ELIZADE UNIVERSITY ILARA MOKIN, ONDO STATE.

FACULTY OF ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

SECOND SEMESTER EXAMINATION, 2018/2019 ACADEMIC SESSION

COURSE TITLE: ELECTROMECHANICAL DEVICES AND DESIGN

COURSE CODE: EEE 316

EXAMINATION DATE:

COURSE LECTURER: DR K. O. TEMIKOTAN

HOD's Signature

TIME ALLOWED: 2 HOURS

INSTRUCTION

1. ANSWER ANY **FOUR** QUESTIONS
2. SEVERE PENALTIES APPLY FOR MISCONDUCT, CHEATING, POSSESSION OF UNAUTHORIZED MATERIALS DURING EXAM.
3. YOU ARE NOT ALLOWED TO BORROW ANY WRITING MATERIALS AND CALCULATORS DURING THE EXAMINATION.
4. SMART WATCHES ARE NOT ALLOWED IN THE EXAMINATION HALL

QUESTION ONE

a. List the main factors which determine the electrical breakdown of insulating materials. (5 marks)
b. The breakdown voltage of an insulator is related to the thickness of the materials by the equation; $V_b = At^{2}/3$
   What does the constant A depend upon? (3 marks)
c. Using a schematic diagram and a phasor diagram, show how to obtain the loss angle of a dielectric material. (5 marks)
d. Write the formula for the dielectric loss. (2 marks)

QUESTION TWO

a. The mechanical force required for motion in rotating electrical machines can be produced both by electrostatic and electromagnetic fields since both fields store energy. Why are electromechanical devices built around electromagnetic fields? (4 marks)
b. How are losses in the magnetic circuit of electrical machines reduced? (3 marks)
c. The hysteresis loss in a sample of iron was found to be 4.9 W/kg at a frequency of 50 Hz and a maximum flux density (B_m) of 1 Wb/m^2.
   i. Calculate the coefficient η in the expression;
   $loss/cycle = \eta B_m^{1.7} J/m^2$ given that the specific gravity of iron is 7.5.
   Take the density of iron as 7500 kg/m^3. (5 marks)
   ii. Calculate the loss per kg at frequency (f) of 25 Hz and a flux density (B_m) of 1.8 Wb/m^2.(3 marks)

QUESTION THREE

a. Why is it especially important to ensure air gap uniformity in an induction motor? (2 marks)
b. What measures are taken in the design and manufacture of induction motor to ensure the uniformity of the air gap? (3 marks)
c. A 75 kW, 50 Hz, 2 - pole machine with sinusoidally distributed flux has the following design data:
   Axial length of core, D = 0,2 m; Stator bore, L = 0.5 m; length of air gap l_g = 5 mm; peak magnetizing mmf per pole = 4500 A.
   Calculate;
   i. Magnetic pull per pole when the rotor is symmetrically centred; (4 marks)
   ii. Unbalanced magnetic pull if the rotor axis is displaced by 1 mm; (3 marks) and
   iii. Ratio of unbalanced magnetic pull to useful force. Neglect saturation. (3 marks)

QUESTION FOUR

a. State the causes of temperature rise in transformers. (2 marks)
b. State the two prime functions of transformer oil. (2 marks)
c. A transformer core of plate width 0.5 m and with a stacking factor 0.94, has a uniformly distributed core loss of 3 W/kg. The thermal conductivity of the steel is 150 W/^{0}C-m and a surface temperature is 40^{0}C. Estimate the temperature of the hot spot if the heat flow is;
   i. All to one end of the core.
   ii. One half to the surface of each end.
   Assume that the heat flow to be along laminal. The density of steel plate is 7800 kg/m^3. (11 marks)

QUESTION FIVE

a. Why are the cores of transformers made of laminations? (2 marks)
b. The cores of modern transformers are made of cold rolled grain - oriented steel sheets having 3% silicon content. State five advantages of using this material for transformer cores (5 marks)
c. Using fundamental principles, derive an equation for the power Q in kilovoltampere (kVA) of a single-phase transformer. (8 marks)

QUESTION SIX

a. It has been established from test results that the ratio of losses to output of small rotating machines vary approximately as $D^{-1}L^{-1/2}n^{-1/2}$ where D, L, and n are respectively the diameter, length, and speed of the machine. Prove that if the temperature rise remains constant the output of a small machine varies as D^3Ln. Assume cooling coefficient $c \propto V_a^{-1/2}$ where V_a is the peripheral speed of the rotor. The effective heat dissipating surface of the machine is proportional to the geometric mean of the end surfaces and the cylindrical surface of the rotor. (7 marks)

b. The design details of two dc machines are tabulated below.

Machine	Diameter D (m)	Core Length L (m)	Speed n (rps)	Slots S	Area of each Slot A_s	Slot space factor S_f	B_m Wb/m^2	Current Density δ (A/mm^2)
A	0.75	0.31	10	72	48 x 11	0.5	0.6	4.5
B	0.55	0.25	7.5	61	44 x 10	0.43	0.56	5.2

Compare their outputs. (8 marks)