## M. Tech Programme in ENERGY AND ENVIRONMENTAL MANAGEMENT (EEM)

### 1st YEAR (I - SEMESTER)

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**Grand Total** 800

### List of PE-1

2. EEM/RE-113 Direct Energy Conversion

### List of PE-2

1. EEM-111 Environmental Pollution and Control
2. EEM-115 Solid and Hazardous Waste Management
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 Skill
## Scheme of Studies & Examinations

### M. Tech Programme in ENERGY AND ENVIRONMENTAL MANAGEMENT (EEM)

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

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### List of PE-3

1. EEM/RE-112 Solar Photovoltaic Technology
2. EEMRE-116 Solar passive heating and cooling

### List of PE-4

1. EEM-114 Water and Waste Water Management
2. EEM-118 Environment Auditing and Impact Assessment
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 ENERGY AND ENVIRONMENTAL MANAGEMENT (EEM)**

#### IIInd YEAR (III - SEMESTER)

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#### List of PE-5

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<td>2</td>
<td>EEM-203</td>
<td>Materials and Devices for Energy Applications</td>
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<tr>
<td>3</td>
<td>EEM-205</td>
<td>Basics of Toxicology and environmental Risk</td>
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<td>4</td>
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<td>Society and Environment</td>
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M. Tech Programme in ENERGY AND ENVIRONMENTAL MANAGEMENT (EEM)

IIInd YEAR (IV - SEMESTER)

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Grand Total 16 100 - 200 300

TOTAL CREDITS: 18+18+16+16 =68
EEM-101: RENEWABLE ENERGY SYSTEMS-I

M. Tech. - EEM (ENERGY AND ENVIRONMENTAL MANAGEMENT) 1st Year (I - Semester)

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<td>75 Marks</td>
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Objectives of the Paper:
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.

**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 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.
COURSE OBJECTIVES:

The students are expected to understand basic knowledge of ecological principles and ecosystems. They will know about different levels of the living world starting with the biology of organisms, then populations and finally the communities. The students will work on case studies related to each level of organization. The course will also provide the understanding of the principles of biodiversity in an ecological and social context. Students learn detailed understating of various aspects of air and soil chemistry.

UNIT-I


UNIT-II

UNIT-III


UNIT-IV

Physio-chemical properties of soil, soil organic matter, microorganisms of soil, decomposition of organic matter in soil, soil formation and distribution, mobility of nutrients and trace elements during soil genesis, effects of modern agriculture on soil geochemistry, soil erosion and reclamation.

Course outcomes:

Upon completion of this course, a fully-engaged student will be able to:

· Describe important ecological processes.
· Demonstrate knowledge of the important ecological principles operating at different levels of organization.
· Develop concepts of basic chemistry associated with toxicology of environmental pollutants.
· Outline fundamental and applied aspects of environmental analytical chemistry.
· Apply analytical tools to determine and measure pollutants in various environmental samples.

Understand various means of soil contamination, their possible effects and control.
· Discuss the method for reducing soil erosion and soil management.

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.

Recommended books:

EEM-105 : ENVIRONMENTAL ENGINEERING LABORATORY I
M. Tech. - EEM (ENERGY AND ENVIRONMENTAL MANAGEMENT) 1st Year (I - Semester)

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Duration of Examination : 3 Hours

COURSE OBJECTIVES:
The course has been designed to train the students in the laboratory for quantitative analysis of various physical, chemical and biological pollutants in water and wastewater and to provide firsthand experience on various instruments.

1. Analysis of water for physical parameters Turbidity and pH.
2. Analysis of water chemical parameters using neutralization methods: acidity, Alkalinity, and free carbon dioxide.
3. Analysis of bioavailable fractions of heavy metals using mild and strong chemicals in soil.
4. Analysis of water for chemical and biological parameters like Dissolve Oxygen, Biochemical oxygen demand, chemical oxygen demand.
5. Analysis of heavy metals in water/ waste water/ industrial water.
6. Analysis of water for chemical parameters chlorides and nitrates.
7. Analysis of water for chemical parameters sulphates and phosphate.
8. Gravimetric analysis of water/wastewater quality parameters TSS and TDS.
9. To calculate the lambda max of the given compound by UV-Vis spectrophotometer.

