MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FOURTH YEAR SECOND SEMESTER SUPPLEMENTARY EXAMINATION FOR BACHELOR OF EDUCATION (SCIENCE)

SPH 401: ELECTRODYNAMICS

DATE: 26/9/2019 **TIME: 11:00 – 1:00 PM**

INSTRUCTIONS:

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

Question 1 carries **30** markss and the others carry **20** markss 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
- Electronic 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

a) State the two Faraday's laws 4 marks

b) Define electric polarization 2 marks

c) Define and write the expression for electric dipole moment. 3 marks

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

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

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

g) Write the differential and integral forms of Stoke's law. 2 marks

h) Write an equation for Lorentz force and give its application to the interaction of matter. 4 marks

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

j) 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

a) An isolated positive point charge, Q, is approached by a positive test charge Q_o, moving from infinity to a distance r from Q. Show that the electric potential V is given by, 5 marks

$$V = KQ/r$$

b) Show that the work done in moving the charge Qo is given by $W = \frac{KQQ_o}{r}$ 6 marks

c) 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

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

QUESTION THREE

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

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

(ii) Determine the electric field within the plates and the energy stored. 6 marks

c) Derive an expression for effective capacitance for three parallel capacitors C_1, C_2, C_3 all connected in parallel to a capacitor C_4. 3 marks

d) 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 7 marks

QUESTION FOUR

a) While indicating their physical meanings, write differential forms of Maxwell's equations. 8 marks

b) State Gauss' theorem and Stoke's theorem and use them to convert Maxwell's equations from differential to integral forms. 8 marks

c) Show that the electric displacement, D, is given by $D = \varepsilon_o(1 + \chi)E$ where χ is the material susceptibility. 4 marks

QUESTION FIVE

a) Identify any three uses of a capacitor? 3 marks

b) 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

c) Using Gauss law, derive the expression of capacitance of a parallel-plate capacitor. 5 marks

d) Find the vector potential when the field intensity $-20z^4$ varies from (-3, -2,2) to (1,0,3). 4 marks

e) Find the flux density B when the potential is given by x i + y j + z k in air. 4 marks