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CMRIT

Internal Assessment Test – 1

Sub: Technologies of Renewable Energy Sources				Code: BEE654B
Date: 27/03/2025	Duration: 90 min	Max Marks: 50	Sem: 6	Section:CSE, ISE, AI&ML, CSE(AI&ML) and CSE(DS)

Answer ANY FIVE full questions. Explain your notations explicitly and clearly. Sketch figures wherever necessary. Good luck!

		Marks	OBE CO	OBE RBT
Q1.	What are the causes for energy scarcity? Mention the factors to be considered for solving the energy crunch problems.	[10]	CO1	L1
Q2.	Define the following terms with respect to solar radiation a. Declination Angle; b. Hour Angle; c. Zenith Angle; d. Tilt Angle; e. Angle of Incidence.	[10]	CO2	L1
Q3.	Calculate the zenith angle of the sun at Lucknow (26.75° N) at 10:00 am on 21st Feb, 2012.	[10]	CO2	L3
Q4.	With neat sketch, explain flat plate collector. Discuss the material aspects of individual parts.	[10]	CO2	L2
Q5.	Draw and explain the I-V Characteristics of solar cell and the factors limiting the efficiency of the cell.	[10]	CO2	L2
Q6.	Find the number of solar cells for the array area of 28.5 m^2 if each cell has a diameter of 2.25 inch. Take 1 inch = 2.54 cm.	[10]	CO2	L3

$S_A = 28.5\ m^2$, $C_d = 2.25 \times 2.54 = 5.715\ cm$, $A_c = \frac{\pi d^2}{4} = 25.65\ cm^2$, $\frac{\text{No. of cells}}{} = \frac{S_A}{A_c}$ = 11,111 cells.

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**********All the Best**********

Q1. $\phi = 26.75°$ $n = 52$ days

$\delta = 23.45 \sin\left[360\left(\frac{284+n}{365}\right)\right] = -11.20°$

$\omega = -\frac{tm}{4} = -\frac{120}{4} = -30°$

$\theta_z = \cos^{-1}(\cos\phi \cos\delta \cos\omega + \sin\phi \sin\delta)$

$\theta_z = 47.85°$

1) What are the causes for energy scarcity? Mention the factors to be considered for solving the energy crunch problem.

→

* Over consumption :- The consumption of energy is not limited. Over consuming.
* Increasing population :- Population increasing at alarming rates equal to 17% of world population
* Uneven distribution :- The is equal distribution of energy makes scarcity
* Natural calamity :- Due to natural calamities like earthquake flood and volcanoes
* Poor distribution system :- The poor distribution system includes tripping and breakdown
* Poor infrastructure :- The outdated equipments use in every area

factors

* Switch to renewable energy
* public transport
* Minimize population
* Energy audit
* Energy management
* Awareness campaign
* Avoid wastage

a) Declination Angle (δ)

The angular position of the sun relative to the Earth's equatorial plane. Varies between +23.45° (Summer Solstice) and -23.45° (Winter Solstice) due to Earth's tilt changes daily as Earth orbit the Sun.

b) Hour Angle (ω)

Measure the time difference from solar noon in angular terms

Defined as 15° per hour (Earth rotates 360° in 24h)

c) Zenith Angle (θ_z)

The angle between the Sun's rays and the vertical (directly overhead).

$\theta_z = 90° - \text{Altitude}(\alpha)$. At solar noon, the zenith angle is at its minimum.

d) Tilt Angle (β)

The angle at which a solar panel or surface is tilted from the horizontal optimized based on latitude.

Typically β = latitude for best year round efficiency

e) Angle of Incidence (θ_i)

The angle between the incoming solar rays and the perpendicular to the surface

Determines how much sunlight is absorbed by surface.

