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

ε_o $=8.85\times10^{-12}$F/m; $K=1/(4\pi\varepsilon_o) = 9\times10^9$, $q_e=-1.6\times10^{-19}$C, $q_p=+1.6\times10^{-19}$C, Mass of an electron, $M_e=9.11\times10^{-31}$Kg, $\mu_o=4\pi\times10^{-7}$Tm/A, 1eV= 1.6×10^{-19}J

QUESTION ONE

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

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

c) Three-point charges q1($-5\mu C$), Q2 ($8\mu C$) and Q3 ($15\mu C$) are located at co-ordinate points (40,0), (0,30) and (0,0) respectively. Determine the net force acting on Q3. *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 **E** and the potential, at a distance of 7cm of an associated point charge Q=4μC. (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 3.00 Ω.

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)

QUESTIONTWO

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, **E,** at a distance **r** from the line of charge is given by; (3 marks)

$$E = {}^{\lambda}/_{4\pi\varepsilon_o r^2}$$

c) Show that the electric potential is given by, $\vec{V} = -\vec{E}.\overrightarrow{dr}$ (5 marks)

d) An isolated positive point charge, Q, is approached by a positive test charge Qo, moving from infinity to a distance r from Q.

i) Show that the electric potential V is given by, (3 marks)

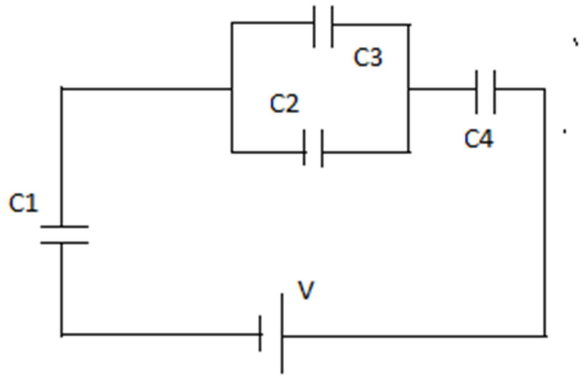
$V = {}^{KQ}/_{r}$

ii) Point charges Q1(4μC), Q2(-7μC) and Q3(2μC) 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;



i) The equivalent capacitance (3 marks)

ii) The charge and the p.d. of each capacitor (4 marks

b) A galvanometer for which 25 mA gives a fsd and has a resistance of 3Ω. Determine the value of the bobbin resistor if it required to be converted into a voltmeter of fsd 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=$1.1\times10^{-8}\Omega$m. Find,

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,

$$J=nqV_d$$

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=80Ω and L=40mH.

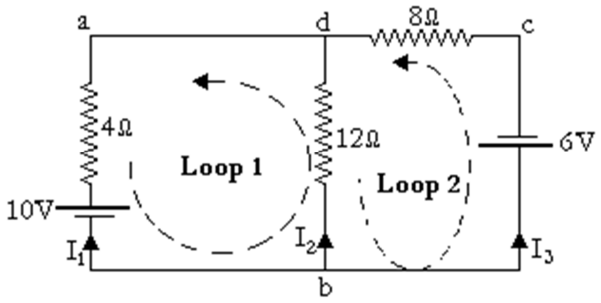
i) At what frequency f does $V_R = V_L$? (3 marks)

ii) At f, what is the phase angle φ? (2 marks)

iii) 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 $V = 10^5\hat{\imath}m/s$ 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 10^5eV 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)