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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2013/2014

COURSE NAME	:	ENGINEERING ELECTROMAGNETICS
COURSE CODE	:	BEF 22903
PROGRAMME	:	BEV
EXAMINATION DATE	:	JANUARY 2014
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE** (5) QUESTIONS ONLY.

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES ONLY.

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Q1 (a) Four point charges are arranged in a rectangle, as shown in Figure Q1(a). Using the Cartesian coordinate system, calculate the net force acting on charge A.

(12 marks)

(b) Assume we have a system of three point charges:

$Q_A = 2\ \mu C$, located at (0, 4.00 m)

$Q_B = 4\ \mu C$, located at (0, 0)

$Q_C = -4\ \mu C$, located at (3.00 m, 0)

(i) What is the electric potential at point P located at (3.00 m, 4.00 m)?

(7 marks)

(ii) Calculate the work required to bring a 3 μC charge from ∞ to P.

(6 marks)

Q2 (a) A point charge of 10.0 μC is placed at the centre of a spherical shell of radius 20.0 cm. What is the total electric flux through

(i) the surface of the shell, and

(3 marks)

(ii) any hemispherical surface of the shell?

(3 marks)

(iii) Do the results depend on the radius? Explain.

(1 mark)

(b) By applying Gauss's Law to a uniformly charged wire of infinite length and having a constant linear charge density λ, show that the electric field due to the wire is given by the expression

$$E = \frac{\lambda}{2\pi\varepsilon_o r}$$

where r is distance from the wire.

(10 marks)

(c) Figure Q2(c) shows a wire having a line charge of 8 nC/m lying along the z axis in free space. Compute the flux density D at a point 3 metres away from the wire.

(8 marks)

Q3 (a) A cylindrical capacitor, shown in Figure Q3(a), consists of an inner conductor of radius a and an outer conductor whose inner radius is b. The space between the conductors is filled with a material of dielectric constant ε_r, and the length of the capacitor is l. Show that the capacitance per unit length of the cable is given by the expression

$$\frac{C}{l} = \frac{2\pi\varepsilon_o\varepsilon_r}{\ln\left(\frac{b}{a}\right)}$$

(10 marks)

(b) When a coaxial cable is used to carry electric power, the radius of the inner conductor is determined by the load current, and the overall size by the voltage and the type of insulating material used. Given that the radius of the inner conductor is 2 mm and the insulating material is polystyrene, determine the inner radius, b, of the outer conductor so that the cable is able to work at a voltage rating of 11 kV. In order to avoid breakdown due to voltage surges caused by lightning and other abnormal external conditions, the maximum electric field intensity in the insulating material is not to exceed 25 % of its dielectric strength.

The dielectric constant and dielectric strength of polystyrene is 2.6 and 20 x 10^6 V/m, respectively.

(15 marks)

Q4 (a) Starting from Poisson's equation, show that the resistance over a length l of a block of charge-free material that has resistivity ρ and cross sectional area A (see Figure Q4(a)) is given by the expression

$$R = \rho \frac{l}{A}$$

(15 marks)

(b) A lead bar ($\sigma = 5 \times 10^6$ S/m) of square cross section has a hole bored along its length of 4 m so that its cross section becomes that shown in Figure Q4(b).

(i) Find the resistance between the square ends.

(5 marks)

(ii) If the square ends of the lead bar are maintained at a potential difference of 9 V, find the power dissipated in the bar.

(5 marks)

Q5 (a) Figure Q5(a) shows two long parallel conductors carrying current I_1 and I_2 amperes respectively, separated by a distance r meters in a medium of relative permeability μ_r.

(i) Show that the mutual force of repulsion on a length L of the conductors is given by the expression

$$F = \frac{\mu_r \mu_o I_1 I_2 L}{2\pi r} \textbf{ newtons}$$

(5 marks)

(ii) Calculate the force of repulsion between two busbars 8 feet long under short circuit conditions when the current in each is 3600 amperes d.c.; the separating distance is 8 inches.

(5 marks)

(b) For the coaxial cable shown in Figure Q5(b), current I flows in the inner conductor and returns through the outer conductor and the resultant m.m.f outside the outer cylinder is zero. By assuming that in the space between the cylinders the flux is entirely due to current in the inner conductor and neglecting flux inside the inner conductor, show that the inductance per metre length of the coaxial cable is given by

$$L = \frac{\mu_o}{2\pi} \log_e \left[\frac{b}{a} \right]$$

(15 marks)

Q6 (a) Describe the physical properties and uses of (i) soft, and (ii) hard magnetic materials.

