GARISSA UNIVERSITY

UNIVERSITY EXAMINATION 2017/2018 ACADEMIC YEAR TWO FIRST SEMESTER EXAMINATION

SCHOOL OF EDUCATION, ARTS AND SOCIAL SCIENCES

FOR THE DEGREE OF BACHELOR OF EDUCATION (ARTS)

COURSE CODE: PHY 211 / PHY 210

COURSE TITLE: ELECTRICITY AND MAGNETISM

EXAMINATION DURATION: 3 HOURS

DATE: 11/12/17 **TIME: 09.00-12.00 PM**

INSTRUCTION TO CANDIDATES

- **The examination has SIX (6) questions**
- **Question ONE (1) is COMPULSORY**
- **Choose any other THREE (3) questions from the remaining FIVE (5) questions**
- **Use sketch diagrams to illustrate your answer whenever necessary**
- **Do not carry mobile phones or any other written materials in examination room**
- **Do not write on this paper**

This paper consists of FIVE (5) printed pages ***please turn over***

QUESTION ONE (COMPULSORY)

Use the following constants where necessary:

Speed of light $c = 3.0 \times 10^{8} m/s$ **;** **Charge of an electron** $e = 1.6 \times 10^{-19} C$

Permittivity of free space $\varepsilon_o = 8.854 \times 10^{-12} F/m$ **; Permeability of free space** $\mu_o = 4\pi \times 10^{-7} T.m/A$

(a) i) State Coulombs law both in words and in mathematical form **[2 marks]**

ii) Calculate the value of two equal charges if they repel one another with a force of 0.1 N when situated 50 cm apart in vacuum. **[2 marks]**

iii) A particle having a charge q= $3x10^{-9}$ C moves from point a to point b along a straight line a total distance of 0.5m. The electric field is uniform with magnitude E= 200N/C. Find potential difference between **a** and **b**. **[2 marks]**

(b) Give the mathematical statement of the Ampere's law and Biot Savart law **[2 marks]**

(c) Derive an expression for the total capacitance for two parallel plate capacitors connected in series with no dielectric material between the plates. **[3 marks]**

(d) i) Define the term potential at any point in the field. **[1 mark]**

ii) An electron is liberated from the lower of the two large parallel metal plates separated by a distance h=20mm. The upper plate has a potential of 2400V relative to the lower. Calculate the time the electron takes to reach it (assume charge-mass ratio, e/m for the electron = 1.8 x 10^{11}C/kg) **[3 marks]**

(e) i) Define the term electric dipole **[1 mark]**

ii) Starting from Coulomb's law, show that the electric potential a distance *r* from a point charge *q* is given by $V = \frac{q}{4\pi\varepsilon_o r}$ **[3 marks]**

(f) i) Define the terms electric current and current density **[2 marks]**

ii)When we refer to a quantity of charge we say that the value is quantized. Explain what is meant by quantized. **[2 marks]**

(g) State the boundary condition for electric field across a dielectric interface **[2 marks]**

QUESTION TWO

(a) State Gauss' law of electrostatics in mathematical form **[1 mark]**

(b) Use Gauss' law to show that the electric field magnitude due to an infinite sheet of charge, carrying a surface density σ, is given by $E = \frac{\sigma}{2\varepsilon_0}$ **[4 marks]**

(c) Show that the electric field outside a charged sphere is $Q / 4\pi\varepsilon_o r^2$, where r is the distance from the centre of the ball. **[4 marks]**

(d) An electron of mass $m_e = 9.1 \times 10^{-31}$ kg is accelerated in the uniform electric field ***E*** between two parallel charged plates, There is no electric field outside of the plates. The electric field has a magnitude $E = 2.0 \times 103$ N/C and electron charge $e = -1.6 \times 10^{-19}$ C. The separation of the plates is 1.5 cm and the electron is accelerated from rest near the negative plate and passes through a tiny hole in the positive plate.(Assume the hole is so small that it does not affect the uniform field between the plates). Find:

i. The force on the electron while it is between the plates **[2 marks]**

ii. Its acceleration and speed when leaving the hole **[2 marks]**

iii. The force on the electron outside of the plates **[2 marks]**

QUESTION THREE

(a) i. What is a dielectric material **[1 mark]**

ii. State two effects of dielectric material **[2 marks]**

(b) Show that when a dielectric is introduced in a parallel plate capacitor the capacitance is increased by a factor, which is equal to the relative permittivity of the dielectric **[6 marks]**

