MACHAKOS UNIVERSITY

University Examinations for 2021/2022 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FOURTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF EDUCATION (SPECIAL NEEDS)

BACHELOR OF EDUCATION (SCIENCE)

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).

Useful Information

- Permittivity of free space, $\varepsilon_O=8.85\times10^{-12}$ F/m, k = 8.99 x 10^9 Nm^2C^{-2}
- Mass of an electron, M_e =9.11×10^{-31} Kg
- Electronic charge, e = 1.6 x 10^{-19} C
- Permeability of free space, $\mu_O=4\pi\times10^{-7}$Tm/A
- 1eV= 1.6×10^{-19}J
- 1 Å= 10^{-10} m

QUESTION ONE (30 MARKS))

a) State Ampere's law (2 marks)

b) Show that the work done in moving a positive charge q_o from a distance r to a charge Q is given by

$$W = \frac{Qq_o}{4\pi\varepsilon_o r}$$ (6 marks)

c) A long straight wire has a current in it. At a perpendicular distance of 0.05 m from the wire the magnetic induction caused by the current is 2×10^{-5} T. Calculate the current in the wire. (3 marks)

d) Calculate the electric field applied on a system with electrons having a velocity 5m/s subjected to a magnetic flux of 3.6 units. (3 marks)

e) An EM wave travels in a medium at a speed of $2x10^8$ m/s. The relative permittivity of the medium is 1.2. Calculate the relative permeability (4 marks)

f) An electron is revolving around the nucleus of an atom in an orbit of radius 0.53 Å. Calculate the equivalent magnetic moment if the frequency of revolution of the electron is 6.8 x 10^9 MHz. (4 marks)

g) A block whose dielectric constant K=1.7 has similar area with the plates of a $3 \times 2.3\ cm$ parallel plate capacitor whose thickness is 2d. Determine the capacitance when the block is placed between the plates and d=2 mm (6 marks)

h) Electromagnetic waves in a vacuum are said to be transverse. Explain the meaning of transverse in this context. (2 marks)

QUESTION TWO (20 MARKS))

a) Show that the electric displacement in a dielectric material with constant ϵ, $\vec{D} = \epsilon\vec{E}$ (4 marks)

b) Use Ampere's law to determine the magnetic field for a toroid of radius R and n loops per unit length when the current is;

(i) Inside the loop (2 marks)

(ii) On the loop (2 marks)

(iii)Outside the loop (3 marks)

c) A coaxial cable connecting a TV to an antenna socket is L m long. The inner conductor has an outer radius of a mm, the outer conductor has an inner radius of b mm. The space between the conductors is filled with plastic with ε_r. Derive the expression for the capacitance of the cable. (9 marks)

QUESTION THREE (20 MARKS))

a) Given two electromagnetic fields $\vec{E}(x,t) = A\sin(kx - \omega t)\,\hat{j}$ and $\vec{B}(x,t) = A\sin(kx\text{-}\omega t)\hat{k}$, solve the consistency of the constants of its wave equations using Maxwell relations. (6 marks)

b) An electric dipole created by a 9 V supply are separated by a distance of 3 cm are placed in an external field of 1.2×10^5 N/C. Calculate;

(i) Dipole moment (3 marks)

(ii) Angled torque at 54^o (3 marks)

c) For a region of empty space with EM waves, show that the non-averaged Poynting vector is given by;

$$\vec{S} = \frac{1}{\mu_o}\vec{E}_o \times \vec{B}_o$$

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

QUESTION FOUR (20 MARKS))

a) Calculate the vector potential when the field intensity $-23y^2$ varies from (1, -2, 0) to (1, 6, 0). (4 marks)

b) Show that the Laplacian function also operates on the magnetic vector potential. (6 marks)

c) While describing their physical meanings, identify both the differential and integral forms of Maxwell's equations . (10 marks)

QUESTION FIVE (20 MARKS))

a) If the displacement current density $J_d = 2$ mA/m^2 in a medium whose $\in_r = 2$, $\sigma = 4.95 \times 10^6$ at a frequency of 1 GHz, then determine the conduction current density J_c (3 marks)

b) Derive the Maxwells's differential form of Faraday's law from the induced electromotive force (5 marks)

c) The magnetic field of a plane EM radiation is $\vec{B} = 10^{-9}\, Cos\left((\pi m^{-1})y + (3\pi \times 10^8 s^{-1})t\right)\hat{\imath}\, T$. Calculate.

(i) The direction does the wave travel (1 mark)
(ii) The wavelength, frequency & speed of the wave (4 marks)
(iii) The complete vector expression for E (2 marks)
(iv) The time-average energy flux carried in the wave (3 marks)
(v) The direction of energy flow (2 marks)