MACHAKOS UNIVERSITY

University Examinations for 2022/2023

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FOURTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING

EEE 303 POWER SYSTEMS I

DATE: **TIME:**

INSTRUCTIONS:

This paper consists of **FIVE** questions.

Answer **QUESTION ONE** and **ANY OTHER TWO** questions.

QUESTION ONE (COMPULSORY) (30 MARKS)

a)

i) List any FOUR factors that should be taken into account when selecting a site for a NUCLEAR power plant. (2 marks)

ii) Sketch a labelled diagram illustrating a nuclear chain reaction. (3 marks)

iii) List THREE types of radiation that would accompany disintegration or decay of unstable atoms. (1.5 marks)

b) Draw a schematic arrangement of a nuclear power plant. Briefly describe the function of each part. (5.5 marks)

c)

(i) A supply is offered on the basis of fixed charges of Ksh 30 per annum plus 3 cents per unit or alternatively, at the rate of 6 cents per unit for the first 400 units per annum and 5 cents per unit for all the additional units. Find the number of units taken per annum for which the cost under the two tariffs becomes the same.

(4 marks)

(ii) A hydro-electric station is to be designed to operate at a mean head of 205m and supplied from a reservoir having a catchment area of 1,000 km^2 with average annual rainfall of 125 cm of which 80% is available for power generation. The expected load factor at the plant is 75%. Allowing a head loss of 5m and assuming efficiency of turbine and generator to be respectively 90% and 95%, calculate suitable MW rating of the station. Comment also on the type of turbine to be installed. (4 marks)

d) A single-phase ac distributor 500m long has a total impedance of $(0.02 + j0.04)\Omega$ and is fed from one end at 250 V. Calculate the voltage drop at the end if it is loaded as under:
   i) 50A at unity power factor 200m from the feed point
   ii) 100A at 0.8 p.f. lagging, 300m from feed point
   iii) 50A at 0.6 p.f. lagging at the far end. (6 marks)

e) A single phase motor connected to 400 V, 50 Hz supply takes 31·7A at a power factor of 0·7 lagging. Calculate the capacitance required in parallel with the motor to raise the power factor to 0·9 lagging. (4 marks)

QUESTION TWO (20 MARKS)

a) A hydro-electric power station is supplied from a reservoir having an area of 50 km^2 and a head of 50m. If the overall efficiency of the plant be 60%, calculate the rate at which the water level will fall when the station is generating 30,000kW. (10 marks)

b) A single phase a.c. generator supplies the following loads:
   i) Lighting load of 20 kW at unity power factor.
   ii) Induction motor load of 100 kW at p.f. 0·707 lagging.
   iii) Synchronous motor load of 50 kW at p.f. 0·9 leading.

   Calculate the total kW and kVA delivered by the generator and the power factor at which it works. (10 marks)

QUESTION THREE (20 MARKS)

a) Calculate the cost of electrical energy and average cost for consuming 375 kWh under block rate tariff quoted as follows:

   First 50 kWh at sh. 4.00 per kWh
   Next 50 kWh at sh. 3.60 per kWh
   Next 50 kWh at sh. 3.00 per kWh

Next 50 kWh at sh. 2.50 per kWh
Excess over 200 kWh at sh. 2.10 per kWh (10 marks)

b) In a 3-phase, 4-wire system, the line voltage is 400 volts and non-inductive loads of 10, 8 and 5 kW are connected between the three line conductors and the neutral, as shown in **Figure Question 3(b)**. Calculate the:

(i) Current in each line

(ii) Current in the neutral conductor (10 marks)

QUESTION FOUR (20 MARKS)

(a) **Figure Question 4(b)** shows a single-line diagram of a power system. The ratings of the generators and transformer are given below:

G1	:	$25MVA, 6.6kV, x_{g1} = 0.20\ pu$
G2	:	$15MVA, 6.6kV, x_{g2} = 0.15\ pu$
G3	:	$30MVA, 13.2kV, x_{g3} = 0.15\ pu$
T_1	:	$30MVA, 6.6\ \Delta - 115\ Y\ kV, x_{T1} = 0.10\ pu$
T_2	:	$15MVA, 6.6\ \Delta - 115\ Y\ kV, x_{T2} = 0.10\ pu$
T_3	:	Appropriately connected single-phase units each rated $10MVA, 6.6/69\ kV, x_{T3} = 0.10\ pu$

Draw the per-unit diagram using base values of 30 MVA and 6.6 kVA in the circuit of generator 1. **(10 marks)**

(b) Calculate the current drawn from a three-phase 440 V line by a three-phase 15 hp motor operating at full load, 90% efficiency, and 80% power factor lagging. Calculate also the values of P and Q drawn from the line. (10 marks)

QUESTION FIVE (20 MARKS)

(a) Show that for both Y-connected and $\Delta -$ connected loads, the total three-phase power is given by $P = \sqrt{3}V_L I_L \cos\theta_p$. **[The terms in the equations have their usual meaning].** (10 marks)

(b) A sub-station supplies power at 11 kV, 0·8 p.f. lagging to a consumer through a single phase transmission line having total resistance (both go and return) of 0.15 Ω. The voltage drop in the line is 15%. If the same power is to be supplied to the same consumer by two wire d.c. system by a new line having a total resistance of 0·05 Ω and if the allowable voltage drop is 25%, calculate the d.c. supply voltage. (10 marks)

