GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering (Mechanical, Energy Engineering)
Subject Code: 3723919
Semester – II
Subject Name: Solar Photovoltaic Devices and Systems

Type of course: Program Elective

Prerequisite: Knowledge of renewable energy

Rationale: The course intends to provide knowledge of photovoltaic cell, photovoltaic systems and solar photovoltaic applications to graduate students.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Physics of PV Cell:** Introduction, Optical Absorption, Semiconductor physics – atomic structure – doping – carrier concentration, Homogeneous and heterogeneous p-n junctions, PV Characteristics and maximizing PV cell performance, Junctions, Solar cells in series and parallel.	**6**
2	**PV Cells:** Working of Solar cell, Crystalline silicone solar cells – production of silicon waters, Fabrication of solar cells, Thin film solar cells – why thin film solar cell?, transparent conducting oxides, III-V PV technology, Thin Film silicon technology, Organic photovoltaic, Hybrid organic-Inorganics solar cells, Third and fourth Generation Concept, Present and proposed PV cells, Different materials for crystalline and Thin film solar cell, Properties of crystalline and thin film solar cells.	**8**
3	**Introduction to PV Systems:** Introduction, Status and prospects of PV Systems, Location issue – position of sun – sun path, PV cell – module – array, Irradiation on PV module, Shadowing, Maximum power point tracking, Types and component of PV system, Energy storage – types of battery - hydrogen storage - fuel cell, PV system load and availability, Associated electronic components, Generators – types and size – characteristics, maintenance - selection, Wiring and code compliance, Balance of system, PV System design – load profile – Meteorological effect – Design of grid and off grid PV system, PV system economy and ecology.	**13**
4	**Solar PV Applications:** Introduction, PV powered fan – module, fan with battery backup, PV powered pumping system – system component requirement – design approach for simple pumping system, PV powered area lighting system – lightening load calculation and system. **Stand Alone PV System:** Need for the refrigeration system – specification and implementation, PV powered Remote cabin – specification and implementation, Hybrid powered residence – specification and implementation, Installation requirement – operation and maintenance, Cost consideration for the PV applications.	**15**

	Utility Interactive PV System: Introduction, Nontechnical barriers Technical consideration for connecting to Grid, Small utility interactive PV system – Array installation – PCU selection and mounting, Residential rooftop system – with AC Module – with battery, medium and large utility interactive PV system.	

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**20**	**20**	**20**	**20**	**10**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1) Photovoltaic Systems Engineering, Roger A. Messenger and Jerry Venture, CRC Press.
2) Solar Photovoltaic: Fundamentals, Technologies and Applications, Chetan Singh Solanki, PHI learning Pvt. Ltd.
3) Solar Energy – Fundamentals, Technology and Systems, K. Jager, O. Isabella, A. H. M. Smets, R. A. C. M. M. van Swaji, M. Zeman, Delft University of Technology, 2014.
4) Thin Film Solar Cells, Kasturi lal Chopra and Suhit Ranjan Das, Springer Science + Business Media, LLC.
5) Handbook for Solar Photovoltaic Systems, Energy market authority, Building and Construction authority.

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To understand the fundamentals / physics of solar photovoltaic cell.	15%
CO-2	To study the various types, materials of solar PV cell and generation development concept.	20%
CO-3	To discuss the components of PV system and design of grid and off-grid PV system.	30%
CO-4	To discuss the various types applications of solar PV systems.	35%

List of Experiments:

1) Identifying and measuring the parameters of a solar PV Module in the field.
2) Series and Parallel connection of PV Modules.
3) Estimating the effect of Sun tracking on energy generation by solar PV modules.
4) Efficiency measurement of standalone solar PV system.
5) Dark and Illuminated Current- Voltage characteristics of solar Cell.
6) Solar cells connected in series and in parallel.
7) Dependence of Solar cell I- V characteristics on light intensity and temperature.
8) Carrier Lifetime measurements for a solar cell.

9) Solar cell simulation using PC1D simulator.
10) SEQUEL: Using the GUI.

Major Equipment:

Solar simulator, Solar cell, Series and parallel connection of solar cell, PV Module characterization kit, Series and parallel connection of PV module, Standalone solar PV System, PC1D simulator, SEQUEL, multi meter for measurement of AC and DC voltage.

List of Open Source Software/learning website:

1) http://ocw.mit.edu/courses/energy-courses/
2) https://nptel.ac.in/courses/117108141/
3) http://www.ese.iitb.ac.in/~chetan/PVmaterial.html
4) https://nptel.ac.in/courses/108105058/17