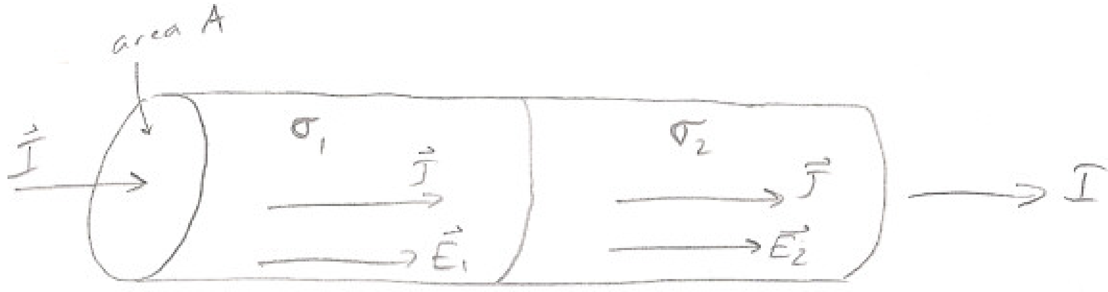
4.5

VRH

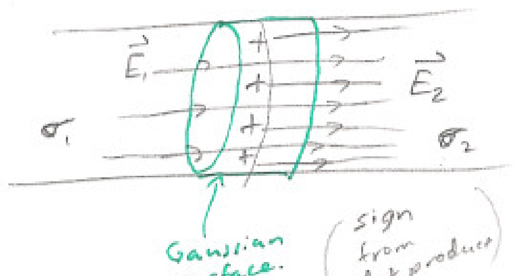


The current density $\vec{J}$ is the same on both sides.

$$\vec{J} = \sigma_1 \vec{E}_1$$
$$\vec{J} = \sigma_2 \vec{E}_2$$

Since $\sigma_1 > \sigma_2$, $\quad E_2 > E_1$.

$E_2 \neq E_1$, so some field lines either terminate or originate on the boundary. A layer of static charge must be on the boundary to account for the jump in electric field.



$$\int_{\text{surface}} \vec{E} \cdot d\vec{a} = 4\pi Q_{\text{enclosed by surface}}$$

$$\int_{\text{left end}} \vec{E}_1 \cdot d\vec{a} + \int_{\text{right end}} \vec{E}_2 \cdot d\vec{a} = 4\pi Q_{\text{static}}$$

(sign from dot product)

$$-E_1 A + E_2 A = 4\pi Q$$

We assume the electric field is uniform over each end of the Gaussian surface.

$$\left(-\frac{J}{\sigma_1} + \frac{J}{\sigma_2}\right) A = 4\pi Q$$

but $JA = I$, so

$$\left(\frac{1}{\sigma_2} - \frac{1}{\sigma_1}\right) I = 4\pi Q$$

$$\boxed{Q = \frac{I}{4\pi}\left(\frac{1}{\sigma_2} - \frac{1}{\sigma_1}\right)}$$