

**KABARAK UNIVERSITY**  
**DEPARTMENT OF MATHEMATICS AND COMPUTING SCIENCES**  
**UNIVERSITY EXAMINATION 2010/2011 FOR THE DEGREE OF BACHELOR**  
**OF COMPUTER SCIENCE**

**PHYS 110: ELECTRICITY AND MAGNETISM**

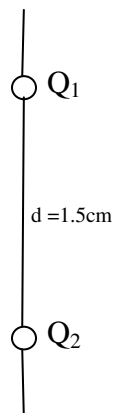
Date..... Time..... (2Hrs).....

**Instructions**

- Answer Question **ONE** and any other **TWO** Questions. Question One carries **30marks** while each of the other Two Questions carry **20marks**.
- **The following constants may be useful**
  - Permeability of free space  $\mu_0 = 4\pi \times 10^{-7} \text{ Wb / A}$
  - Permittivity of free space  $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 / \text{NM}^2$
  - Resistivity of Iron  $\rho = 9.68 \times 10^{-8} \Omega \text{m}$
  - Acceleration due to gravity  $g = 9.8 \text{m / s}^2$

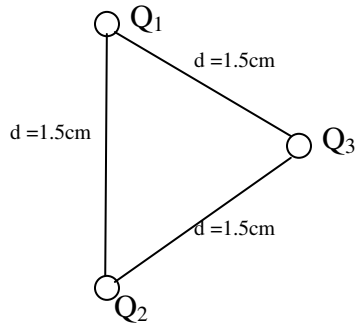
**QUESTION 1 (30 marks)**

- a) i) Name two types of electric charges (1mk)  
ii) Explain why conductors cannot be charged by friction. (1mk)
- b) i) State the principle of superposition (1mk)  
ii) The diagram below shows two charges  $q_1$  and  $q_2$  held at a fixed distance  $d$  apart.



I. Find the strength of the electric force that acts on  $q_1$ , given that  $q_1 = q_2 = 4.3\mu\text{C}$  and  $d = 1.5\text{cm}$  (3mks)

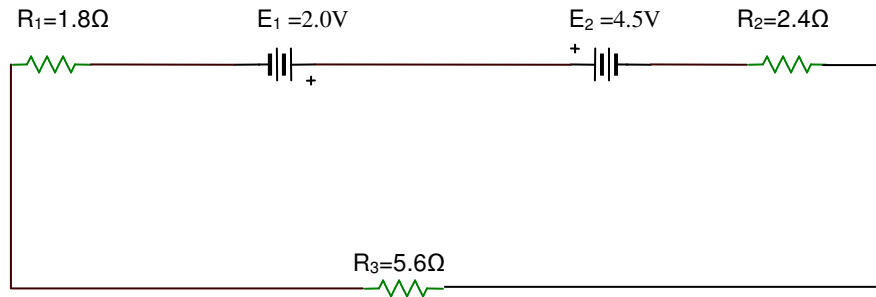
II. A third point charge  $q_3 = 4.3\mu\text{C}$  is brought in and placed as shown. Find the strength of electric force on  $q_1$  now (3mks)



c) Show how Coulomb's law can be deduced from Gauss' law (3mks)

d) A rectangular block of Iron has dimensions 2.4cm by 2.4cm by 50cm. Find the resistance of the block between the two square ends. (2mks)

e) i) State Kirchoff's voltage law. (1mk)  
 ii) Calculate the current in the given circuit (3mks)



f) Define Lorentz force and give its mathematical expression? (2mks)

g) Consider a circuit of capacitance (C) and resistance (R) connected in series to a d.c source.

i). Derive an expression of charge (Q) at any time (t) during charging process.(4mks)

ii). Show that time constant ( $\tau$ ) is equal to time taken to charge the capacitor to 63% of its maximum charge. (2mks)

h) i) State and explain two factors that affect the magnitude of torque experienced by a current carrying wire in a magnetic field. (2mks)

ii) An electron with magnetic dipole moment  $3.6 \times 10^{-24} \text{ J/T}$  is in a uniform magnetic field of 450T at an angle of  $30^\circ$ . Calculate the magnetic torque on the electron. (2mks)

