Name: **Enrolment No:**	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2018

Course: Renewable Energy Technologies – 2 **(EPEC 8003)** **Semester: III**
Programme: M.Tech. Energy Studies
Time: 03 hrs. **Max. Marks: 100**
Instructions: ***"Open Book Exam" – textbooks and notes are allowed during the Examination***

SECTION A

S. No.		Marks	CO
Q 1	a) Explain the three main types of Thermal Storage systems. b) Give one advantage and one disadvantage of sensible heat storage systems.	4	**CO1**
Q 2	a) Show the main components of a "Stand-Alone Solar PV system" on a schematic. b) What are the two main functions of the Charge Controller ?	4	**CO2**
Q 3	State the typical structure of a Cadmium telluride / Cadmium sulphide solar cell on a glass substrate, with a metal back contact and a transparent front contact. Indicate the direction from which solar radiation strikes the solar cell. (Cadmium Telluride has a band gap of 1.4 eV, and Cadmium Sulphide has a band gap of 2.4 eV)	4	**CO2**
Q 4	A wind monitoring station has a 30 meter wind mast that measures wind speeds at two levels: 20 m and 30 m above ground level (a.g.l.). If the wind speed at 20 m a.g.l. is 5.0 m/s when the wind speed at 30 m a.g.l. is 5.5 m/s, then, using the power law estimate the wind speed at 50 m.	4	**CO3**
Q 5	a) Explain the difference between Combustion and Gasification. b) Explain the difference between Biogas and Producer gas.	4	**CO4**
	SECTION-B		
Q 6	Calculate the Monthly Average Daily Radiation (for February) falling on a flat-plate collector facing south with a slope of 30 degrees. The collector is located in New Delhi – use radiation data given in Appendix-3 of your textbook. Assume Ground Reflectivity to be 0.2	10	**CO1**
Q 7	Define the following terms: a) Short circuit current b) Open circuit voltage c) Fill Factor d) Maximum Power Point	10	**CO2**

	Indicate the above 4 terms on the "I-V curve" for a typical silicon solar photovoltaic module.		
Q 8	The rotor blades of a mechanical Windpump are made from Curved Plates (10% curvature). The blades are strengthened with a tube welded along the length of the blade in the middle. The tube can be welded either on the concave side or on the convex side of the curved plate. Compare the Airfoil characteristics of these two options (given in the Table below) and explain whether it is better to use a "Curved plate with tube on concave side" or a "Curved plate with tube on convex side". **Table 9.3** Airfoil characteristics C_d/C_l α C_l Flat plate 0.10 5 0.80 Curved plate (10% curvature) 0.02 3 1.25 Curved plate with tube on concave side 0.03 4 1.10 Curved plate with tube on convex side 0.20 14 1.25 Airfoil NACA 4412 0.01 4 0.80	10	**CO3**
Q 9	Explain the process for producing the biofuel Ethanol from Molasses. Draw a schematic to show the main steps in the process. Give Chemical Equations wherever necessary. **OR** a) Explain the production of Briquettes from fine biomass residues such as sawdust. (Draw a schematic). b) Discuss the advantages of Briquetting.	10	**CO4**
	SECTION-C		
Q 10	Design a stand-alone Solar PV system which can be installed in New Delhi for supplying power to a house having following AC load: • Ten Lights, 20W each • Two Fans, 65W each • One Refrigerator, 150W Refrigerator is operated three hours every day, and all Lights and Fans for five hours a day. The system should be designed so that it runs smoothly for three consecutive foggy days in Delhi in the month of December. Use the following equipment that is already available : • 75 Wp SPV modules, Nominal Voltage = 12V, Peak current = 4A.	20	**CO2**

