Name: **Enrolment No:**	UPES UNIVERSITY OF TOMORROW

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, May 2022

Course: Solar Thermal Systems **Semester: VIII**
Program: B.Tech Mechanical **Time : 03 hrs.**
Course Code: MECH 4028P **Max. Marks: 100**

Instructions: Attempt all questions

SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q.1	Draw diagram to Illustrate the angle of incidence, the zenith angle and the solar altitude angle?	**4**	**CO1**
Q.2	Explain the variation of temperature along x, y and z axis of liquid flat plate collector?	**4**	**CO1**
Q.3	Explain the effect of number of covers on collector performance considering selective surfaces?	**4**	**CO2**
Q.4	Explain the limitations of two tank molten salt TES systems?	**4**	**CO1**
Q.5	Explain the performance characteristic of solar cell?	**4**	**CO1**

SECTION B
(4Qx10M= 40 Marks)

Q.6	Calculate the angle made by beam radiation with the normal to a flat plate collector on May 1 at 0900 h LAT. The collector is located in New Delhi ($28^0$35'N, $77^0$12'E). It is tilted at an angle of 36^0 with the horizontal and is pointing due south.	**10**	**CO3**
Q.7	Explain energy balance equation of flat plate collector considering top loss, bottom loss and side loss coefficient.	**10**	**CO2**
Q.8	Explain Thermal Ratcheting and geometrical modification required to avoid failure due to thermal ratcheting?	**10**	**CO1**
Q.9	Draw layout of concentrated solar power plant with and without thermal energy storage systems	**10**	**CO2**

SECTION-C
(2Qx20M=40 Marks)

Q.10	A cylindrical parabolic focusing collector is used for heating a thermic fluid (C_p = 2.2 kJ/kg-K) which enters with a temperature of 160 ^{0}C. The concentrator has an aperture of 1.8 m and a length of 3 m. The absorber tube has an inner diameter of 2.8 cm and outer diameter of 3.2 cm and has a concentric glass cover around it. Given that: Specular reflectivity of concentrator surface : 0.82 Intercept factor : 0.91 $(\tau\alpha)_b$: 0.8	**20**	**CO3**

	Beam radiation incident normally on aperture plane : 152 W/m^2-K Overall loss coefficient : 9.5 W/m^2-K Convective heat transfer coefficient on inside of absorber tube : 325 W/m^2-K Ambient Temperature : 27 ^{0}C Mass flow rate of the fluid : 360 kg/h Calculate the useful heat gain rate, the exit temperature of the fluid and the instantaneous efficiency.		
Q.11	Evaluate annual energy usage of a residential house based on the appliances and power consumption given in table below. Also calculate the number of PV panel require if each PV panel wattage capacity is 220 watt	**20**	**CO3**

S.No	**Appliances**	**Power consumption (watt)**	**Nos**	**Hours used each day**
1	LED Bulb	9	3	6
2	LED Bulb	9	3	8
3	LED Bulb	9	4	6
4	Fan	75	3	16
5	TV	40	1	5
7	AC (1.5 ton - 5 Star)	1350	1	10
9	Fridge (@ ENERGY STAR - 5 Star)	24.5	1	24
11	Speaker	25	1	5
12	Mobile charger	4	1	6

OR

Calculate the performance of a conventional solar air heater with the following data:

Length of collector	2.1 m
Width of collector	1.1 m
Length of absorber plate	2 m
Width of absorber plate	1 m
Spacing between absorber plate and bottom plate	1.5 cm
Air flow rate	200 kg/h
Air inlet temperature (T_{fi})	50 ^{0}C
Ambient temperature	20 ^{0}C
I_T	950 W/m^2
$(\tau\alpha)avg$	0.85
Top loss coefficient (U_t)	6.2 W/m^2-K
Bottom loss coefficient (U_b)	0.8 W/m^2-K
$\varepsilon_b = \varepsilon_p$	0.95

Useful Empirical Relations

1. Declination Angle, $\delta(in\ degree) = 23.45\ \sin\left[\frac{360}{365}\ (284 + n)\right]$ where, n = no. of days
2. Incident angle, $\cos\theta = \sin\varphi\ (\sin\delta\cos\beta + \cos\delta\cos\Upsilon\cos\omega\sin\beta) + \cos\varphi(\cos\delta\cos\omega\cos\beta - \sin\delta\cos\Upsilon\sin\beta) + \cos\delta\sin\Upsilon\sin\omega\sin\beta$
3. Liquid Flat plate collector-Collector efficiency factor: $F' = \frac{1}{WU_l\left[\frac{1}{U_l[(W-D_o)\varphi+D_0]} + \frac{\delta_A}{k_A d_0} + \frac{1}{3.14Dihf}\right]}$
4. Liquid Flat plate collector – Heat removal factor: $F_R = \frac{\dot{m}C_p}{U_l A_p}\left[1 - exp\left\{-\frac{F\prime U_l A_p}{\dot{m}C_p}\right\}\right]$
5. Parabolic collector-Collector Efficiency factor: $F' = \frac{1}{U_l\left[\frac{1}{U_l} + \frac{D_o}{D_i h_f}\right]}$
6. Parabolic Trough Collector – Heat Removal Factor : $F_R = \frac{\dot{m}C_p}{3.14 * D_o U_l L}\left[1 - exp\left\{-\frac{F' pi * U_l D_o L}{\dot{m}C_p}\right\}\right]$