(21)

Program: M. Sc. Eng./Ph.D. (ME)/M.Sc.Te

Date: 16 May 2023 (Tuesday)
Time: 10:00 AM – 1:00 PM

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester Final Examination | **Summer Semester: AY 2021-22**
Course Code: MCE 6241 | **Full Marks: 150**
Course Title: Renewable Energy | **Time: 3 Hours**

There are **six** questions. Answer **all** of them. The symbols have their usual meanings. Marks of each question are written in the brackets. Assume reasonable data if necessary. Formula sheet is attached in the third page.

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1 (a) Solar Energy is considered as the principal source for all Renewable Energy. The potential for solar energy is enormous, since about 200,000 times the world's total daily electric-generating capacity is received by Earth every day in the form of solar energy. Solar energy can be harnessed through many different ways. **(15)**

i) Describe the basic methods for solar energy conversion stating different types of devices and technologies used.

ii) What are the methods currently available in your country for Electricity and Heat production from solar energy? Explain in details.

(b) Determine the day's total solar radiation on a horizontal surface in the absence of atmosphere, at latitude 23° 45′ N on May 16. Also calculate the amount of solar radiation received on that surface between the hours 8 AM to 5 PM. **(10)**

2 (a) Wind Energy can be harnessed by using Wind Turbines. These machines are efficient and critically designed. From your study, **(15)**

i) Explain the design criteria for wind turbines.

ii) For wind power, what range of wind speeds is most productive? For electricity generation by wind power into a utility grid network, why is a wind speed of less than 3 m/s of negligible benefit; yet a wind speed of 6 m/s is beneficial? Explain.

(b) For wind turbines, explain the three non-dimensional scale factors: Power Coefficient, Tip Speed Ratio and Torque Coefficient. Draw a relationship between them and explain their effects and importance in wind turbine designing. **(10)**

3 (a) Hydropower remains the most established, widely used and long-lasting renewable resource for electricity generation. It is also one of cleanest form of electricity with very high efficiency for conversion. However there are drawbacks also. From your study, **(15)**

i) Explain the working principle of a hydro-electric power plant. What are the different types of machines used here?

ii) Discuss the adverse effects of building a hydropower dam on environment and water eco-system. How this can be mitigated?

3 (b) Explain the I-V characteristic curve of a Solar PV cell with the effects of temperature and irradiance on it. **(10)**

4 (a) What is Geothermal Energy? Discuss the classification of geothermal regions and explain how heat can be obtained from it. **(12)**

(b) i) Calculate the initial temperature, and heat content per square kilometre above 32 °C, of an aquifer of thickness 0.75 km, depth 2.8 km, porosity 7%, under sediments of density 2250 kg/m^3, specific heat capacity 750 J/kg-K, temperature gradient dT=35°C/km. Suggest a use for the heat if the average surface temperature is 10 °C. **(13)**

ii) Calculate the time constant for useful heat extraction considering with a pumped water extraction 0.25 m^3/s-km^2.

iii) What is the thermal power extracted initially and after 15 years.

5 (a) The Wave Energy is a form of clean ocean renewable energy that can be harnessed from the vertical motion of the ocean surface to generate power. Discuss about different types of wave energy converters with their working principles. State some advantages and disadvantages also. **(15)**

(b) Consider you have been appointed as a Project Engineer in a Renewable based power production company at your country. The company has been working with renewable power for some years and installed micro/mini stand alone plants for domestic and SME use. Now they are planning for a bigger plant to supply the energy to a small town having demand of 10 MW. As an engineer your task is to conduct a feasibility analysis. Based on your country's scenario, point out some key challenges that must be mitigated and adressed in the feasibility report. **(10)**

6 (a) Bioenergy is by far the most used renewable energy resource by energy value, being about 10% of global total primary energy supply. Despite the historic use of biofuels, there is a great potential for more energy-efficient and sustainable use in both developing and developed countries. Based on your study, briefly discuss different thermochemical, bio-chemical and agrochemical processes for bioenergy production. State some advantages and disadvantages also. **(13)**

(b) Write a short note on Ocean Thermal Energy Conversion (OTEC). In your writing emphasize on OTEC principles and systems. **(12)**

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Formula Sheet

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

$$\begin{aligned}\cos\theta = {} & \sin\delta\sin\phi\cos\beta - \sin\delta\cos\phi\sin\beta\cos\gamma \\ & + \cos\delta\cos\phi\cos\beta\cos\omega + \cos\delta\sin\phi\sin\beta\cos\gamma\cos\omega \\ & + \cos\delta\sin\beta\sin\gamma\sin\omega\end{aligned}$$

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

$$\gamma_S = \text{sign}(\omega)\left|\cos^{-1}\left(\frac{\cos\theta_z\sin\phi - \sin\delta}{\sin\theta_z\cos\phi}\right)\right|$$

$$\cos\omega_s = -\frac{\sin\phi\sin\delta}{\cos\phi\cos\delta} = -\tan\phi\tan\delta$$

$$\tan\alpha_p = \frac{\tan\alpha_s}{\cos(\gamma_s - \gamma)}$$

$$H_o = \frac{24\times 3600 G_{sc}}{\pi}\left(1 + 0.033\cos\frac{360n}{365}\right) \times \left(\cos\phi\cos\delta\sin\omega_s + \frac{\pi\omega_s}{180}\sin\phi\sin\delta\right)$$

For $\omega_s \le 81.4°$

$$\frac{H_d}{H} = \begin{cases} 1.0 - 0.2727K_T + 2.4495K_T^2 - 11.9514K_T^3 + 9.3879K_T^4 & \text{for } K_T < 0.715 \\ 0.143 & \text{for } K_T \ge 0.715 \end{cases}$$

and for $\omega_s > 81.4°$

$$\frac{H_d}{H} = \begin{cases} 1.0 + 0.2832K_T - 2.5557K_T^2 + 0.8448K_T^3 & \text{for } K_T < 0.722 \\ 0.175 & \text{for } K_T \ge 0.722 \end{cases}$$

Geothermal Resource Analysis

$$\frac{E_0}{A} = C_a(T_2 - T_1) \quad ; \quad C_a = [p'\rho_w c_w + (1-p')\rho_r c_r]Ah \quad ; \quad E = E_0\exp(-t/\tau_a) \quad ;$$

$$\tau_a = \frac{C_a}{\dot{V}\rho_w c_w} = \frac{[p'\rho_w c_w + (1-p')\rho_r c_r]h}{\dot{V}\rho_w c_w}$$

~End~