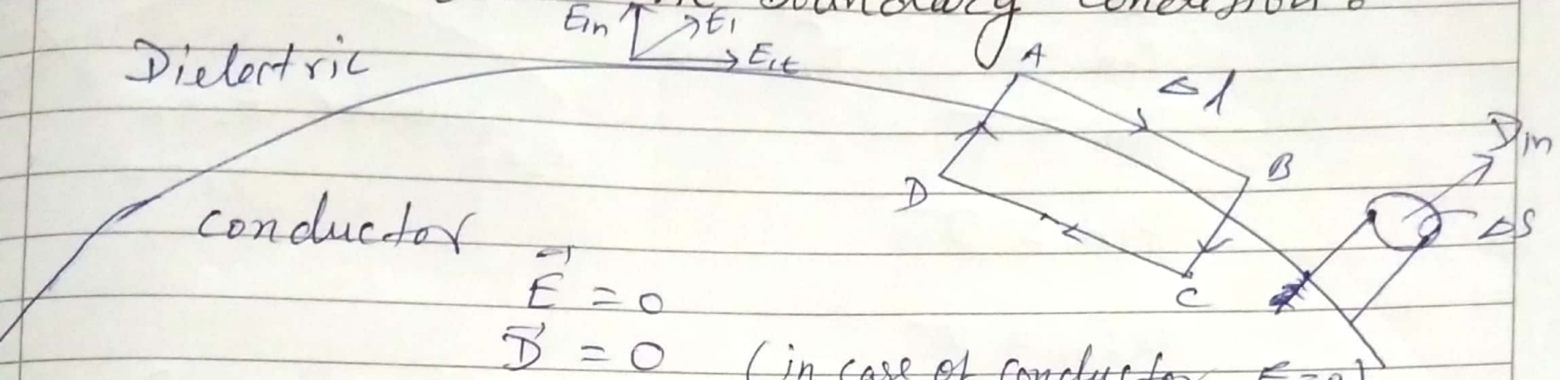
Conductor - dielectric boundary condition :->



$\vec{E} = 0$

$\vec{D} = 0$ (in case of conductor $E=0$)

$$\oint \vec{E}\cdot\vec{dl} = 0$$

$$\int_A^B \vec{E}\cdot\vec{dl} + \int_B^C \vec{E}\cdot\vec{dl} + \int_C^D \vec{E}\cdot\vec{dl} + \int_D^A \vec{E}\cdot\vec{dl} = 0$$

$$E_{1t}\,\Delta l - \cancel{E_{in}\frac{\Delta h}{2}} + 0 + 0 + 0 + \cancel{E_{in}\frac{\Delta h}{2}} = 0$$

$E_{1t}\,\Delta l = 0$

$E_{1t} = 0$ tangential component is zero.

$D_{1t} = 0$ tangential component of D is zero.

$E_{2t} = 0$

$D_{2t} = 0$

$$\int \vec{D}\cdot\vec{dS} = Q$$

$D_{1n}\,\Delta S = \sigma\,\Delta S$

$D_{n} = \sigma$ Discontinuous.

$\epsilon E_{1n} = \sigma$

$E_{1n} = \frac{\sigma}{\epsilon}$

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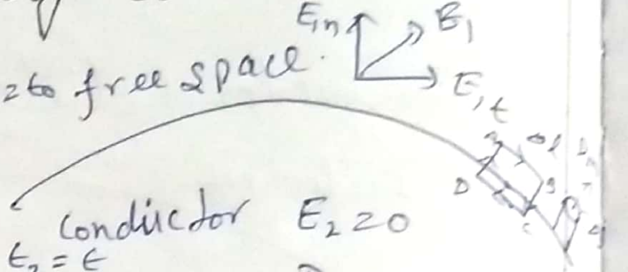
Conductor free space boundary condition :-

$E_{2t} = 0$, $D_{2t} = 0$ $\epsilon_1 = \epsilon_0$ free space

$E_{2n} = 0$ $\quad$ $D_{2n} = 0$



$D_{1n} = \sigma$

$D_{1n} = \sigma$

$\epsilon_0 E_{1n} = \sigma$

$$\boxed{E_{1n} = \frac{\sigma}{\epsilon_0}}$$

$$\boxed{E_{1t} = 0}$$

$$\boxed{D_{1t} = 0}$$

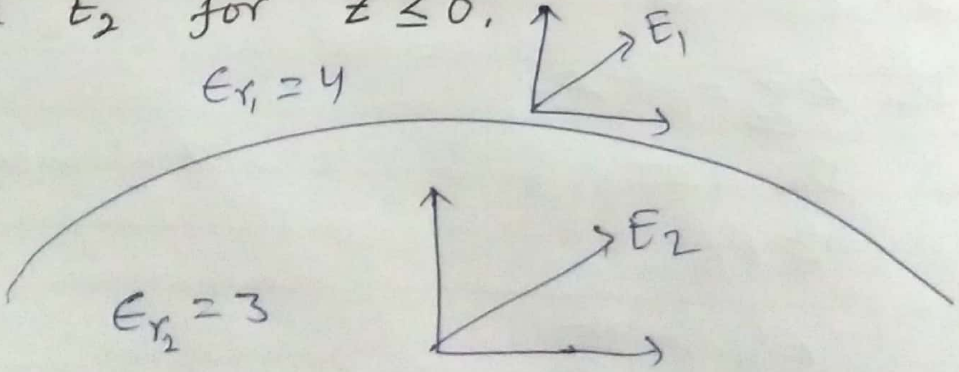
$$\int_A^B \vec{E}\cdot d\vec{l} + \int_B^C \vec{E}\cdot d\vec{l} + \int_C^D \vec{E}\cdot d\vec{l} + \int_D^A \vec{E}\cdot d\vec{l} = 0$$

