

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering



Study Programme : Bachelor of Technology Honours in Engineering
Name of the Examination : Final Examination
Course Code and Title : **DMX6536 /MEX6236 New and Renewable Sources of Energy**
Academic Year : 2018
Date : 02.02.2019
Time : 0930-1230 hrs
Duration : 3 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of 08 questions and 04 pages.
3. **Answer any 05 questions only.** All questions carry equal marks.
4. Answer for each question should commence from a new page
5. Relevant charts/ equations are provided.
6. This is a Closed Book Test (CBT).
7. Answers should be in clear hand writing.
8. Do not use Red colour pen.

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- Q1
1. Define renewable energy.
 2. Indicate from the following list of energy sources which are originally derived from solar energy. Justify your answer with facts.

Crude Oil, Coal, Natural Gas, Hydro Power, Biomass, Wind Power, Geothermal Power, Tidal Power, Wave Energy.
 3. Name which energy sources are renewable from above list.
 4. List the advantages and disadvantages of renewable energy sources.
 5. Why renewable energy is given more attention than before in today's context?

Q2. Give answers in brief to the following questions.

1. What is the power output of the Silvermills Dendro power plant you have seen in your field visit? Describe how do they generate electricity in this plant with important parameters. What is the biomass requirement in this plant?
2. What are the types of Anaerobic digester systems available at the NERD centre? Describe one of them with clear sketches.
3. What are the factors affecting biogas production in an anaerobic digestion? Explain how you increase the biogas production of a given anaerobic digester.
4. It is well known that fire wood stoves available in Sri Lanka are very low efficient and produce smoke affecting the health of the people in the house. What is your solution to this problem?

- Q3.
1. Describe the process of gasification.
 2. "Gasification is a biological conversion process of converting biomass to a useful energy". Do you agree with this statement? If not give reasons.
 3. Name two processes, where gasification is a part of the energy conversion process.
 4. Diesel Engine with 35% efficiency is used to produce 2 MW of electricity. It has been decided to replace 80% of diesel from wood. Dry wood usually consists of 46% Carbon (C), 48% Oxygen (O) and 6% Hydrogen (H). Moisture content of wood is 20%. If the efficiency of the Dendro power plant is 50%
 - (a) What is the lower heating value (LHV) of the dry wood?
 - (b) What is the water content (w) of the wood?
 - (c) What is the LHV of the moist wood.
 - (d) Calculate the amount of diesel required to run the Engine if the density of the Diesel is 825 kg/m^3 and LHV Diesel is 43 MJ/kg .
 - (e) What is the mass flow rate of wood required to feed the Dendro power plant in kg/h ?
 - (e) What is the output power of the Dendro power plant in MW?

$$\text{LHV}_{\text{dry}} = 0.35 X_C + 0.939 X_H - 0.108 X_O \text{ MJ/kg}$$

$$\text{LHV}_{\text{moist}} = \text{LHV}_{\text{dry}} (1-w) - h_{fg} w$$

$$\text{enthalpy of evaporation of water } h_{fg} = 2256 \text{ kJ/kg}$$

$$w = \text{water content}$$

- Q4.
1. What are the main factors affecting the power of a wind turbine?
 2. Describe how wind energy is harvested using a wind turbine.
 3. Sketch a Horizontal Axis Wind turbine and name four main components. Describe function of each components.
 4. There are several types of wind farms available today. Name three of them.
 4. Describe “cut in speed” and “Cut out speed “of a wind turbine?
 5. What are the advantages of Vertical Axis Wind Turbines over Horizontal axis Wind Turbines?
 6. People in a village of Durne in Netherlands want to have a small wind farm to electrify the village. Two (02) small wind turbines of having 20 m blade length at 100 m height running at 50% efficiency and One (01) large wind turbine of having 50 m blade length at 150 m height at 55% efficiency is proposed. Wind turbine with less elevation is running at 12 m/s wind speed while higher elevation wind turbine running at 15 m/s wind speed.
 - a) Calculate total power output of each turbines.
 - b) One person in the team proposed to have only one Mega Turbine at an elevation of 200 m at 16 m/s wind speed, what would be the power output of the . . . turbine if the blade length is 50 m? Assume . . . turbine work at its maximum efficiency.
 - c) After the analysis of both option what would you proposed and why?

Wind Power (P) = $\frac{1}{2} \rho A V^3 \eta$ where ρ is the density of the air (1.225 kg/m³), A is the swept area of the wind, and V is the wind speed. η is the efficiency of the wind turbine.

- Q5. Write short notes on the following.
- (i) Visual pollution
 - (ii) Pyrolysis
 - (iii) Gasification
 - (iv) Anaerobic Digestion
 - (v) Geothermal energy and its applications.

- Q6. a) Describe in brief
- (i) Solar declination angle
 - (ii) Solar altitude angle
 - (iii) Solar hr angle.
- b) On September 21st at 8.00 am at 40^o N latitude (ϕ), Determine

- (i) The direct normal extraterrestrial irradiance (I_0)
- (ii) Solar declination angle (δ)
- (iii) Solar hr angle (W)
- (iv) Solar altitude angle (α)
- (v) The extraterrestrial irradiance on a horizontal surface (H_0)
- (vi) Sunrise/ Set angle (W_{SS})
- (vii) Daily total radiation received on the horizontal surface (\underline{H}_0)

Following equations are given with their usual notations.

$$I_0 = I_{sc} [1 + 0.034 \cos (360N/365)] \text{ where } I_{sc} = 1353 \text{ w/m}^2,$$

$$\delta = 23.45 \sin [360 (284+N)/365] \text{ where } N \text{ is the day number from January 01}$$

$$\sin \alpha = \sin \phi \sin \delta + \cos \phi \cos \delta \cos W, \quad H_0 = I_0 \sin \alpha, \quad W_{SS} = \cos^{-1} [\tan \phi \tan \delta]$$

$$\underline{H}_0 = 24/\pi I_0 [\cos \phi \cos \delta \sin w_{SS} + \pi/180 W_{SS} \sin \phi \sin \delta]$$

Q7. Write short notes on the following

- a) Ocean Thermal Energy Conversion to electricity
- b) Solar PV systems
- c) Active and Passive solar systems
- d) CSP systems
- e) Solar systems available at the NERD centre

- Q8. a) What are the main components of a Hydropower Plant. Describe the function of each in brief.
- b) How do you classify hydropower plants? According to your classification name four types of such hydropower plants.
- c) What are the advantages and disadvantages of a Hydropower plant?
- d) Other than producing electricity, what are the other purposes a hydroelectric dam can be used for the benefit of people and nature?
- e) A dam will be constructed to generate 2000 MW of hydropower in the city of Alqueva in Portugal. It has decided to build a secondary dam below the reservoir to pump back the water to the main reservoir during off peak hours using wind power.
- i) What is the type of turbine you proposed in this project? And why?
 - ii) How many turbines are required to generate 2000 MW of power if they used 100MW capacity turbines with 95% efficiency.
 - iii) What would be the minimum height of the dam? If the discharge rate of flow at the turbine is 300 m³/s. Assume density of water as 1000kg/m³ and $g=10\text{ms}^{-2}$