EMBU UNIVERSITY COLLEGE

(A CONSTITUENT COLLEGE OF THE UNIVERSITY OF NAIROBI)

FIRST SEMESTER EXAMINATIONS 2013/2014

FIRST YEAR EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE

SPH 102: ELECTRICITY AND MAGNETISM 1

DATE: DECEMBER 4, 2013 **TIME: 2.00 – 4.00PM**

INSTRUCTIONS:

Answer Question ONE and ANY Other TWO Questions.

Constants

Electronic charge, e	=	1.602×10^{-19} C
Velocity of light, c	=	3.0×10^{8} m/s
1 eV	=	1.602×10^{-19} J
Mass of electron, m_e	=	9.11×10^{-31} kg
Mass of proton, m_p	=	1.67×10^{-27} kg
Permittivity, ε_0	=	8.85×10^{-12} C^2/Nm^2
Acceleration due to gravity, g =		10 m/s^2
Density of water	= 1 g/cm^3	

QUESTION ONE:

a) i) Give a summary of coulombs law. (3mks)

i) Consider a system containing many charges $q_1, q_2, q_3, \ldots, q_n$. Demonstrate how to obtain the force F_j on charge q_j due to a number of other charges q_i. (3mks)

ii) Two similar balls of mass m are hung from silk threads of length, l and carry similar charges. Prove that the separation (4mks)

$$x = \left(\frac{q^2 l}{2\pi\varepsilon_0 mg}\right)^{1/3}$$

iii) A copper wire has 8×10^{28} atoms per cubic meter and cross-sectional area $5\ mm^2$. If a current of $5\ A$ flows through the wire, find the drift velocity of the electrons. (3mks)

b) i) Differentiate between relative permeability from absolute permeability. (1mk)

i) Consider a solenoid which is carrying an electric current of $5\ A$. Show that the magnetic induction for it is given by:- (3mks)

$$\vec{B} = \frac{5\mu_0}{2\pi r}$$

c)

i) A $100\ v$ d.c supply is used to charge two capacitors in parallel. One of the capacitors is $4\mu F$ and the other $5.0\mu F$. Determine the energy stored in the capacitors. (3mks)

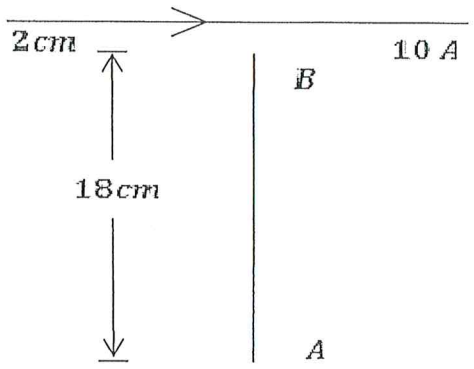
ii) Calculate the flux density and field intensity at a distance of $10cm$ in air from a north pole with strength of $10,000\ ampere-meters$. (2mks)

Also find the force on another north pole of equal strength at this distance. Assume that the poles are at a large distance. (2mks)

d) An ammeter of resistance 0.80Ω can measure currents up to $1.0\ A$. Find the shunt resistance to enable the ammeter to measure currents up to $5.0\ A$. (3mks)

i) Consider a rectangle $ABCD$. At corners BC and D of the rectangle are placed charges $+10 \times 10^{-12}\ C, -20 \times 10^{-12} C$ and $+10 \times 10^{-12} C$ respectively. Calculate the potential at the fourth corner A. Take side $AB = 4cm$ and $BC = 3cm$. (4mks)

e) A copper rod AB is moving with a velocity of $5m/s$ parallel to a straight wire carrying a current of $10\ A$. Calculate the induced emf in the rod if its lower end A is $18cm$ away from the wire and its upper end B is $2cm$ away from wire as shown (4mks)



f) In an oscillatory circuit $L = 0.4\ Henry$ and $C = 0.0024\ \mu F$. Find the maximum value of reactance for the circuit to be oscillated. (3mks)

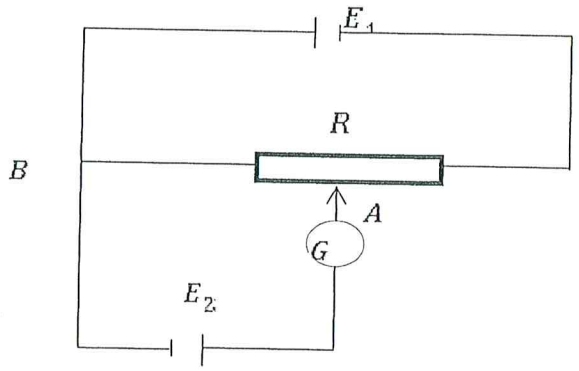
g) The resistance of a platinum wire at 0^0C is 4 Ω. Find the resistance of the wire at 100^0C. (Temperature coefficient of platinum is 0.0038^0C). (2mks)

QUESTION TWO

a) A potential difference of $20\ KV$ is applied to a parallel plate capacitor with a plate area of $0.01\ m^2$. The plates are separated by a dielectric $2\ mm$ thick. The capacitance of the capacitor is $2 \times 10^{-4} \mu F$. Find

i) Total electric flux. (2mks)
ii) Potential gradient. (2mks)
iii) Relative permittivity of the medium. (3mks)
iv) Energy stored. (3mks)

b) A standard cell of $emf\ E_1$, a potentiometer of resistance R, a storage battery of unknown $emf\ E_2$ and a galvanometer are connected as shown:



Determine the e.m.f of the storage battery if the current ceases to flow through galvanometer when resistance in the section of potentiometer AB = 9 ohms, in this case take E1 is 2V and R is 10 ohms. (5mks)

QUESTION THREE

a) Two points charges of $12 \times 10^{-10} C$ and $8 \times 10^{-10} C$ are $10\ cm$ apart. Find the work done in bringing the charges $4\ cm$ closer. (6mks)

b) Two wires each $1\ m$ carrying a current of $500\ amperes$ in the same direction are placed with their axis $0.20\ m$ apart. Calculate the force between them per meter length. (3mks)

c) A solenoid of 1200 turns is wound uniformly in a single layer on a glass tube $2\ m$ long and 0.2 m in diameter. Find the strength of the magnetic field at the center of the solenoid. (3mks)

d) A milli-voltmeter can read up to a maximum of $800\ mV$ and has a resistance of $40\ \Omega$. How can it be converted into a milli-ammeter reading up to $100\ mA$? (3mks)

QUESTION FOUR

a) Three charges of $\frac{2}{3} \times 10^{-9} C$, $\frac{8}{3} \times 10^{-9} C$ and $\frac{10}{3} \times 10^{-9} C$ are placed at three corners of an equilateral triangle of sides $20\ cm$. Find the resultant force on the charge of $\frac{10}{3} \times 10^{-19} C$.

(6mks)

b) Sketch construction of a moving coil galvanometer and explain its principle of operation.

(9mks)

QUESTION FIVE

a) Consider a positive test charge q that is fired with a velocity $\vec{V}$ through a point p. Suppose the charge experiences a sideways deflection force F. Using a three dimensional reference frame, define the magnetic induction vector. (8mks)

b) Show that the potential at a point A due to a point charge $+q$, at a distance x is given by

$$V = \frac{q}{4\pi\epsilon_0 \epsilon_r r} \ volts$$

(Assume that the charge is placed in air where $\epsilon_r = 1$) (7mks)

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