	• 60 Ah Batteries with Nominal Voltage = 6V. Use solar radiation data for New Delhi given in Appendix-3 of your textbook. Assume: • Inverter Efficiency = 95% • Depth of Discharge of batteries = 80% • Battery Efficiency = 85% Your design should provide the technical specification of the Inverter, Solar PV Array, Battery Bank and Charge Controller.		
Q 11	Time series Hourly Wind Data for one year was separated into bins having a wind speed interval of 2 m/s as shown in Table below (left side). The Table on the right side shows the Wind Turbine Power Curve for a Bergey EXCEL-R wind turbine rated at 7.5 kW that is installed at a site with this wind speed frequency at hub height. Using the Method of Bins, Calculate: a) Average Wind Speed. b) Average Wind Power Density (Air Density = 1.225 kg/m^3). a) Annual Power Generation of this wind turbine. b) Capacity Utilization Factor (Rated Power = 7.5 kW).	20	**CO1** **CO3**

Wind Speed Frequency Distribution	
Bin Width	Number of Occurences
m/s	Hours
0 - 2	440
2 - 4	935
4 - 6	1313
6 - 8	1468
8 - 10	1515
10 - 12	1192
12 - 14	860
14 - 16	514
16 - 18	311
18 - 20	149
20 - 22	63
TOTAL =	**8760**

POWER CURVE for Wind Turbine	
Wind Speed	Power Output
m/s	kW
0	0.0
1	0.0
2	0.0
3	0.0
4	0.2
5	0.7
6	1.4
7	2.2
8	3.1
9	4.3
10	5.4
11	6.6
12	7.5
13	8.1
14	8.1
15	7.9
16	7.8
17	7.5
18	7.3
19	7.1

		20	7.0
		21	6.7
		22	6.5

OR

Using the Isotropic Diffuse model and the Erbs *et al* correlation given below, estimate the beam, diffuse and ground-reflected components of solar radiation, and the total radiation on a vertical surface facing south at Mumbai (19°07'N, 72°51'E) for the hour 11:00 to 12:00 on March 16. Use solar radiation data for Mumbai given in Appendix-3 of your textbook. Assume Ground Reflectance = 0.2

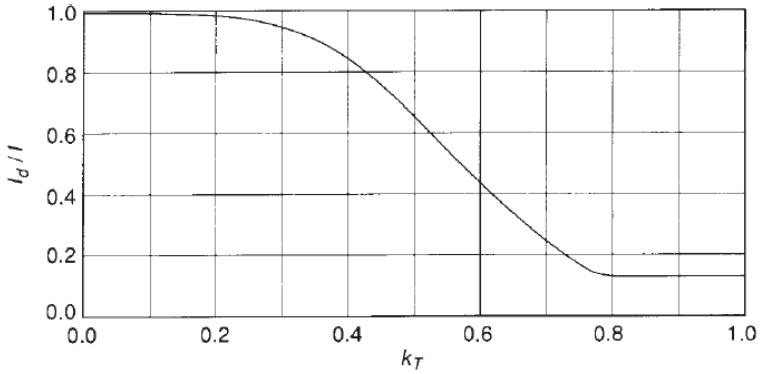


Figure 2.10.3 The ratio I_d/I as a function of hourly clearness index k_T. From Erbs et al. (1982).

correlations are shown in Figure 2.10.2. They are essentially identical, although they were derived from three separate databases. The Erbs et al. correlation (Figure 2.10.3) is[11]

$$\frac{I_d}{I} = \begin{cases} 1.0 - 0.09k_T & \text{for } k_T \le 0.22 \\ 0.9511 - 0.1604k_T + 4.388k_T^2 & \\ \quad -16.638k_T^3 + 12.336k_T^4 & \text{for } 0.22 < k_T \le 0.80 \\ 0.165 & \text{for } k_T > 0.8 \end{cases} \qquad (2.10.1)$$

