EL 273 ELECTROMAGNETIC FIELD THEORY

Answer all questions

Question 1

a. A parallel plate capacitor has three similar plates, the outside two being joined together. The inner plate is movable so that it can be used as a variable capacitor. If C_1 is the capacitance when the inner plate is exactly midway between the outer plates and C_2 is the capacitance when the inner plate is three times as near one plate as the other, with the aid of sketches find C_1/C_2 **(15 Marks)**

b. A field is given as: $\vec{G} = \frac{25}{\sqrt{x^2 + y^2}} \left(x \hat{i}_x + y \hat{i}_y \right)$

Find: i. a unit vector in the direction of $\vec{G}$ at *P(3, 4,−2)*. **(5 Marks)**

ii. the angle between $\vec{G}$ and $\hat{i}_x$ at *P*. **(5 Marks)**

iii. the value of the following double integral $\int_{x=0}^{4} \int_{z=0}^{2} \vec{G} \bullet dx\, dz\, \hat{i}_y$ on the plane $y = 7$. **(5 Marks)**

Question 2

a. The electric field in air above a block of paraffin having relative permittivity equal to 2.1 is at an angle of 45° with respect to the plane surface of the block. Find the angle between the electric field intensity vector and the surface of the paraffin. **(15 Marks)**

b. Find the potential at the point P at the center of a square of side 1m. The square has a point charge $Q_1 = +10^{-12}$ C at the upper left corner, a point charge $Q_2 = -10^{-11}$ C at the lower left corner and a line distribution of charge of uniform density $\lambda_L = 10^{-11} \frac{C}{m}$ along the right edge. Take $\varepsilon_0 = 8.854 \times 10^{-12}$ **(15 Marks)**

Question 3

a. Find the potential at r = 40 cm and r = 10 cm from a charge Q = 2 × 10^{-4} μC and also the potential difference between these two points. **(9 Marks)**

b. Calculate: $\nabla \times \left[\nabla \left(\nabla \bullet \vec{G} \right) \right] if\ \vec{G} = 2x^2\, y\, z\, \hat{i}_x - 20\, y\, \hat{i}_y + \left(x^2 - z^2 \right) \hat{i}_z$ **(9 Marks)**

c. Given the field $\vec{H} = 20 r^2 \hat{i}_\phi\ A/m$:

(i) Determine the current density $\vec{J}$. **(4 Marks)**

(ii) Integrate $\vec{J}$ over the circular surface $r = 1$, $0 < \phi < 2\pi$, $z = 0$, to determine the total current passing through that surface in the $\hat{i}_z$ direction. **(4 Marks)**

(iii) Find the total current once more, this time by a line integral around the circular path $r = 1$, $0 < \phi < 2\pi$, $z = 0$. **(4 Marks)**

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