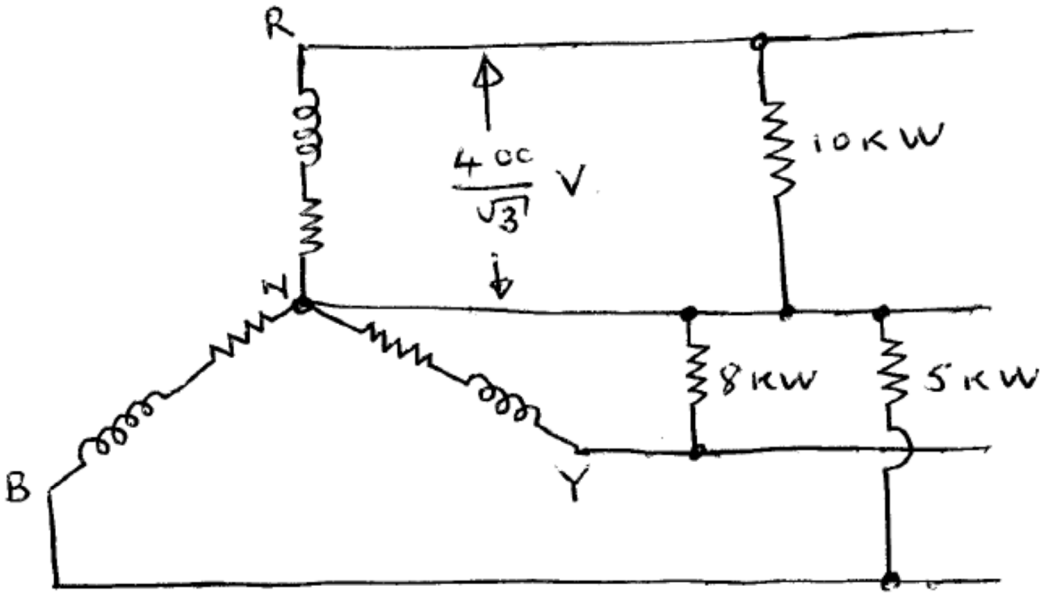

FIGURE QUESTION 3 (b)

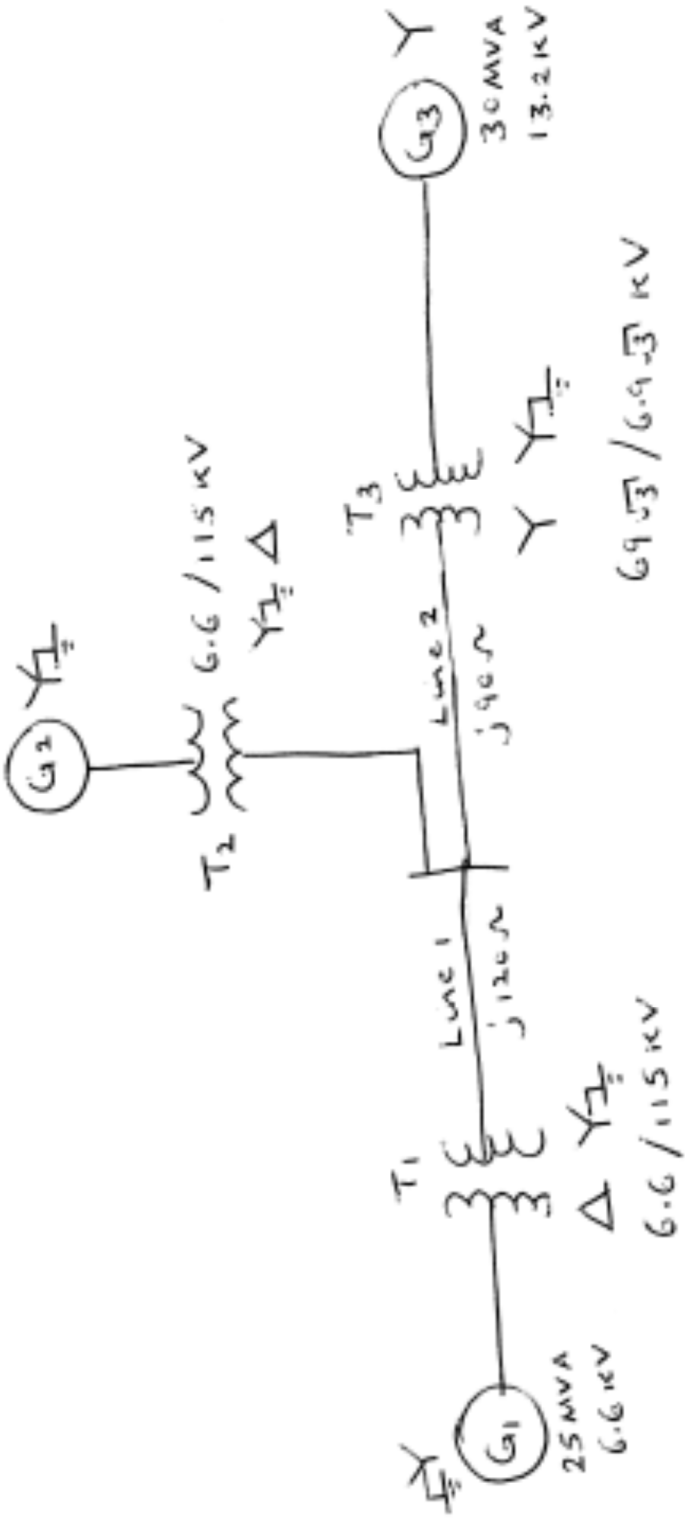

Figure Question 4(b)