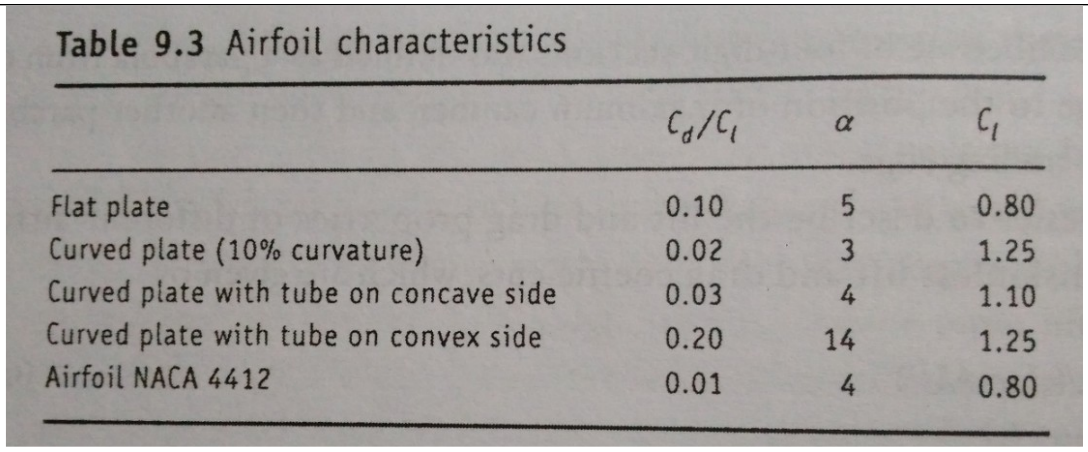
Name: **Enrolment No:**	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2018

Course: Renewable Energy Technologies – 2 **(EPEC 8003)** **Semester: III**
Programme: M.Tech. Energy Studies
Time: 03 hrs. **Max. Marks: 100**
Instructions:

SECTION A

S. No.		**Marks**	**CO**
Q 1	a) What is meant by "Tilt Factor" for Beam, Diffuse and Reflected solar radiation? b) Give an expression for calculating the Global radiation falling on a Tilted Surface and explain all the parameters used.	4	**CO1**
Q 2	Explain the following terms: a) P-type semiconductor b) Drift of carriers c) Intrinsic Semiconductors d) Metallurgical grade silicon	4	**CO2**
Q 3	a) What is the difference between a "Stand-Alone Solar PV system" and a "Grid-connected Solar PV system" ? b) Show the main components of a "Stand-Alone Solar PV system" on a schematic.	4	**CO2**
Q 4	At a height of 20 metres above ground level (a.g.l.) the reference wind speed is 5.0 m/s. Using the Logarithmic Law, estimate the wind speeds at a height of 30 metres a.g.l. The terrain at the site is 'Rough pasture' whose Surface Roughness Length = 10 mm.	4	**CO3**
Q 5	Explain why a Down-draft Gasifier is better than an Up-draft Gasifier for power generation.	4	**CO4**
Q 6	Calculate the Monthly Average Hourly Radiation (for 10 am – 11 am in March) falling on a flat-plate collector facing south with a slope of 20 degrees. The collector is located in Mumbai – use radiation data given in Appendix-3 of your textbook. Assume Ground Reflectivity to be 0.2	10	**CO1**
Q 7	a) What are the three types of Silicon used to manufacture solar photovoltaic cells ? b) Describe the equipment used and the process for manufacturing single crystal silicon using the Czochralski method. (draw a schematic).	10	**CO2**

Q 8	**Table 9.3** Airfoil characteristics  The Table given above shows the Airfoil characteristics of five different rotor blades used in wind turbines. a) Which of the five airfoils would you use for the rotor of a Wind Electric Generator and why? b) A low-cost mechanical Windpump is fabricated with a rotor made from Curved Plates (10% curvature). Compare the three airfoils in the table that are suitable for this application.	10	**CO3**
Q 9	Explain the process for producing the biofuel Methanol from Natural Gas. Draw a schematic to show the main steps in the process. Give Chemical Equations wherever necessary **OR** Compare the Environmental Impacts of Biochemical conversion with Thermochemical conversion of lignocellulosic materials to Ethanol.	10	**CO4**
	SECTION-C		
Q 10	Design a stand-alone Solar PV system which can be installed in Mumbai for supplying power to a School having following AC load: • Twenty Lights, 15W each • Ten Fans, 60W each • Two Computers, 100W each The computers are operated four hours every day, and all Lights and Fans for eight hours a day. The system should be designed so that it runs smoothly for three consecutive days without sunshine in Mumbai in the month of August. Use the following equipment that is already available : • 75 Wp SPV modules, Nominal Voltage = 12V, Peak current = 4A • 60 Ah Batteries with Nominal Voltage = 6V. Use solar radiation data for Mumbai given in Appendix-3 of your textbook. Assume: • Inverter Efficiency = 95%	20	**CO2**

