KABARAK UNIVERSITY

UNIVERSITY EXAMINATIONS

2010/2011 ACADEMIC YEAR

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: PHYS 110

COURSE TITLE: ELECTRICITY AND MAGNETISM

STREAM: SESSION II

DAY: WEDNESDAY

TIME: 2.00 – 4.00 P.M.

DATE: 13/04/2011

INSTRUCTIONS:

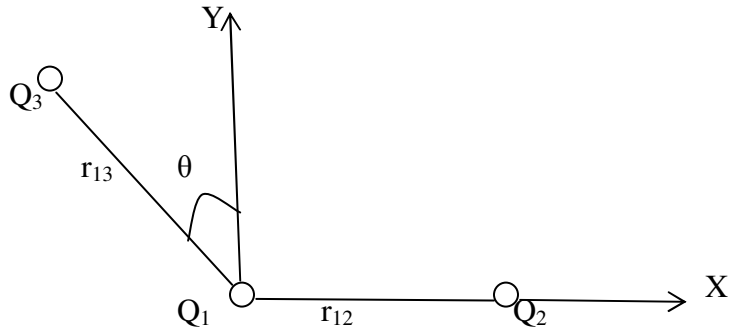
- *Answer Question **ONE** and any other **TWO** Questions. Question One carries **30marks** while each of the other Two Questions carry **20marks**.*
- ***The following constants may be useful***
  - Permeability of free space $\mu_0 = 4\pi \times 10^{-7} Wb/A$
  - Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12} C^2/NM^2$
  - Resistivity of Iron $\rho = 9.68 \times 10^{-8} \Omega m$
  - Acceleration due to gravity $g = 9.8 m/s^2$

PLEASE TURN OVER

QUESTION 1 (30 marks)

a) i) Differentiate between conductors and insulators (1mk)
ii) Explain why conductors cannot be charged by friction. (1mk)

b) i) State Coulomb's law in words and give its mathematical expression (2mks)
ii) The diagram below shows three charged particles held in place.

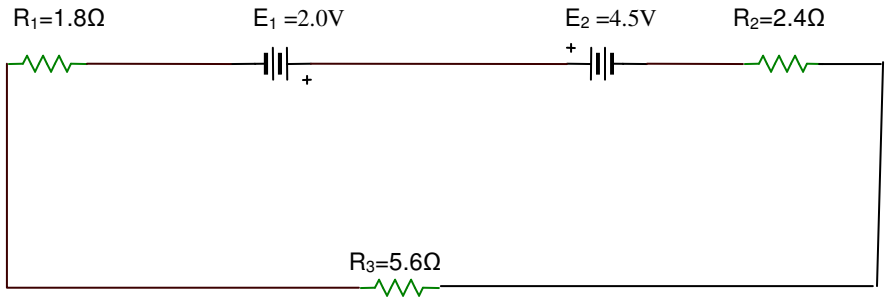


Given that $Q_1 = -2.0\mu C$, $Q_2 = +4.8\mu C$, $Q_3 = -2.4\mu C$, $r_{12} = 20cm$, $r_{13} = 10cm$ and $\theta = 30^0$
Calculate;

I) the resultant force on Q_1 due to the other two charges (4mks)
II) The direction of this resultant force (2mks)

c) 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. (3mks)

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



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

f) 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 (τ) is equal to time taken to charge the capacitor to 63% of its maximum charge. (2mks)

g) 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 $3.6\times10^{-24}\,J/T$ is in a uniform magnetic field of 450T at an angle of 30°. Calculate the magnetic torque on the electron. (3mks)

QUESTION 2 (20 marks)

a) Define the following terms (3mks)

i). Flux of a vector field

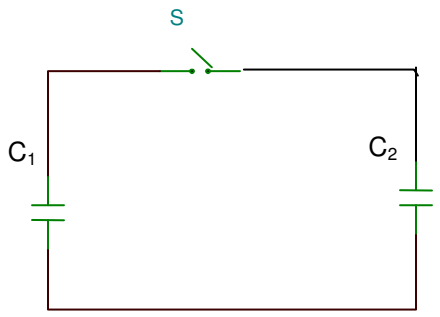
ii). Negative flux

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 (λ). 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> (5mks)

c) A 2.5μF capacitor C_1 is charged to a potential difference $V_0 = 12V$, using a battery. The charging battery is then removed, and the capacitor is connected as shown in Figure below to an uncharged 8.0μF 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)

