KABARAK UNIVERSITY

EXAMINATIONS

2008/2009 ACADEMIC YEAR

FOR THE DEGREE OF BACHELOR OF SCIENCE IN COMPUTER SCIENCE

COURSE CODE: **PHYS 110**

COURSE TITLE: **ELECTRICITY & MAGNETISM**

STREAM: **Y1S1**

DAY: **THURSDAY**

TIME: **9.00 – 11.00 A.M**

DATE: **26/03/2009**

INSTRUCTIONS

Answer **QUESTION 1** and **ANY OTHER TWO**

You may need the following constants:

Electron charge $e = -1.6 \times 10^{-19}$C.

$\pi = 3.14$

$\varepsilon_o = 8.85 \times 10^{-12}$ F/m

$\mu_o = 4\pi \times 10^{-7}$ Tm/A

1 electron volt $=1.6 \times 10^{-19}$ Joules

PLEASE TURN OVER

Question 1 (30 marks)

(a) Define the following:

- (i) Point charge density (1 mk)
- (ii) Volume charge density (1 mk)

(b) A line charge density $\lambda(x)$ is given by $\lambda(x) = 3x^2$ C/m. Calculate the total charge contained between the points x=0 and x=3mm. (3 mks)

(c) (i) Define an electric dipole (1 mk)

(ii) Sketch the electric field flux of a dipole (1 mk)

(d) Two equal charges of each 3μC are initially separated by a distance of *2.0 mm*. An external force alters their separation to *1.0 mm*. What is the change in potential energy? (3 mks)

(e) State the purpose of filling the space between capacitor plates with a dielectric. (1 mk)

(f) Explain why electricity distribution companies lose more power in summer than in winter. (2 mks)

(g) Explain why a potentiometer can be referred to as a voltmeter with infinite resistance. (2 mks)

(h) Sketch charging and discharging curves of a capacitor (2 mks)

(i) Show that the motion of a charged particle in a magnetic field is a circle. (3 mks)

(j) A strip of copper carrying a current *I* is placed within a magnetic field $\underline{B}$. State TWO forces experienced by the electrons inside the copper strip. (2 mks)

(k) Calculate the magnetic field at a point 2 mm from an infinitely long conductor carrying a current of 4 A. (3 mks)

(l) Sketch the variation of the magnetic field strength inside and outside a conducting wire assuming the current is uniformly distributed through the wire. (2 mks)

(m) Show that the relationship between the potential energy and electric force is of the form $F = -\nabla U$. (3 mks)

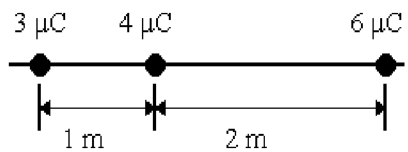
Question 2 (20 marks)

(a) (i) Define Electric field. (3 mks)

(ii) Show that the electric field for a point charge can be expressed as:

$E = k\dfrac{Q}{r^2}$ where k is a constant and r is the distance between charge Q and the test charge. (3 mks)

(iii) Three charges are placed in a straight line as shown in figure below. Determine the force exerted on the 6 μC charge by the other two charges. (6 mks)



(b) (i) Consider a point charge Q enclosed by a surface S and show that the differential form of Gauss's law for electric fields for a collection of charges is of the form

$$\oint_S \mathbf{E} \cdot d\mathbf{S} = \sum Q / \varepsilon_0$$

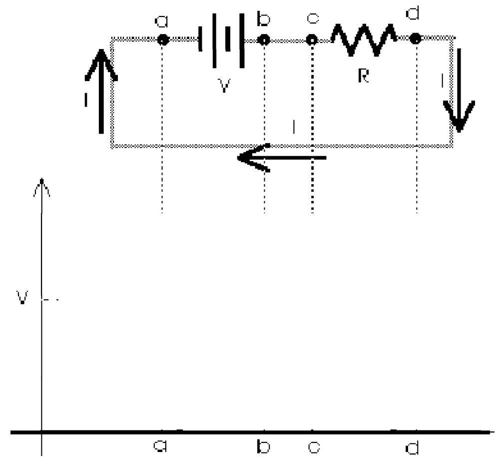
where E is the electric field. (5 mks)

(ii) A conducting sphere of radius r = *3 mm* carries a charge Q = 6μC on its surface. Calculate the electric field at the surface.

(3 mks)

Question 3 (20 marks)

(a) In the figure below, sketch a graph showing the variation of potential on the various points between a and d. (5 mks)

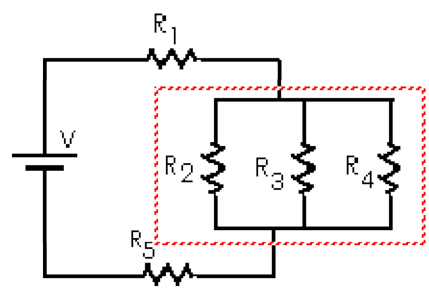


(b) (i) Derive a general expression for equivalent resistance for many resistors connected in parallel. (4 mks)

(ii) Show that for two resistors, R_1 and R_2 connected in parallel, the total resistance is $R_{total} = \frac{R_1 R_2}{R_1 + R_2}$ (2 mks)

(1ii) In the figure below, R_1 = 3kΩ, R_2 = 0.3 kΩ, R_3 = 2kΩ, R_4 = 5kΩ, R_5 = 6 kΩ and V = 12 volts. Assuming that the voltage source has zero internal resistance, determine

(I) Current through R_3 (6 mks)
(II) Total power dissipated by the circuit. (3 mks)



Question 4 (20 marks)

(a) (i) State Faraday's law of electromagnetic induction. (1 mk)

(ii) Show that the torque (τ) exerted on a rectangular coil of N turns carrying a current I oriented at an angle of φ in a magnetic field B can be expressed as $\tau = BIAN \sin\varphi$, where A is the cross sectional area of the coil. Hence calculate the maximum torque for a coil N=100 turns, A=50mm^2, I = 2A subjected to a B field of 10 Tesla. (7 mks)

(b) (i) State Amperes law. (2 mks)

(ii) Derive an expression for the magnetic field (B) of a solenoid carrying current I, length L and having N number of turns. (3 mks)

(ii) A solenoid has 100 turns and a length of 10 cm. It carries a current of 0.500 A. What is the magnetic field inside the solenoid? (3 mks)

(c) Describe the following electromagnetic induction losses

(i) Hysteresis losses (2 mks)
(ii) Winding losses (2 mks)