Note: At least six (6) out of ten (10) experiments will be carried out in one semester. Addition and deletion in the list of experiments may be made from time to time by the department depending on the requirement of course.
Course outcome:

The students will be able to

1. Analyse and quantify various environmental parameters/pollutants present in environment.
2. Perform environmental quality measurements.

Design various experiments for reducing the pollution load from water and wastewater streams.
Objectives of the Paper:

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.

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.
Objectives of the Paper:

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. Markvat, 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.
COURSE OBJECTIVES:
This course aims to provide the students with a variety of perspectives on the air, water, soil and noise pollution issues. The students will get an insight into sources of various types of pollution, their effects and dispersion in the environment. The students will be acquainted with pollution control devices, their constructional features and working principles.

UNIT-I
Air pollution: Definition, Air Quality and Standards: Classification of air pollutants, their sources, criteria pollutants, characteristics and effects, Air quality standards.
Dispersion of pollutants – Wind velocity, Lapse rate, atmospheric stability, inversion, atmospheric dispersion, maximum mixing depth and plume rise.
Control of Particulates and gaseous pollutants- Characteristics of particulates - Filters, gravitational, centrifugal-multiple type cyclones, wet collectors, Electrostatic Precipitation, bag filter Scrubbers.

UNIT-II
Noise Pollution and Control:
The decibel Scale, Sound intensity level, Classification of noise, noise standards, effects of noise, Noise control methods, Role of vegetation in noise control, Environmental problems associated with noise pollution.

UNIT-III
Water pollution and control: Definition, Classification, Sources, Water quality standards, Characterisation of water, Principle forms of water pollutants and their sources, suspended, colloidal and dissolved solids (TSS, TDS, Volatile and fixed solid).
Water pollution and control: Indicators, Hardness and determination of DO, BOD, COD of water, and water pollution due to heavy metals and organic pollutants, bio indicators of water pollution.
UNIT-IV
Soil pollution and control: Inorganic and Organic-Definition of pollution and contamination, sources of soil pollution, Effects of chemical residues on soil, (pesticides, fertilizers, heavy metals etc.), Soil pollution from nitrogen, phosphorus, sulfur, micronutrients or trace elements, Heavy metal pollution of soils, heavy metal remediation of soil. Introduction to, Marine pollution (Sources, classification and effects).

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.

Recommended Books

1. Environmental Pollution – Peavy and Rowe.
2. Environmental Pollution and Solution – Asthana and Asthana.
4. Environmental Science – A study of Inter relationships – E D Enger and B E Smith.
6. Air Pollution A K Srivastava.

Course outcomes:

On completion of the course, the students will be able to:

1. Understand the type and nature of pollutants, the behaviour of plumes and relevant meteorological determinants influencing the dispersion of air pollutants.
2. Discuss the pollution emission standards.
3. Suggest suitable pollution prevention equipments and techniques for various pollutants to industries.
4. Understand the technical aspects of regulating and controlling air and noise pollution.
EEM/RE-113: DIRECT ENERGY CONVERSION

M. Tech. - EEM (ENERGY AND ENVIRONMENTAL MANAGEMENT) 1st Year (I-Semester)

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Total: 100 Marks

Duration of Examination: 3 Hours

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.

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:

The course will provide the basic knowledge of solid waste in terms of characteristics and composition. The students will become aware of environmental and health impacts of solid waste management. Further, the course will provide the understanding of engineering, financial and technical options for waste management. Student will get aware about problems of municipal waste, biomedical waste, hazardous waste, e-waste, and radioactive waste. This course provides an in-depth understanding of solid and hazardous waste characteristics and management.

UNIT-I

**Solid Waste:** Definition, history, types, sources, composition and properties of solid waste, need for management, solid waste generation: Solid waste handling, storage, processing, collection, transfer and transport.

