MACHAKOS UNIVERSITY

University Examinations for 2023/2024 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

THIRD YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EEE 304: ELECTROMAGNETIC FIELDS AND WAVES

DATE: **TIME:**

INSTRUCTIONS

QUESTION ONE (30 marks)-Compulsory

(a) Given that $A = \boldsymbol{a_x} + 2\boldsymbol{a_y} - 3\boldsymbol{a_z}$, $\boldsymbol{B} = 2\boldsymbol{a_x} + 4\boldsymbol{a_y}$ and $C = 2\boldsymbol{a_y} - 4\boldsymbol{a_z}$. Determine the:

i. The unit vector $\widehat{\boldsymbol{a}}_{\boldsymbol{A}}$

ii. The component of $\boldsymbol{B}$ along C

iii. $\boldsymbol{A} \times \boldsymbol{C}$

(6 marks)

(b) For the scalar function $T = \frac{1}{2}e^{\frac{r}{5}}cos\phi$ determine its directional derivative along the radial distance $\tilde{\boldsymbol{r}}$ and then evaluate it at $(2, \frac{\pi}{4}, 3)$.

(5 marks)

(c) The electric flux density inside a dielectric sphere of radius a centered at the origin is

$$\vec{D} = \boldsymbol{a_r}\rho_0 r \ \ C/m^2$$

where ρ_0 is a constant. Determine the total charge inside a sphere. (4 marks)

(d) (i)State Amperes circuital law in words

(ii) In a certain conducting region, the magnetic field is given in cylindrical coordinates by:

$$H = \widehat{\Phi}\frac{4}{r}[1 - (1 + 3r)e^{-3r}]$$

Determine the current density $\boldsymbol{J}$ (4 marks)

(e) State Maxwell's equation in **in point form** form (4 marks)

(f) Use Amperes law to obtain $\boldsymbol{H}$ due to an infinitely long straight filament of current I

(2 marks)

(g) Determine the force on a straight conductor of length 0.30m carrying a current of 5 A in the $-\boldsymbol{a_z}$ direction where the field is given by $\boldsymbol{B} = 3.50 \times 10^{-3}(\boldsymbol{a_x} - \boldsymbol{a_y})$ T

(3 marks)

(h) Write down the expression of the electric field strength $\boldsymbol{E}$ for electrodynamics field in terms of the electric and magnetic potentials $\boldsymbol{V}$ and $\boldsymbol{A}$ respectively.

(2 marks)

QUESTION TWO (20 MARKS)

a) (i) From Gauss law, derive the Laplace equation

(ii) A region lies between two concentric right circular cylinders centered along the $z - axis$ with the inner cylinder radius $r = 1\ mm$ corresponding to $V = 0$ and the outer cylinder of $r = 25mm$ corresponding to $V = 175\ volts$. For the region, determine the:

I. Potential function
II. Electric field intensity (9 marks)

b) For the potential function given by $V = 6\rho^2 cos2\phi$

i. Determine V at $\rho = 3, \phi = \frac{\pi}{3}, z = 2)$
ii. The volume charge density ρ_v (5 marks)

c) Figure 1 shows a charge free dielectric interface at $z = 0$.The electric field intensity in medium 1 is given by $\boldsymbol{E_1} = 3\boldsymbol{a_x} - 4\boldsymbol{a_y} + 5\boldsymbol{a_z}\ \boldsymbol{V/m}$. Determine the:

i. Electric flux density D_2
ii. The angles $\theta_1\ and\ \theta_2$

(6 marks)

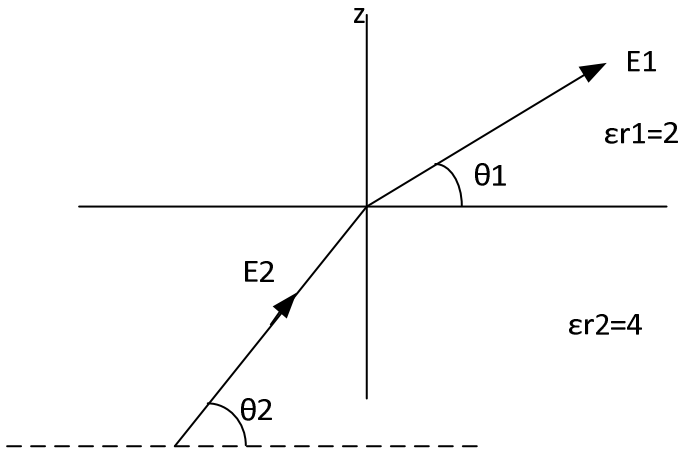

Figure 1

QUESTION THREE (20 MARKS)

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

(3 marks)

(b) Point charges Q_1 =5μC and Q_2 =-4μC are located at (3,2,1) and (-4,0,0) respectively. Determine the

i. force on Q_1

ii. electric field strength **E** at Q_1

(7 marks)

(c) The electric flux density in a region is given by

$$\rho_v = \begin{cases} \frac{10}{r^2} & \frac{mC}{m^3} \quad 1 < r < 4 \\ 0 & elsewhere \end{cases}$$

Determine the:

i. Net flux crossing the surface at $r = 2m$ and $r = 6m$

ii. Flux density D at $r = 1m$ and at $r = 5$

(10 marks)

QUESTION FOUR (20 MARKS)

(a) Write down the Biot-Savart law equation. Explain all the symbols used. (4 marks)

(b) (i) Derive the expression for the magnetic field intensity at the center of a current carrying loop with radius a and current I

(ii) A current loop of radius 0.5m carries a certain current to produce magnetic field $H = 1mA/m$ at the center. Determine the:

I. Current

II. Magnetic field H at a distance 2m from the loop axis

(10 marks)

(c) (i) State the Amperes law

(ii) The current density Jin cylindrical coordinates for a region $0 < r \leq 0.6m$ $J5e^{-2r}\tilde{a}_r A/m^2$ and $J = 0$ elsewhere. Determine the magnetic field intensity using Amperes law.

(6 marks

QUESTION FIVE (20 MARKS)

(a) State Maxwell's equations in **integral form** (4 marks)

(b) The electric field intensity $\boldsymbol{E}$ is given by $\boldsymbol{E} = E_m \sin(\omega t - \beta z)$ in free space, determine the

i. Electric flux density $\boldsymbol{D}$

ii. Magnetic flux density $\boldsymbol{B}$

iii. Magnetic field strength $\boldsymbol{H}$

(7 marks)

(c) A co-axial capacitor with inner radius $6mm$ outer radius $8mm$ and length $500mm$ has a dielectric for which $\varepsilon_r = 6.7$ and an applied voltage of $v(t) = 250sin377tvolts$. Determine the

i. Potential function v

ii. Electric field strength $\boldsymbol{E}$

iii. Flux density $\boldsymbol{D}$

iv. Displacement current density J_d

v. Displacement current i_d

(9 marks)