THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND COMMUNICATION ENGINEERING

SECOND SEMESTER EXAMINATION (2023)

EE425 RENEWABLE ENERGY SYSTEMS

ELECTRICAL ENGINEERING - YEAR 4 (POWER & COMM.)

TIME ALLOWED: 3 HOURS

INFORMATION FOR STUDENTS

1. You have **TEN (10)** minutes to read the paper.
   You must **NOT** begin writing during this time.

2. All answers must be written in the **ANSWER BOOK** supplied.
   COMPLETE THE DETAILS REQUIRED ON THE FRONT COVER OF YOUR ANSWER BOOK - DO THIS NOW.

3. Drawing instruments and calculators are permitted.

4. Mobile phones and head phones are **NOT** permitted

5. Answer **ALL FIVE (5)** questions. Total of 50 marks.

6. For each question marks are shown for each part.

7. If you are found cheating in the Examination, the penalties specified by the University shall apply.

QUESTION ONE Solar Energy.

A photovoltaic module has the following parameters: I_{sc} = 4.45 A, V_{oc} = 18.5 V, V_{mp} = 13.6 V, I_{mp} = 3.46 A recorded at an irradiance of S = 1000 W/m^2. The length of the module is L = 1.5 m and the width of the module is W = 0.8 m.

(a) Calculate the fill factor, FF. ***(2)***

(b) The module is connected to a variable resistive load at an irradiance of S = 950 W/m^2. The voltage across the resistance was V = 15.4 V and the current flowing in the resistance was I = 2.86 A. Calculate the module efficiency, η. ***(4)***

(c) The irradiance is increased from S = 950 W/m^2 to S = 1000 W/m^2. How much would you increase or decrease the load resistance to extract maximum power from the photovoltaic module? ***(4)***

QUESTION TWO Wind Energy.

A 6-kW DC generator is driven by a fixed pitch–angle wind turbine. The generator delivers its rated output at a rated wind speed of 10 m/sec. The generator is connected to a large 120 V battery bank. The generator is driven at rated wind speed, delivering its rated output.

(a) Calculate the generator output current, I. ***(4)***

(b) The wind speed was reduced to 6 m/sec; the generator efficiency stayed the same but the aerodynamic coefficient became 80% of what it was. Calculate the power output of the generator. The battery voltage stays constant at 120 V. ***(6)***

QUESTION THREE **Biomass Energy.**

Gasification is a thermochemical process where solid biomass is converted into gaseous fuel without leaving any solid residue.

(a) Fig. 4.0 shows a schematic diagram that illustrates the biomass gasification technology. Describe the process of gasification and state the four methods involved in the process. ***(5)***

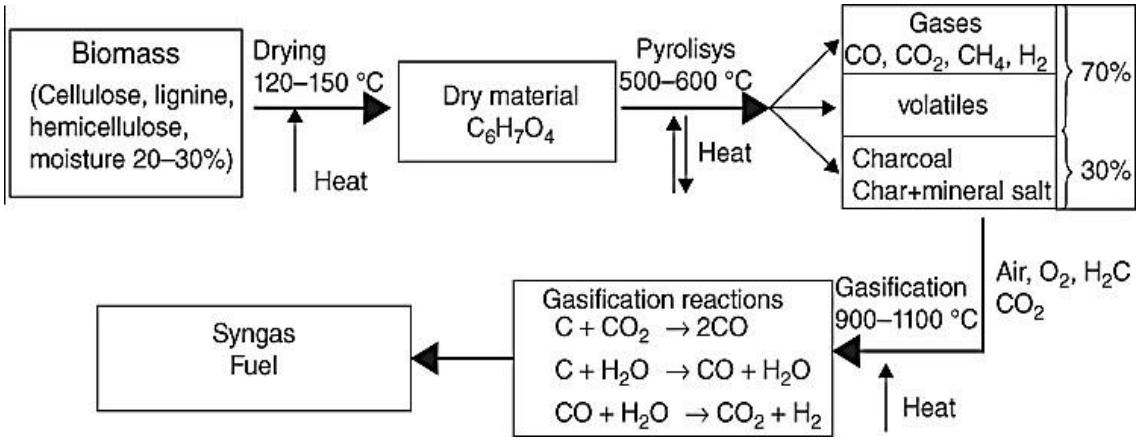

Fig. 4.0 Gasification flow diagram

(b) Fermentation is a chemical process where glucose breaks down to form ethanol and CO_2. With the aid a diagram (fermentation process flowchart) describe the three processes used in fermentation of biomass to produce 100% pure ethanol. **(5)**

QUESTION FOUR **Hydropower Energy.**

(a) Consider a reaction turbine with an external diameter of 0.6 m. The width of the wheel and the velocity of flow at inlet are 150 mm and 3 m/s, respectively. Find the rate of flow passing through the turbine. Assuming the internal diameter of the turbine is equal to 0.3 m and considering a constant velocity of flow through the runner, calculate the width of the wheel at the outlet. ***(5)***

(b) Consider a reaction turbine running at 500 rpm, which has an external diameter and a width of 500 mm and 200 mm, respectively. The absolute velocity of water at inlet is equal to 30 m/s and the guide vanes are at 25° to the wheel tangent. Obtain discharge through the turbine and inlet vane angle. ***(5)***

QUESTION FIVE **Wave and Tidal Energy.**

(a) Discuss the principle and working of sea wave energy conversion system ***(3)***

(b) Discuss the performance and limitations of sea wave energy conversion plants. ***(2)***

(c) A tidal power plant of single-basin type has a pool area 90×10^4 m^2. The tidal has a range of 10 m. However, the turbine stops operating when head on it falls below 2 m. Calculate the energy generated in one filling process in kW-h, if the turbine–generator efficiency is 85%. ***(5)***