Course number : ENR 124
Course title : **Renewable energy conversion technologies - I**
No. of credits : 4
No. of lectures-tutorial-practicals : 52-4-0
Faculty Name : Dr. Ramkishore Singh, Ms Ashu Verma, Dr. Najmur Rahman

Course outline

Solar energy is one of the most abundant and freely available natural energy resources. Solar energy is used for various applications including space heating, cooling, lighting, process heat for industrial purposes and also electricity generation through PV system and steam power plant. The conversion of solar energy into electricity through both ways is very crucial and involves technical issues. This course covers the basics of conversion technologies and system designing techniques and also the methods of direct use of solar energy in daily life. After undergoing this course, the students will be able to handle the conversion process, and system designing as per the application and their impact on environment.

Evaluation procedure

- Assignments : 20%
- Two Minor Exams : 15% each
- Major Exam : 50%

Details of course contents and allotted time

Sr. No	Contents	Time allotted (hours)		
		Lecture	**Tutorial**	**Practical**
Part A: Solar photovoltaic* systems *(1.5 credits)				
1.	***Physics of semiconductors and solar cells:*** crystal structure, band theory, energy band diagrams, carrier transport phenomena, depletion region, formation of barrier, measurement of barrier height, ohmic contact, Intrinsic and extrinsic semiconductors, thermoelectric and photoelectric effects, photoconductivity, doping, p-n junctions, homo junctions, heterojunctions, photodetectors and solar cells, working of solar cells, I-V characteristics, C-V characteristics, conversion efficiency, losses in solar cells, high efficiency solar cells, quantum dots, multi junction solar cells	6	1	0

Sr. No	Contents	Time allotted (hours)		
		Lecture	**Tutorial**	**Practical**
2.	***Solar cell technologies:*** Material selection, solar cell fabrication, amorphous, single and poly crystalline silicon solar cells, thin film solar cells, organic solar cells, first-, second- and third-generation solar cells, advantages, drawbacks, latest developments; concentrated PV systems. Testing, standardization and evaluation of solar cells.	3	0	0
3.	***Solar PV systems:*** Solar PV generator, battery storage, charge controller, inverter, stand alone, direct coupled and hybrid systems, SPV system design guideline and methodologies, thumbrules, system sizing, introduction to PVSys, ANSOL, HOMER	8	1	0
4.	***Solar PV applications****:* Lighting, refrigeration, telecommunications, aerospace, agriculture, fencing, water purification, navigation, defence, offshore, etc.	2	0	0
Part B: Solar thermal systems (1.5 credits)				
1.	***Solar collectors:*** General description; general characteristics; thermal analysis; short term and long term performance; evacuated tube collectors; thermo-siphon system	6	1	0
2.	***Concentrating solar collectors:*** General description; concentrators, receivers and orienting systems; general characteristics; thermal analysis; performance; materials; parabolic collectors; dish collectors.	5	0	0
4.	***Energy Storage:*** Sensible heat and latent heat storage systems, thermo-chemical storage, shallow solar pond, collector-cum-storage heaters, salinity gradient solar pond, solar thermal storage systems.	6	1	0
3.	***Utilization Systems:*** Solar cookers: Box type and dish type cookers; water heaters; dryers; desalination systems; power	2	0	0

Sr. No	Contents	Time allotted (hours)		
		Lecture	**Tutorial**	**Practical**
	generation systems: power tower, distributed line focus and point focus systems, solar pond based power plants; furnaces.			
Part C: Passive solar architecture: (1 credit)				
1.	***Climate and human thermal comfort:*** Factors affecting climate; climatic zones and their characteristics; urban climate; microclimate; implications of climate on building design; principles of energy conscious design, Building materials, embodied energy of building materials, alternative building materials	5	0	0
2.	***Thermal performance of buildings:*** Heat Transfer: conduction, convection, radiation; evaporation; solar radiation; radiation on tilted surfaces; unshaded surface; shaded surface; simplified method for performance estimation	3	0	0
3.	***Passive concepts for heating and cooling:*** Passive heating: direct gain, indirect gain, thermal storage wall, roof top collectors, isolated gain, solarium Passive cooling: Ventilation cooling, wind tower, nocturnal cooling, evaporative cooling, roof surface evaporative cooling (RSEC), direct evaporative cooling using drip-type (desert) coolers, nocturnal radiation cooling, earth coupling, earth-air pipe system Daylighting: basic principles and systems	4	0	0
4.	***Rating systems of energy efficient buildings:*** LEED, GRIHA and others	2	0	0
	Total	**52**	**4**	**0**

The course is reviewed by the following experts.

Prof. J S Saini, Professor Emeritus, Department of Mechanical and Industrial Engineering, IIT Roorkee

Dr. OS Sastry, Scientist F, Solar Energy Centre (MNRE), Gwalpahari, Gurgaon.

Dr. G Rajeswaran, Group Chief Technology Officer, Moser Baer India Ltd.

Suggested readings

Text Books:

- **Renewable Energy Engineering and Technology – A Knowledge Compendium**, ed. VVN Kishore (TERI Press, *2008*).

Reference Books:

- SM Sze, Kwok K Ng: **Physics of semiconductor devices**, third edition (John Wiley & Sons, 2007)
- MA Green: **Solar Cells Operating Principles, Technology, and System Applications** (Prentice-Hall, 1981)
- MA Green: **High Efficiency Silicon Solar Cells** (Trans Tech Publications)
- SJ Fonash: **Solar Cell Device Physics** (Academic Press, 1982)
- **Handbook of photovoltaic science and engineering,** ed. Antonio Luque and Steven Hegedus (John Wiley and Sons)
- Anna Mani, S Rangarajan: **Handbook of Solar Radiation Data for India, 1980** (Allied Publishers)
- Richard C Neville, RC Neville, Bas Van Der Hoek: **Solar Energy Conversion: The Solar Cell** (Elsevier Science & Technology)
- Peter Würfel : **Physics of Solar Cells: From Basic Principles to Advanced Concepts** (Wiley-VCH)
- JF Kreider and F Kreith: **Solar Heating and Cooling: Active and Passive Design** (Hemisphere Publishing Corporation, 1982)
- **Low Temperature Engineering Application of Solar Energy**, ed. RC Jordan (ASHRAE)
- HP Garg and J Prakash: **Solar Energy: Fundamentals and Applications** (Tata McGraw Hill)
- AB Meinel & MP Meinel: **Applied Solar Energy: An Introduction** (Addison)
- JA Duffie and WA Beckman: **Solar Engineering of Thermal Processes**, Third Edition (John Wiley & Sons)
- S Sukhatme and J Nayak: **Solar Energy: Principles of Thermal Collection and Storage**, Third Edition (Tata McGraw Hill, 2008)