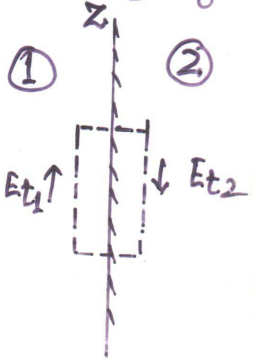
Tangential Component of Electric Field: Consider tangential comp. of electric field on either side of the surface separating two media, and assume that a unit electric +charge is carried a short distance Δz parallel to boundary in medium 1. After crossing the boundary it is then carried an equal distance in opposite direction in medium 2 and then brought to starting point. The work done in carrying the charge around a closed path is

$$\oint \vec{E}.d\vec{l} = (E_{t_1} - E_{t_2})\Delta z = -\frac{\partial \vec{B}}{\partial t}\Delta x \Delta z$$

$\Delta x \to 0 \Rightarrow$ magnetic flux linking path $= 0$

$$\Rightarrow \boxed{E_{t_1} = E_{t_2}}$$

$\Rightarrow$ Tangential component of electric field are continuous across the boundary.

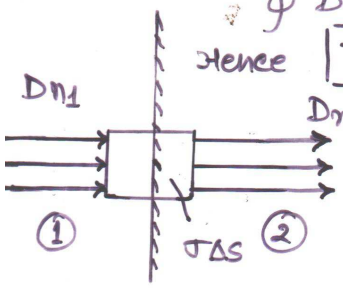


Normal Component of electric field: Consider a small surface enclosing an incremental boundary Δs. Using Gauss's law

$$\oint \vec{D}.d\vec{S} = (D_{n_2} - D_{n_1})\Delta s = \sigma \Delta S$$

σ = charge density

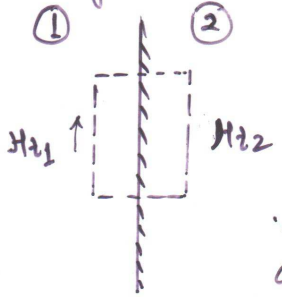
Hence $\boxed{D_{n_2} - D_{n_1} = \sigma}$



if $\sigma = 0$, then $D_{n_2} = D_{n_1}$

or, $\frac{E_{n_1}}{E_{n_2}} = \frac{\epsilon_2}{\epsilon_1}$

Tangential Component of magnetic field



Ampere's law

$$\Rightarrow \oint \vec{H}.d\vec{l} = (H_{t_1} - H_{t_2})\Delta z = I$$

where I is current flowing through area enclosed by line integral

$\because H_{t_1}$ and H_{t_2} are at infinitesimal distance apart, the area is vanishingly small,

$$\oint \vec{H}.d\vec{l} = 0$$

$$\Rightarrow \boxed{H_{t_1} = H_{t_2}}$$

Exception, in case of perfect conductor

$$\boxed{H_{t_1} - H_{t_2} = J_S}$$

J_S current density

Normal component of magnetic flux density

Gauss's law for magnetic field

$$\Rightarrow \quad \oint \vec{B} \cdot d\vec{s} = 0$$

$$\Rightarrow \quad \boxed{B_{n_1} = B_{n_2}}$$

Therefore, boundary conditions are,

(i) Tangential components of electric field are continuous across the boundary.

(ii) Normal components of electric flux density differ by an amount equal to surface charge density.

(iii) Tangential components of magnetic field differ by an amount equal to the surface current density. It may be assumed to be zero in all cases except for perfect conductors.

(iv) Normal components of magnetic flux density are continuous across the boundary.