(c) Obtain the expression of the electric displacement vector in terms of electric vector and the polarization vector. **[6 marks]**

QUESTION FOUR

(a) A point charge $q = -8.0$ nC is located at the origin. Find the electric-field vector at the field point $x = 1.2$ m, $y = -1.6$ m. **[3 marks]**

(b) Two straight, parallel, superconducting wires 4.5 mm apart carry equal currents of 15,000 A in opposite directions. Find force, per unit length, each wire exert on the other. **[3 marks]**

(c) i) Define the terms polarization and Electric displacement vector **[2 marks]**

ii. A 12V battery is connected to a 5 ohms resistor. The current in the circuit is found to be 2A. Calculate the internal resistance of the battery and power dissipated in the Resistor **[3 marks]**

(d) A capacitor of capacitance $C = 500\ \mu F$ is charged to a voltage of 900 V and is then discharged through a resistance $R = 200\ k\Omega$ when a switch is closed.

i. Find the initial charge stored in the capacitor. **[2 marks]**

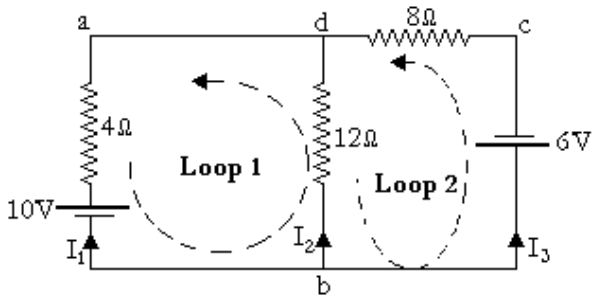
ii. Find the time constant of this capacitor resistor network combination **[2 marks]**

QUESTION FIVE

(a) State two differences between electric field and magnetic field **[2 marks]**

(b) Using the Maxwell's Law $\nabla \times \mathbf{B} = \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t}$ derive expression for the electric and magnetic field **[5 marks]**

(c) i) State the Kirchhoff's current law and Kirchhoff's voltage law. **[2 marks]**



ii) Consider the circuit above. Calculate the current I_1, I_2 and I_3 in the circuit of figure **[6 marks]**

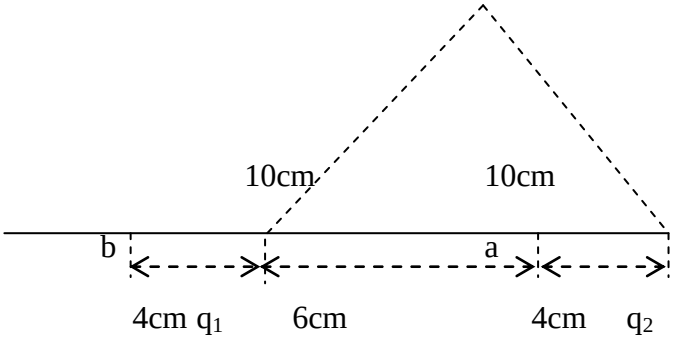
QUESTION SIX

(a) Use Ampere's law to calculate the magnetic field for a long cylindrical conductor of radius *R* and a current *I* flowing through it at a distance *r* from the central axis of the conductor when (a) $r > R$ and (b) $r < R$ **[4 marks]**

(b) A 2 m long wire weighs 4 g and carries a 10 A current. It is constrained to move only vertically above another wire carrying 15 A in the opposite direction. At what separation would its weight be supported by magnetic force **[3 marks]**

(c) Two point charges q_1 and q_2 ,$+12x10^{-9}$C and$-12x10^{-9}$C are placed 0.1m apart as shown in the diagram. Calculate the electric fields due to these charges at points a, b and c

[4 marks]



ii) using Gauss's law derive the expression of electric field for long wire of length L having charge per unit length λ. considering the wire as a cylindrical Gaussian surface of radius r.

[4 marks]