CHUKA  **UNIVERSITY**

UNIVERSITY EXAMINATIONS

EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING

EENG 232: ELECTROMAGNETIC FIELD THEORY

STREAMS: BSC EENG **TIME: 2 HOURS**

DAY/DATE: MONDAY 23/12/2024 **2.30 P.M – 4.30 P.M.**

INSTRUCTIONS:

1 This paper consists of **four** questions
2 Question ONE is COMPULSORY and carries 30 Marks
3 The other questions carry 20 Marks Each
4 Attempt Question **ONE** and **ANY OTHERTWO** questions
5 Use the following constants where applicable

$\in_0 = 8.854 \times 10^{-12}$ F/m

$$\varepsilon_0 = \frac{1}{36\pi} \times 10^{-9} F/m$$

$$\mu_0 = 4\pi \times 10^{-7} \frac{H}{m}$$

QUESTION ONE (30 MARKS)

a) Define a the following terms as used in electromagnetism **[4 Marks]**

(i) Vector
(ii) Field
(iii) Flux

(iv) Curl of a vector

b) Explain any TWO applications of electromagnetic **[4 Marks]**

c) Given point P (−2, 6, 3) and vector **A** = y$\mathbf{a_x}$ + (x + z)$\mathbf{a_y}$ **.** Express P and **A** in cylindrical and spherical coordinates **[4 Marks]**

d) Calculate the vector associated with (3, -4, 5) if,

$\vec{F}(x,y,z) = xy^2z\vec{a}_x + x^2yz\vec{a}_y + xyz^2\vec{a}_z$ **[3 Marks]**

e) Find the gradient of the scalar field φ = x^2yz^3 + xy^2z at P (1, 3, 2) **[4 Marks]**

f) Determine the curl of vector field **P** = $x^2yz\mathbf{a_x}$+ $xz\mathbf{a_z}$ **[3 Marks]**

g) State Coulomb's law **[2 Marks]**

h) Determine the force between two identical charges, of magnitude 10 pC, separated by a distance of 1mm situated in free-space. **[2 Marks]**

i) Given a plane wave with f = 1M Hz propagating in Region1. Air, σ = 0, $\varepsilon_1 = \varepsilon_0$ and $\mu_1 = \mu_0$ and Region 2. Copper σ = 5.8 x10^7 $\varepsilon_1 = \varepsilon_0$ and $\mu_1 = \mu_0$ Determine the attenuation constant, phase constant, velocity of propagation wavelength in both regions **[4 Marks]**

QUESTION TWO (20 MARKS)

a) Define the following terms as used in electrostatics:

(i) Electric field intensity

(ii) Potential difference

(iii) Static electric field **(3 marks)**

b) Point charges 1mC and -2mC are located at (3, 2, −1) and (−1, −1, 4) respectively. Calculate the electric force on a 10 nC charge located at (0, 3, 1) and the electric field intensity at that point **(7 marks)**

c) Given the potential field, $V = 2x^2y - 5z$, and a point P(-4,3,6), Evaluate

(i) The potential V, at point P **[1 mark]**

(ii) The electric field Intensity **E**, at point P **[2 Marks]**

(iii) The direction of **E, a_{EP}** **[2 Marks]**

(iv) The electric flux density **D,** **[1 Marks]**

(v) The Volume charge density ρv **[1 Marks]**

d) An electromagnetic wave is propagating in the z-direction in a lossy medium with attenuation constant $\alpha = 0.5$= Np/m. If the wave's electric-field amplitude is 100 V/m at z = 0, how far can the wave travel before its amplitude will have been reduced to 10 V/m **[3 Marks]**

QUESTION THREE (20 MARKS)

a) With the aid of vectors define the Biot- Savart's law and show that the magnetic field intensity is given by $d\vec{H} = \frac{Idl\sin\alpha}{4\pi R^2}$. Where *I* is the current element, α is the angle between the element and line joining the point and *R* is the distance between the element and thepoint **[4 Marks]**

b) A circular loop located on $x^2 + y^2 = 9$, z = 0 carries a direct current of 10 A along $\boldsymbol{a_\phi}$. Determine **H** at (0, 0, 4) and (0, 0, -4). **[6 Marks]**

c) Derive the Poisson's equation from the Gauss's law $\nabla \cdot \vec{D} = \rho v$, where **D** is the flux density and ρ_v is the volume charge density **[4 marks]**

d) Two parallel discs are separated by a distance of 5mm at z = 0 and z =5mm. If V = 0 at z = 0 and V = 100V at z = 5mm find the charge densities on the discs **[6 marks]**

QUESTION FOUR (20 MARKS)

a) A square plate in the x–y plane is situated in the space defined by −3 m ≤ x ≤ 3 m and −3 m ≤ y ≤ 3 m. Find the total charge on the plate if the surface charge density is given by $\rho s = 4y^2$ (mC/m2). **[3 Marks]**

b) A horizontal wire with a mass per unit length of 0.2 kg/m carries a current of 4 A in the +x-direction. If the wire is placed in a uniform magnetic flux

density B, what should the direction and minimum magnitude of B be in order to magnetically lift the wire vertically upward? (Hint: The acceleration due to gravity is g = −zˆ 9:8 m/s2.) **[4 Marks]**

c) Distinguish between reflection and transmission coefficients as used in Electromagnetic waves and state their effect on travelling waves [**6 Marks]**

d) A plane wave in air with electric field amplitude of 20 V/m isincident normally upon the surface of a lossless, nonmagnetic medium with $\varepsilon_r = 25$ Determine the:

(i) reflection and transmission coefficients **[3 Marks]**

(ii) standing-wave ratio in the air medium **[1 Mark]**

(iii) average power densities of the incident, reflected, and transmitted waves **[3 Marks]**
