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The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Bachelor of Technology Honours in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX6236 New and Renewable Sources of Energy**
Academic Year	:	2016/2017
Date	:	23.11.2017
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. All questions carry equal marks.
3. Answer only 05 questions.
4. Formulas are provided at the end of each question whenever needed.

Q1

(i) Describe active solar heating systems and passive solar heating systems.

(ii) Name three types of each systems.

(iii) What is the main advantage of passive solar system?

(iv) What do you mean by CSP? Describe how a solar thermal power plant works?

(v) What are the main components of a solar PV system? Describe how a solar PV system works?

(vi) What are the four types of PV cells? [20 marks]

Q2.

(i) What are the main components of a hydropower plant? Describe the function of each components.

(ii) What is the purpose of having a surge tank in a Hydropower system?

(iii) What are the four major types of Hydropower plants?

(iv) Describe one of them with the help of a schematic diagram.

(v) Why high head power plants are highly economical?

(vi) Name three types of turbines used in Hydro power plants?

(vii) What are the three criteria you apply on selecting these three turbines depending on their head and flow rate.

(viii) Explain the terms "Design flow" and "Reserved flow" used in Hydropower systems.

(ix) A water reservoir at an elevation of 1000 m high mountain is used to generate electricity using a hydropower station constructed at the bottom of the mountain at a distance of 1.7 km away from the crest of the reservoir sending the water through a penstock of 2000 m long. The rate of the discharge of water at the end of the penstock is 10 m^3/s. If the density of the water is 1000 kg/m^3 and the efficiency of the turbine is 90% find the maximum capacity of the hydropower plant.

(x) What is the best suitable turbine you recommended for this hydropower plant? Use the **turbine selection chart** attached at the end of the question paper (**page6**). [20 marks]

Q3. (a) Identify the main objective of the gasification process and discuss how it is being achieved.

(b) A diesel engine running to produce electricity is decided to replace 90% of diesel from fuel wood. The moist wood is converted to syngas by using a gasifier. A dryer is used before fuel wood is feed into the gasifier to reduce the amount of moisture in the moist wood.

Wood has following data:

C - 47% wt, H- 7% wt , O - 46% wt

Moisture content of the wood before dryer = 29%

Moisture content of the wood after the dryer = 12%

Diesel Generator set (Diesel engine + Generator) has following data:

Electricity output Capacity of 90 kW

Electricity required uninterrupted throughout the year

Diesel engine has 28% efficiency and Generator has 98% efficiency.

Diesel fuel has following data:

LHV of diesel = 43 MJ/kg

Density of diesel = 825 kg/m^3

Gasifier data:

Gasifier efficiency =95%

LHV Gas = 4.6 MJ/m^3

Following formulas are given:

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

$LHV_{moist} = LHV_{dry}\ (1\text{-}w) - h^{LV}\ w$ MJ/kg

enthalpy of evaporation of water $h^{LV} = 2256$kJ/kg

w = water content in moist wood

Gasifier efficiency is given by the formula given below:

$$\eta CG = \frac{LHV_{gas} \times \dot{V}_{gas}}{LHV_{moist} \times \dot{m}_{fuel}} x100\%$$

LHV gas – Lower Heating Value of the producer gas in MJ/m^3
LHV moist – Lower Heating Value of Moist wood in MJ/kg
m_{fuel} = rate of moist wood to feed the gasifier in kg/s

Calculate;

(i) the water content of the moist wood entering the Dryer.
(ii) the water content of the moist wood entering the Gasifier
(iii) the Lower Heating value (LHV) moist wood entering the Gasifier.
(iv) the amount of Diesel required to run this engine to generate electricity.
(v) the amount of wood required to replace 90 % of diesel consumed in the engine to run the generator.
(vi) the gas flow rate comes out from the Gasifier. [20 marks]

Q4. (i) Biomass can be converted to convenient gas or liquid fuel. But raw biomass has several disadvantages as a fuel. What are they?

(ii) What are the two main biomass conversion processes?

(iii) Fill the blank spaces of the diagram at **page 7** and attach it with your answer script.

