# MACHAKOS UNIVERSITY

**University Examinations 2017/2018**

**SCHOOL OF PURE AND APPLIED SCIENCES**
**DEPARTMENT OF PHYSICAL SCIENCES**

**FOURTH YEAR SECOND SEMESTER EXAMINATION FOR**

**BACHELOR OF EDUCATION SCIENCE**

**SPH 401: ELECTRODYNAMICS**

**DATE:11/12/2017** **TIME: 8.30-10.30 AM**

## *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.

***YOU MAY USE:***

You may need to use the following constants

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

**QUESTION ONE (COMPULSORY) (30 MARKS)**

a) State Gauss's law (2 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 $\lambda$ 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

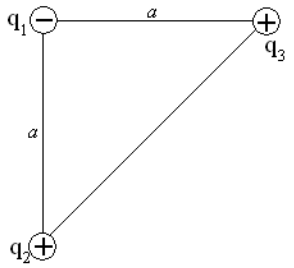
h) Write an equation for Lorentz force and give its application to the interaction of matter. (4 marks)

i) Define Laplace and Poisson equations and 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 (20 MARKS)**

a) Consider three point charges located at the corners of a right triangle as shown in Figure below, where q1 = q3 = 5.0 μC, q2 = - 2.0 μC, and a = 0.10 m. Find the resultant force exerted on q3. (6 marks)




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

i) Show that the electric potential V is given by, (5 marks)

$$V = KQ/r$$

ii) Point charges $Q_1$ (4μC), $Q_2$ (-7μC) and $Q_3$ (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. (4 marks)

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

**QUESTION THREE (20 MARKS)**

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

b) 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)

c) 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)

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 (20 MARKS)**

a) Write Maxwell's equations in both differential and integral forms. (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 $\chi$ is the material susceptibility. (4 marks)

**QUESTION FIVE (20 MARKS)**

The magnetic vector of a plane electromagnetic wave is described by;

$$\vec{B} = \vec{k}B_o \cos\lfloor(10 metre^{-1})y + (3 \times 10^9 s^{-1})t \rfloor$$

where $B_o$ is the magnetic field at the origin y=0, $\vec{k}$ is a unit vector in the z-direction, y is in meters and t in seconds.

a) What is the wavelength $\lambda$ of the wave? (4 marks)

b) What is the period T of the wave? (3 marks)

c) In which direction does this wave propagate to? Explain why you chose this direction. (4 marks)

d) Write an expression for the electric vector of the wave in terms of the quantities given and the speed of light, $c$ (4 marks

e) What is the time-dependent Poynting vector associated with this wave? Give both magnitude and direction. (5 marks)