	C_d/C_l	α	C_l
Flat plate	0.10	5	0.80
Curved plate (10% curvature)	0.02	3	1.25
Curved plate with tube on concave side	0.03	4	1.10
Curved plate with tube on convex side	0.20	14	1.25
Airfoil NACA 4412	0.01	4	0.80

	• Depth of Discharge of batteries = 80% • Battery Efficiency = 85% Your design should provide the technical specification of the Inverter, Solar PV Array, Battery Bank and Charge Controller.		
Q 11	Wind speed data is given in the Table below (left side) as Frequency of Occurrence (f-j) in Bins having a width = 4 m/s. The Table on the right side shows the Wind Turbine Power Curve for a Bergey EXCEL-R wind turbine rated at 7.5 kW that is installed at a site with this wind speed frequency at hub height. Calculate: a) Average Wind Speed. b) Average Wind Power Density (Air Density = 1.225 kg/m^3). c) Annual Power Generation d) Capacity Utilization Factor (Rated Power = 7.5 kW).	20	**CO1** **CO3**

V, m/s	f-j
0 - 4	1,375
4 - 8	2,781
8 - 12	2,707
12 - 16	1,374
16 - 20	460
20 - 24	58
24 - 28	5
TOTAL	**8760**

POWER CURVE for Wind Turbine	
Wind Speed	Power Output
m/s	kW
0	0.0
1	0.0
2	0.0
3	0.0
4	0.2
5	0.7
6	1.4
7	2.2
8	3.1
9	4.3
10	5.4
11	6.6
12	7.5
13	8.1
14	8.1
15	7.9
16	7.8
17	7.5
18	7.3
19	7.1
20	7.0
21	6.7
22	6.5
23	6.3
24	6.0
25	5.8

OR

Using the Isotropic Diffuse model and the Erbs *et al* correlation given below, estimate the beam, diffuse and ground-reflected components of solar radiation, and the total radiation on a vertical surface facing south at New Delhi for the hour 13:00 to 14:00 on January 17. Use solar radiation data for New Delhi given in Appendix-3 of your textbook. Assume Ground Reflectance = 0.2

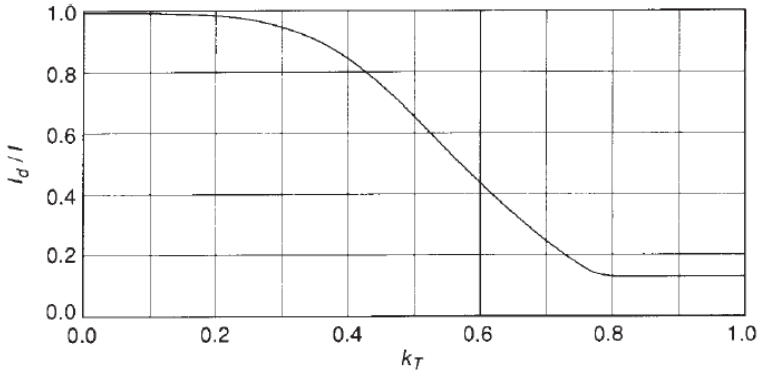


Figure 2.10.3 The ratio I_d/I as a function of hourly clearness index k_T. From Erbs et al. (1982).

correlations are shown in Figure 2.10.2. They are essentially identical, although they were derived from three separate databases. The Erbs et al. correlation (Figure 2.10.3) is[11]

$$\frac{I_d}{I} = \begin{cases} 1.0 - 0.09k_T & \text{for } k_T \leq 0.22 \\ 0.9511 - 0.1604k_T + 4.388k_T^2 & \\ \quad -16.638k_T^3 + 12.336k_T^4 & \text{for } 0.22 < k_T \leq 0.80 \\ 0.165 & \text{for } k_T > 0.8 \end{cases} \qquad (2.10.1)$$