



MACHAKOS UNIVERSITY

University Examinations 2019/2020 academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF EDUCATION (SCIENCE)

SPH 101: ELECTRICITY AND MAGNETISM I

DATE: 22/1/2021

TIME: 2.00-4.00 PM

INSTRUCTIONS:

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

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

YOU MAY USE:

You may need to use the following constants

$\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$; $K = 1/(4\pi\epsilon_0) = 9 \times 10^9$, $q_e = -1.6 \times 10^{-19} \text{ C}$, $q_p = +1.6 \times 10^{-19} \text{ C}$, Mass of an electron, $m_e = 9.11 \times 10^{-31} \text{ Kg}$, $\mu_0 = 4\pi \times 10^{-7} \text{ Tm/A}$, $1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$

QUESTION ONE

- Define a capacitor and list any four (4) uses of a capacitor (5 marks)
- State the fundamental law of electrostatics and the Coulomb's law for electrostatics and write its mathematical expression. (3 marks)
- Three-point charges $q_1(-5\mu\text{C})$, $Q_2(8\mu\text{C})$ and $Q_3(15\mu\text{C})$ are located at co-ordinate points (40,0), (0,30) and (0,0) respectively. Determine the net force acting on Q_3 . Assume dimensions in cm. (4 marks)

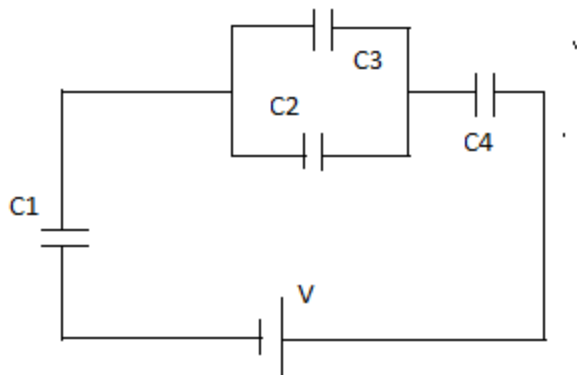
- d) i) Sketch the electric field lines associated with interacting positive and negative point charges. (2 marks)
- ii) Determine the electric field $\mathbf{E}$ and the potential, at a distance of 7cm of an associated point charge $Q=4\mu\text{C}$. (3 marks)
- e) Write down an expression for the conductivity of a conductor. What is its relationship with resistivity? (3 marks)
- f) A parallel-plate capacitor has plates with dimensions 7cm by 9 cm separated by 4mm. The plates are connected across a 48V battery.
- i. Determine the capacitance and the charge on each plate. (3 marks)
- ii. Determine the energy stored. (2 marks)
- g) A battery has an emf of 12.0 V with 0.3Ω internal resistance. Its terminals are connected to a load resistance of 3.00Ω .
- i. Find the current in the circuit and the terminal voltage of the battery. (3 marks)
- ii. Calculate the power delivered to the load resistor. (2 marks)

QUESTION TWO

- a) State the two definitions of Ohm's law (4 marks)
- b) A line of charge with a line charge density λ C/m has a length L. Show that the electric field, $\mathbf{E}$, at a distance r from the line of charge is given by; (3 marks)
- $$E = \lambda / 4\pi\epsilon_0 r^2$$
- c) Show that the electric potential is given by, $\vec{V} = -\vec{E} \cdot \vec{dr}$ (5 marks)
- d) An isolated positive point charge, Q, is approached by a positive test charge Q_0 , moving from infinity to a distance r from Q.
- i) Show that the electric potential V is given by, (3 marks)
- $$V = KQ/r$$
- ii) Point charges $Q_1(4\mu\text{C})$, $Q_2(-7\mu\text{C})$ and $Q_3(2\mu\text{C})$ are located at coordinates (0,0), (0,30) and (40, 0) respectively. Determine the electric potential at point (40,30) due to all these charges. (5 marks)

QUESTION THREE

- a) Consider the circuit below. Given that $V=48V$, $C1 = 6\mu F$, $C2 = 1\mu F$, $C3 = 3\mu F$ and $C4 = 12\mu F$, Calculate;



- The equivalent capacitance (3 marks)
 - The charge and the p.d. of each capacitor (4 marks)
- b) A galvanometer for which 25 mA gives a f.s.d and has a resistance of 3Ω . Determine the value of the bobbin resistor if it required to be converted into a voltmeter of f.s.d 1.2V. (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) State the two laws of magnetic induction (3 marks)

QUESTION FOUR

- a) Derive the expression of resistivity in terms of length (L), resistance (R) and area of cross-section (A) of a conductor. (4 marks)
- b) The radius of a copper wire is 1.47mm. A potential difference (p.d) of 44V is applied across a 3m length of this wire. Resistivity of copper= $1.1 \times 10^{-8} \Omega m$. Find,
- Its resistance (2 marks)
 - The current (1 mark)
 - 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,

$$J=nqVd$$

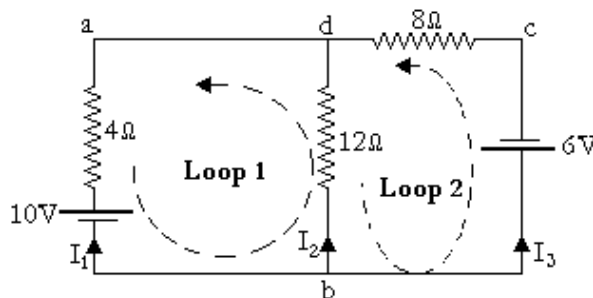
Where the symbols have their usual meanings

(4 marks)

- d) A variable frequency EMF source with $V=6V$ is connected to a resistor and an inductor with $R=80\Omega$ and $L=40mH$.
- At what frequency f does $V_R = V_L$? (3 marks)
 - At f , what is the phase angle ϕ ? (2 marks)
 - What is the current amplitude and RMS value? (3 marks)

QUESTION FIVE

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



- b) An electron has a velocity of $V = 10^5 \hat{m}/s$ in a magnetic field of $B = 2 \times 10^{-3} \hat{k}T$. Determine the magnitude and direction of the force acting on the charge. (5 marks)
- c) For an electron with K.E. of $10^5 eV$ moves perpendicular to the lines of uniform field $B = 10^{-4}T$. Calculate;
- The period of the orbit (4 marks)
 - The radius of the orbit (3 marks)