MACHAKOS UNIVERSITY

University Examinations 2023/2024 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES
FOURTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN APPLIED PHYSICS AND TECHNOLOGY

BACHELOR OF EDUCATION SCIENCE

SPH 401: ELECTRODYNAMICS

DATE: **TIME:**

INSTRUCTIONS:

- The paper consists of two sections.
- Section A is compulsory (30 marks).
- Answer any two questions from section B (each 20 marks).

SECTION A

QUESTION ONE (30 MARKS)

a) State what happens to an electromagnetic wave when it encounters a conducting surface? **(2 Marks)**

b) (i)What role does the ionosphere play in propagation of electromagnetic waves? **(2 Marks)**

(ii)Find the dielectric constant for ionospheric plasma using Maxwell's equations **(6 Marks)**

c) (i) State the FIVE properties of electric field lines **(5 Marks)**

(ii) Sketch the electric field lines for a positive isolated charge **(3Marks)**

d) Using Greens theorem, derive the expression of Maxwell's equation for Gauss Law in differential form. **(6 Marks)**

e) You are on a call discussing a very important business matter as you enter a skyscraper in Nairobi. As you enter the lift, you momentarily lose the client on the other side of the connection. Using principals of electrodynamics:

i. Explain what happened **(4 Marks)**

ii. Sate what me asures would have been put in place during construction to minimize this occurrence **(2 Marks)**

SECTION B

QUESTION TWO (20 MARKS)

a) What is meant by the term Gauge transformation of electromagnetic field vectors? **(2 Marks)**

b) Starting from Maxwell's equation for Faraday's law in integral form,

(i) Show that in static media,

$$\nabla \times \vec{E} = 0$$

For the electric field vector **(6 Marks)**

(ii) What is the physical significance of the equation in (i) above? **(2 Marks)**

c) (i) Use Ampere's law to derive the expression of the magnetic field that varies with time **(5 Marks)**

(ii)Hence determine the field intensity $\vec{B}$ from c(i) above **(5 Marks)**

QUESTION THREE (20 MARKS)

a) (i) State Lorentz force law indicating all parameters in the equation **(3 Marks)**

(ii) What is the physical interpretation of the law in (i) above? **(2 Marks)**

b) (i)What is meant by skin depth in electromagnetism? **(2 Marks)**

(ii) How is the skin depth affected by the frequency of the em wave? **(3 Marks)**

(iii)Where does the concept in b(ii) above find application? **(2 Marks)**

c) An em wave propagating in a medium has electric and magnetic field vectors given by

$$\vec{E}_I = E_{oI} e^{i(\omega t - k_1 z)} \hat{x}$$

$$\vec{B}_I = B_{oI} e^{i(\omega t - k_1 z)} \hat{y}$$

respectively. If the waves approach a conducting surface at normal incidence,

(i) What will be the respective field vectors for the reflected and transmitted waves? **(4 marks)**

(ii) State what happens to the wave vectors above if they are incident on a perfectly conducting surface? **(3 Marks)**

(iii) Briefly describe any one day to day application of the concept highlighted in (i) above **(2 Marks)**

QUESTION FOUR (20 MARKS)

a) State the boundary conditions that govern the em field vectors as they traverse different media **(4 Marks)**

b) The concept of dispersion of light has been successfully accounted for in optics for example the bending of light of different wavelengths as it passes through a glass prism. Discuss briefly how this concept is tackled in electromagnetic waves. **(6 Marks)**

c) How do we treat electromagnetic waves travelling in a waveguide?

(4 Marks)

(ii) Determine the magnetic field vector $\vec{B}$ of an electromagnetic wave travelling in a coaxial transmission line consisting of a wire of radius ***a*** surrounded by a cylindrical conducting sheath of radius ***b***.

(6 Marks)

QUESTION FIVE (20 MARKS)

(a) List down all the forces that act on a charged particle in the ionosphere

(5 Marks)

(b) (i) What is the physical significance of Poynting vector of an electromagnetic wave?

(2 Marks)

(ii) An electromagnetic wave propagating in the positive x-direction is given by

$$\vec{E} = E_o \sin(kz - \omega t)\hat{i}$$

Determine the Poynting vector $\vec{S}$ of the wave **(5 Marks)**

(iii) Starting from electric potential ϕ and magnetic potential A, use d'Alambertian operator on arbitrary constants α and β to present the Lorentz gauge in form that satisfies the wave equation.

(8 Marks)

END