KENYATTA UNIVERSITY
UNIVERSITY EXAMINATIONS 2011/2012
SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN ENERGY ENGINEERING

SET 445: ENERGY STORAGE AND DISTRIBUTION

DATE: Tuesday 17th April, 2012 **TIME:** 11.00 a.m. – 1.00 p.m.

Instructions

a) This paper contains five questions

b) **Attempt question ONE and select any other two questions**

c) All questions carry equal marks

d) State assumptions made and define all symbols used

Question 1:

a) Using illustration, describe the principle behind the operation of pumped energy storage system and how it can be used to meet energy needs in Kenya [7 marks]

b) Consider a pumped hydro system that is used for energy storage. During off-peak hours, excess electricity is used to pump water up to a storage reservoir. During peak demand periods the flow is reversed and electric power is generated by flowing the water through a hydraulic turbine. The storage reservoir is 200 m above the hydro turbine/pump units and the hydraulic turbine can accommodate up to 500 kgs^{-1} of flow (taking into account the full flow-based power capacity of the turbine).

c) Estimate the theoretical energy the energy storage system. Express your answer in Jm^{-3} [8 marks]

d) Estimate power density of the system that stores water during the times that power is generated. Express your answer in Wm^{-3} for power density. [5 marks]

Questions 2:

a) Using an illustration describe the basic components of a flywheel energy storage system and its principle of operation. [10 marks]

b) A passenger bus used to ferry tourist to and from on Mount Kenya derived its motive power energy stored in a large flywheel. The flywheel was brought up to the speed, when the bus stopped at the station, by an electric motor which could be attached to the electric power lines. The flywheel was a solid steel cylinder of mass 1000 kg, diameter 180 cm, and would

turn up to 3000 revolutions per minute. At its top speed, determine the kinetic energy and energy storage density of the wheel ? [10 marks]

Question 3.

a) Using an illustration, describe the basic principles of packed bed energy storage systems and its application in real life application in Kenya [5 marks]

b) A pebble bed for storing heat during night heating has the following characteristics

Length in air flow direction = 4 m
Cross-sectional area = 20 m
Air velocity = 1m/s
Pebbles equivalent diameter = 10 mm
Bed porosity = 0.50
Pebble density materials = 1250 kg/m^3
Pebble material specific heat capacity = 0.80 kJ/kg ^oC
Pebble material thermal conductivity , k = 0.80 W/m ^oC
Pebble surface area per unit volume $250m^2/m^3$

i) Determine volumetric heat transfer [5 marks]

ii) Determine Reynolds number [5 marks]

iii) Determine pressure drop across the bed [5 marks]

Questions 4.

a) Describe the basic principles and types of compressed air energy storage systems and possible applications in Kenya [8 marks]

b) Describe why electric power being transmitted over long distances is maintained at high voltages [2 marks]

c) What are latent heat energy storage systems and briefly describe how latent heat energy storage can be applied in real life situation in Kenya. [5 marks]

d) Describe the basic principles and theory of operation of accumulators [5 marks]

Question 5:

A small well insulated passive solar house requires an average internal heat supply of 1 kW. Together with the free gains of lighting, this will maintain an internal temperature of 20°C. It is decided to build a hot water storage with rectangular configuration whose top forms the floor of the house with area 200 sq-m. The heating must be adequate for 100 days as all the heat loss from the tank passes by conduction through the floor and as the water cools from initial 60°C to a final 40°C.

a) Determine the volume of the tank [5 marks]

b) Determine thermal resistance of the heat path from the tank to the floor; [5 marks]

c) Determine energy storage density [5 marks]

d) Suggest how the tank should be enclosed thermally [5 marks]