(5 marks)

(b) Explain the following: (i) hysteresis loss, and (ii) eddy current loss in ferromagnetic materials.

(5 marks)

(c) An iron ring of 25 cm diameter and 10 sq.cm cross-sectional area has an air-gap of 1 mm. It is wound with 500 turns of wire carrying a current of 8 A. If the relative permeability of the iron is 600 under these conditions, determine

(i) the magnetomotive force of the coil,

(5 marks)

(ii) the reluctance of the magnetic circuit, and

(5 marks)

(iii) the flux density in the air-gap.

(5 marks)

Q7 (a) Figure Q7(a) shows an electromagnet with an armature displaced at a distance x from the pole face. Show that if the displacement of the armature causes a change in the inductance, then the x-component of the force on the armature is given by the expression

$$f_x = \frac{1}{2} i^2 \frac{dL}{dx}$$

(10 marks)

(b) Two magnetic poles made of highly permeable material are separated by an air gap of length 1.0 mm. Each pole measures 10 mm by 10 mm in cross section. A coil of 1000 turns, carrying a current of 1.0 A, drives magnetic flux across this gap.

(i) What is the magnitude of the flux density if all the MMF is dropped across it?

(5 marks)

(ii) What is the magnitude of the force attracting the poles together?

(5 marks)

(iii) If one pole is offset by 1.0 mm, calculate the force attracting it back.

(5 marks)

- END OF QUESTION –

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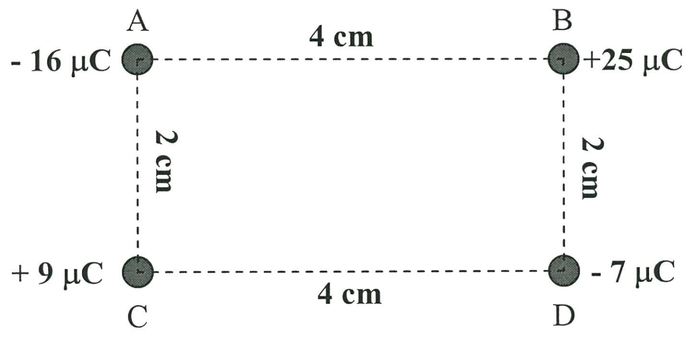

FIGURE Q1(a)

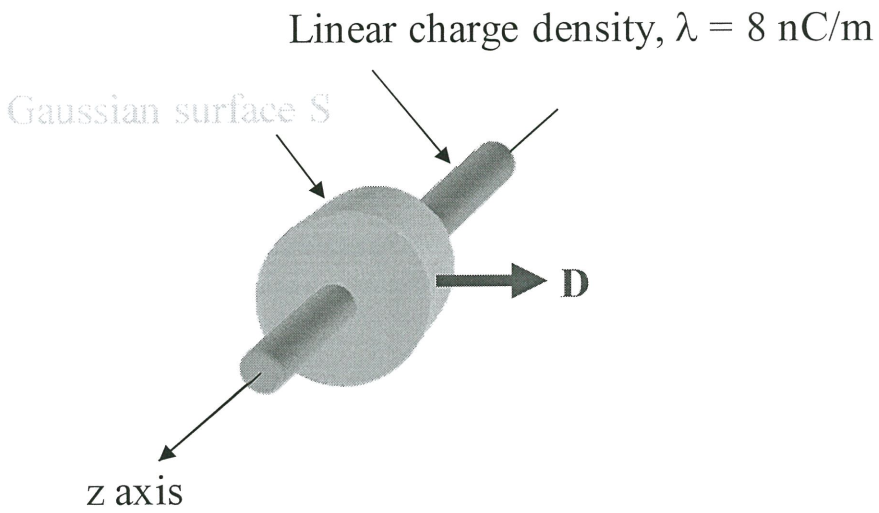

FIGURE Q2(c)

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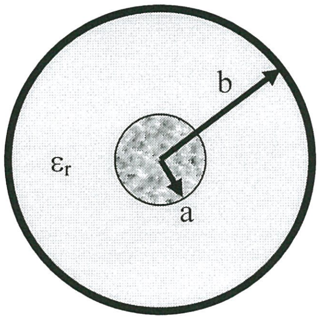

FIGURE Q3(a)

