Total No. of printed pages = 8

PG/1st/PGET101

2021

GREEN ENERGY TECHNOLOGY

Full Marks – 100

Time – Three hours

The figures in the margin indicate full marks for the questions.

1. Answer any *fifteen* of the following questions : 2×15=30

   (a) What are the major components of ligno-cellulosic biomass ?

   (b) Write the four major gasification reactions.

   (c) Define the term "combustion". What are the reactants and products ?

   (d) Distinguish between the meaning of the 90% and 150% theoretical air of a combustion process.

   (e) What do you mean by the term '*ebb*' ? Define tidal range.

[Turn over

(f) What are the spring and neap tides ?

(g) Mention any two factors that cause the wind.

(h) What does the mechanical energy of a flowing fluid consist of ? Express each term in an equation and explain. Which part of mechanical energy is used in wind power conversion ?

(i) What do you mean by Betz limit ? What is its maximum value ?

(j) Mention any two names of a working fluid that are used in a geothermal binary cycle power plant.

(k) An absorption refrigeration system provides 15 kW of cooling by receiving heat in the generator at a rate of 21 kW. What is the COP of this system ?

(l) Estimate the power available from a proposed micro hydel scheme at a site having a small stream with 110 litre/s flow at a head of 25m. Assume the density of freshwater as 996 kg/m^3 and the overall efficiency of the whole system as 60%.

(m) What is the difference between a run-of-river plant and a waterwheel ?

(n) State Lambert's law of absorption.

(o) Draw a schematic diagram of a closed cycle ocean thermal energy conversion plant.

(p) What do you understand by the concentration factor (CR) of a concentrating solar collector ? What is the physical meaning of the greater value of CR ?

(q) Define air mass. What is the value of air mass when the sun is at its zenith ?

(r) What is the value of extraterrestrial radiation on the 3rd March 2022 ?

2. Explain briefly any *four* of the following : 5×4=20

(a) Geothermal base ammonia-water cooling system.

(b) Basic biochemical process of anaerobic digestion (AD).

(c) First-generation ethanol production processes.

(d) Single Basin : single and double effect OTEC scheme.

(e) Mechanism of solar radiation received at earth's surface.

(f) Low-temperature power generation cycle using liquid flat-plate collectors.

3. Answer any *five* of the following : 8×5=40

(a) Determine the local apparent time (LAT) corresponding to 1430 h (IST) at Mumbai (19°07′ N, 72°51′ E) on June 21, 2021. In India, standard time is based on 82.50°E.

Hints. *Use the equation of time correction :*

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

(b) Calculate the angle made by the beam radiation with the normal to a flat-plate collector on March 1 at 1000 h (LAT). The collector is located at CIT Kokrajhar (26°28′ N, 90°18′ E). It is tilted at an angle of 30° with the horizontal and is pointing due south.

Hints. *Use the following relation :*

$$E = 229.18\,[0.000075+0.001868\cos B-0.032077\sin B-0.014615\cos 2B-0.04089\sin 2B]$$

(c) (i) Determine the average temperature of the sun for the following data :

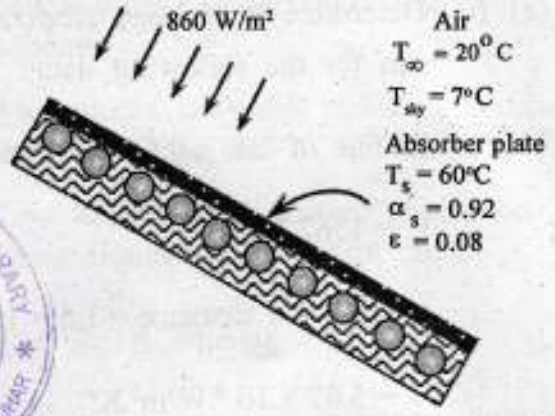
Radius of sun = 0.619×10^9 m,

$I_{sc} = 1367$ W/m^2

Mean earth distance = 1.5×10^{11}m,

$\sigma = 5.67 \times 10^{-8}$ W/m^2.K^4

(ii) The absorber surface of a solar collector is made of aluminium coated with black nickel oxide ($\alpha_s = 0.92$ and $\varepsilon = 0.08$). Solar radiation is incident on the surface at a rate of 860 W/m^2. The air and the effective sky temperatures are 20 and 7°C, respectively, and the convection heat transfer coefficient is 15 W/m^2·K. For an absorber surface temperature of 60°C, determine the net rate of solar energy delivered by the absorber plate to the water circulating behind it.