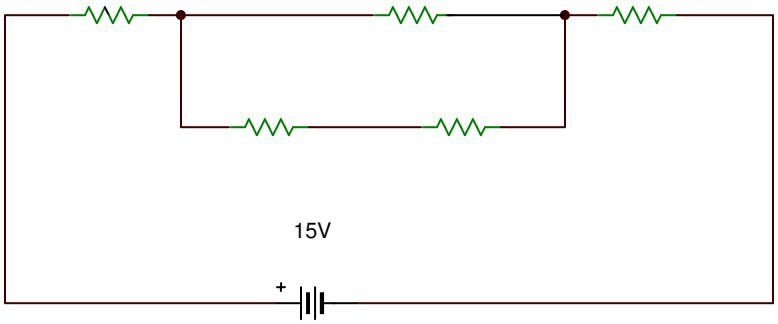
ii). What is the energy stored after the switch is closed (3mks)

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.

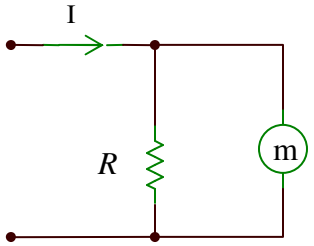


Assuming that each resistor is 5Ω, Calculate;

I.) Total resistance (3mks)

II.) the total current in the circuit (2mks)

b) Consider the given circuit

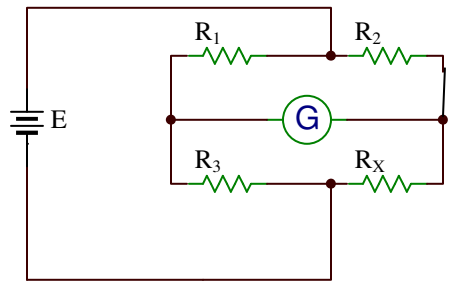


If the meter has internal resistance (R_m);

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 900Ω. 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)

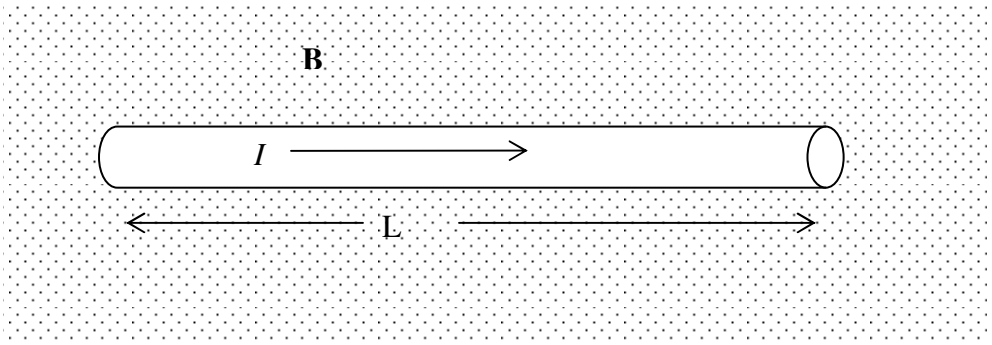
d) Derive the expression of finding the electric potential difference at a point (P) a distance (Z) along the axis of a uniform ring of radius (R) carrying total charge Q. (5mks)

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 $(\overrightarrow{F_B})$ 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 $1.6\times10^{-19}C$ being moved at a velocity of $3.2\times10^{7}m/s$ in a uniform magnetic field of $1.2\times10^{-3}T$ at an angle of 30°.

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 $1.67\times10^{-27}Kg$ (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 10Ω 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)