level, ballistic and diffusive transport in nanosystems, coulomb blockade, resonant tunnelling, carrier separation techniques

Unit III. Nanotechnology for Solar Energy Conversion
Unit IV. Nanotechnology for Energy Storage
Nanostructured electrodes fabrication, nanotubes for energy storage, nanotechnology for electrochemical storage, Nanotechnology for conversion of solar energy to hydrogen

Unit V. Nanotechnology for Energy Efficient Devices
Energy efficient devices –fabrication and applications of quantum well LED as light device, – optical amplifiers, quantum well lasers, optical switch, Quantum dot luminescence materials.

Reference
1. Quantum Chemistry, Levine, Prentice Hall
2. Statistical Mechanics and properties of matter, E.S.R Gopal, Ellis Horwood
3. Introduction to solids, Azaroff, Tat Mc-Graw Hill

GETY 615: Energy Audit and Management

(Soft Core Course)

Course Outcome:
Course is designed to impart necessary knowledge on energy conservation and its management. Students shall learn energy conservation act (ECA), role of State and Central government in implementing ECA, role of Bureau of Energy Efficiency (BEE), various types of energy audits, techno-economic analysis of various energy conservation measures. Student shall be in a position to carryout material and energy balance calculation for various energy intensive systems.

Unit I. Energy Auditing Techniques
Energy Audit: Definition, need and objectives, types of Energy Audit, Energy audit strategies, Basic Components of Energy Audit, Energy Audit Instruments, Important survey items: Methodologies of conducting energy audit: Post audit analysis:

Unit II. Furnaces and Boilers
Furnaces: Classification, general fuel economy measures in furnaces, excess air and heat distribution losses, temperature control, draft control, case studies.
Boilers: Types, analysis of losses, performance evaluation, feed water treatment, blow down, energy conservation opportunities, FBC boilers, case studies.
**Unit III. Insulation and Refractories**
Insulation type and application, economic thickness of insulation, heat savings and application criteria, refractory-types, selection and application of refractories, case studies.

**Unit IV. Steam system, Cogeneration, Cooling tower and Waste heat recovery**
Steam system
Properties of steam, assessment of steam distribution losses, steam leakages, steam trapping, condensate and flash steam recovery systems, identifying opportunity for energy saving, case studies
Cogeneration
Need, applications, advantages, topping cycles, bottoming cycles, combined cycles, steam tracking mode, electricity tracking mode, saving potential, case studies
Cooling Tower
Types and performance evaluation, efficient system operation, flow control strategies and energy saving opportunities, case studies
Waste heat recovery
Availability and reversibility, first and second law efficiency, classification, advantages and applications, commercially viable heat recovery devices, saving potential, case studies
HVAC and refrigeration system, vapor compression refrigeration cycle, refrigerants, factors affecting refrigeration and air conditioning system performance and savings potential.
Vapor absorption refrigeration system, working principle, types and comparison with vapor compression system, saving potential, distribution system for conditioned air.

**Unit V. Energy Conservation (Electrical Systems)**
Electrical systems and bill analysis: Electricity billing, electrical load management, maximum demand control, Energy conservation opportunities in Lighting systems, Electric motors, Compressed air systems, HVAC & refrigeration system, Fans & blowers, Pumps, Cooling tower and DG system, case studies.

**Text Books**
GETY619: BIOREFINERIES

Course Outcome:
Learn various methodologies to convert biomass to biocrude. Acquire knowledge on conversion of biomass feedstock to complex and value added biomolecules. Specifically gain understanding on developing end-to-end solution for biofuel production and commercially sustaining the process in algae based biofuel conversion process.

Unit I.  

Unit II.

Unit III.