3. Calculate zenith angle of sun at Lucknow (26.75° N) at 10.00 am on 21 Feb 2012

Solution: Total no. of days = 53

$$\delta = 23.45 \times \sin\left(360 \times \frac{284 + 53}{365}\right)$$

$$= -19.1^\circ \text{ (approx)}$$

$$t_m = 12:00 - 10:00 = 120 \text{ min}$$

$$\omega = 1/4 \times t_m = 1/4 \times 120 = 30$$

$$\phi = 26.75$$

$$\cos\theta_z = \cos\phi \cos\delta \cos\omega + \sin\phi \sin\delta$$

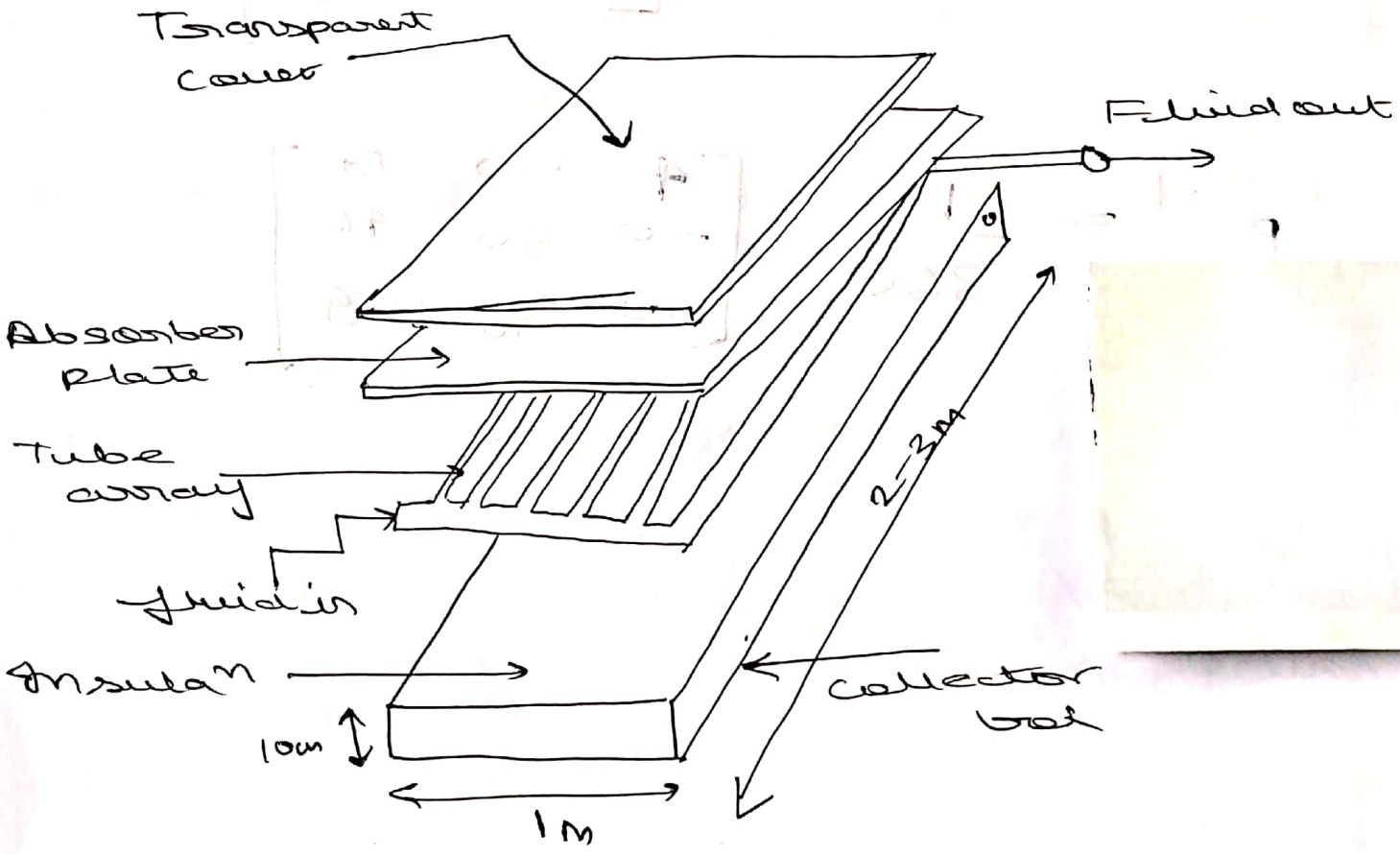
$$= \cos(26.75) \cdot \cos(-19.1) \cos(30) + \sin(26.75) \sin(-19.1)$$

$$= 0.673$$

$$\theta_z = \cos^{-1}(0.673)$$

$$= 47.7^\circ$$

4) With neat sketch, explain flat plat collector. Discuss the material aspect of individual parts.



