Name:

Enrolment No:

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2018

Programme Name: B.Tech Mechanical | **Semester : VII**
Course Name : Solar Thermal Technologies | **Time : 03 hrs**
Course Code : MHEG 451 | **Max. Marks : 100**
Nos. of page(s) : 4
Instructions: Assume the suitable data if required

SECTION A

S. No.		Marks	CO
Q 1	Differentiate between the Flat plate solar collectors and concentrating solar collectors.	4	CO2
Q 2	Explain thermo-syphon system for water heating.	4	CO3
Q 3	Describe the solar thermal air heating system for domestic house.	4	CO1
Q 4	Why the orientation is needed in concentrating type collectors?	4	CO1
Q 5	A compound parabolic collector, 1 m long, has an acceptance angle of 20^0. The absorber surface of the collector is flat and has a width of 10 cm. Calculate the concentration ratio, the aperture, the height and the surface area of the concentrator.	4	CO4

SECTION B

Q 6	Describe the solar thermal power plant with a neat diagram.	10	CO1
Q 7	Explain the working of solar refrigeration cycle with a neat diagram.	10	CO5
Q 8	Explain the working principle of compound parabolic collector with a neat sketch.	10	CO2
Q 9	Classify the concentrated solar collectors and mention its applications (OR) Explain the working of solar cookers.	10	CO2 CO3

SECTION-C			
Q 10	Explain the working of parabolic trough collector and describe its components. Discuss the limitations of its concentration ratio and derive an equation for useful heat gain.	**20**	**CO3**
Q 11	Calculate the overall heat loss coefficient U_l for the receiver of a cylindrical parabolic concentrating collector system. The receiver consists of a selectively – coated absorber tube with one glass cover around it. The following data is given: Absorber tube inner diameter : 7.5 cm Absorber tube outer diameter : 8.1 cm Glass cover inner diameter : 14.4 cm Glass cover outer diameter : 15.0 cm Emissivity of absorber tube surface : 0.15 Emissivity of glass : 0.88 Mean temperature of absorber tube : 170^0C Ambient temperature : 25^0C Wind speed : 4 m/s (OR) A CPC is mounted on a horizontal E - W axis and oriented with its aperture plane sloping at an angle of 40^0. The concentration ratio of the collector is 6.5, the width of its absorber tube plate is 6 cm and its length is 2 m. The collector is used for heating a fluid (Cp = 2.35 kJ/kg-K) which enters at a temperature of 130^0C. Calculate the exit temperature of the fluid and the instantaneous collection efficiency for the following situation. Location of the collector : New Delhi (28.58^0N) Date : November 5 Sun hour : 15^0 Ig : 0.735 kW/m^2 Id : 0.162 kW/m^2 Number of tubes : 2 Tube outer diameter : 18 mm Tube inner diameter : 14 mm Transmissivity of glass cover : 0.89 Reflectivity of concentrator : 0.87 Absorptivity of absorber surface : 0.94 Overall heat loss coefficient : 10.5 W/m^2-K Heat transfer coefficient on inside of absorber tube : 230 W/m^2-K Mass flow rate of fluid : 1.25 kg/min Ambient temperature : 21^0C	**20**	**CO2** **CO3** **CO4**

Equations for cylindrical parabolic concentrating collector.

1) Useful heat for unit length

$$\frac{q_l}{L} = h_{p-c}(T_{pm} - T_c)\pi D_o + \frac{\sigma \pi D_o (T_{pm}^4 - T_c^4)}{\left\{\frac{1}{\varepsilon_p} + \frac{D_o}{D_{ci}}\left(\frac{1}{\varepsilon_c} - 1\right)\right\}}$$

2) Useful heat for unit length

$$\frac{q_l}{L} = h_w(T_c - T_a)\pi D_{co} + \sigma \pi D_{co} \varepsilon_c (T_c^4 - T_{sky}^4)$$

3) Heat transfer coefficient between absorber tube and glass tube

$$\frac{k_{eff}}{k} = 0.317 \ (\mathrm{Ra}^*)^{1/4}$$

$$(\mathrm{Ra}^*)^{1/4} = \frac{\ln(D_{ci}/D_o)}{b^{3/4}\left(\frac{1}{D_o^{3/5}} + \frac{1}{D_{ci}^{3/5}}\right)^{5/4}} \mathrm{Ra}^{1/4}$$

$$\frac{2\pi k_{eff}}{\ln(D_{ci}/D_o)}(T_{pm} - T_c) = h_{p-c}\pi D_o(T_{pm} - T_c)$$

$$h_{p-c} = \frac{2k_{eff}}{D_o \ln(D_{ci}/D_o)}$$

4) Heat transfer coefficient on the outer surface of the glass cover.

$$\mathrm{Nu} = C_1 \mathrm{Re}^n$$

where C_1 and n are constants having the following values:

For $40 < \mathrm{Re} < 4000$, $C_1 = 0.615$, $n = 0.466$

For $4000 < \mathrm{Re} < 40\,000$, $C_1 = 0.174$, $n = 0.618$

For $40\,000 < \mathrm{Re} < 400\,000$, $C_1 = 0.0239$, $n = 0.805$

5) Take the air properties at 104^{0}C

At this temperature,

$k = 0.0323$ W/m-K

$\nu = 23.52 \times 10^{-6}$ m^2/s

$\mathrm{Pr} = 0.688$

Equations for Compound parabolic collector.

1) Heat flux

$$S = \left[I_b r_b + \frac{I_d}{C} \right] \tau \rho_e \alpha$$

2) Useful heat gain

$$q_u = F_R W L \left[S - \frac{U_l}{C} (T_{fi} - T_a) \right]$$

$$F_R = \frac{\dot{m} C_p}{b U_l L} \left[1 - \exp\left\{ - \frac{F' b U_l L}{\dot{m} C_p} \right\} \right]$$

$$\frac{1}{F'} = U_l \left[\frac{1}{U_l} + \frac{b}{N \pi D_i h_f} \right]$$

3) Tilt angle

$$r_b = \frac{\cos(L - \beta) \cos\delta \cos\omega + \sin(L - \beta) \sin\delta}{\cos L \cos\delta \cos\omega + \sin L \sin\delta}$$