Unit IV. Bio-refinery Concepts

Unit V. Algal Bio-refinery

Text Books:
GETY 610: ENERGY LABORATORY – III
(Virtual Instrumentation and Case Studies on Sustainable Energy Systems)

Course Core Course)

Course Outcome:

- Gain simulation and modeling skill.
- Apply computational and programming skill set to solve renewable energy technology related problem.
- Acquire basic concept of virtual instrument based programming and interfacing.
- Learn the programing skill to control and interact with devices in real-time.

Virtual Instrumentation and Case Studies

The trend engineering design today, is towards more digital prototyping and computer-based evaluation and testing before a time-consuming and expensive production of either scale models or full-size physical prototypes of components or systems. During this lab course, the student is expected to gain practical experience on case studies related to alternate and green technologies. Students will be given the opportunity to develop a detailed prototype interactive virtual instrumentation system for a sustainable energy project that they can use as the basis of their final industrial project, to be pursued at the fourth semester. Students are expected to give two seminars and submit a system document that must include sufficient technical content along with resource assessment, economic appraisal, development schedule and plan as well as environmental, economic and social impact assessment.

Course Contents

Virtual Instrumentation basics: Front panel and block diagram- Dataflow programming model
 Modular Programming: Basics of modular programming with subVIs- Creating an icon and connector pane
 Graphing with LabVIEW: Using waveform charts to display data, XY graphs to display data
 Strings and File I/O: Creating string controls and indicators, Using File I/O VIs
 Data Acquisition: Plug-in DAQ devices, Performing analog I/O, Counters, Digital I/O,
 Instrument Control, Sensors and Transducers, PC Based Measurement Data Acquisition & Signal Conditioning., Intelligent Instrumentation.

Manuals & References:
1. LabVIEW for Data Acquisition (Paperback) Bruce Mihura Prentice Hall, 2001
2. LabVIEW for Electric Circuits, Machines, Drives, and Laboratories, by Nesimi Ertugrul, Prentice Hall 2002
3. LabView: Advanced Programming Techniques, SECOND EDITION Rick Bitter,

5. LabVIEW for Everyone: Graphical Programming Made Easy and Fun (3rd Edition) (Hardcover) – Jeffrey Travis,


Manuals & References:
5. A Matlab-Based Modeling and Simulation Package for Electric and Hybrid Electric Vehicle Design IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 48, NO. 6, NOVEMBER 1999
SEMESTER - IV

GET 620 Green Technology Dissertations:
(Hard Core Course) Full-time Dissertation work

Course Outcome:
1. Student shall specialize through industrial training and/or research work in the renewable energy field of their choice & basic degree specialization
2. Learn to identify a research problem or industrial problem, devise a methodology to solve the same.
3. Trained on design, fabrication and testing of energy products
4. Learn the entrepreneurship potential in renewable energy technologies.

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To be carried out with due permission from the Chairperson / Coordinator for one semester (four months) in any industry or a research organization outside Pondicherry University and practicing green energy technologies

A thesis written for this project will be evaluated by an expert followed by viva-voce.

Minimum credit requirement = 72; All teaching, learning and evaluations will follow Choice Based Credit System (CBCS) which is in vogue in Pondicherry University.

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OTHER SOFT-CORE COURSES

These courses will be offered in any of first three semesters depending on the availability of the resource faculty.

(Bridge Course)  

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A scientific or research article published in a peer reviewed journal is a technical document that describes a significant experimental, theoretical or observational extension of current knowledge, or advances in the practical application of known principles. A research article should report on research findings that are not only verifiable, reproducible and previously unpublished and should add to new understanding of the concerned subject. Unlike a novel, newspaper article or an essay, a research article should adhere to a structure and style, which is internationally acceptable. It should have an introduction, methods used, results obtained and discussion on the results and conclusions drawn. However, a RA is not only a technically rigid document, but also a subjective intellectual product that unavoidably reflects personal opinions and beliefs. Therefore, it requires good skills in both structuring and phrasing the discoveries and thoughts. These skills are acquired through experience, but can also be taught through instructional course like the one proposed now. Thus, above bridge course offered by English Department will help students to learn how to write research articles to be published in a scientific journal. In addition to scientific article writing this course will also cover principles of research methodology and scientific ethics. All the students of the GET program are expected to take this course and pass. However, students with appropriate background may be exempted from taking this course provided enough evidence exists in the form of clearance of a screening test.

