MACHAKOS UNIVERSITY

University Examinations for 2021/2022

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

SECOND YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 214: ELECTRICAL ENGINEERING 11

DATE: 17/3/2022 **TIME 8.30-10.30 AM**

INSTRUCTIONS: This examination paper contains five questions. Answer **Question ONE** and any other **TWO Questions**. Question ONE carries 30 Marks and ALL the other questions carry 20 Marks each.

QUESTION ONE (COMPULSORY) (30 MARKS)

a) What is the necessity of a starter in a dc motor? (2 marks)

b) What are some of the problem/troubles that may arise during the operations of DC motors. (2 marks)

c) An iron of 15cm diameter and 10cm^2 cross sectional area with a saw cut of 2mm wide is wound with 200turns of wire. The flux density is 1Wb/m^2. The relative permeability of iron is 600. Find the exciting current. Neglect leakage. (4 marks)

d) A single-phase transformer has 480 turns on primary and 90 turns on the secondary. The mean length of the flux path in the iron core is 180cm and the joints are equivalent to the airgap of 0.1mm. If the maximum value of flux density is 1.1Wb/m^2, when a p.d of 2200V at 50Hz is applied to the primary. Calculate

   i) The cross sectional area of the core. (2 marks)

   ii) The secondary voltage on no load. (1 mark)

   iii) The primary current and power factor on no load. (4 marks)

   Assume ampere turns/meter for 1.1Wb/m^2, the corresponding iron loss to be 2Wb/kg at 50Hz and density of iron to be 7.8g/cm^3.

e) A dc shunt motor drives an elevator load that requires a constant torque of 300 Nm. The motor is connected to a 600 V dc supply and the motor rotates at 1500 rpm. The armature resistance is 0.5 Ω.

i) Determine the armature current. (4 marks)

ii) If the shunt field flux is reduced by 10%, determine the armature current and the speed of the motor. (5 marks)

f) A single-phase transformer on no-load takes 4.5A at a power factor of 0.25 lagging when connected to a 230V, 50Hz supply. The number of turns on the primary winding is 250. Calculate:

i) The magnetizing current. (2 marks)

ii) The core loss and (2 marks)

iii) The maximum value of flux in the core. (2 marks)

QUESTION TWO (20 MARKS)

a) Give two types of DC machines and draw their equivalent circuit. (2 marks)

b) Explain the functions of the following parts of a DC machine. (4 marks)

i) The commutator,

ii) The brushes,

iii) The electric circuit of the motor,

iv) The magnetic circuit,

c) A single-phase, two winding transformers has 1000 turns on the primary side and 50 turns on the secondary winding with primary voltage of 220V. The transformer can be considered ideal.

i) Determine the secondary voltage of the transformer. (1 mark)

ii) Determine the load impedance. (1 mark)

iii) Determine the load impedance referred to the primary side. (1 mark)

d) A 400V, dc shunt motor takes 5A at no-load. Its armature and field resistances are 0.5Ω and 200Ω respectively. Calculate the efficiency when the motor takes 50A at full load. Also calculate the percentage change in speed from the no load to full load. (4 marks)

e) A 4-pole, 250V, wave-connected shunt motor gives 10kW when running at 1000rpm and drawing armature and field current of 60A and 1A respectively. It has 560 conductors. Its armature resistance is 0.2 Ω. Assuming a drop of 1 volt per brush, determine: (7 marks)

i) Total torque

ii) Useful torque

iii) Useful flux per pole,

iv) Rotational losses

v) Efficiency

QUESTION THREE (20 MARKS)

a) Give four different types of transformers. (2 marks)

b) With the aid of a diagram, show how transformers are connected in parallel. (2 marks)

c) Three 1φ, 50kVA, 2300/230V, 60Hz transformers are connected to form a 3φ, 4000/230 V transformer bank. The equivalent impedance of each transformer referred to low voltage is 0.012 + j0.016 Ω. The 3φ transformer supplies a 3φ, 120kVA, 230V, 0.85 PF (lag) load.

i) Draw a schematic diagram showing the transformer connection (2 marks)

ii) Determine the transformer winding currents (2 marks)

iii) Determine the primary voltage (line-line) required. (3 marks)

iv) Determine the voltage regulation. (2 marks)

d) A 10kW, 100V, 1000 rpm dc machine has $R_a = 0.1\ \Omega$ and is connected to a 100V dc supply.

i) Determine the starting current if no starting resistance is used in the armature circuit. (2 marks)

ii) Determine the value of the starting resistance if the starting current is limited to twice the rated current. (2 marks)

iii) This dc machine is to be run as a motor, using a starter box. Determine the values of resistances required in the starter box such that the armature current I_a is constrained within 100 to 200% of its rated value (i.e., 1 to 2 pu) during start-up. (3 marks)

QUESTION FOUR (20 MARKS)

a) Tests are performed in a single-phase, 10kVA, 2200/220V, 60Hz transformer and the following data obtained.

	Open-Circuit test. (HV side open)	**Short-circuit test** (LV side shorted)
Voltmeter	220V	150V
Ammeter	2.5A	4.55A
Wattmeter	100W	215W

a) Derive the parameters for the approximate- equivalent circuit referred to the low voltage and high voltage side. (10 marks)

b) Express the excitation current as a percentage of the rated current (1 mark)

c) Determine the power factor for the no-load and short circuit tests. (2 marks)

d) Determine the voltage regulation in percentage for the following load conditions (3 marks)

   i) 75% full load, 0.6 p.f lagging and at 0.6 pf leading.

   ii) Draw the phasor diagrams for both conditions.

e) Determine: (4 marks)

   i) Efficiency of the transformer at 75% rated output and 0.6 p.f

   ii) Power output at maximum efficiency and the value of maximum efficiency. At what percentage of full load does this maximum efficiency occurs?

QUESTION FIVE (20 MARKS)

a) Derive the equation of the developed torque in a dc machine. (10 marks)

b) Give the names of two types of induction motors based on their rotor structure (1 mark)

c) With use of diagram, explain the three modes of operation of induction motor . (2 marks)

d) A three phase, 460V, 100hp, 60Hz, 6-pole induction machine operates at 3% slip (positive) at full load.

   i) Determine the speeds of the motor and its direction relative to the rotating field. . (2 marks)

   ii) Determine the rotor frequency (1 mark)

   iii) Determine the speed of the stator field. (1 mark)

   iv) Determine the speed of the rotating airgap field. (1 mark)

   v) Determine the speed of the rotor relative to

      a) The rotor structure. (1 mark)

      b) The stator structure (1 mark)

      The stator rotating field