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Dept. of EE, IIT Tirupati
EE3001 : Electromagnetic Fields (Aug - Nov 2018)
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Tutorial Quiz - 3

Note: The tutorial quizzes are part of your assignment. This is an effort to test your learning outcome while solving assignment problems independently.

1. Region $y \leq 0$ consists of a perfect conductor while region $y \geq 0$ is a dielectric medium ($\epsilon_{1r} = 2$). If there is a space charge of 2 nC/m^2 on the conductor, determine $\vec{E}$ and $\vec{D}$ at (a) A(3, -2, 2) and (b) B(-4, 1, 5)

2. A normally incident E field has amplitude $E_0 = 1$ V/m in free space just outside the sea water in which ϵ_r=80, $\mu_r = 1$ and $\sigma = 2.5$ S/m. For a frequency of 30 MHz, at what depth will the amplitude of E be 1 mV/m.

Conductor | Dielectric

$\epsilon_r = 2$

$y = 0$

Space charge $= 2\ nC/m^2$

(a) A (3, -2, 2) $\longrightarrow$ inside the conductor as $y = -2$.

$\Rightarrow \vec{E} = 0$

$\therefore D = 0$

(b) B (-4, 1, 5) $\longrightarrow$ In the dielectric medium as $y = 1$.

$$\oint_S E \cdot ds = \frac{q_{enc}}{\epsilon}$$

(direction will be normal to the surface)

$$E \cdot A = \frac{\rho_s \cdot A}{\epsilon}$$

$$E = \frac{\rho_s}{\epsilon} \hat{a}_y$$

$$\vec{E} = \frac{2\times10^{-9}}{2\times8.85\times10^{-12}}\,\hat{a}_y$$

$$\boxed{\vec{E} = 112.99\ V/m\,\hat{a}_y}$$

$$\vec{D} = \epsilon\vec{E}$$

$$\boxed{\vec{D} = 2\times10^{-9}\ C/m^2\,\hat{a}_y}$$

2. $E_0^i = 1\ V/m$

Sea $\Rightarrow$ $\epsilon_r = 80$

$\mu_r = 1$

$\sigma = 2.5\ S/m$

$f = 30\ MHz$.

$\therefore$ $\eta_1 = 377\ \Omega$

$\eta_2 = 9.73\ \angle 43.5^\circ$

$$\frac{E_0^t}{E_0^i} = \frac{2\eta_2}{\eta_1+\eta_2} \Rightarrow E_0^t = 5.07\times10^{-2}\ V/m$$

$z \downarrow$ (6)

$E_0^{t.f} = 1\ mV/m$.

$$\gamma = \sqrt{j\omega\mu(\sigma + j\omega\epsilon)}$$

$$= 24.36 \angle 48.53^\circ$$

$$\alpha = 16.76 \text{ Np/m}.$$

So, distance at which it reduces to $1 \text{ mV/m} \Rightarrow$ 'z'

$$1 \times 10^{-3} = 5.07 \times 10^{-2} e^{-\alpha z}$$

$$\Rightarrow \boxed{z = 0.243 \text{ m}}.$$