(iv) Describe in detail the physio chemical biomass conversion process shown in the figure at **page 7**.

(v) Name the type of biofuel you can obtain from the process described in (iv).

(vi) What is Anaerobic Digestion?

(vii) What are the factors affecting the biogas yield in anaerobic digestion?

(viii) Describe the most popular types of Anaerobic Digesters available in Sri Lanka. Explain why most of them are not active while some of them are running efficiently. [20 marks]

Q5. a) Describe in brief

(i) Tilt Angle
(ii) Collector Azimuth angle
(iii) Solar Incident angle.

For a surface tilted at 60^0 facing south and located at $40\ ^0$N latitude,

b) Calculate the daily total of the extra-terrestrial irradiance on June 21st

(i) The direct normal extra-terrestrial irradiance (I_0)
(ii) Solar declination angle (δ)
(iii) Collector Azimuth angle (τ_c)
(iv) Tilt angle (β)
(v) Latitude (φ)
(vi) Sun Rise /Set angle (w_{ss})
(vii) The total of the extra-terrestrial irradiance on a tilted surface (H_0t)

Following equations are given with their usual notations.

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

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

$w_{ss} = \cos^{-1}\ [-\tan\delta\ \tan(\varphi-\beta)]$

$\underline{H_{0t}} = 24/\pi\ \ I_0\ [\cos\delta\ \sin w_{ss}\ (\cos\varphi\ \cos\beta + \text{Sin}\ \varphi\ \text{Sin}\beta\ \cos\tau_c)\ + \pi/180\ \ w_{ss}\ \sin\delta\ (\sin\varphi\ \cos\beta$

$-\ \cos\varphi\ \sin\beta\ \cos\tau_c]$ [20 marks]

Q6. (a) What are the

(i) Design factors
(ii) Control factors
(iii) Environmental factors

Affecting the power of a Wind Turbine?

(b) Why tip speed ratio is an important factor for a wind turbine?

(c) Why do turbine blades have "twisted shape"?

(d) Why angle of attack is important in wind turbine blade designing?

(e) What are the main components of a rotor of a wind turbine?

(f) Describe function of following components of a wind turbine.

(i) Blades & Rotor

(ii) Gear Box

(iii) Yaw mechanism

(g) Five 1 MW power Horizontal Axis Wind Turbines (HAWT's) have been operating over 20 years in an urban area of Utrecht city of Netherlands. If the wind velocity at a hub height of 50 m is given as 5 m/s, the density of air is given as 1.225 kg/m^3 and the C_p =0.59

(i) What is the length of the blade of each turbine?

(ii) It has been decided to replace all five HAWT's with a one Mega Turbine having blade length of 160m. What should be the hub height of the new turbine to generate the same power output?

The wind velocity variation with hub height is given as below;

$$v_2 / v_1 = \left[h_2 / h_1\right]^p$$

Where v_1 – velocity of wind in (m/s) at hub height of h_1 in (m)

v_2– velocity of wind in (m/s) at hub height of h_2 in (m)

p – wind shear exponent and for urban areas p can be taken as p= 0.15 [20 marks]

Q7.

(i) What is Geothermal Energy?

(ii) Can Geothermal energy be considered as a renewable energy?

(iii) What are the three basic types of Geothermal Power plants?

(iv) Describe how Binary cycle Geothermal power plant works with a help of a diagram.

(v) What are the main advantages and disadvantages of binary cycle Geothermal power plants?

(vi) What is district heating?

(vii) How can you apply Geothermal energy for district heating? [20 marks]

Q8.

(i) Name five Ocean wave energy generation design concepts.

