SOUTH EASTERN KENYA UNIVERSITY

UNIVERSITY EXAMINATIONS 2016/2017

FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE (PHYSICS/ELECTRONICS/GEOLOGY/METEOROLOGY) and BACHELOR OF EDUCATION (SCIENCE)

SPH 102: ELECTRICITY AND MAGNETISM I

9TH DECEMBER, 2016 **TIME: 8.00-10.00 A.M**

INSTRUCTIONS TO CANDIDATES

- This paper consists of FIVE questions.
- Answer question **ONE** and any other **TWO** questions.
- Question **ONE** carries 30 mark while the other **TWO** questions carry 20 marks each
- Use the following constants where necessary

Coulomb's Constant $k_e = 8.99\times10^{9}\, N.m^2/C^2$

Permittivity of free space $\varepsilon_o = 8.85\times10^{-12} C^2/N.m^2$

Permeability of free space $\mu_o = 4\pi\times10^{-7}\, H/m$

Proton or electron charge $e = 1.6\times10^{-19} C$

Proton mass $m_p = 1.67\times10^{-27} kg$

Electron mass $m_e = 1.67\times10^{-31} kg$

QUESTION ONE (COMPULSORY) (30 MARKS)

a) State coulomb's law of electrostatic forces. (2 marks)

b) Given that the radius of a hydrogen atom is $r = 0.529 \times 10^{-10}$ m. Calculate the

(i). Potential difference between an electron and proton (2 marks)

(ii). Potential energy (2 marks)

c) Define the term capacitance and state its SI Units (1 marks)

d) A spherical capacitor has an internal radius a and an external radius b. Show that its capacitance is given as $C = 4\pi\varepsilon_o \ln\left(\frac{ab}{b-a}\right)$. (4 marks)

e) Two seats of e.m.f's $\varepsilon_1 = 2.4V$ and $\varepsilon_2 = 4.4V$ Have internal resistance $r_1 = 1.8\Omega$ and $r_1 = 2.3\Omega$ respectively. If they are connected in series with a resistor R of resistance $R = 5.5\Omega$ as shown in figure 1 below

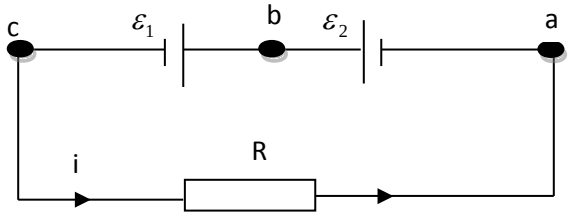

Figure 1.

Calculate the

(i). The current through the circuit (3 marks)

(ii). Potential difference between the points a and b. (3 marks)

(f). A moving coil galvanometer gives full scale deflection with 15mA and has a resistance of 5Ω. Design the following:

(i). An ammeter to measure up to 1A . (2 marks)

(ii). A voltmeter to measure up to 10V. (2 marks)

(g). A wire of length 1m has a resistance of 0.3Ω. It is uniformly stretched to a length of 2m. Calculate the new resistance of the wire. (5 marks)

(h). A uniform magnetic field **B** with magnitude 1.2mT, points vertically upward through the volume of a room. A 5.3 MeV proton moves horizontally from south to north through a certain point in the room. Calculate

(i). The deflection force acting on the proton as it passes through the point. (3 marks)

(ii). The acceleration of this proton. (2 marks)

QUESTION TWO (20 MARKS)

a) Define the term electric field and state its SI units. (2 marks)

b) There point charges $q_1 = 15\mu C$ is located at the point (6m,8m), $q_2 = 10\mu C$ is located on the positive x-axis a distance of 8m from the origin and $q_3 = 25\mu C$ is located at origin. Find the magnitude and direction of the electric force on q_3. (10 marks)

c) Show that the electric potential difference at a distance r from a point charge q is given as $V = \frac{k_e q}{r}$, where k_e is the Coulomb's constant. Assume that $V = 0$ at $r = \infty$. (4 marks)

d) Calculate the electric field at a point which is at a distance of 5cm from a charge $q = 2\times10^{-6} C$ .Assume that the charge is at the origin and that the point under consideration is on positive y-axis. (3marks)

QUESTION THREE (20 MARKS)

a) State three types of capacitors. (3 marks)

b) Show that the potential energy stored in electric field of a parallel plate capacitor in a vacuum is given as $U_d = \frac{1}{2}\varepsilon_o E^2$. (7 marks)

c) The space between the conductors of a long coaxial cable used in TV signal transmission has an inner radius $a = 0.30mm$ and an outer radius $b = 4.2mm$. Calculate the capacitance the cable if it is $12m$ long. (3 marks)

d) A resistor $R = 12.4M\Omega$ and a capacitor $C = 4.5\mu F$ are connected in series with a 12V battery of negligible internal resistance.

(i). Calculate the capacitive time constant of the circuit. (3 marks)

(ii). At what time after the battery is connected does the potential difference across the capacitor equal 11.2V? (4 marks)

QUESTION FOUR (20 MARKS)

(a) State the Kirchhoff's Laws (2 marks)

(b) Using Kirchhoff's laws, calculate the current i_1 , i_2 and i_3 across resistor $R_1 = 1\Omega$ $R_2 = 2\Omega$ and $R_3 = 3\Omega$ respectively as shown in figure 2 below. (9 marks)

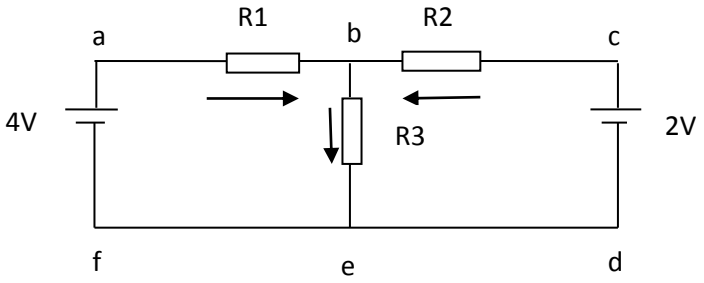

Figure 2.

(c) A 16 – gauge copper wire of diameter *1.29mm* can safely carry maximum current 6A.

(i). What is the maximum potential difference that can be safely applied across 40m of such a wire when carrying 6A? Resistivity of copper is $\rho = 1.7 \times 10^{-8} \Omega m$. (3 marks)

(ii). Find the current density in the wire. (2marks)

(d) A Wheatstone bridge is composed of a fixed resistor R=200Ω and 1m slide wire of uniform cross-section. Calculate the value of the unknown resistance when the bridge balances at the 18cm mark (2 marks)

QUESTION FIVE (20 MARKS)

(a) State the faradays law of electromagnetic induction. (2 marks)

(b) A solenoid 1.33m long and 2.60cm in diameter carries a current of 17.8A. The magnetic field inside the solenoid is 2.4mT. Find the length of the wire forming the solenoid. (5 marks)

(c) (i). Find the self induction of a solenoid of length 10cm, area 5cm^2 and 100 turns. (3 marks)

(ii). At what rate must the current in the solenoid in (i) above changes to induce an e.m.f of 10V . (3 marks)

(d) State any four factors that affect mutual inductance. (4 marks)

(e) A transformer is to be used to provide 60V lamp from a.c mains supply of 240V. Find the number of turns of the secondary coil if the primary coil has 4000 turns. (3 marks)