UNIT-II

**Solid waste management:** Material flow in society, Reduction in raw material usage, reduction in solid waste quantities, reuse of solid waste material, material recovery, energy recovery (biological and thermal), materials and energy recovery system, day to day management of solid waste.

UNIT-III

**Hazardous waste:** Definition, history, Sources and Characterization of waste, Transport processes of hazardous wastes, Handling and management of Biomedical, Agriculture and E-waste and radioactive waste management.
UNIT-IV

Hazardous waste management: Transport processes of hazardous wastes, Chemical treatment processes for MSW (combustion, stabilization and solidification of hazardous wastes), physicochemical processes for hazardous wastes (soil vapour extraction, air stripping, chemical oxidation), Composting, bioreactors, incineration, landfill disposal.

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 outcomes:

On completion of the course, the students will be able to:
1. Do sampling and characterization of solid waste.
2. Understand health and environmental issues related to solid waste management.
3. Distinguish among different streams of solid wastes and understand factors affecting variations.
4. Apply steps in solid and hazardous waste management - waste reduction at source, collection techniques, materials and resource recovery/recycling, transport, optimization of solid waste transport, treatment and disposal techniques.

Recommended books:

2. Environmental Engineering by H.S. Peavy, D.R. Rowe and George Techobanogloous
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.
EEM-102: RENEWABLE ENERGY SYSTEMS-II

M. Tech. - EEM (ENERGY AND ENVIRONMENTAL MANAGEMENT) 1st Year (II - Semester)

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

Objectives of the Paper:
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:
**Hydel Energy:** Hydro power: Potential, Hydropower Generation and Distribution, Mini and Microhydel Power (MHP) Generation: Classification of hydel plants, Concept of micro hydel, merits, MHP plants: Components, design and layout, Turbines, efficiency, Status in India. Integrated Energy systems and their cost benefit analysis.
Unit IV:

**Nuclear Energy:** Potential of Nuclear Energy, Nuclear Energy Technologies – Fuel enrichment, Different Types of Nuclear Reactors, Nuclear Waste Disposal, and Nuclear Fusion.

**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.
COURSE OBJECTIVES:
The objective of the course is to develop sampling and analytical skills of the students which are required in environmental monitoring. The students will be able to perform quantitative analysis of various physical, chemical and biological pollutants in environment with reference to air, water and soil. The students will acquire knowledge about various standard protocols used in environmental monitoring. The course will also help the students to learn the theory and concepts and develop their practical skills to use the contemporary tools and various techniques required.

UNIT-I
Basic concepts of quantitative analytical chemistry: The law of mass action, Chemical equilibrium, Ionic product, Buffer solution, solubility product, common ion effect, electrode potential, oxidation reduction reactions, preparation of standard solution, primary standard and secondary standard, normality, morality, molality, mole fraction.

UNIT II
Titrmetric methods: Acid base titration, precipitation titration, complexometric titration, oxidation-reduction titration. Chemical speciation – Alkali metal, Cu subgroup, Zn subgroup, Chromium subgroup

UNIT-III
Chromatography- Thin Layer chromatography, Liquid Chromatography, High Pressure Liquid Chromatography, Gas Chromatography, ion chromatography.

UNIT IV

**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 OUTCOMES:**

1. On completion of the course, the students will be:
2. Trained in analytical and conceptual skills required for environmental chemistry research.
3. Able to design and carry out a method of environmental chemical analysis, including instrumental analysis.

**Recommended Books:**

1. Environmental chemistry by Mannahan.
2. Environmental chemistry by A K De.
3. Introduction to environmental science and engineering by Gilbert M. Masters
6. Environmental Soil Chemistry by Donald L. Sparks.
8. Environmental Pollution – principles, Analysis and control, by P. Narayanan.
COURSE OBJECTIVES:

The course has been designed to train the students in the laboratory for quantitative analysis of various physical and chemical pollutants in air and soil, and to provide firsthand experience on various instruments.

