Course and Evaluation Plan - EN 516 [Spring-2024]

School: **Engineering**
Department: **Energy**
Course Code: **EN 516**
Course Name: **Advanced Solar Thermal Energy**
Total credit **3-0-0 (L–T–P)**
Instructor: **Dr Vikas Verma**

1. Abstract:

This course deals with the understanding of solar energy, various types of solar thermal collectors for design aspects, thermal energy storage and its applications. Performance analysis of all types of solar thermal collector is taught in this course using theory and numerical examples. This course includes an overview of the main design features of different types of thermal collectors, advantages and disadvantages and their applicability to commercial as well as industrial point of view.

2. Objective: (*what the course seeks to do*)

The course is designed with an objective to educate students for different solar thermal energy conversion and storage devices and to develop competency for research and development of such devices. At the end of the course, the student should be capable to:

i. Design and development of different components of solar thermal systems
ii. Address challenges of solar thermal collectors and storage
iii. Estimate and model losses in different solar energy components and systems
iv. Apply the understanding of types of solar collectors and power generation.

Furthermore, the objective of the different units of the course has been given in the table below. At the end of the following units the student is capable of:

Unit	Topic	Learning Objectives
Unit 1:	Solar thermal system and radiation transmission	To understand the importance of Solar thermal energy and radiation transmission and its application.
Unit 2:	Flat plate and evacuated tube collector	To understand the different conversion devices of solar radiation in different fields of thermal energy requirement.
Unit 3:	Concentrating collector	To understand the conversion of solar energy to heat energy, various aspects of design and their application
Unit 4:	Solar thermal power plant and industrial process	To understand the importance and technique of solar thermal power generation.
Unit 5:	Thermal energy storage	To understand the importance of thermal energy storage and its applications.

3. Prerequisites of the course:

Student must have understanding on various solar thermal energy conversion processes and devices in various utilities.

4. Course outline:

Units/Modules	Topic to be covered	Tentative Lecture/ Tutorial
Unit 1: Solar thermal system and radiation transmission	1. General overview of solar Energy and solar thermal system 2. Different design and components of solar thermal system 3. Radiation transmission and absorption through glazing 4. Selective surfaces: Ideal coating characteristics, Anti reflection coating	**7**
Unit 2: Flat plate and evacuated tube collector	1.Theory and basic design of flat plate collector, performance analysis 2. Thermal analysis and effective heat loss, operating principles 3. Flat plate solar dryer, issues and challenges 4. Basic construction of an evacuated tube collector: Thermal analysis, effective energy loss and applications	**8**
Unit 3: Concentrating collector	1. Concentrating collector: Classification of concentrating collector, concentrating collector configurations 2. Concentration ratio: optical, geometrical 3. Thermal performance of concentrating collector, Optical and thermal performance of different concentrating collector designs 4. Parabolic trough concentrators, Compound parabolic concentrator, Concentrators with point focus	**10**
Unit 4: Solar thermal power plant and industrial process	1.Solar thermal power plant: Central receiver systems; Heliostats 2. Comparison of various designs: Parabolic trough systems, Rankine cycle, Parabolic Dish - Stirling System, Combined Cycle 3. Solar industrial process heat: Integration of solar thermal system with industrial processes 4. Mechanical design considerations, Economics of industrial process heat	**10**
Unit 5: Thermal energy storage	1. Solar thermal energy storage: Sensible storage, Latent heat storage 2. Thermo-chemical storage, High temperature storage 3. Designing thermal storage systems	**6**
Total		**41**

5. Pedagogy:

The classroom teaching will include lectures; interactive sessions on the topics of the course; seminars on the chosen topics of current research on solar energy etc. Students will be required to submit one write-up on the chosen seminar topics. It is expected that this kind of teaching-learning activities will help in developing analytical and research oriented thinking of the students. In summary teaching learning method to be adopted for the course are:

- Lecture/Discussion using ICT tool and white board
- Flipped classroom
- Interactive sessions
- Assignment and Presentations
- Problem Solving

6. Evaluation plan

Course Outcomes	CO1	C02	CO3
Weightage (%)	35	30	35
Marks	52.5	45.0	52.5

Course Outcomes	Weightage of Marks	Test I (25)	Mid Term Test (40)	Test II (25)	Semester End (60)	Total (150)
CO1	35	20	15		18	53
C02	30	5	15	5	20	45
CO3	35		10	20	22	52
Total	100	25	40	25	60	150

Assessment Criteria			Marks distribution				
Bloom Taxonomy	Level	Marks Weightage (%)	Marks	Test I (25)	Mid Term Test (40)	Test II (25)	Semester End (60)
Knowledge	Easy	10	15	5	5		5
Understanding	Easy	10	15	5	5		5
Application	Average	30	45	15	15		15
Analysis	Above average	30	45		10	15	20
Synthesis	Difficult	12	18			10	8
Evaluation	Difficult	8	12		5		7
TOTAL		100	150	25	40	25	60

7. Expected outcome:

Solar energy has got a lot of attention globally to mitigate adverse effect of power generation on environment. Human resource is required to design, develop and operate different solar energy systems which are installed and in process of development. This course will contribute in learning of the students of M.Tech in Energy Technology course to develop new technologies in the area of solar thermal energy system either through research or industrial initiative.

8. Suggested reading materials

Text Book

1. Duffie J. A. and Beckman W. A. (2013); Solar Engineering of Thermal Processes, John Wiley
2. Solanki C. S. (2009); Solar Photovoltaics: Fundamentals, Technologies and Applications,

Reference Book

1. Goswami D Y, Frank Kreith and J F Kreider, Taylor & Francis (1999), Principles of Solar Engineering, Taylor & Francis, USA
2. Garg H.P. and Prakash S (1997), Solar Energy: Fundamental and Application, Tata McGraw Hill, New Delhi
3. Kreith F. and J. F. Kreider, (1978), Principles of Solar Engineering , McGraw Hill