

**SOLAR ENERGY ENGINEERING
(REEN 5201)**

Time Allotted : 3 hrs

Full Marks : 70

Figures out of the right margin indicate full marks.

*Candidates are required to answer Group A and
any 5 (five) from Group B to E, taking at least one from each group.*

Candidates are required to give answer in their own words as far as practicable.

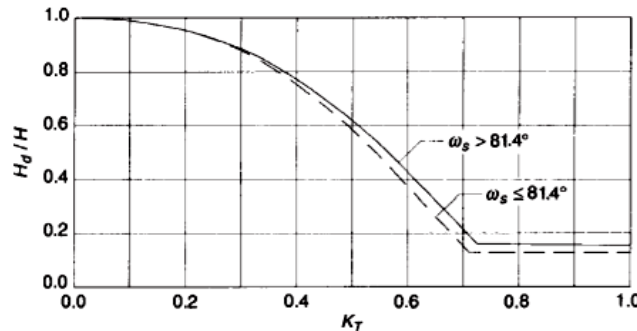
**Group - A
(Multiple Choice Type Questions)**

1. Choose the correct alternative for the following: **10 × 1 = 10**
- (i) Collector performance is given by the following formula
(a) $\eta = \frac{Q_u}{I_T A_C}$ (b) $\eta = \frac{Q_u}{I_b A_C}$ (c) $\eta = \frac{A_C Q_u}{I_T}$ (d) $\eta = \frac{A_C Q_u}{I_T}$
- (ii) Diffuse radiation energy can be calculated
(a) if total radiation is known
(b) if total radiation and clearness index is known
(c) if clearness index is known
(d) none of above.
- (iii) Which of the following material is used in solar cells?
(a) Barium (b) Silicon (c) Silver (d) Selenium
- (iv) Reflector mirrors employed for exploiting solar energy are called the
(a) mantle (b) heliostats (c) diffusers (d) ponds.
- (v) Sputtering is a mode of film deposition in
(a) silicon solar cells (b) organic solar cells
(c) a-Si solar cells (d) chalcopyrite based solar cells.
- (vi) The radiation factor R_b for a tilted surface measure the ratio of
(a) $\cos \theta / \sin \theta$ (b) $\cos \theta / \sin \theta_z$ (c) $\cos \theta_z / \sin \theta$ (d) $\cos \theta / \cos \theta_z$
- (vii) Diffuse radiation model includes radiation energy from
(a) isotropic sky (b) circumsolar radiation
(c) all of above (d) only (a)
- (viii) Which among the following surface can absorb the maximum radiations coming from sun?
(a) Silver surface (b) Black surface
(c) White surface (d) All of the above

- (ix) The process of edge isolation in silicon solar cell processing
 (a) electrically insulates the wafer edge
 (b) electrically separates one wafer from another
 (c) is done through chemical vapour desposition
 (d) is not needed.
- (x) Thin film conducting oxides are needed
 (a) single crystalline solar cells
 (b) dye-sensitive solar cells
 (c) CdTe solar cells
 (d) none of above.

Group- B

2. (a) Calculate the angle of incidence of beam radiation on a surface located at Kolkata India (22N and 88E), at 10:30 am on April 13 if the surface is tilted 45° from the horizontal and pointed 15° west of south. [(CO1,CO2)(Analyze/IOCQ)]
 (b) The day's total radiation on a horizontal surface for Kolkata India (22N 88E) is 23.0 MJ/m² on April 13. Estimate the amount and fraction that is diffuse radiation. The following chart may be used



[(CO1,CO2)(Estimate/HOCQ)]

6 + 6 = 12

3. (a) Find the convection heat transfer coefficient between the plate and cover of a flat plate collector separated by 25mm with a 35° tilt angle. The plate is at 80°C and the cover is at 50°C. The Nusselt number can be obtained from the following equation:

$$Nu = 1 + 1.44 \left[1 - \frac{1708(\sin 1.8\beta)^{1.6}}{Ra \cos \beta} \right] \left[1 - \frac{1708}{Ra \cos \beta} \right]^+ + \left[\left(\frac{Ra \cos \beta}{5830} \right)^{1/3} - 1 \right]^+$$

The properties of air are $k = 0.029$ W/m K, $\nu = 1.88 \times 10^{-5}$ m²/s, and $\alpha = 2.69 \times 10^{-5}$ m²/s.

[(CO1,CO2)(Estimate/HOCQ)]

- (b) Discuss the differences in forced and natural convection solar water heating systems. Comment on the peripherals that are different in the two systems.

[(CO1,CO2)(Remember/HOCQ)]

5 + 7 = 12

Group - C

4. (a) Define optical losses and thermal losses of a solar collectors.

[(CO2)(Understand/IOCQ)]

- (b) What is the efficiency of parabolic collector? Describe the thermal performance characteristics parabolic trough collectors. [(CO2)(Analyze/LOCQ)]
5 + 7 = 12
5. (a) What is aperture area in a solar collector? [(CO2)(Understand/LOCQ)]
(b) Define solar concentrators and receivers and their importance. State the desired properties of solar concentrator. [(CO2)(Understand/IOCQ)]
(c) Describe the working principle of Paraboloid dish collectors. [(CO2)(Understand/LOCQ)]
(d) Obtain an optimized expression of angle of incident for each mode of solar tracking. [(CO2)(Analyze/HOCQ)]
2 + 5 + 2 + 3 = 12

Group - D

6. (a) Define solar cell. Define fermi level and energy bang gap of a material. [(CO4)(Remember/LOCQ)]
(b) Why doping is required for the solar cell? Define n-type and p-type semiconductor. [(CO3)(Remember/LOCQ)]
(c) Define drift and diffusion current. [(CO3)(Analyze/IOCQ)]
(2 + 4) + 4 + 2 = 12
7. (a) Describe the generation and recombination processes. C, Si and Ge have same lattice structure. Why is C insulator while Si and Ge intrinsic semiconductors? [(CO3)(Remember/LOCQ)]
(b) What is the difference between solar array and solar module? What are the main advantage of concentrator system over flat plate system? [(CO3)(Understand/LOCQ)]
(c) Define PC1D and its importance in the solar cell. [(CO3)(Understand/LOCQ)]
4 + 3 + 5 = 12

Group - E

8. (a) In what step of the a-Si cell manufacturing process are plasma assisted process used and how? [(CO5,C04)(Analyse/IOCQ)]
(b) Describe the chemical bath deposition process with detailed chemistry for the chalcopyrite based cells? [(CO5)(Remember/LOCQ)]
(c) State two advantages of chalcopyrite based solar cells. [(CO5)(Remember/LOCQ)]
6 + 4 + 2 = 12
9. (a) Why is the bypass diode thermal test done? What is PID degradation? [(CO5,C04)(Remember/LOCQ)]
(b) What is an exciton? Describe the working mechanism of an OPV. [(CO5)(Remember/LOCQ)]
6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	53.12	25	21.88

Course Outcome (CO):

After the completion of the course students will be able to

1. Students will be able to characterize different modes of heat transfer with emphasis on solar radiation.
2. Students will be able to identify different technologies used for solar collectors.
3. Students will be able to evaluate the performance and efficiency of different devices that extract power from solar energy.
4. Students will be able to explain the basics of solar PV cells and relevant parameters for its characterization.
5. Students will be able to explain the important features of first to third generation solar cell technology

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Quest