THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

UNIVERSITY EXAMINATIONS

February / March 2014

EEE 3351

ELECTROMECHANICS AND ELECTRICAL MACHINES

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) Tabulate an analogy of at least five parameters between an electrical conduction field and a thermal conduction field. [**5 marks]**

(b) Write brief notes on each of the following terms:

(i) Insulation resistance

(ii) Dielectric strength

(iii) Dielectric constant

(iv) Dielectric dissipation factor

[4 × 2 marks]

(c) (i) In the definition of the electric field on a positive test charge given as;

$E = \lim_{q \to 0}\left(\frac{F}{q}\right) = \frac{Q}{4\pi e_0 e_r r^2}, N/C,$ why is the condition $q \to 0$ necessary? **[2 marks]**

(ii) The electric field strength on the surface of a sphere of 1 cm radius is equal to the corona-inception gradient in air of 30 kV/cm. Find the charge and potential on the sphere. [**5 marks]**

Q2. (a) With regard to magnetic circuits, what is mean length and its importance? **[2 marks]**

(b) In the magnetic circuit detailed in figure **2(b)-i** with all dimensions in mm, calculate the required current to be passed in the coil having 200 turns in order to establish a flux of 1.28 mWb in the air gap. Neglect fringing effect and leakage flux. The B-H curve of the material is given in figure **2(b)-ii**. **[18 marks]**

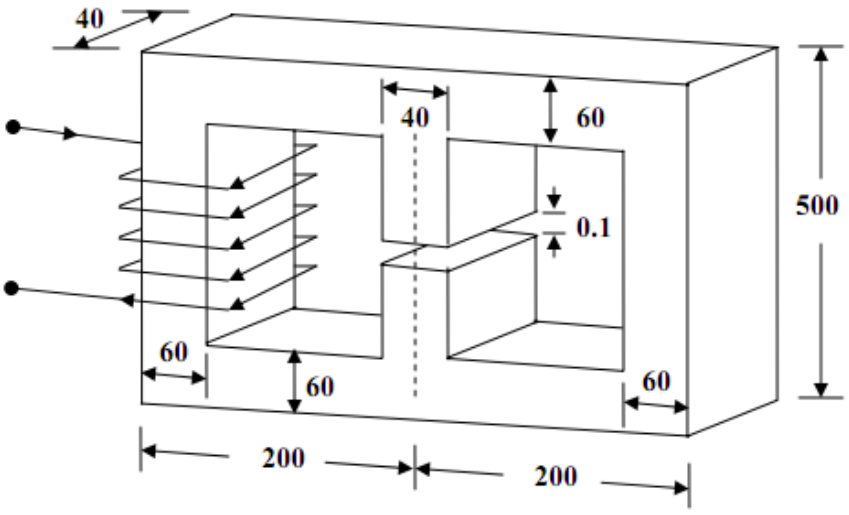

Figure **2(b)-i**

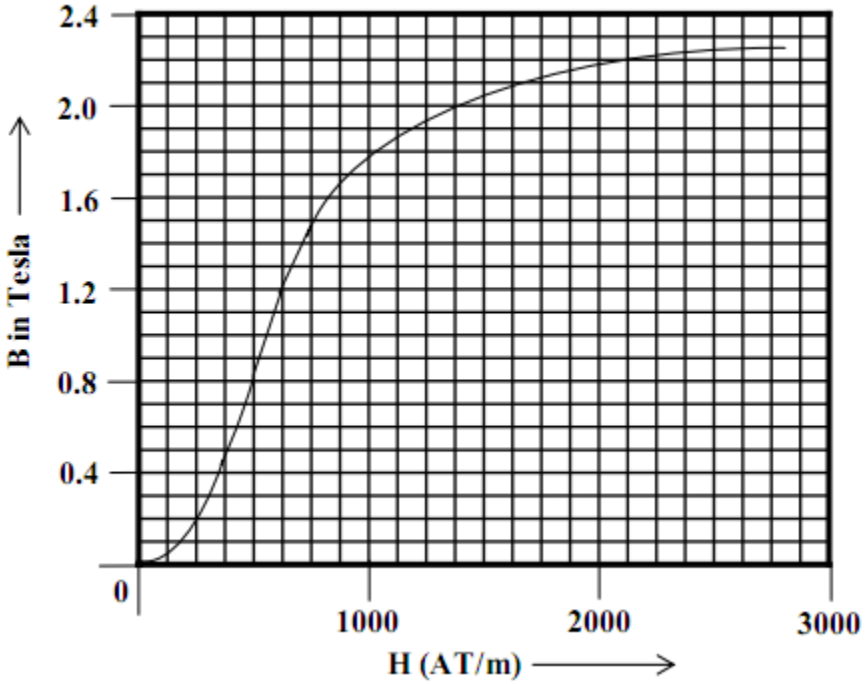

Figure **2(b)-ii** B-H curve for the selected material

Q3. A 6 kVA, 500/250 V, 50 Hz, single-phase transformer has the following test results:

OC test (LV side): 250 V, 1.5 A, 80 W

SC test (HV side): 22 V, 10 A, 90 W

Determine the following:

(a) The approximate equivalent circuit referred to HV side. **[10 marks]**

(b) Voltage regulation and efficiency of the transformer at full-load and 0.8 power factor lagging load. **[10 marks]**

Q4. (a) Show the connections of the two-wattmeter method for measuring power in a three-phase system. Prove that this method gives total power even in a general unbalanced situation. **[8 marks]**

(b) A 380-V line feeds two balanced three-phase loads. The first load is at 5 kVA at 0.8 lagging power factor while the second is a 10-kVA load at 0.9 lagging power factor. What is the line current measured at the line terminal? Determine the readings of two wattmeters connected at the terminals to measure the total power. **[12 marks]**

Q5. (a) With the help of equivalent circuits, predict the torque-speed characteristics of the DC Shunt motor and DC series motor. **[10 marks]**

(b) A 400-V dc shunt motor takes 50 A on full-load, and the speed is then 1000 rev/min. For this full-load condition, the field current is 2 A, and the windage, friction and iron losses amount to 600 W. If the armature resistance is 0.5 Ω calculate the total losses, the efficiency and output torque. **[10 marks]**

Q6. (a) Show how a constant speed "rotating" magnetic field of fixed magnitude is produced from a set of balanced three-phase sinusoidal currents.

[8 marks]

(b) A 3-phase, 6-pole induction motor operates on a 50-Hz supply. The frequency of the rotor-induced current is 4 Hz.

(i) What is the slip?

[2 marks]

(ii) What is the speed of the rotor?

[2 marks]

(iii) What is the speed of the rotor mmf with respect to the rotor and with respect to the stator?

[2 marks]

(c) Describe the principal features which establish the three phase ac machine as either an induction machine or a synchronous machine.

[6 marks]

Q7. (a) State the two basic laws of illumination.

[4 marks]

(b) Deduce an expression for the relation between the illumination ***E*** and any point on a plane surface due to a light source of luminous intensity ***I***, suspended at height ***h*** from the surface.

[6 marks]

(c) A tennis court is 20 m wide and 40 m long including the boundary walkway. It is desired to use four 7-metre poles for lighting, one at each corner, to produce an average of 400 lx at the center of the court. If 250-W high pressure sodium lamps, each giving a luminous flux of 25000 lumens, are used, determine the minimum number of lamps per pole if

(i) no reflector of any kind is used

[6 marks]

(ii) reflectors which direct 40 % of the light on the court are used.

[4 marks]

END OF EEE3351 EXAMINATION