Course Contents

Semester-I Courses

ES601 Foundations for Energy Engineering 3-1-0

Course Content

Thermodynamics: Basic Concepts and Definitions. first law and its application, second law and its application, Exergy and Irreversibility, Basic power generation cycles.

Fluid Mechanics: Fundamental concepts and fluid properties, Kinematics ana Dynamics of fluid flow, continuity, momentum and energy equations, Flow through pipes.

Heat Transfer: conduction, radiation and convective heat transfer. Conduction of heat in steady state without and with heat generation. Insulation, Free and forced convections, Measurement of temperature by thermocouple.

Text/References:

- M. W. Zemansky, Heat and Thermodynamics 4th Edn. McGraw Hill, 1968.
- A. L. Prasuhn, Fundamentals of Fluid Mechanics, Prentice Hall, 1980
- S. P. Sukhatme, A Text book on Heat Transfer, Orient Longman, 1979.
- P. C. Sen, Modern Power Electronics, Wheeler, New Delhi, 1998.

ES602 Energy Resources, Economics & Environment 3-1-0

Course Content

Overview of World Energy Scenario – Dis-aggregation by end-use, by supply Fossil Fuel Reserves - Estimates, Duration Overview of India's Energy Scenario - Dis-aggregation by end-use, by supply, reserves Country Energy Balance Construction - Examples Trends in energy use patterns, energy and development linkage. Energy Economics - Simple Payback Period, Time Value of Money, IRR, NPV, Life Cycle Costing, Cost of Saved Energy, Cost of Energy generated, Examples from energy generation and conservation, Energy Chain, Primary energy analysis Life Cycle Assessment, Net Energy Analysis Environmental Impacts of energy use - Air Pollution - SOx, NOx, CO, particulates Solid and Water Pollution, Formation of pollutants, measurement and controls; sources of emissions, effect of operating and design parameters on emission, control methods, Exhaust emission test, procedures, standards and legislation; environmental audits; Emission factors and inventories Global Warming, CO_2 Emissions, Impacts, Mitigation Sustainability, Externalities, Future Energy Systems.

Text/References:

- Energy and the Challenge of Sustainability, World energy assessment, UNDP New York, 2000.
- AKN Reddy, RH Williams, TB Johansson, Energy after Rio, Prospects and challenges, UNDP, United Nations Publications, New York, 1997.
- Nebojsa Nakicenovic, ArnulfGrubler and Alan McDonald Global energy perspectives, Cambridge University Press, 1998
- Fowler, J.M., Energy and the environment, 2nd Edn., McGraw Hill, New York, 1984

ES 603 Renewable Energy Systems 3-1-0

Course Content

Global & National energy scenarios, Forms & characteristics of renewable energy sources, Solar radiation, Flat plate collectors, Solar concentrators, Thermal Applications of solar energy, Photovoltaics technology and applications, Energy storage, Energy from biomass, Thermochemical, Biochemical conversion to fuels, biogas and its applications, Wind characteristics, Resource assessment, Horizontal & vertical axis wind turbines, Electricity generation and water pumping, Micro/Mini hydropower systems, Water pumping and conversion to electricity, Hydraulic ram pump, Ocean Thermal Energy Conversion (OTEC), Geothermal, Tidal and Wave energies, Material aspects of Renewable energy technologies and systems. Hydrogen and fuel cells.

Text/References:

- Sukhatme, S.P., Solar Energy, Tata McGraw Hill, 1984.
- Twidell, J.W. and Weir, A., Renewable Sources, EFN Spon Ltd.,1986.
- Kreith, F and Kreider, J. F., Principles of Solar Engineering, McGraw-Hill, 1978.
- Godfrey Boyle, Renewable Energy, Power for a Sustainable Future, Oxford University Press, U.K, 1996.

ES605 Energy Audit and Management 3-1-0

Course Content

General aspects of energy management: Current energy scenario, principles of energy management, energy policy, energy action planning, need for renewable energy and energy efficiency. Energy auditing: need, type and components of energy audit, Methodology, instruments, equipment used in energy audit, analysis and recommendation of energy audit with examples, audit report. ECO in boiler and steam system, furnaces, DG sets, HVAC systems, pumping system, cooling tower etc. Energy Economics, Energy efficiency in thermal utilities like boilers, furnaces, heat exchangers, fans and blowers, pumps, compressors etc. Electrical energy management and lighting systems. Cogeneration and waste heat recovery. .