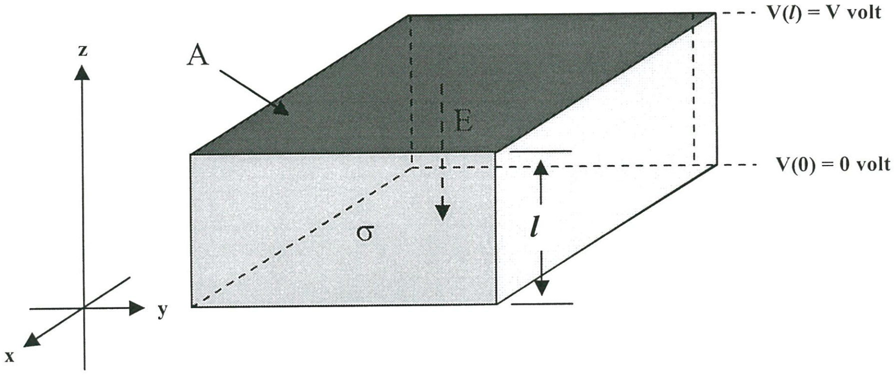

FIGURE Q4(a)

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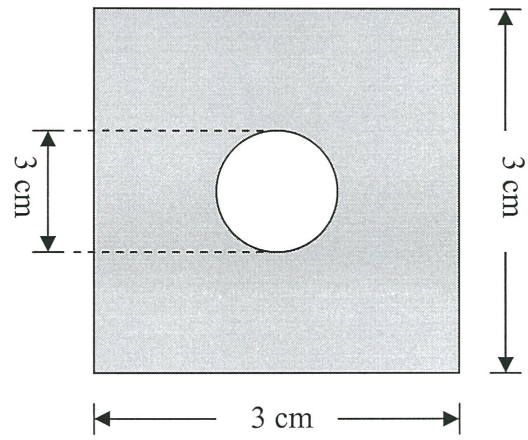

FIGURE Q4(b)

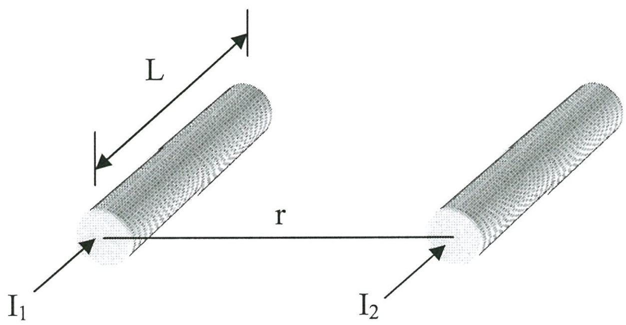

FIGURE Q5(a)

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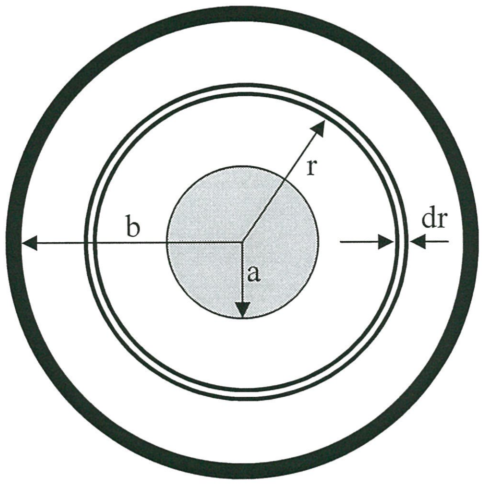

FIGURE Q5(b)

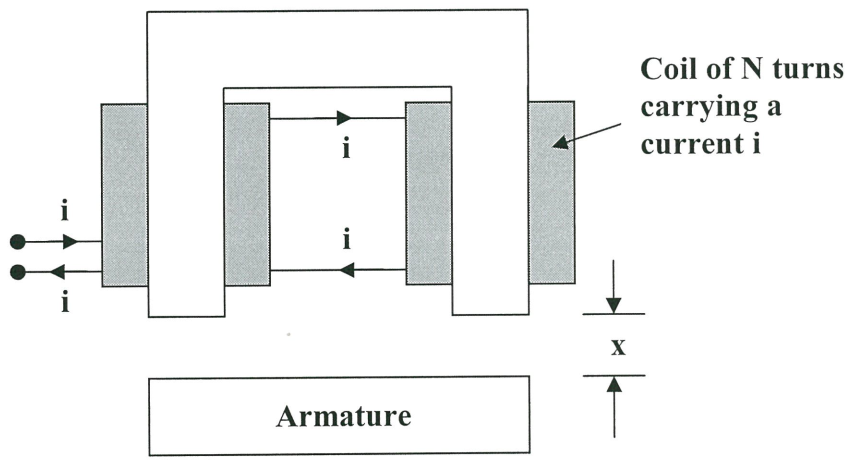

FIGURE Q7(a)