

CHUKA



UNIVERSITY

## UNIVERSITY EXAMINATIONS

**THIRD YEAR EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF  
SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING**

**EENG 362: RENEWABLE ENERGY SYSTEMS****STREAMS:****TIME: 2 HOURS****DAY/DATE: THURSDAY 13/04/2023****2.30 P.M. –4.30 P.M.****INSTRUCTIONS**

- This paper consist four questions
- Attempt Question one and any other two.

**QUESTION ONE (30 MARKS)**

- a). Explain the significance of the bandgap energy in relation to the photovoltaic effect. (2 marks)
- b). i). With various expressions, distinguish between Spectral Irradiance, Insolation, and Radiation (5 marks)
- ii). A photovoltaic module that has an area of  $0.3 \text{ m}^2$  receives a light whose spectral irradiance is  $1000(\text{W}/\text{m}^2 \mu\text{m})$  limited over the wavelength from  $\lambda$   $0.60$  to  $0.7 \mu\text{m}$ . Calculate the insolation received and the radiation after one day. (4 marks)
- c). Discuss two main advantages and disadvantages of tidal power systems. (4 marks)
- d). Discuss the significance of the blade length and the number of blades in a HAWT paying attention to the output power and application of the turbine. (4 marks)
- e). i). Explain why biomass is, in principle, a solar source of energy. (4 marks)
- ii). Calculate the volume of air-dried wood that is needed to bring one liter of pure water from  $25^\circ\text{C}$  to the boiling point (i.e., to  $100^\circ\text{C}$ ). Given that the specific heat of water =  $4,200 \text{ J}/\text{kg K}$ , the

mass of 1 liter of water is 1 kg, the energy density of air-dried wood is 15 MJ/ kg, and the density of air-dried wood is  $600 \text{ kg/ m}^{-3}$ . (4 marks)

f). Discuss the shortcomings of using straw as the main fuel for a power generation plant. (3 marks)

### QUESTION TWO (20 MARKS)

a). Discuss four factors that affect the efficiency of a solar cell. (4 marks)

b). A solar cell has a reverse saturation current of  $I_0 = 10^{-10} \text{ A}$  and a short-circuit current of 5A at full insolation and room temperature. Given that its ideality factor is unity, determine its;

i. Open-circuit voltage at full insolation (3 marks)

ii. The percentage change in the open-circuit voltage if the insolation is reduced by 50%. (3 marks)

iii. Comment on the results of b). ii. Above. (2 marks)

c). With a neat structure, discuss the operation of a generic PV cell (8 marks)

### QUESTION THREE (20 MARKS)

a). With the use of sketch diagrams, explain the difference between a drag and a lift type wind turbine. (6 marks)

b). A proposed hydropower plant is to provide an annual energy output of 400 GWh. Determine the required rated capacity if the plant is to supply;

i. Base load only

ii. Peak load with 20% capacity factor (CF). (6 marks)

c). Sketch a typical power-speed curve of a wind turbine and use it to define the following terms: cut-in speed, rated speed, shutdown speed, and rated power of a wind turbine. (8 marks)

### QUESTION FOUR (20 MARKS)

a). Highlight three primary forms of Direct Use of Geothermal Energy (3 marks)

b). with the aid of a diagram explain the principle of electrical power generation in a hydroelectric plant. (6 marks)

c). A tidal stream turbine has an efficiency of 20% and generates an output of 50 kW in a flow velocity of 2.5 (m/s). Calculate the diameter of the turbine. You may assume that the density of water is  $\rho = 1000 \text{ kg/ m}^3$ . (6 marks)

d). Using appropriate diagrams, explain the operation of a single basin tidal barrage power plant and explain why such power plants have difficulties in meeting typical variations in power demand during the course of a day. (5 marks)

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