Text/References:

- L.C.Witte, P.S.Schmidt, D.R.Brown , Industrial Energy Management and Utilisation, Hemisphere Publ, Washington,1988.
- Industrial Energy Conservation Manuals, MIT Press, Mass, 1982.
- I.G.C.Dryden, Butterworths, The Efficient Use of Energy, London, 1982
- W.C.Turner, Wiley, Energy Management Handbook, New York, 1982.
- Technology Menu for Efficient energy use- Motor drive systems, Prepared by National Productivity Council and Center for & Environmental Studies- Princeton Univ, 1993.

ES606 Direct Energy Conversion Systems 3-1-0

Course Content

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 Introduction to irreversible thermodynamics. Thermoelectric conversion: thermoelectric effects, analysis of thermoelectric generators and coolers, figure of merit, device configuration Photovoltaic conversion: Optical effects of p-n junction, design and analysis of PV cells. PV cell fabrication, System design Thermionic conversion: thermionic effects, analysis of converters, application of heat pipes. Magneto hydrodynamic conversion: gaseous conductors, analysis of MHD generators. Batteries and fuel cell: Thermodynamic analysis, design and analysis of batteries and fuel cells. Other modes of direct energy conversion.

Text/References

- Kettani, M.A., Direct energy conversion, Addison-Wesley, Reading, Mass, 1970
- AngristS.W. ,Direct Energy Conversion. 4th Ed. Allyn And Bacon, Boston, 1982
- Green M.A. ,Solar Cells, Prentice-Hall, Englewood Cliffs, 1982
- Hand book Batteries and Fuel Cells. Linden, McGraw Hill, 1984.

ES607 Solar Thermal Systems 3-1-0

Course Content

Solar Radiation, availability, measurement and estimation; Isotropic and anisotropic models; empirical relations, Solar Collector and thermal storage: steady state and dynamic analysis, Solar pond, Modelling of solar thermal systems and simulations in process design Design of active systems by f-chart and utilizability methods. Water heating systems: active and passive, Passive heating and cooling of buildings, Solar distillation, Solar drying

Text/References:

- S. P. Sukhatme, Solar Energy - Principles of thermal collection and storage, second edition, Tata McGraw-Hil, New Delhi, 1996
- J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, second edition, John Wiley, New York, 1991
- D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia, 2000
- M. S. Sodha, N. K. Bansal, P. K. Bansal, A. Kumar and M. A. S. Malik, Solar Passive Building: science and design, Pergamon Press, New York, 1986
- M. A. S. Malik, G. N. Tiwari, A. Kumar and M.S. Sodha, Solar Distillation. Pergamon Press, New York, 1982.

Elective-I

ES604 Alternative Fuels for I.C Engines 3-1-0

Course Content

An introduction to hydrocarbon fuels–their availability and effect on environment, Gasoline and diesel self-ignition characteristics of the fuel, Octane number, Cetane number, Alternative fuels - liquid and gaseous fuels, Physico-chemical characteristics, Alternative liquid fuels, Alcohol fuels - ethanol and methanol, Fuel composition, Fuel induction techniques, Fumigation, Emission of oxygenates, Applications to engines and automotive conversions, Biodiesel formulation techniques, Trans esterification, Application in diesel engines, DME (Dimethyl ether), properties fuel injection consideration general introduction to LPG and LNG, Compressed natural gas components, mixtures and kits, fuel supply system and emission studies and control, Hydrogen combustion characteristics, Flashback control techniques, Safety aspects and system development, NOx emission control, Biogas, Producer gas and their characteristics system development for engine application.