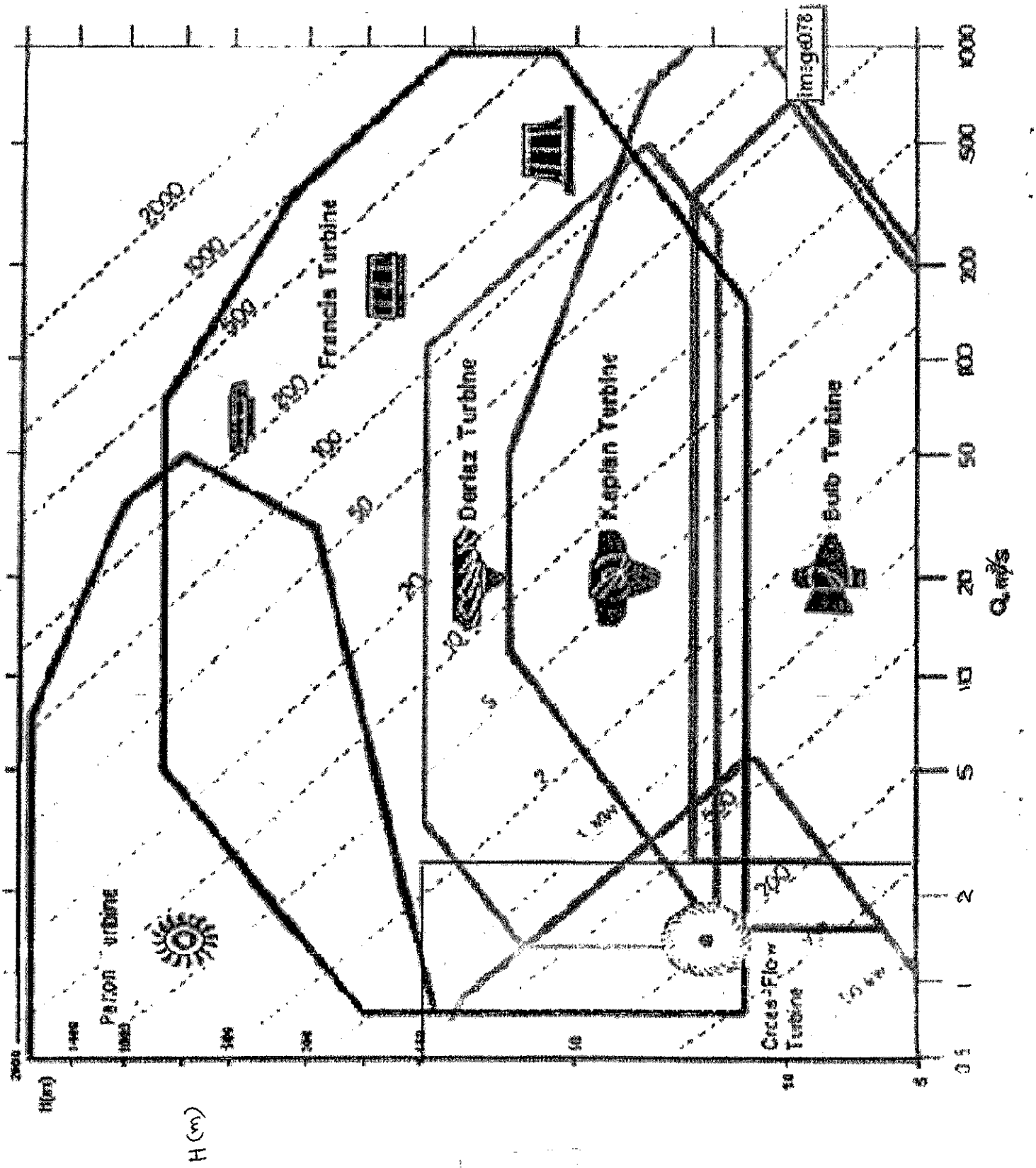
(ii) Describe one of them with a clear schematic diagram how electricity can be generated using ocean waves.

(iii) Describe how Ocean Thermal Energy Convert (OTEC) to electricity.

(iv) What are the advantages of OTEC?

(v) What are the possible environmental effects of OTEC. [20 marks]

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Pelton turbine
Francis Turbine
Deriaz Turbine
Kaplan Turbine
Bulb Turbine
Cross-Flow Turbine
H (m)
Q m³/s

Q4 (iii)

Fill in the boxes and submit this sheet together with the rest of your answers