THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

UNIVERSITY EXAMINATIONS

June/July 2015

EEE 3352

TIME	:	Three (3) hours
INSTRUCTIONS	:	Answer any five (5) questions
ADDITIONAL INFORMATION	:	*permeability of free space* $\mu_0 = 4\pi \times 10^{-7}$ H/m
		permittivity of free space $\varepsilon_0 = 8.85\times 10^{-12}$ F/m

Q1. (a) Determine the electric flux density distance r from an infinity line charge of q C per unit length. Use this result to calculate the electric field strength in air 5 mm from a line charge of 16 pC/m.

[5 marks]

(b) Consider a simple electric circuit containing a capacitor C and current i flowing in the circuit. Given that voltage V is applied across the capacitor with cross-sectional area A and length l between the electrodes, derive the expression for the energy density (in J/m^3) in this electrostatic field.

[5 marks]

(c) Consider figure Q1 below depicting a capacitor where the symbols given have their usual meaning. (Note: there is no air-gap below and above the inserted dielectric)

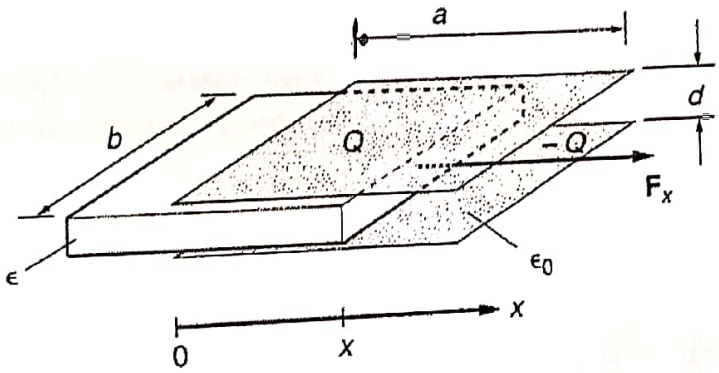

Figure Q1

Show that the force F_x acting on the dielectric that is partly inserted between the two electrodes is given as

$$F_x(x) = \frac{V^2}{2}\frac{b}{d}(\varepsilon - \varepsilon_0)$$

[10 marks]

Q2. (a) Draw a reluctance model and a corresponding Ampere's circuital law model for a series magnetic circuit consisting of iron, steel and air-gap.

[4 marks]

(b) Given that the magnetic circuit in 2(a) has N turns and current $i(t)$ to produce the required magnetomotive force, show that the inductance L in the circuit is given by

$$L = \frac{N^2}{R_i + R_s + R_g}$$

where R_i, R_s and R_g are the reluctances for the iron, steel and air-gap respectively.

[8 marks]

(c) A closed magnetic circuit made of silicon iron consists of a 40 mm long path of cross sectional area 90 mm^2 and a 15 mm long path of cross-sectional area 70 mm^2. A coil of 50 turns is wound around the 40 mm length of the circuit and a current of 0.39 A flows. Find the flux density in the 15 mm length path if the relative permeability of the silicon iron at this value of magnetising force is 3000.

[8 marks]

Q3. (a) Draw and explain the phasor diagram of a transformer on load at unity power factor. In addition, draw the corresponding equivalent circuit to which the phasor diagram you have drawn refers.

[10 marks]

(b) The following data were obtained on a 20 kVA, 50 Hz, 2000/200 V distribution transformer:

Open Circuit Test (on L.V. side): 200 V, 4 A, 120 W

Short Circuit Test (on H.V. side): 60 V, 10 A, 300 W

By taking the voltage drop across the transformer into account, determine the efficiency of this transformer at half full load and 0.8 power factor lagging load.

[10 marks]

Q4. (a) Explain the advantages of having a three-phase system compared to a single-phase system in a power system.

[6 marks]

(b) Show, by suitable derivations, how the power factor of a 3-phase load can be determined from the readings of two wattmeters.

[6 marks]

(c) Find the readings of the two wattmeters used to measure real power on a 3-wire, 240-V system with a balanced delta-connected load of $20\underline{/80^{o}}\ \Omega$.

[8 marks]

Q5. (a) Derive the torque-speed characteristic of a dc series motor.

[8 marks]

(b) A dc series motor, connected to a 440-V supply, runs at 600 rpm when taking a current of 50 A. Calculate the value of a resistor which, when inserted in series with the motor, will reduce the speed to 400 r/min, the gross torque being then half its previous value. Resistance of the motor armature is 0.2 Ω. Assume the flux is proportional to the field current.

[12 marks]

Q6. (a) Prove that a set of balanced three-phase sinusoidal currents of peak value I_m in coils of N turns on the stator produces a "rotating" magnetomotive force F of constant magnitude given by $|F| = \frac{3}{2} N I_m$.

[8 marks]

(b) Explain the principal feature which establishes a three phase AC machine as either an induction machine or a synchronous machine.

[4 marks]

(c) A three-phase, 50-Hz, 6-pole, 220-V, wound-rotor induction motor has its stator connected in delta and its rotor in star. The rotor has half as many turns as the stator. The frequency of the rotor-induced voltage at one operating condition is 4 Hz. Calculate

(i) the slip

[2 marks]

(ii) the operating speed

[2 marks]

(iii) the rotor induced-voltage per phase.

[4 marks]

Q7. (a) Derive, from basic principles, the inverse square law of illumination and the cosine law of illumination.

[8 marks]

(b) Two lamps are hung at a height of 9 m from the floor level. The distance between the lamps is 1 m. The first lamp has a luminous intensity of 500 cd. If the illumination on the floor below the first lamp is 20 lx, find the luminous intensity of the second lamp.

[6 marks]

(c) A room whose floor measures 12 m by 12 m is to have direct lighting giving average illuminance of 80 lx on the working plane. If the efficacy of the 100-W lamps available is 14.75 lm/W and the uitilisation and maintenance factors are 0.5 and 0.8, respectively, determine the number of lamps required.

[6 marks]

END OF EEE 3352 EXAMINATION