Text/ References:

- CI Engine Performance for Use with Alternative Fuels, Society of Automotive Engineers, 2009.
- Maxwell, T.T. and Jones, J, Alternative Fuels: Emissions, Economics and Performance, Society of Automotive Engineers, 2002.
- Hordeski, M. F., Alternative Fuels: The Future of Hydrogen, CRC Press, 2006.
- Commercial Vehicle Alternative Fuels, Society of Automotive Engineers, 2007

Elective-II

ES608 Bio-Mass Energy Conversion 3-1-0

Course Content

Biomass and solid wastes, Broad classification, Production of biomass, photosynthesis, Separation of components of solid wastes and processing techniques, Agro and forestry residues utilisation through conversion routes: biological, chemical and thermo chemical, Bioconversion into biogas, mechanism, Composting technique, Bioconversion of substrates into alcohols, Bioconversion into hydrogen, Thermo chemical conversion of biomass, conversion to solid, liquid and gaseous fuels, pyrolysis, gasification, combustion, Chemical conversion processes, hydrolysis and hydrogenation, Solvent extraction of hydrocarbons, Fuel combustion into electricity, case studies.

Text/References:

- M.M. EL-Halwagi, Biogas Technology- Transfer and diffusion, Elsevier Applied science Publisher, New York, 1984.
- D.O Hall and R.P. Overeed, Biomass – regenerable energy, John Willy and Sons Ltd. New York.

ES609 Thermal and Nuclear Power Plants 3-1-0

Course Content

Recapitulation: types of power plants, cycles, site and equipment selection, feasibility studies. Fuels and combustion. Fuel and air handling equipment. Steam generators, supercritical and LEBS. Nuclear power plants–reaction physics, type and sizing of reactors and steam generators. Turbines, feed water heaters, condensers, deaeration–sizing and performance calculations. Cooling water systems–sizing and load calculations. Cogeneration systems–types and sizing. Control and instrumentation. Environmental and safety aspects. Operation, performance and condition monitoring. Future trends.

Text /References:

- P.K.Nag ,Power Plant Engineering ,TMH
- R.K.Rajput, Power Plant Engineering, Lakshmi Publications.
- P.C.Sharma, Power Plant Engineering, Kataria Publications.
- Wakil ,Power Plant Technology.

ES610 Power Generation and System Planning 3-1-0-4

Course Content

Overview of the Indian power sector, Thermodynamic analysis of Conventional Power Plants. Advanced Power Cycles, Kalina (Cheng) Cycle, IGCC, AFBC/PFBC Steam Turbine - Superheater, reheater and partial condenser vacuum. Combined Feed heating and Reheating. Regenerative Heat Exchangers, Reheaters and Intercoolers in Gas Turbine power plants. Hydro power plants, turbine characteristics. Auxiliaries, Water Treatment Systems, Electrostatic Precipitator / Flue gas Desulphurization, Coal crushing / Preparation - Ball mills / Pulverisers, ID/FD Fans, Chimney, Cooling Towers. Power plant control systems, Review of control principles, Combustion control, pulveriser control, control of air flow, Furnace pressure and feed water, steam temperature control, Safety provisions / Interlocks. Analysis of System load curve, plant load factor, availability, Loss of load Probability calculations for a power system, Maintenance Scheduling Pricing of Power, Project cost components, Analysis of Power Purchase Agreements (PPA), Debt/Equity Ratio and effect on Return on Investment, Environmental Legislations/Government Policies Optimal Dispatch, Scheduling of Hydro-Thermal plants. Load Forecasting - Time series, Econometric, end use techniques. Least Cost Power Planning, Integration of DSM, Renewable into supply.

Text/References:

- R.W.Haywood, Analysis of Engineering Cycles, 4th Edition, Pergamon Press, Oxford, 1991.
- D. Lindsay, Boiler Control Systems, Mcgraw Hill International, London, 1992.
- H.G. Stoll, Least Cost Electrical Utility / Planning, John Wiley & Sons, 1989.
- T.M. O' Donovan, Short Term Forecasting: An introduction to the Box Jenkins Approach, Wiley, Chichester, 1983.
- A.B.Gill, Power Plant Performance, Butterworths, 1984.
- Wood, A.J., Wollenberg, B.F., Power Generation, operation & control, John Wiley, New York, 1984.