**QUESTION 2 (20 marks)**

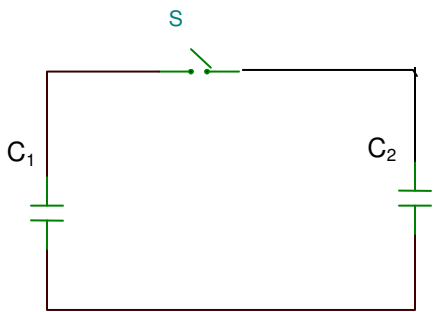
a) Define the following terms (3mks)

- i). Flux of a vector field
- ii). Negative flux
- iii). Gaussian surface

b) i) Show how Coulomb's law can be deduced from Gauss' law (3mks)

ii) A long cylindrical solid conductor of length (L) and radius (R) has charge per unit length ( $\lambda$ ). Find the expression of electric field ( $\vec{E}$ ) inside and outside the cylinder and sketch the variation of ( $\vec{E}$ ) against (r) for  $0 < R \leq r$  and for  $r > R$  (5mks)

c) A  $2.5\mu\text{F}$  capacitor  $C_1$  is charged to a potential difference  $V_0 = 12\text{V}$ , using a battery. The charging battery is then removed, and the capacitor is connected as shown in Figure below to an uncharged  $8.0\mu\text{F}$  capacitor  $C_2$ . After the switch S is closed, charge flows from  $C_1$  to  $C_2$  until equilibrium is established, with both capacitors at the same potential difference V.



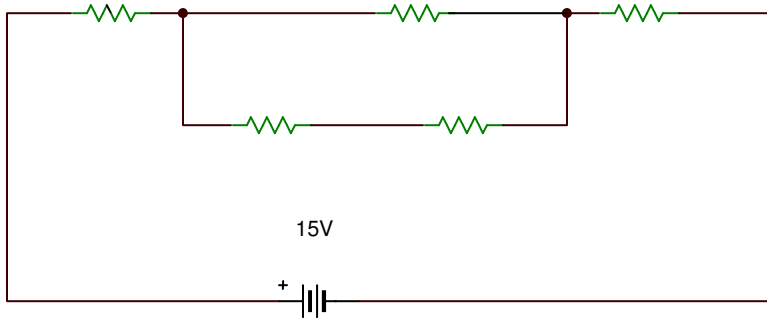
i). Calculate the common potential difference (V) (3mks)

ii). What is the energy stored after the switch is closed (3mks)

d) State three effects of dielectrics on capacitors. (3mks)

**QUESTION 3 (20 marks)**

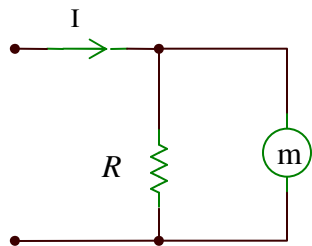
- a) i) State ohm's law in words and give its mathematical expression. (2mks)  
ii) Consider the given resistor network circuit.



Assuming that each resistor is  $5\Omega$ , Calculate;

- I.) Total resistance (3mks)  
II.) the total current in the circuit (2mks)

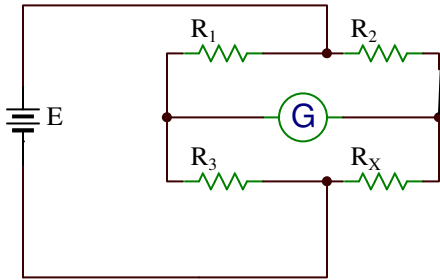
b) Consider the given circuit



If the meter has internal resistance ( $R_m$ );

