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 412 POWER SYSTEMS III

DATE: 15/12/2022 **TIME: 8:30 – 10:30 AM**

INSTRUCTIONS

This paper consists of **FIVE** questions.

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

QUESTION ONE (COMPULSORY) (30 MARKS)

a) A 3-phase transmission line has a resistance per phase of 5Ω and an inductive reactance of 15Ω per phase. Graphically, determine the load which the line will be supplying at 132kV and 0.8 p.f. lagging. The sending-end voltage is 140kV.

If a synchronous phase modifier is connected in parallel with the load to improve the power factor to 0.95 lagging, **graphically determine** the leading MVAR supplied by the synchronous phase modifier. Receiving-end voltage and load remain unchanged. (6 marks)

b) A diesel station supplies the following loads to various consumers:

Industrial consumer = 1500 kW ; Commercial establishment = 750 kW

Domestic power = 100 kW; Domestic light = 450 kW

If the maximum demand on the station is 2500 kW and the number of kWh generated per year is 45×10^5, Calculate the :

(i) diversity factor

(ii) annual load factor. (6 marks)

c) A 15 km long 3-phase overhead line delivers 5 MW at 11kV at 0.8 lagging p.f. Line loss is 12% of power delivered. Line inductance is 1.1 mH per km per phase. Calculate:

i) Sending-end voltage

ii) Voltage regulation (6 marks)

d) Calculate the percentage saving in feeder copper if the line voltage in a two-wire dc system be raised from 220 V to 500 V for the same power transmitted. State any assumption made. (6 marks)

e) A power station has a daily load cycle as under :

260 MW for 6 hours; 200 MW for 8 hours; 160 MW for 4 hours; 100 MW for 6 hours.

If the power station is equipped with 4 sets of 75 MW each, calculate:

i) daily load factor

ii) plant capacity factor

iii) daily requirement if the calorific value of oil used were 10,000 kcal/kg and the average heat rate of station were 2860 kcal/kWh. (6 marks)

QUESTION TWO (20 MARKS)

(a)

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

(ii) Sketch a labelled diagram illustrating the energy flow in a steam power plant. (2 marks)

(iii) List the TWO broad categories of losses that occur in steam power plants. (2 marks)

(b) Draw a schematic arrangement of a modern coal fired power plant. (8 marks)

(c)

(i) In a power plant, the efficiencies of the electric generator, turbine (mechanical), boiler, cycle and the overall plant are 0.97, 0.95, 0.92, 0.42 and 0.33, respectively. Calculate the percentage of the total electricity generated consumed in running the auxiliaries of the plant. (2 marks)

(ii) A thermal station has an overall efficiency of 21% and 0.75 kg of coal is burnt per kWh of generated energy. Calculate the calorific value of coal. (2 marks)

(iii) A steam power station of 100 MW capacity uses coal of calorific value of 6,400 kcal/kg. The thermal efficiency of the station is 30% and electrical generation efficiency is 92%. Calculate the mass of coal required per hour when the plant is working at full load. (2 marks)

QUESTION THREE (20 MARKS)

a) State the limitations of the fossil fuels as sources of energy (3 marks)

b) With the help of a schematic diagram, explain the structure of a diesel power station (8 marks)

c) A diesel engine power plant has one 700KW and two 500KW generating units. The fuel consumption is 0.28kg per KWh and the calorific value of fuel oil is 10200kcal per kg. The plant capacity is factor is 40%. Determine the overall efficiency of the plant **.** (9 marks)

QUESTION FOUR (20 MARKS)

a) A d.c. 3-wire system is to be converted into a 3-phase, 4-wire system by adding a fourth wire equal in X-section to each outer of the d.c. system. If the percentage power loss and voltage at the consumer's terminals are to be the same in the two cases, find the extra power at unity power factor that can be supplied by the a.c. system. Assume loads to be balanced. (10 marks)

b) A power supply is having the following loads :

Type of Load	**Max Demand(kW)**	**Diversity of Group**	**Demand Factor**
Domestic	1,500	1.2	0.8
Commercial	2,000	1.1	0.9
Industrial	10,000	1.25	1

If the overall system diversity factor is 1·35, calculate the:

i) maximum demand

ii) connected load of each type. (10 marks)

QUESTION FIVE (20 MARKS)

a) A 50 km long transmission line supplies a load of 5 MVA at 0·8 p.f. lagging at 33kV. The efficiency of transmission is 90%. Calculate the volume of aluminium conductor required for the line when :

   i) single phase, 2-wire system is used

   ii) 3-phase, 3-wire system is used.

   The specific resistance of aluminium is $2.85 \times 10^{-8}\ \Omega$ m (10 marks)

b) It has been desired to install a diesel power station to supply power in a suburban area having the following particulars :

   i) 1000 houses with average connected load of 1·5 kW in each house. The demand factor and diversity factor being 0·4 and 2·5 respectively.

   ii) 10 factories having overall maximum demand of 90 kW.

   iii) 7 tubewells of 7 kW each and operating together in the morning.

   The diversity factor among above three types of consumers is 1·2. Calculate the minimum capacity of the power station? (10 marks)