ES611 Materials and Devices for Energy Applications 3-1-0

Course Content

Device fabrication technologies: diffusion, oxidation, photolithography, sputtering, physical vapor deposition, chemical vapor deposition (CVD), plasma enhanced CVD (PECVD), hot wire CVD (HWCVD), etc. Introduction to material characterization: Scanning electron microscopy (SEM), Transmission electro microscopy (TEM), X-ray diffraction (XRD), Raman spectroscopy, Atomic force microscopy (AFM), Spectral response of solar cells, quantum efficiency analysis, dark conductivity, I-V characterization. Introduction to physics of semiconductor devices and basics of solar cells High efficiency solar cells, PERL Si solar cell, III-V high efficiency solar cells, GaAs solar cells, tandem and multi-junction solar cells, solar PV concentrator cells and systems, III-V, II-VI thin-film solar cells (GaAs, Cu(In,Ga)Se2, CdTe) Nano-, micro- and poly-crystalline Si for solar cells, mono-micro silicon composite structure, crystalline silicon deposition techniques, material and solar cell characterization, advanced solar cell concepts and technologies (Porous Si layer transfer, Metal induced crystalization, etc.). Amorphous silicon thin-film (and/or flexible) technologies, multi-junction (tandem) solar cells, stacked solar cells. Conjugated polymers, organic/plastic/flexible solar cells, polymer composites for solar cells, device fabrication and characterization. Materials and devices for energy storage; Batteries, Carbon Nano-Tubes (CNT), fabrication of CNTs, CNTs for hydrogen storage, CNT-polymer composites, ultra-capacitors etc. Polymer membranes for fuel cells, PEM fuel cell, Acid/alkaline fuel cells.

Text/References:

- Solar cells: Operating principles, technology and system applications, by Martin A. Green, Prentice-Hall Inc, Englewood Cliffs, NJ, USA, 1981.
- Semiconductors for solar cells, H. J. Moller, Artech House Inc, MA, USA, 1993. Solid State electronic devices, Ben G. Streetman, , Prentice-Hall of India Pvt. Ltd., New delhi 1995.
- Carbon nanotubes and related structures: New material for twenty-first century, P. J. F. Harris, Cambridge University Press, 1999.
- Thin-film crystalline silicon solar cells: Physics and technology, R. Brendel, Wiley-VCH, Weinheim, 2003.

Elective-III

ES612 Solar Heating and Cooling 3-1-0

Course Content

Conversion of solar energy to heat, overview of solar technologies, energy supplied by solar technologies, solar collectors, collectors for higher temperatures, thermal energy storage, temperature stratification, thermal design of air based storage systems, solar energy economics, solar system optimization, Design and operation of solar water heating systems, passive solar space heating systems, space heating loads, passive system performance prediction. Mechanical solar- space heating systems, Solar cooling, cooling requirements, collector design for solar-cooled building, comparison of mechanical and absorption refrigeration systems, Desiccant cooling systems, Non mechanical systems, solar photovoltaic energy systems, solar pond, wood stoves.

Text / References:

- Daniel D. Chiras, The Solar House: Passive Heating and Cooling, chelsea green publishing company
- Frank Kreith ,Solar Heating and Cooling: Active and Passive Design,CRC Press
- David Bainbridge, Ken Haggard, Passive Solar Architecture: Heating, Cooling, Ventilation, Daylighting and more using natural flows ,chelsea green publishing company
- T. J. Consroe, F. M. Glaser, R. W. Shaw, Potential environmental impacts of solar heating and cooling systems

ES613 Wind Energy Conversion 3-1-0

Course Content

Wind machine types, classification, parameters. Wind, its structure, statistics, measurements, data presentation, power in the wind. Wind turbine aerodynamics, momentum theories, basic aerodynamics, airfoils and their characteristics, Horizontal Axis Wind Turbine (HAWT) - Blade Element Theory, wake analysis, Vertical Axis Wind Turbine (VAWT) aerodynamics. HAWT rotor design considerations, number of blades, blade profile, 2/3 blades and teetering, coning, power regulation, yaw system, tower. Wind turbine loads, aerodynamic loads in steady operation, wind turbulence, static - dynamic - fatigue analysis, yawed operation and tower shadow, WECS control system, requirements and strategies. Wind Energy Conversion System (WECS) siting, rotor selection, Annual Energy Output (AEO). Synchronous and asynchronous generators and loads, integration of wind energy converters to electrical networks, inverters. Testing of WECS. Noise. Miscellaneous topics.

Text/References:

- Freris L.L., Wind Energy Conversion Systems, Prentice Hall 1990.
- Spera D.A., Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering, ASME Press, NY 1994.
- Johnson, G.L., Wind Energy Systems, Prentice Hall, 1985.