1. To determine moisture content, pH and conductivity of soil sample.
2. Analysis of heavy metals in different types of soil.
3. Working, standardization of flame photometer and plotting calibration curve for metal ions.
4. Conductivity of water and wastewater samples using conductivity and TDS meter.
5. Removal of pollutants from wastewater by Adsorption methods.
6. Sampling and analysis of SPM in stationary sources.
7. Study of TSPM, PM10 and PM2.5 in ambient air.
8. Analysis of ash contents of coal.
9. A visit to normal and secured landfill site, biological composting/vermicomposting units in the city.
10. Chemical speciation of heavy metal in soil (Any one heavy metal).

Note: At least six (6) out of ten (10) experiments will be carried out in one semester. Addition and deletion in the list of experiments may be made from time to time by the department depending on the requirement of course.

Course outcome:

The students will be able to
Analyse and quantify various environmental parameters/pollutants present in environment. Perform environmental quality measurements. Design various experiments for reducing the pollution load from water and wastewater streams.
Objectives of the Paper:

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

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.

Course outcomes:
Students will be knowledgeable on the:
Procedure to be adopted for performance analysis and optimization of energy utilities
Methodology to be adopted for the quantification of performance governing parameters
EEM-110: ENERGY RESEARCH LABORATORY-II

M. Tech. - EEM (ENERGY AND ENVIRONMENTAL MANAGEMENT) 1st Year (II - Semester)

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Total: 100 Marks

Duration of Examination: 3 Hours
Objectives of the Paper:

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.
EEM-114 : WATER AND WASTE WATER MANAGEMENT

M. Tech. - EEM (ENERGY AND ENVIRONMENTAL MANAGEMENT) 1st Year (II - Semester)

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COURSE OBJECTIVES:

The objective of the course is to develop understanding of water quality criteria, standards, impacts of water pollutants and treatment methods. It focuses on causes and effects of water pollution and water quality degradation from different sources. The students will be educated on the principles, designs and functions of the unit processes in water or wastewater treatment and basic equipments that each process uses.

UNIT-I

Water-Global water scenario, Structure and basic properties of water, water sources-Surface and ground water, hydrological cycle, Physical and Chemical Characteristics of water – color, taste, odour, temperature, pH, Electrical Conductivity, Turbidity, Alkalinity, Acidity, Hardness, Sulphates, Fluorides, Nitrates, Total solids, Suspended Solids, Volatile Solids, Non Volatile Solids- Dissolved Oxygen, BOD and COD, Heavy metals in water, Disinfection of water

UNIT-II

Water Treatment: Introduction :Quality standard of domestic and industrial water,


Filtration: Slow sand filter, Rapid sand filter, Pressure filter, filter media, components, cleaning & backwashing process the under drain system and filter control.

UNIT-III

UNIT-IV


Course Outcomes:

- After completion of this course, the students will be able to:
- Acquire the knowledge of basic rationale of water quality management.
- Suggest the suitable technologies for the treatment of drinking water and wastewater.
- They will be able to operate and manage troubleshoot problems of municipal and industrial water and wastewater treatment plants.
- Know the various methods for water resource management.

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.

Recommended books:

1. Environmental Pollution – Peavy and Rowe.
2. Environmental Pollution and Solution – Asthana and Asthana.
5. Water supply and sewage by Terence J.Mc. Ghee
6. Industrial Water Pollution Control by W. Wesley and Eckenfelder, Jr
7. Water and Wastewater Engineering by Mackenzie L. Davis
**Objectives of the Paper:**

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 outcome:

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 students will acquire a better understanding of theoretical ideas of social impact, cultural and environmental impact due to development. This course will provide the basic knowledge to the students with an insight into environmental impact assessment (EIA) methodologies, environmental settings, prediction, evaluation of impacts and their mitigation plan. The students will also get idea to interpret environmental management plans and EIA documents. A comprehensive understanding of the need and procedures for environmental auditing will be provided to the students.

UNIT-I


UNIT-II

Environmental impact assessment: preliminary, impact prediction, evaluation, mitigation, decision, public participation, review, Monitoring and auditing, EIA techniques: Checklist, matrices, overlay map, network, and GIS, Practical consideration in writing impact statements.