- i). What is the relation between the terminal current ( $I$ ) and the meter movement current ( $I_m$ ). (2mks)  
ii). When resistor ( $R$ ) is disconnected from the circuit, the meter has a full scale deflection current of  $100\mu A$  and a resistance of  $900\Omega$ . When resistor ( $R$ ) is connected into the circuit, the meter has a full scale deflection current of  $1mA$ . Determine the value of  $R$ . (4mks)

c) Consider the bridge circuit shown



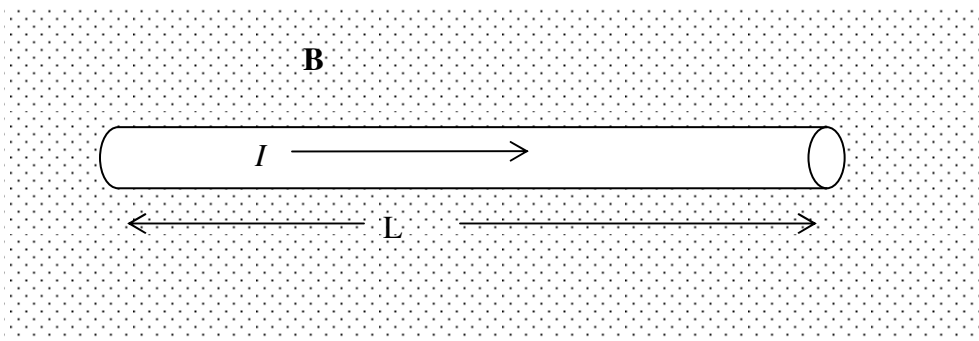
Show that at null condition,  $R_x = \left(\frac{R_2}{R_1}\right)R_3$  (2mks)

d) Derive the expression of finding the electric potential difference at a point (P) a distance (Z) along the axis of a uniform ring of radius (R) carrying total charge Q. (5mks)

**QUESTION 4 (20 marks)**

- a) i) What is magnetic field? (1mk)
- ii) State two differences and two similarities between magnetic force and electric force. (4mks)

b) i) The diagram below shows a wire segment placed in a uniform magnetic field ( $\vec{B}$ ) that point out of the plane of the diagram.



If the wire carries a current ( $I$ ), from left to right as shown, derive the expression of the resultant magnetic force ( $\vec{F}_B$ ) experienced by the wire. (5mks)

ii) A straight horizontal segment of copper wire carries a current  $I = 28A$ . What are the magnitude and direction of magnetic field needed to balance its weight? Given that it's linear mass density is  $46.6g / m$ . (4mks)

c) Consider a proton of charge  $1.6 \times 10^{-19} C$  being moved at a velocity of  $3.2 \times 10^7 m/s$  in a uniform magnetic field of  $1.2 \times 10^{-3} T$  at an angle of  $30^\circ$ .

i). Find the magnitude of magnetic force experienced by the proton (3mks)

ii). What will be the acceleration of the proton given that its mass is  $1.67 \times 10^{-27} Kg$  (3mks)

**QUESTION 5 (20 marks)**

a) Define the following terms (2mks)

i). Electromagnetic induction

ii). Magnetic flux

b) State Lenz's law in words and give its mathematical expression (2mks)

c) i) Define inductance (1mk)

ii) Calculate the inductance of a solenoid containing 10,000 turns if the length of the solenoid is 25cm and its cross sectional area is  $2cm^2$ . (2mks)

d) Consider a series RL circuit connected to a d.c. source. Derive the expression of finding current (I) at any time (t) during current decay in the circuit. (5mks)

e) An RL circuit with an inductor of inductance 8H and resistor of  $10\Omega$  is connected to the terminals of a battery of e.m.f. 15V and negligible internal resistance. Find

i). The initial rate of increase of current in the circuit (2mks)

ii). The rate of increase at the instant when the current is 0.5A (2mks)

iii). The current 0.5s after the circuit is closed (2mks)

iv). The final steady state current (2mks)