(d) A single basin type tidal power plant has a basin area of 3 km^2. The tide has an average range of 10m. Power is generated during the ebb cycle only. The turbine stops operating when the head on it falls below 3m. Calculate the average power generated by the plant in a single emptying process of the basin if the turbine generator efficiency is 0.65. Also, estimate the average annual energy generation of the plant. Given, density of sea water = 1025 kg/m^3.

(e) A wind turbine with a blade diameter of 25m is to be installed in a location where average wind velocity is 6 m/s. If the overall efficiency of the turbine is 34 %, determine–

(i) The average electric power output.

(ii) The amount of electricity produced from this turbine for an annual operating hour of 8000h.

(iii) The revenue generated if the electricity is sold at a price of Rs. 7/kWh. Take the density of air to be 1.3 kg/m^3.

(f) Calculate the monthly energy content of the wind per square metre for the following situations :

Location : Indore,

Month : February

Height above ground : 10.9m,

Density : 1.20 kg/m^3.

Table 1: Percentage frequency distribution of hourly wind speed

Location: Indore Airport

Interval (kmph)	J	F	M	A	M	J	J	A	S	O	N	D	Annual
00	10.0	10.4	9.9	9.3	3.2	2.3	2.3	3.3	7.1	14.9	8.9	8.0	7.7
00-02	3.8	1.7	1.9	1.4	1.6	1.1	0.6	0.3	2.4	3.0	5.9	1.6	2.1
02-04	6.3	1.9	3.0	0.9	0.9	0.6	0.5	0.4	3.1	3.4	4.1	2.2	2.1
04-06	5.1	4.1	2.7	1.5	1.3	0.7	1.1	0.4	3.3	4.2	4.5	4.4	3.7
06-08	4.3	3.6	2.1	2.2	2.0	1.4	1.2	0.8	3.1	3.9	4.7	5.6	2.9
08-10	2.6	0.5	1.1	0.6	1.3	0.4	0.9	0.4	0.6	1.2	1.7	1.2	1.0
10-12	6.8	5.4	3.8	4.4	3.9	2.9	3.4	1.7	5.2	5.2	6.2	8.9	4.8
12-14	6.9	6.4	5.4	3.2	4.0	3.9	3.5	2.2	4.5	5.9	7.9	8.5	5.1
14-16	9.2	8.9	9.0	5.1	6.3	7.0	7.7	4.2	6.5	8.2	10.4	10.8	7.7
16-18	8.2	10.0	8.8	5.2	6.2	7.1	8.3	5.4	7.5	9.6	13.6	9.9	8.2
18-20	8.7	9.2	9.0	5.3	6.5	6.2	9.2	6.0	7.2	8.3	12.9	9.1	8.1
20-22	10.8	11.4	10.1	10.2	10.3	10.4	11.3	10.5	10.1	9.7	9.7	10.5	10.4
22-24	6.0	6.7	7.7	6.8	7.4	7.7	9.5	7.4	7.3	7.3	4.5	7.5	7.2
24-26	4.9	4.9	6.2	6.2	6.0	9.6	10.2	10.1	9.5	6.5	2.9	5.6	7.6
26-28	1.6	3.4	3.2	7.1	4.3	6.4	3.6	4.6	4.4	3.1	1.5	3.2	4.0
28-30	1.9	1.9	4.9	5.8	5.1	5.2	7.4	7.9	4.3	2.4	1.1	1.5	4.2
30-32	1.6	3.0	3.5	8.5	7.5	8.6	7.0	10.5	7.0	1.8	0.7	0.7	5.2
32-34	0.5	0.6	2.0	6.5	4.5	2.2	3.7	5.1	2.5	0.7	0.4	0.5	2.6
34-36	0.4	0.6	1.5	4.0	5.7	3.5	3.0	5.5	2.5	0.4	0.3		2.4
36-38	0.4	0.3	1.2	2.5	4.1	3.7	2.8	5.1	1.2		0.1		1.9
38-40		0.1	0.5	1.1	1.7	2.0	1.1	2.4	0.6				0.5
40-42			0.2	1.4	2.2	3.1	0.7	2.2	0.1				0.5
42-44				0.3	0.8	0.6	0.2	0.8					
44-46				0.2	0.7	0.4		0.7					
46-48					0.1			0.3					

Sensor 10.9 m above ground

4. Prove that the power potential of tidal energy for a single-pool tidal system is $P_{av} = 0.225AR^2$, where A is the pool's surface area, R is the tidal range. 10