UNIT-III

Types of Impacts, Prediction and assessment of impacts on the air environment, water environment, noise environment, biological, cultural, human health and socio-economic environment, Problems of EIA in developing countries.

UNIT-IV

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 outcomes:

On completion of the course, the candidate will be able to:

1. Appreciate the importance of EIA as an integral part of planning process
2. Understand the methods and tools of identification, prediction and evaluation of environmental impacts of developmental projects.
3. Understand the legal requirements for getting environmental clearance for new projects.
4. Know the requirements to become EIA consultant.
5. To be a part of EIA team to conduct EIA study for various projects.
6. Acquire basic skills to take up environmental auditing and lifecycle analysis at specific industries.

Recommended books:

1. Environmental Impact Assessment by W. Canter
2. Environmental Audit by Mhastear, A.K.
3. EIA for developing countries by Biswas Asit, K.
4. Environmental Management by Vijay Kulkarni and T.V. Ramachandra
5. Environmental Impact Assessment Methodologies by Y. Anjaneyulu and Valli Manickam
6. Environmental Impact Assessment by, Clark D. Brain, Biesel Donald
Objectives of the Paper:

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 outcome:

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.


**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.
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

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.
EEM- 205 : BASICS OF TOXICOLOGY AND ENVIRONMENTAL RISK ASSESSMENT

M. Tech.-EEM (ENERGY AND ENVIRONMENTAL MANAGEMENT) 11rd Year (III - Semester)

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COURSE OBJECTIVES:

The objective of the present course is to acquaint the students with various aspects of ecological toxicology. The students will be taught about the properties, origin, fate and behavior of environmental toxicants in the environment and in food. They will get to know about toxicological test methods, exposure measurements, calculations and risk valuation methods,

UNIT-I

Introduction to toxicity and its effects, fate of chemical toxicants in body (absorption, distribution and storage, biotransformation and elimination), basic of pharmacokinetics or toxicokinetic, toxic effects, structural affinity of toxicants, mechanism of toxic action and manifestation of toxic effects, classification of toxic action and effects, types and limitations of epidemiological studies.

UNIT-II

Basics of contaminants, contaminants release in environment, transport of contaminants in sub-surface, fate of contaminants in sub-surface, dispersion and transport of contaminants in atmosphere, contaminants as toxicants, toxicity reduction, bio-concentration and bio-magnification, brief introduction to contaminants degradation.

UNIT-III

Carcinogens and non-carcinogens, concepts of threshold, NOAEL (no observed adverse effect level), ADI (Acceptable daily intake) and RfD (reference dose) Toxicological database, calculation procedure for assessment of non-carcinogenic risk, initiation, promotion and progression of cancer, classification and types of carcinogens, role of carcinogenic chemicals,
concept of affinity of carcinogens and receptors, brief introduction to testing of carcinogenicity.

UNIT-IV


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 Outcomes:

After completion of this course, the students will:

1. Know about the environmental toxicants, contaminants, their effects and fate environment and in human body;
2. Know various means to ensure the protection, promotion and maintenance of the health;
3. Be able to quantify the risks to human health of exposure to chemicals;
4. Increase skill to perform a scientifically based risk assessment of chemicals;
5. Have some idea about carcinogens and carcinogenicity;
6. Have ability to plan and perform a short scientific study and present the results in writing and orally.

Recommended books:

1. Environmental Impact Assessment Methodologies by Y. Anjaneyulu and Valli Manickam
5. Lu basic toxicology: fundamentals, target organs, and risk assessment by Byung-Mu Lee, Sam Kacew Hyung Sik Kim, 7th ed.
7. Environmental Management 2nd ed. By Bala Krishnamoorthy
8. Introduction to environmental engg. And Science 3rd ed. By Gilbert M. Masters and Wendell P. ELA.
COURSE OBJECTIVES:
The course intends to introduce the students to the vast field of ethics and Policies both at the national and international level relating to environment. 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

Introduction to Environmental ethics, ethical theories, Environmental ethics and population, environmental ethics and pollution, animal ethics, biocentrism, ecocentrism.

