MACHAKOS UNIVERSITY

University Examinations 2022/2023 Academic year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (TELECOMMUNICATION AND INFORMATION TECHNOLOGY)

BACHELOR OF EDUCATION (SPECIAL NEEDS)

BACHELOR OF SCIENCE (MATHEMATICS)

BACHELOR OF EDUCATION (SCIENCE)

SPH 101: ELECTRICITY AND MAGNETISM I

DATE: 18/4/2023 **TIME: 2:00 – 4:00 PM**

INSTRUCTIONS TO CANDIDATES

Answer **QUESTION ONE** and **ANY OTHER TWO** questions.

Question 1 carries **30** marks and the others carry **20** marks each.

Useful Constants:

You may need to use the following constants

ε_o =8.85×10^{-12}F/m; K=1/(4πε_o) = $9 \times 10^9\ m/F$, Electron charge, q e=-1.6×10^{-19}C, Proton charge, q_p=+1.6×10^{-19}C, Mass of an electron, Me=9.11×10^{-31}Kg, μ_o=4π×10^{-7}Tm/A, 1eV= 1.6×10^{-19}J

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Define a capacitor and list any four (4) uses of a capacitor (5 marks)

b) State the Coulomb's law of electrostatics and write its mathematical expression. (3 marks)

c) A galvanometer for which 25 mA gives a full-scale deflection and has a resistance of 3Ω. Determine the value of the bobbin resistor if it required to be converted into a voltmeter of full-scale deflection 1.2V. (4 marks)

d) i) Sketch the electric field lines associated with interacting positive and negative point charges. (2 marks)

ii) Determine the electric field **E** and the potential, at a distance of 7 cm of an associated point charge Q=4μC. (3 marks)

e) Two electrons are separated by a distance of $2 \times 10^{-6}\ m$. Calculate the force between the two particles (3 marks)

f) Define current density (1 mark)

g) A parallel-plate capacitor has plates with dimensions 7 cm by 9 cm separated by 4 mm. The plates are connected across a 48 V battery.

i) Determine the capacitance and the charge on each plate. (3 marks)

ii) Determine the electric field within the plates and the energy stored. (2 marks)

h) A battery has an emf of 12.0 V. Its terminals are connected to a load resistance of 3.00 Ω.

i) Find the current in the circuit and the terminal voltage of the battery. (2 marks)

ii) Calculate the power delivered to the load resistor. (2 marks)

QUESTION TWO (20 MARKS)

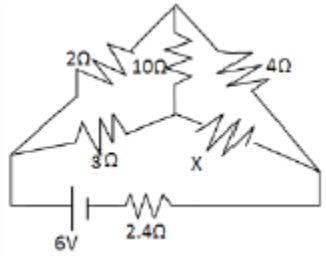
a) With aid of diagrams, state Kirchoff's laws of electricity (4 marks)

b) Two charges $Q_1(3\mu C)$ and Q_2 $(6\mu C)$ are separated by 100 cm. Determine;

(i) Neutral point (4 marks)

(ii) E-field at neutral point (2 marks)

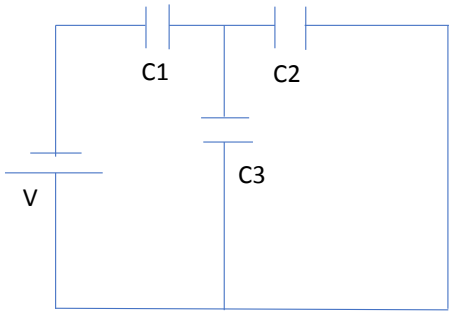
c) Find the value of X and current drawn from the battery of emf 6V of negligible resistance. (5 marks)



d) Consider the circuit below. Given that V=3.2V, $C1 = 4\mu F, C2 = 0.8\mu F$ and $C3 = 3\mu F$, Calculate;

(i) the equivalent capacitance (3 marks)

(ii) The total charge flowing in the circuit (2 marks)



QUESTION THREE (20 MARKS)

a) Define a galvanometer and draw its electronic symbol (2 marks)

b) Two charges Q1(4μC) and Q2(-7μC) are located at coordinates (0,0) and (40,0) respectively. Assuming distance in metres, calculate the electric field associated with these charges. (4 marks)

c) For a balanced wheatstone bridge, derive the expression for the resistance of the variable resistor ensuring that the current flowing through the galvanometer is zero (0). (6 marks)

d) Define a magnetic field and sketch the field lines associated with an isolated magnet. (3 marks)

e) Differentiate between magnetic field density and intensity while giving their mathematical expression on their relationship (2 marks)

f) State the two laws of magnetic induction (3 marks)

QUESTION FOUR (20 MARKS)

a) Derive the expression of resistivity in terms of length (L), resistance (R) and area of cross-section (A) of a conductor. (5 marks)

b) The radius of a copper wire is 1.47mm. A potential difference (p.d) of 44V is applied across a 3 m length of this wire. Resistivity of copper=$1.1\times10^{-8}\Omega$m. Calculate,

i) Its resistance (2 marks)

ii) The current (1 mark)

iii) The electric field (1 mark)

c) Show that the current density, *J*, for a current carrying wire of cross-sectional area A is given by,

$$J=nqVd$$

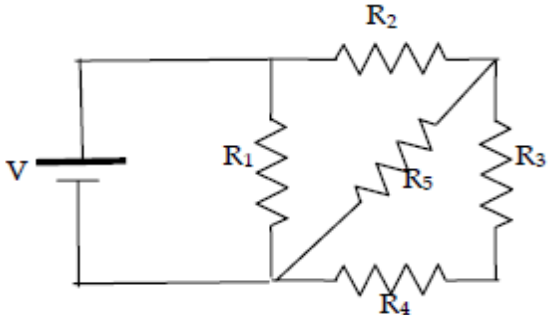
Where the symbols have their usual meanings (4 marks)

(c) For the circuit shown find

(i) The equivalent resistance, (4 marks)

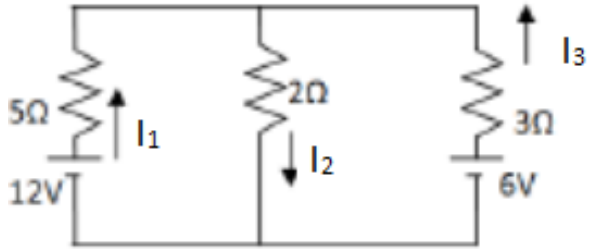
(ii) The current provided by the battery. (3 marks)

($V = 90.0$ V, $R_1 = 3.00\ \Omega$, $R_2 = 4.00\ \Omega$, $R_3 = 1.00\ \Omega$, $R_4 = 2.00\ \Omega$ and $R_5 = 6.00\ \Omega$).



QUESTION FIVE (20 MARKS)

a) Consider the following circuit. Calculate the current I_1, I_2 and I_3 in the above circuit. (8 marks)



b) An electron has a velocity of $V = 10^5 \hat{\imath} m/s$ in a magnetic field of $B = 2 \times 10^{-3} \hat{k} T$. Determine the magnitude and direction of the force. (5 marks)

c) For an electron with K.E. of 10^5eV moves perpendicular to the lines of uniform filed $B = 10^{-4}$T. Calculate;

i) The period of the orbit (4 marks)

ii) The radius of the orbit (3 marks)