Centre for Energy Studies, Indian Institute of Technology Delhi
ESL 740: Non-Conventional Sources of Energy (I Semester, 2018-19)

Time: One Hour **Minor Test - I** **Maximum Marks: 20**

Note: Please answer all questions in legible handwriting. The maximum marks assigned to a question are indicated at the end of the question within square brackets. In case, any required details appears to be missing in numerical questions, please make a suitable assumption and explicitly mention the same in the response to the question. ***A few formulae are given at the end of the question paper (on the backside of this sheet).***

1. Define the following terms and explain their relevance **(any two)**:
   a) Solar constant
   b) Air mass
   c) Heat removal factor for a flat plate solar collector [3]

2. Explain why **(any two)**
   a) Earth usually receives less solar radiation in the morning and evening hours as compared to that received at solar noon?
   b) In locations with cold climates, flat plate solar collectors may usually have double glazing?
   c) Horizontal axis wind turbines usually having three blades? [3]

3. Calculate the angle of incidence of the beam component of solar radiation on a flat plate solar collector inclined at 30° from horizontal and oriented 30° east of south located at New Delhi (Latitude: 28.61° N and Longitude: 77.2° E) on August 23, 2018 at Indian standard time of 10:30 hours. The standard meridian for India is 82.5° E. [5]

4. Calculate the thermal efficiency of a flat plate solar collector with the following details. The values of the solar radiation incident on the aperture of the collector and the solar radiation absorbed by the absorber plate are 800 W/m^2 and 600 W/m^2 respectively. The overall heat loss coefficient for the solar collector is 3.75 W/m^2 K. The mean temperature of the absorber plate and glass cover are 90°C and 41°C respectively. The aperture area of the collector is 6 m^2. The ambient temperature is 30°C. [2]

5. A flat plate collector of 2 m x 1.5 m x 0.2 m is installed at New Delhi for water heating. The mean absorber plate temperature is 85°C and ambient air temperature is 30°C. The values of top, bottom and sides heat loss coefficients of the collector are 6 W/m^2 K, 0.75 W/m^2 K and 0.15 W/m^2 K respectively. Calculate the overall heat losses from the collector. [3]

P.T.Q.

6. At what wind speed the available power density in the wind would be equivalent to Solar Constant? The density of air is 1.226 kg/m^3. [2]

7. A wind turbine of rotor diameter 12 m is placed at a hub height of 20 m with the prevailing wind speed of 12 m/s. Calculate the percentage increase in available wind power to the turbine, if the hub height increased to 30 m. [2]

Formulae:

1. Angle of incidence:

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

2. Declination angle: $\delta = 23.45 sin\left[\frac{360}{365}(284+n)\right]$

3. Solar time (ST): ST = Standard time $\pm$ 4 (L_{std}-L_{loc}) + E

   E = 229.2 (0.000075 + 0.001868cosB- 0.032077SinB- 0.014615 cos2B - 0.04089 Sin2B)

   $B = \frac{360(n-1)}{365}$

4. The variation of wind velocity with altitude: $v = v_r (z/z_r)^{1/7}$