MACHAKOS UNIVERSITY

University Examinations 2019/2020Academic year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

AUGUST SESSION EXAMINATION FOR

BACHELOR OF EDUCATION

SPH 401: ELECTRODYNAMICS

DATE: SCHOOL BASED **TIME:**

INSTRUCTIONS TO CANDIDATES

Answer **QUESTION ONE** which is *COMPULSORY* and **ANY OTHER TWO** questions.

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

YOUMAYUSE:

You may need to use the following constants

- Permittivity of free space, $\varepsilon_o = 8.85\times10^{-12}$ F/m ($k = 8.99 \times 10^{9}\ Nm^2C^{-2}$)
- Mass of an electron, $M_e = 9.11\times10^{-31}$ Kg
- Electron charge, $e = 1.6 \times 10^{-19}$ C
- Permeability of free space, $\mu_o = 4\pi\times10^{-7}$ Tm/A
- $1eV = 1.6\times10^{-19}$ J

QUESTION ONE (30 MARKS)

a) Sketch a graph of the magnitude of electric charge on either plate of a capacitor versus the magnitude of the potential difference between the plates. What does its slope indicate? And based on this curve, provide the two SI units representing this relationship. (4 marks)

b) State the two Faraday's laws (3 marks)

c) A photon feels an electric field of $2.5 \times 10^3\ V/m$ and is traveling as an electromagnetic wave in air. Calculate the magnetic field it experiences during flight. (3 marks)

d) Define and write the expression for magnetic dipole moment. (3 marks)

e) Derive the expression for the electric field for a current carrying cylindrical conductor radius r with a line charge density of λ c/m and length L? (4 marks)

f) Use the constants permittivity and permeability of free-space to calculate the speed of light. (3 marks)

g) State the continuity equation and write its expression from Maxwell's equation. (4 marks)

h) Define Laplace and Poisson equations? Give their physical meaning (4 marks)

i) Determine the force experienced by a charge $2.5\mu C$ in an electric field of 5N/C and magnetic field of 7.25Tesla and traveling with a velocity of 1.5m/s (2 marks)

QUESTION TWO (20 MARKS)

a) Point charges Q_1 (4μC), Q_2 (-7μC) and Q_3 (2μC) are located at coordinates (0, 0), (0, 3) and (4, 0) respectively. Determine the electric potential at point (4, 3) due to all these charges. (4 marks)

b) Use Gauss' law to derive the expression for the electric displacement in a dielectric capacitor. (5 marks)

c) A coaxial cable connecting a TV to an antenna socket is 3 m long. The inner conductor has an outer radius of 0.5 mm, the outer conductor has an inner radius of 3 mm. The space between the conductors is filled with plastic with κ= 2.6. Derive the expression to be used and use it to determine the capacitance of this cable? (11 marks)

QUESTION THREE (20 MARKS)

a) Show that the energy density for a parallel plate capacitor in an electric field is given by;

$U_E = \frac{1}{2}\varepsilon_o E^2$ (4 marks)

b) Using Gauss' law, find the electric field due to a uniformly distributed charges over a sphere of radius R and surface charge density of ρ where;

i. r>>R (3 marks)

ii. r=R (2 marks)

iii. r<<R (3 marks)

c) For a region of empty space with EM waves, show that the total energy density, u_T is given by;

$u_T = \varepsilon_o E^2$

where all the constants have their usual meanings (8 marks)

QUESTION FOUR (20 MARKS)

a) While indicating their physical meanings, write both the differential and integral forms of Maxwell's equations. (12 marks)

b) Show that the Laplacian function also operates on the vector potential $\vec{A}$ as $\nabla^2\vec{\boldsymbol{A}} = -\mu\boldsymbol{J}$. (8 marks)

QUESTION FIVE (20 MARKS)

a) An electric dipole consisting of two charges of 0.2 μC separated by a distance of 2.0 cm is placed in an external field of 10^5 N/C. What maximum torque is exerted by the dipole? (4 marks)

b) Using Gauss law, derive the expression of capacitance of a spherical-shaped capacitor. (7 marks)

c) Derive the expression of the differential form of Ampere's law. (5 marks)

d) Calculate the flux density **B** when the potential is given by x **i** + y **j** + z **k** in air. (4 marks)