$$E_{1t}\,\Delta l - \cancel{E_{1n}\frac{\Delta h}{2} - 0} + 0 + 0 + \frac{\Delta h}{2} - 0$$

$$E_{1t}\,\Delta l = 0$$

$$E_{1t} = 0 .$$

Q. Two extensive homogeneous dielectric metal on the plane $z \geq 0$, $\epsilon_{r_1} = 4$ and for $z \leq 0$ $\epsilon_{r_2} = 3$, A uniform electric field is given as $\vec{E_1} = 5\,\hat{a}_x - 2\,\hat{a}_y + 3\,\hat{a}_z \ \frac{kV}{m}$ exist for $z \geq 0$ Find $\vec{E_2}$ for $z \leq 0$.



$$\vec{E_1} = 5\hat{a}_x - 2\hat{a}_y + 3\hat{a}_z$$

$$\vec{E_1} = \vec{E_{1n}} + \vec{E_{1t}}$$

$$\vec{E_{1n}} = (E_1 \cdot \hat{a}_z) \cdot \hat{a}_z$$

$$\vec{E_{1n}} = 3\hat{a}_z$$

$$\vec{E_{1t}} = \vec{E_1} - \vec{E_{1n}}$$

$$\vec{E_{1t}} = 5\hat{a}_x - 2\hat{a}_y + \cancel{3\hat{a}_z} - \cancel{3\hat{a}_z}$$

$$\vec{E_{1t}} = 5\hat{a}_x - 2\hat{a}_y$$

we know $\vec{E_{1t}} = \vec{E_{2t}}$

So $\vec{E_{2t}} = 5\hat{a}_x - 2\hat{a}_y$

$$D_{1n} = D_{2n} \Rightarrow \epsilon_1 \vec{E_{1n}} = \epsilon_2 \vec{E_{2n}}$$

$$\epsilon_1 = \epsilon_0 \epsilon_{r_1}$$
$$\epsilon_2 = \epsilon_0 \epsilon_{r_2}$$

$$\cancel{\epsilon_0} \epsilon_{r_1} \vec{E_{1n}} = \cancel{\epsilon_0} \epsilon_{r_2} \vec{E_{2n}}$$

$$4\vec{E_{1n}} = 3\vec{E_{2n}}$$

$$\vec{E_{2n}} = \frac{4}{3}\vec{E_{1n}}$$

$$\vec{E_{2n}} = \frac{4}{\cancel{3}}(\cancel{3}\hat{a}_z)$$

$$\boxed{\vec{E_{2n}} = 4\hat{a}_z}$$

$$\vec{E_2} = \vec{E_{2n}} + \vec{E_{2t}}$$

$$\vec{E_2} = 4\hat{a}_z + 5\hat{a}_x - 2\hat{a}_y$$

$$\boxed{\vec{E_2} = 5\hat{a}_x - 2\hat{a}_y + 4\hat{a}_z}$$

Ans.

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Wave Equations :- According to the maxwell's equations in the absence of current and charges, the $\vec{E}$ and $\vec{B}$ fields also satisfy maxwell's wave equations.

$$\boxed{\frac{\partial^2 \vec{E}}{\partial x^2} = \mu_0 \epsilon_0 \frac{\partial^2 \vec{E}}{\partial t^2}}$$

$$\boxed{\frac{\partial^2 \vec{B}}{\partial x^2} = \mu_0 \epsilon_0 \frac{\partial^2 \vec{B}}{\partial t^2}}$$

these are the wave equations in free space.

Plane electromagnetic wave in dielectric media :-

If there is no free charge then the maxwell's equations for electromagnetic fields.

$$\vec{\nabla}\cdot\vec{D} = 0, \qquad \vec{\nabla}\cdot\vec{B} = 0$$

$$\vec{\nabla}\times\vec{E} = -\frac{\partial \vec{B}}{\partial t}, \qquad \vec{\nabla}\times\vec{B} = \mu_0 \vec{J} + \mu \frac{\partial \vec{D}}{\partial t}$$

$$\vec{D} = \epsilon \vec{E} \qquad (\because \vec{D} = \epsilon \vec{E})$$

$$\vec{B} = \mu \vec{H}$$

$$\vec{J} = \sigma \vec{E}$$

where ϵ, μ, σ denotes respectively the dielectrics permittivity, magnetic permeability and conductivity of the medium.