GETY 518: Environmental Risk Management  

(Soft Core Course)  

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References

4. HMSO, Environmental Assessment, a guide to the procedures (Essential reading) 1989 , DOE , Welsh Office.
GETY 527: Green management

(Soft Core Course)

L T P C
3 0 0 3 45L

Unit I. [9]
The concept of green management; evolution; nature, scope, importance and types; developing a theory; green management in India; relevance in twenty first century

Unit II. [9]
Organizational environment; internal and external environment; Indian corporate structure and environment; how to go green; spreading the concept in organization; Environmental and sustainability issues for the production of high-tech components and materials, life cycle analysis of materials, sustainable production and its role in corporate social responsibility (CSR) and corporate environmental responsibility (CER).

Unit III. [9]
Approaches from ecological economics; indicators of sustainability; ecosystem services and their sustainable use; bio-diversity; Indian perspective; alternate theories

Unit IV. [9]
Environmental reporting and ISO 14001; climate change business and ISO 14064; green financing; financial initiative by UNEP; green energy management; green product management

Unit V. [9]
Definition; green techniques and methods; green tax incentives and rebates (to green projects and companies); green project management in action; business redesign; eco-commerce models

1. References
3. Green Marketing and Management: A global Perspective by John F. Whaik, 2005
4. The Green Energy Management Book by Leo A. Meyer
5. Green Project Management by Richard Maltzman And David Shiden
6. Green Marketing by Jacquelin Ottman
7. Green and World by Andrew S. Winston
GETY 528: GREEN CHEMISTRY

(L T P C) 2 0 4 3 53L

Green chemistry about chemical research and engineering that develops the design of chemicals and environmentally benign processes that minimize the use and generation of hazardous substances. In this course concepts of green chemistry will be exposed with real world applications in pharmaceutical industry and fine chemical industry. Apart from theory the course will have practical component where students are encouraged to do mini project involving principles of green chemistry.

Unit I. [8]
Introduction to Organic Chemistry/ Analytical Chemistry /Basic Chemical Engineering

Unit II. [9]
Introduction to Green Chemistry: Principles of Green Chemistry, Reasons for Green Chemistry (resource minimization, waste minimization, concepts), Green reactions solvent free reactions, Catalyzed (heterogeneous/homogeneous) reactions, MW/ Ultrasound mediated reactions, Bio catalysts etc

Unit III. [8]
Introduction to Pharmaceutical Process Chemistry: Introduction to process chemistry, the difference between synthesis and process, Rote design, Route optimization, DOE,

Unit IV. [6]

Unit V. Scale-up aspects including PE in Process Chemistry: Case Studies; New Initiatives: Micro reactors, Spinning Disc reactors [6]

Practical chemistry (Mini project): [16]

References
5. Albert Matlack, Introduction to Green Chemistry (Hardcover), CRC Press; 1 edition (2001)
7. Green Chemistry in the Pharmaceutical Industry, Peter Dunn (Editor), Andrew Wells (Editor), Michael T. Williams (Editor), Wiley-VCH (2010)a
Unit I. Basic Concepts
Introduction, Heat transfer in engineering, Mechanism of heat transfer, Temperature field and temperature gradient, Conduction, Thermal Conductivity, Thermal insulation, Contact resistance, Convection, Thermal radiation, Concept of driving potential, Combined mechanism of heat transfer.

Unit II. Conduction
Conduction equation; Steady state conduction in simple geometries: Thermal contact resistance; Critical thickness of insulation; Multidimensional steady state heat conduction, Conduction in other shapes, Shape factor, Steady state heat conduction in solid/hollow cylinders with uniform heat generation, Transient heat conduction; Lumped heat capacity analysis; Heiler’s charts for semi-Infinite medium; Slab cylinder and sphere.

