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

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Study Programme	:	Bachelor of Technology Honours in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	:	**DMX7305 Renewable Sources of Energy**
Academic Year	:	2021/2022
Date	:	17.02.2023
Time	:	1330-1630 hrs
Duration	:	3 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of 07 questions and 05pages.
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 handwriting.
8. Do not use red colour pen.
9. Write your Index No in every page of your answer book.
10. Write down in the bottom of the first page left side questions you answered clearly.

Q1 1. "Renewable energy sources enhance energy security" Do you agree or disagree? Describe in brief why it is vital for a country like Sri Lanka.

2. Demand for energy is ever increasing. It is important to give highest priority for power generation to supply electricity uninterruptedly. But as a consequence of not addressing this issue properly, Sri Lanka is now facing the biggest energy crisis ever. Give recommendations for how to cope with this using all possible renewable energy options available in Sri Lanka while minimising the use of fossil fuel-based energy sources.

3. Hydropower options are now minimum as it has almost finished most of the hydropower projects. If you will get another chance of building a hydropower dam to produce 250 MW of electricity in Sri Lanka, explain your suggestions and recommendations to get the maximum output while running the power plant even during dry seasons catering the demand more efficiently.

4. What would be the best Solar power option for Sri Lanka to give uninterrupted power supply even during rainy and cloudy seasons as well as nights. You assume that a huge foreign grant is offered to build a 700 MW power plant in this new project and the cost involved in this exercise is not an issue to the country and its people.

5. Sustainability is a very popular theme among every sector in the country. Describe in brief from the point of view of energy production why sustainability is playing a very big role in the industry today.

6. What is CO_2 emission? Explain clearly with reliable facts why renewable energy sources are playing a major role in minimising CO_2 emission. [20 Marks]

Q2. (a) What is geothermal power?

(b) What are the main heat sources of Geothermal fields?

(c) Describe in brief how geothermal fluids are transmitted to the power plant. What are the main obstacles you may face during transmission of geothermal fluids?

(d) What are the power generation cycles used in geothermal power? Describe one of them with a clear layout diagram.

(e) What are the differences between dry steam power plants and binary cycle power plants used in geothermal power applications? [20 Marks]

Q3. 1. What are the three main Gasification types?

2. Describe the process of gasification? What are the output products of Gasification?

3. What are the three main Gasifier Designs? Describe one of them with a clear sketch.

4. Why liquification of biomass is important?

5. "Production of liquid transport fuels such as fischer-tropsch is one of the best options to replace fossil fuels." Do you agree or disagree? Give your comments on this statement.

6. A home is heated by an oil-fired burner. It has been decided to replace the oil-fired burner with biomass fired burner. Calculate the reduction of CO_2 emission due to replacement of the oil-fired burner with a biomass fired burner. Assume biomass fired burner CO_2 emission is negligible.
Oil fired burner used 1 lit of oil / kWh (heat)
Oil contains 0.50 kg of Carbon / kg of oil.
Density of oil = 920 kg/m^3
Home consumes 16000 kWh per year (heat)
Molecular weight of Carbon and Oxygen are C=12, O=16 [20 Marks]

Q4. Explain why wind speed is more important than other factors affecting the wind energy.

2. Give reasons why hight of the tower is important in installation of wind turbines.

3. Compare and contrast Horizontal Axis Wind Turbines (HAWT) with Vertical Axis Wind Turbines (VAWT).

4. Why wind direction is so vital in the generation of power by a wind turbine? Explain in brief how you address this issue both in the case of HAWT and VAWT.

5. What are the disadvantages of Wind Energy?

6. You have assigned in a project to supply electricity using wind energy in a rural village. There are 500 families living in the village. Assume that there are three categories of families living in this village such as a high income, middle income, and lower income as shown in the table No 1.

Table 1

Population (Number of families)		
High income	Middle income	Lower income
100	200	200

Assume electricity consumption of families as shown in the table No.2.

Table 2

Electricity consumption (kWhr/day)		
High income	Middle income	Lower income
11	5	3

Calculate

(i) the electrical power requirement in kWhrs.
(ii) the capacity of the wind turbine in kW.
(iii) the blade length of the wind turbine in m.

Assume average wind speed of the area is 10 m/s. Type of the turbine is VESTAS with 55% efficiency.

Wind Power (P) = $1/2\ \rho\ A\ V^3\ \eta$ where ρ is the density of the air (1.225 kg/m^3) , A is the swept area of the wind in m^2, and V is the wind speed in m/s. η is the efficiency of the wind turbine. [20 Marks]

Q5. Write short notes on the following.

(i) Solar PV and its applications.
(ii) Active and passive solar heating.
(iii) Anaerobic digestion systems available in Sri Lanka.
(iv) Pump storage hydropower systems with examples.
(v) Geothermal power applications.

[20 Marks]

Q6. a) Describe the following

(i) Equinox and Solstice
(ii) Solar Incident angle
(iii) Tilt angle and the importance of south facing orientation.

b) At 40 ^{0}N latitude (φ) on 17th February at 9.30 am

(i) What is the direct normal extra-terrestrial irradiance?
(ii) What is the extra-terrestrial irradiance on a horizontal surface?
(iii) What is the total extra-terrestrial radiation received on the horizontal surface on this day?

Following equations are given with their usual notations.

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

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

$w = 15(H-12)$

$w_{SS} = \cos^{-1}[-\tan\varphi \tan\delta]$

$\sin\alpha = \sin\phi \sin\delta + \cos\phi \cos\delta \cos w$ and $H_0 = I_0 \sin\alpha$

$$H_O = \frac{24}{\pi} I_o \left[Cos\ \emptyset Cos\delta Sin\ W_{SS} + \frac{\pi}{180} W_{SS} \sin\emptyset \sin\delta\right]$$

[20 Marks]

Q7. a) How do you classify hydropower plants?

b) Distinguish traditional hydropower plants from pump storage hydropower plants.

c) Describe in brief how do you select a most suitable turbine type for a given hydropower project. You may use the turbine selection chart for your explanation.

d) Why are Francis turbines preferred most in pump storage hydroelectric systems?

e) What is the main difference between wicket gate and trash track?

f) What are the basic design parameters of a hydropower power station?

g) Name three biggest hydropower plants in the world with their capacities.

h) The Xiluodu hydropower plant built on the Jinsha River in central Sichuan Province of China has an installed capacity of 13.86GW. The power plant features the world's first ultra-high concrete double-curvature arch dam at an elevation of 610m. The maximum height of the dam is 285 m and the reservoir area is 454,400km^2. The hydroelectric plant is installed with 18 Francis turbine-generator units of 770MW each.

(i) What is the flow rate of water entering into a turbine?

(ii) What is the plant generating average output power in TWh/year?

Take the turbine efficiency as 95%, density of water as 1000 kg/m^3 and g=9.8ms^{-2}

[20 Marks]