Programme: M. Sc. (Physics)
Course Code: PHC-309 **Title of the Course:** Physics of Non-conventional Energy Sources
Number of Credits: 4
Effective from AY: 2018-19

Prerequisites for the course:	Student should have studied the energy science at B.Sc. level and aware of different types of renewable energy sources and how to harness energy from them.	
Objective:	To develop the awareness among M.Sc. II students about different types of energy sources and their application to solve the present energy crisis and our day to day need of energy. It also helps them to understand the basic physics involved in different ways by which they can extract the energy from wind, ocean, biomass, geothermal, solar energy sources. It also give them basic understanding of fuel cell and hydrogen as an energy source for future generations.	
Content:	1. **An Introduction to Energy Sources** Renewable and non-renewable energy sources, energy consumption Global and National scenarios, Prospects of non-conventional Energy Sources- scope and potential. **Solar radiations** Extra terrestrial radiation, Spectral distribution of solar radiation, Solar constant, Measurement of solar radiations, Solar radiation geometry, Flux on a plane surface, Latitude, Declination angle, Surface azimuth angle, Hour angle, Zenith angle, Solar altitude angle, expression for angle between incident beam and the normal to a plane surface. **Solar energy** Solar thermal power and it's conversion, Solar collectors, Flat plate, Performance analysis of flat plate collector, Solar concentrating collectors, Types of concentrating collectors, Thermodynamic limits to concentration, Cylindrical collectors, Thermal analysis of solar collectors, Tracking CPC and solar swing . Solar thermal energy storage, Different systems, solar pond. Applications: Water heating, Space heating & cooling, Solar distillation, solar pumping, solar cooking, Greenhouses, Solar power plants. **Solar photovoltaic system** Photovoltaic effect, Efficiency of solar cells, Semiconductor materials for solar cells, Solar photovoltaic system,	20 hours 20 hours

	Standards of solar photovoltaic system, Applications of PV system, PV hybrid system.	8 hours
	2. **Wind Energy** Principle of wind energy conversion; Betz model, wind mills- horizontal axis and vertical axis, horizontal axis wind turbines, their components. Vertical axis- Magnus effect, Madaras & Darrieus turbine. Analysis of aerodynamic forces acting on wind mill blades and estimation of power output.	4 hours
	3. **Energy from Biomass** Photosynthesis, Bio gas production Aerobic and anaerobic bio-conversion process, Raw materials, Properties of bio gas, Producer gas, Biomass conversion technologies, Biogas generation plants, classification, advantages and disadvantages, Fuel properties of bio gas, utilization of biogas.	4 hours
	4. **Geothermal Energy** Structure of earth's interior, geothermal sites, geothermal resources, Principle of working, Estimation and nature of geothermal energy, Types of geothermal stations, advanced concepts, Problems associated with geothermal conversion.	6 hours
	5. **Energy from the ocean** Principle of ocean thermal energy conversion, systems like open cycle, closed cycle, Hybrid cycle, Energy from tides, basic principle of tidal power, single basin and double basin tidal power plants, advantages, limitation and scope of tidal energy. Wave energy conversion machines, power plants based on ocean energy advantages and disadvantages of wave energy.	3 hours
	6. **Fuel Cells** Introduction, Design principle and operation of fuel cell, Types of fuel cells, conversion efficiency of fuel cell, application of fuel cells. Efficiency of fuel cells, operating characteristics of fuel cells, Advantages and future potential of fuel cells.	3 hours
	7. **Hydrogen Energy** Properties of hydrogen as a source of renewable energy, Hydrogen Production methods, Hydrogen storage, hydrogen transportation, utilization of hydrogen gas as a fuel, hydrogen as alternative fuel for vehicles. Development of hydrogen cartridge.	
Pedagogy:	lectures/ tutorials/laboratory work/ field work/ / project work/viva/ seminars/term papers/assignments/ presentations/ self-study	

Learning Outcomes:	1 General awareness among students regarding energy sector, its scenarios and crisis. 2 How to harness energy from different non-conventional energy sources like sun, wind, geothermal energy, ocean, fuel cell, biomass, hydrogen etc 3 The basic physics and technical intricacies involved in energy extraction from non conventional energy sources. 4. Understand the importance of utilizing energy wisely or else to face the dire consequences.	
References/Readings	1. N. K. Bansal, Manfred Kleemann, Michael Meliss, Renewable energy sources and conversion technology, Tata Mc Graw Hill (1990). 2. D.P. Kothari, K. C. Singal, R. Ranjan, Renewable energy resources and emerging technologies, Prentice Hall of India Pvt. Ltd (2011). 3. Rai G.D, Non-Conventional energy Sources, Khanna Publishers (2011). 4. Ashok V. Desai, Nonconventional Energy, New Age International Publishers Ltd (2005). 5. J. Twidell and T. Weir, Renewable Energy Sources, Taylor & Francis (1986). 6. Sukhatme, Solar Energy, Tata McGraw-Hill Education, (1996). 7. B. S. Mangal, Solar Power Engineering, McGraw-Hill Education (India) Pvt Limited, (1999). 8. D. Yogi Goswami, Frank Kreith, Jan F. Kreider, Principles of Solar Energy, Taylor & Francis (2000).	