KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2021/2022 ACADEMIC YEAR

FOURTH YEAR SECOND SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF B.SC (RENEWABLE ENERGY AND BIOFUELS TECHNOLOGY)

COURSE CODE: REN 421

COURSE TITLE: HYDROPOWER

DATE: 30/08/2022 **TIME:** 9:00AM-11:00AM

INSTRUCTIONS TO CANDIDATES

TIME: 2 Hours

Answer question ONE and any TWO of the remaining

Question One (Compulsory)

a) Briefly describe the hydrological cycle. (4 marks)

b) List the various institutions tasked with the development of hydropower in Kenya and briefly highlight Kenya's hydropower development policy. (5 marks)

c) Highlight the advantages and disadvantages of hydropower projects in comparison with other sources of energy. (5 marks)

d) Differentiate between a forebay and surge tank as used in hydro-power plants. (2 marks)

e) State four factors to be considered while selecting a suitable site for hydro-electric power plant. (4 marks)

f) Define tidal energy and distinguish between the single-basin and double basin arrangements. (5 marks)

g) State five limitations of tidal energy as compared to other energy sources. (5 marks)

Question Two

The county government of Mombasa intends to install a hydropower project for the provision of electricity to its residents. A stream of treated wastewater runs down a hill to the Mombasa shoreline where it is possible to construct a simple hydropower scheme. The effective head (H) is 25m and the rate of water flow (Q) through the system is $0.5m^3$/sec. The simple inexpensive hydropower scheme has a working efficiency of 85%.

i) Determine the power that can be generated with this system per year. (7 marks)

ii) Find how many houses this energy can support, assuming an average community consumption of 12,000kWh per year per house. (3 marks)

iii) How much oil would be required in an oil-fired power plant to generate the equivalent amount of electrical energy as the hydropower generates in a year, given the energy content of oil is 11,630kWh/ton. (5 marks)

iv) How much carbon (IV) oxide emissions would be emitted if the power plant was used, given the power plant produces 0.27kg CO_2 per kWh. (5 marks)

Question Two

a) State and explain three types of turbines used in hydropower plants. (6 marks)

b) A hydropower plant receives a design discharge of $25m^3/s$ from 150m height. The annual output of the plant is 220GWh. If the peak load demand is 30 MW, assuming overall efficiency of 85% and neglecting head loss in the penstock, determine. (8 marks)

i) Annual load factor

ii) Capacity factor

iii) Utilization factor

c) A hydropower plant has a design discharge of 60 m^3/s and a net head of 90m. Design a Francis turbine for this power plant (number of turbines, specific speed, diameter, and setting of turbines). Take turbine efficiency of 94%. (6 marks)

Question Four

a) With the aid of a well-labeled curve, describe the rated turbine characteristics of tidal stream turbines. (4 marks)

b) Explain the various tidal energy harvesting devices. (8 marks)

c) Suppose the net tangential force per blade on a 12m diameter three-bladed tidal stream turbine rotor operating at a tip speed ratio of 4 in a flow velocity of 2.4 m/s is 10.6kN, and the force acts at a radial position of 5m. (8 marks)

i) determine the approximate C_p of the turbine? (Assume the density of water is 1000 kg/m^3).

ii) Explain why the value in (a) above is an approximation.

iii) If the solidity of the rotor is 0.2, determine the mean chord length of each blade.

Question Five

a) Explain the principle of harnessing energy from ocean tides. (6 marks)

b) Explain the possible environmental impacts associated with tidal stream turbines. (10 marks)

c) The Bay of Funday, Canada is known for having the highest tidal range in the world. The tidal range could approach 17m in extremity. About 110 billion tons of water flow into and out of the bay in one cycle. Calculate the total potential tidal energy of the Bay of Funday in this extreme case in one year by using bidirectional turbines. (Gravity acceleration 9.81 m/s^2). (4 marks)