Flat Plate Collectors:

- Uses air as heat transport medium
- Absorber plates can be made of metal sheets, layers of screen, or non-metallic materials.
- Air passes through absorber using natural convection or fan and absorbs heat.
- Warm air is vented out into the space

Components :

- Metallic plate and tubes, copper, aluminium steel or plastic
- Have good thermal efficiency
- Metallic tubes diameter ranges from 1cm to 1.5 cm
- Soldered, welded, brazed or pressure bonded to absorber plate.

Glazing :

→ Transparent and most widely used, absorb shorter wavelength radiation

→ Opaque for infrared radiations, traps heat and reduces reflection.

Insulation :

→ Reduces heat losses

→ Resists high temperature

→ Does not shrink or melt

Casing

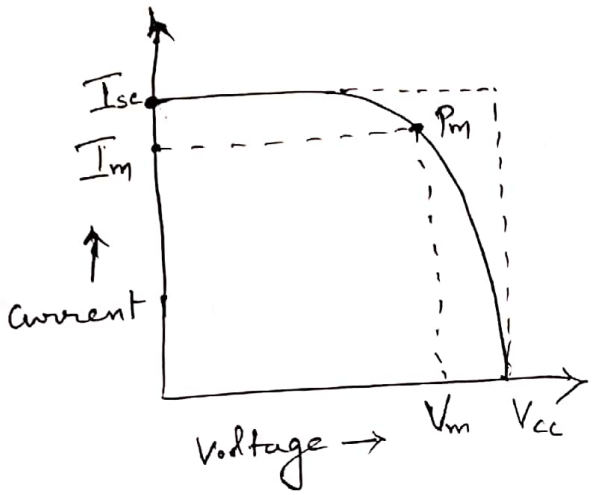
→ Provides Structural Stiffness

→ Holds together the transport cover, the absorber and the insulation

→ Drain and ventilation holes to avoid penetration

Q.) Draw and explain I-V characteristics of solar cell and factors

(5) I-V Characteristics of Solar Cell :-



A solar cell converts sunlight into electricity through the photovoltaic effect. Its performance is represented by the current voltage (I-V) characteristics which describe the relationship between output current (I) and output voltage (V) under different conditions.

Key parameters of I-V :

* Short circuit Current (I_{sc})
The maximum current when the solar cell is shorted ($V=0$)

* Open circuit Voltage (V_{oc})
The maximum voltage when no current flows ($I=0$)

* Maximum Power point (P_{max})
The operating point where solar cell delivers maximum power.

* Fill Factor (FF)

$$FF = \frac{(V_{mpp} \times I_{mpp})}{(V_{oc} \times I_{sc})}$$

* Efficiency (η)

$$\eta = \left(\frac{P_{max}}{P_{in}}\right) * 100\%$$

Factor limiting solar cell

→ Recombination Losses

When electrons and holes recombines before contributing to current, reducing efficiency.

→ Temperature effect

High temperature reduce V_{oc}, lowering efficiency

S.l: Cooling systems and better heat-resistant materials

→ Optical Losses

Some sunlight is reflected instead of being absorbed.

6. Find the no. of solar cells of the array area 28.5 m^2 if each cell has a diameter of 2.25 inch. Take 1 inch = 2.5cm.

Sol: Diameter = 2.25 × 2.54 = 5.715 cm = 0.05715 m

Area of one solar cell

$$\text{Area} = \pi \times (d/2)^2$$

$$\Rightarrow \pi \times \left(\frac{0.05715}{2}\right)^2$$

$$= 0.002565\ m^2$$

$$\text{No. of solar cells} = \frac{\text{total array area}}{\text{Area of one cell}}$$

$$\Rightarrow \frac{28.5\ m^2}{0.002565\ m^2}$$

$$\Rightarrow 11,111 \text{ cells}$$