MACHAKOS UNIVERSITY

University Examinations for 2020/2021

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EEE 304: ELECTROMAGNETIC FIELDS AND WAVES

DATE: 12/8/2021 **TIME: 2:00 – 4:00 PM**

INSTRUCTIONS:

This paper consists of **FIVE** questions. Answer Question **ONE** and any other **TWO** questions

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Distinguish between
   i. Scalar quantity and scalar field
   ii. Vector quantity and vector field (4 marks)

b) Explain the significance of the curl of a vector (2 marks)

c) Given $\boldsymbol{A} = (2x + 3y)\boldsymbol{a_y} - (2y + 3z)\boldsymbol{a_y} + (3x - y)\boldsymbol{a_z}$ determine the unit vector parallel to $\boldsymbol{A}$ at (1, -1, 2) (3 marks)

d) Determine the gradient of the scalar $\Phi = x^2 + y^2 + 2xy$ (3 marks)

e) Define the following terms as used in Electrostatic field
   i. Electric potential;
   ii. Potential difference;
   (2 marks)

f) State the **Amperes law**. Write down Maxwell's version of the equation in integral form (3 marks)

g) State and explain the Lorentz force equation (4 marks)

h) Write down the differential form of the Maxwell's equations (4 marks)

i) The conduction current flowing through a wire with conductivity $\sigma = 2 \times 10^7 S/m$ and relative permittivity $\epsilon_r = 1$ is given by $I_c = 2sin\omega t\ (mA)$. If $\omega = 10^9\ rad/s$. Determine the expression of the displacement current (3 marks)

j) Figure 1 shows infinitely long parallel wires carrying currents of 6 A in opposite directions. Determine the magnetic flux density B at point P (2 marks)

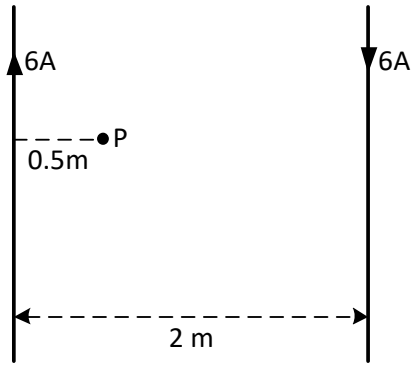


Figure 1

QUESTION TWO (20 MARKS)

a) State **Gauss law** of Electrostatics (2 marks)

b) The charge distribution in a hollow sphere of inner radius a and outer radius b have density ρ given by

$$\rho = \begin{cases} 0 & r < a \\ \dfrac{8a}{r} & a \leq r \leq b \\ 0 & r > b \end{cases}$$

Determine $\boldsymbol{E}$ in each of the following regions

i. $r < a$
ii. $a \leq r \leq b$
iii. $r > b$

(12 marks)

c) The charge is distributed along the $x - axis$ from $x = -b$ to $-\infty$ and $x = b$ to $+\infty$ with a charge density of λ. Determine $\boldsymbol{E}$ on the $y - axis$ (6 marks)

QUESTION THREE (20 MARKS)

a) State **three** factors that affect Coulomb's Force (3 marks)

b) Three point charges $-1nC$, $4nC$ and $3nC$ are located at $(0,0,0)$, $(0,0,1)$ and $(1,0,0)$ respectively. Determine the energy in the system. (7 marks)

c) Two concentric conducting spherical shell with radii a and b are maintained at a potential difference V_0 such that $V(r = a)$ and $V(r = b)$

i. Use Laplace equation to determine V
ii. Determine $\boldsymbol{E}$
iii. If the region is filled with dielectric material of relative permittivity ϵ_r determine the capacitance of the capacitance

(10 marks)

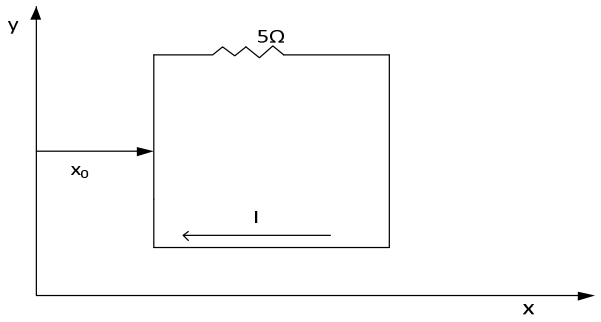
QUESTION FOUR (20 MARKS)

a) (i) State Faraday's law of electromagnetic induction

(ii) The square loop shown in Figure 2 (side length=10cm) moves at a velocity of 3m/s in the $+x$ direction in air where the magnetic flux density is defined as

$$\vec{B} = \frac{2}{x^2}\vec{a}_z \quad \mu T$$

Determine the current I induced in the loop as a function of $\boldsymbol{x_0}$ (10 marks)



b) A single turn circular loop antenna of radius 20 cm lies in the y-plane (in air) and centered at the coordinate origin. Determine the emf induced in the loop given by $\boldsymbol{B} = 100\cos(\omega t)\,\vec{a}_z(nT)\,, f = 1MHz$ (3 marks)

c) Current I flows along a positive z −direction in the inner conductor of along coaxial cable and returns through the outer conductor. The inner conductor has radius a and the inner and outer radii of the outer conductor are b and c respectively. Determine the magnetic field in each of the following regions

i) $0 \le r \le a$

ii) $a \le r \le b$

iii) $b \le r \le c$

iv) $r \ge c$

(7 marks)

QUESTION FIVE (20 MARKS)

a) With the aid of hysteresis curve, describe the magnetization process

(6 marks)

b) (i) State the boundary conditions for magnetic fields

(ii) The plane boundary defined by $z = 0$ separates air from a block of iron. If $B_1 = 4\boldsymbol{a_x} - 6\boldsymbol{a_y} + 8\boldsymbol{a_z}$ in $(z \le 0)$ given that $\mu = 5000\mu_0$ for iron.

(7 marks)

c) The electric field intensity E is given by $E = E_m \sin(\omega t - \beta z)\boldsymbol{a_y}$ in free space. Determine each of the following:

i. Electric flux density D

ii. Magnetic flux density B

iii. Magnetic field strength, H

(10 marks)