Unit III. Heat Transfer with Extended Surfaces (Fins)

Unit IV. Convection & Radiation
Principle of similarity, Mechanism of convection, Convective heat transfer coefficient, Free convection (Laminar, Turbulent &Mixed) on horizontal, vertical and Inclined plates, cylinder and sphere, forced convection inside tubes and ducts, Forced convection over exterior surfaces, Blackbody radiation, View factor algebra, Enclosures with black surfaces and grey surfaces, Radiosity, Heat exchangers and its types.

Unit V. Heat Exchangers
Introduction, Overall heat transfer coefficient, Classification of heat exchangers, Log mean temperature difference, Heat exchanger performance: Effectiveness, Pressure drop and pumping power, Special cases, Effectiveness-NTU chart, Storage type heat exchangers, Compact heat exchangers.

References

GETY 532 Electrical Power Generation and Power System Analysis
(Soft Core Course)

L T P C 3 0 0 3 45L

Unit I. Power Generation

Unit II. Electrical Power System Analysis

Unit III. Power Transmission
Power quality of AC Transmission: Overhead and cables, Transmission line equations, Regulation and transmission line losses, Reactive power compensation, Flexible AC transmission, HVDC Transmission: HVDC converters, Advantages and economic considerations converter control characteristics, Analysis of HVDC link performance, Multi terminal DC system, HVDC and FACTS.
Unit IV. Distribution
Distribution: Distribution systems, Conductors size, Kelvin’s law performance calculations and analysis, Distribution inside and commercial buildings entrance terminology, Substation and feeder circuit design considerations, Distributions automation, Futuristic power generation.

UNIT V. Power System Monitoring

Text/References
10. T.M. O’Donovan, Short Term Forecasting: An introduction to the Box Jenkins Approach, Wiley, Chichester, 1983

GETY 618: Green Concepts in Buildings
(Soft Core Course)
Pre-requisite (undergraduate degree in civil engineering)
Learn the process of energy cost in developing dwelling for human activity.

Unit I. [9]

Unit II. [9]
Unit III. [9]

Unit IV. [9]

Unit V. [9]

References
12. Fundamentals of Integrated Design for Sustainable Building By Marian Keeler, Bill Burke

GETY 618: Carbon sequestration at landscape level

Course Outcome:
- Learn the concept of CO2 generation and fixation in the globe.
- Familiarize the international laws, convention and regulation on carbon sequestration
- Develop basic understanding on biomass synthesis, available energy potential, its exploitation, current scenario in India.

Unit I. Climate change and International agreements [9]
The green-house effect. The United Nations Framework Convention on Climate Change (UNFCCC). The Intergovernmental Panel on climate change (IPCC), the Kyoto Protocol, the Clean Development Mechanism

Unit II. Primary productivity: mechanisms and assessment
Photosynthesis, absorption and yield. C3, C4 and CAM pathways. Laboratory measurement of primary productivity: cell, plant, ecosystem. Direct field measurements of biomass and primary productivity: allometric models, harvest methods for forests, grasslands and ocean. Indirect measurements of biomass and primary productivity: remote sensing and other methods. The CDM methodologies for measurement of stocks and fluxes.

Unit III. Biogeochemistry

Unit IV. Remote sensing and spatial analysis
Sensors. Reflectance of vegetation. Measuring biomass with remotely sensed data. Measuring primary productivity with remotely sensed data. High resolution satellites, use and limitations to measure biomass and primary productivity. Low resolution satellites use and limitations to measure biomass and primary productivity. Regional and global assessments of biomass and primary productivity. Introduction to Geographic Information Systems (GIS). Land-use and land-use changes assessment. The Clean Development Mechanism (CDM) methodologies for measurement of stocks and fluxes at the landscape level.

Unit V. Biomass as a major source of energy in India

References

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