UNIT-II

Concept of Sustainable development, threats to sustainability, guiding principles of sustainable development, sustainability indicators, sustainable development goals, national sustainable development strategies, environmental performance index, sustainable development in India: perspectives and strategies.

UNIT-III

Global Environmental Change - Stratospheric ozone layer: Causes of depletion and consequences; Global efforts for mitigation ozone layer depletion. Ozone hole, Climate change: Greenhouse effects; Chlorofluoro carbons, Drivers of climate change; Greenhouse gases and their sources; Implications on climate, oceans, agriculture, natural vegetation, wildlife and humans; Effects of increased CO2 on plants.

UNIT-IV

Global warming, El-Nino, Asian Brown Cloud, Photo-chemical smog, Acid rain and its effect on plants, animals, microbes and ecosystems. Pollution disaster- past, present and future (Bhopal gas tragedy, Chernobyl nuclear accident, Minamata accident, Leaded gasoline, Sukinda Valley, Space waste.

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 outcomes:

On completion of the course, the students will be able to:

1. To sensitize students towards environmental concerns and issues, and make them able to apply their knowledge for sustainable development.
2. To orient the students towards efficient environmental decision-making and management.
3. To develop understanding about the impacts of climate change and related mitigation strategies.

Recommended Books:

2. Environmental science and technology by M Anji reddy
4. Environmental ethics by Joseph R. DesJardins
5. Sustainable Development by Kumar Das
6. The Age of Sustainable Development by Jeffrey D. Sachs.
EEM-209: Phase-I Dissertation

M. Tech. - EEM (ENERGY AND ENVIRONMENTAL MANAGEMENT)IIND YEAR(III-SEM)

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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

COURSE OBJECTIVES:

The objective of the course is to develop understanding of water quality criteria, standards, impacts of water pollutants and treatment methods. It focuses on causes and effects of water pollution and water quality degradation from different sources. The students will be educated on the principles, designs and functions of the unit processes in water or wastewater treatment and basic equipments that each process uses.
UNIT-1
Water-Global water scenario, Structure and basic properties of water, water sources-Surface and ground water, hydrological cycle, Physical and Chemical Characteristics of water – color, taste, odour, temperature, pH, Electrical Conductivity, Turbidity, Alkalinity, Acidity, Hardness, Sulphates, Fluorides, Nitrates, Total solids, Suspended Solids, Volatile Solids, Non Volatile Solids- Dissolved Oxygen, BOD and COD, Heavy metals in water, Disinfection of water

UNIT-2
Water Treatment: Introduction :Quality standard of domestic and industrial water,


Filtration: Slow sand filter, Rapid sand filter, Pressure filter, filter media, components, cleaning & backwashing process the under drain system and filter control.

UNIT-3

UNIT-4
Course Outcomes

- After completion of this course, the students will be able to:
  - Acquire the knowledge of basic rationale of water quality management.
  - Suggest the suitable technologies for the treatment of drinking water and wastewater.
  - They will be able to operate and manage troubleshoot problems of municipal and industrial water and wastewater treatment plants.
  - Know the various methods for water resource management.

**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.

**RECOMMENDED BOOKS:**

1. Water supply and sewage by Terence J.Mc. Ghee
2. Industrial Water Pollution Control by W. Wesley and Eckenfelder, Jr
3. Water and Wastewater Engineering by Mackenzie L. Davis
6. Environmental Pollution and Solution – Asthana and Asthana.
7. Water supply and sewage by Terence J.Mc. Ghee
8. Industrial Water Pollution Control by W. Wesley and Eckenfelder, Jr
9. Water and Wastewater Engineering by Mackenzie L. Davis
EEM-202: Phase-II Dissertation
M. Tech. –(ENERGY AND ENVIRONMENTAL MANAGEMENT) 2nd Year (IV – Semester)

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Course Objectives:
1. To provide specialized training on IC Engines, Thermal Engineering, Solar Energy, Hydrogen Energy, Gas Sensing and Photocatalytic 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)