N. B. :

i) Solve any **FOUR** questions.
ii) Assume suitable additional data if necessary & draw the sketches wherever required
iii) Refer annexure 1 for empirical formulae

Q.1	a)	What is Solar Pond? Explain in details	07
	b)	Describe different solar air heaters with simple sketches.	07
	c)	Explain a sun-shine recorder	06
Q.2	a)	Discuss various types of Solar Energy Collectors.	10
	b)	Calculate the angle of incidence of beam radiation on a flat plate collector for the following situation Location: Nagpur (21º 06' N, 79º 03' E) Slope of collector: 31 º Surface azimuth angle: 15 º Date: December 1, 2016 Time: 09:00 hr (IST)	10
Q.3	a)	In the context of Solar Thermal Applications, Explain i) Initial cost ii) Annual solar savings iii) Cumulative solar savings iv) Life cycle savings v) Payback period	10
	b)	What do you understand by Extra-terrestrial and Terrestrial radiation in regards of SUN, discuss in detail? Explain Solar constant and its significance	10
Q4	a)	Explain Government policies for promotion of Solar Energy Use in India	10
	b)	How can solar energy be used for agro products drying and food preservation? Explain in detail.	10

Q.5 A flat plate collector is used for heating water. Following is the data given 20

Length of collector		2	m
Width of collector		1	m
Length of absorber plate		1.82	m
Width of absorber plate		0.91	m
Location of the collector	Latitude	27º47' N	
	Longitude	76º28' E	
Date		February 14	
Time		11:30	h (IST)
Collector tilt		25º	
Surface azimuth angle		30º	
Water flow rate		85	liters/h
Ig		635	W/m^2
Id		110	W/m^2
Ambient temperature		30	ºC
Reflectivity of the surrounding surfaces		0.2	
(τα)b of the collector		0.8	
(τα)d of the collector		0.73	

The temperature rise across the collector is measured to be 6.3 ºC for an inlet temperature of 50 ºC. If the inlet temperature is decreased by 10 ºC with all other data remaining the same, the temperature rise across the collector is 7.5 ºC.
Calculate

i. The total incident flux on the collector surface
ii. The flux absorbed by the absorber plate
iii. Overall loss coefficient of the collector
iv. Collector heat removal factor

Q.6 Write short notes **any FOUR** 20

I. F-chart method
II. PV generators
III. Thermal Stratification
IV. Solar distillation
V. Building orientation and design

Annexure:1 Formula Sheet

Extra terrestrial radiation

$I'_{sc} = I_{sc}\ (1 + 0.033 \cos (360n/365))$

Angle of Incidence (θ)

$$\cos\theta = \sin\phi(\sin\delta\cos\beta + \cos\delta\cos\gamma_s\cos\omega\sin\beta) + \cos\phi(\cos\delta\cos\omega\cos\beta - \sin\delta\cos\gamma_s\sin\beta) + \cos\delta\sin\omega\sin\gamma_s\sin\beta$$

Zenith angle (θ_z)

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

Azimuth angle (γ) is given by

$$\cos\gamma = \frac{\sin\phi\cos\delta\cos\omega - \cos\phi\sin\delta}{\sin\theta_z}$$

Zenith angle(θz) is given by

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

Sunrise and sunset hour angle is given by

$$\omega_s = -\cos^{-1}(\tan\phi\tan\delta)$$

Time difference between noon sunrise or sunset (hour)

$$h_{ss/sr} = \frac{1}{15}\left[-\cos^{-1}(\tan\phi\tan\delta)\right]$$

Day length

$$T_{day\_length} = \frac{2}{15}\left[-\cos^{-1}(\tan\phi\tan\delta)\right]$$

Equation of time correction

E = 229.18 (0.000075 + 0.001868 cos B – 0.032077 sin B – 0.014615 cos 2B – 0.04089 sin 2B)

where B = (n - 1) 360/365 and n is the day of the year

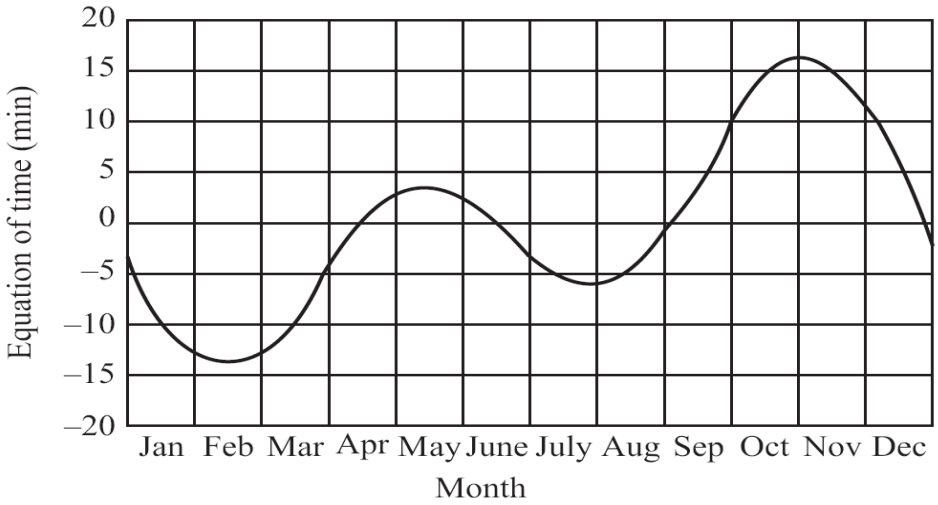

Fig. 3.14 *Equation of time correction*

LAT = Standard time ± 4 (standard time longitude – longitude of location)

+ (equation of time correction)

Declination (δ)

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

Useful heat gain by the collector

$$q_u = F_R A_p [\, I_T (\tau\alpha)_{av} - U_L (T_{fi} - T_a)]$$

$m = - (A_P U_L F') / \{C_p . \ln\{ 1- [U_L (T_{fo}-T_{fi}) / S-U_L (T_{fi} - T_a)\}$

For array of identical collectors

$F_R(\tau\alpha) = F_{R1}(\tau\alpha)_1 \{ [1-(1-K)^N / NK]\}$

$F_R U_L = F_{R1} U_{L\,1} \{[1-(1-K)^N / NK]\}$

Where $K = (A_p F_R U_L) / m C_p$