Electric Feilds in meterial space

ε_0: permibility in vacuum (free space)

For electric properties of bulk material

σ: conductivity (conductors)
ε: permibility (dialectrics)

Perfect conductors

$\sigma \to \infty$

Perfect insulators

$\sigma \to 0$

Ohm's Law

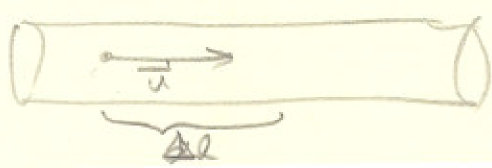
$\vec{J} = \sigma \vec{E}$

Types of currents

Convection
Conduction
Displacement

Current: A flow of change through space

$$I = \frac{dQ}{dt} = \frac{\Delta Q}{\Delta t}$$



In an interval Δt;

$$\Delta Q = \rho_v \underbrace{u \Delta t}_{\text{volume of tube}} S$$

surface being considered

charge density

$$I = \frac{\Delta Q}{\Delta t} = \frac{\rho_v U \Delta t S}{\Delta t} = \rho_v U S$$

$\vec{J}$: current density $(\rho_v U)$

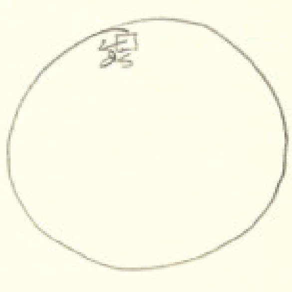
$$\frac{I}{S} = |\vec{J}|$$

Now...

$$I = \rho_v U S = \rho_v \vec{u} \cdot \vec{S}$$

Defininition of current then is:

$$I = \int_S \vec{J} \cdot d\vec{S}$$



$\vec{J} \cdot d\vec{S}$ is a small amount of current through $d\vec{S}$

Every charge carrier is subject to a force

$$\vec{F} = q\vec{E} = m\vec{a} \qquad \text{(in free space)}$$

In conductors for conduction currents Newtons Law does not apply.

Collisions with atoms produce random scatterings

$$q\vec{E} = \frac{m\vec{u}}{\tau} \qquad \text{(works better)}$$

τ: average time between collisions.

Aside Mean free Path $|\vec{u}|\tau$

$$\rho = nq$$

depends on 2 factors Ⓐ density of carrier Ⓑ Charge of carrier.

$$\vec{J} = \rho\vec{u} = nq\left(\frac{q\vec{E}\tau}{m}\right) = \frac{n\tau q^2}{m}\vec{E}$$

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

$$\frac{n\tau q^2}{m}$$

In ideal conductors electrons are free

$$\tau \to \infty \quad \therefore \quad \sigma \to \infty$$

In dialectrics; electrons are not free

$$\tau = 0 \quad \therefore \quad \sigma \to 0$$

In a perfect conductor

$$\vec{J} = \infty \quad \& \quad \sigma = \infty$$

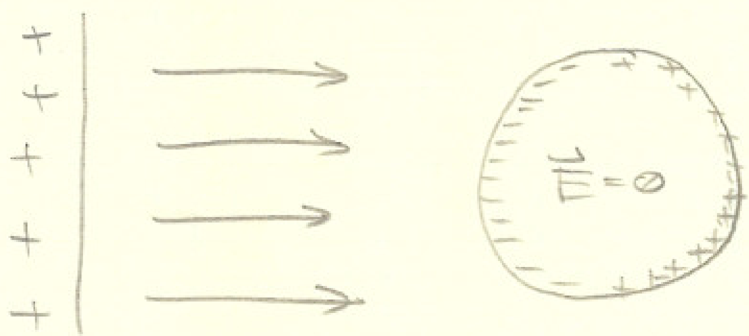
$$\therefore \quad \vec{E} = \infty$$

In a perfect conductor in a static case situation

$$\vec{E} = 0$$

$$V_{A,B} = -\int_A^B \vec{E} \cdot d\vec{l} = 0$$

Imagine I plunge a perfect conductor into an external feild.



$$\oint \vec{D} \cdot d\vec{S} = q_{enclosed}$$

$$\oint \varepsilon_0 \vec{E} \cdot d\vec{S} = q_{enclosed}$$

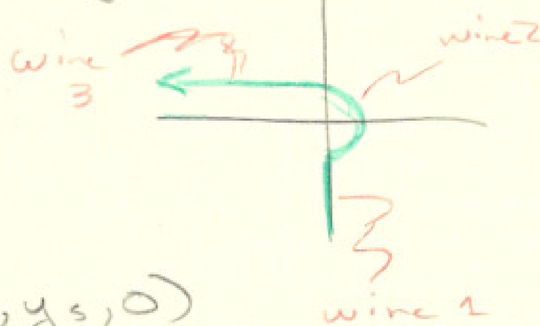
$$\oint \vec{E} \cdot d\vec{S} = \frac{q_{enclosed}}{\varepsilon_0}$$

$q_{enclosed} = 0$ inside conductor

$$V_{AB} = 0 = -\int \vec{E} \cdot d\vec{l} \qquad \text{(for A, B inside conductor)}$$

Tutorial

EX A infinitely long thin wire arriving from $-\infty$ along $\hat{y}$ is bent in a semicircle of radius "a" centered at the origin, and returns to negative infinity along the line $y=a$. If wires carry a uniform charge density λ, C/m; find electric potential at the origin.



SOL for $\vec{R}$

$$\vec{R} = \vec{R}_p - \vec{R}_s$$

$$\vec{R} = (0,0,0) - (0,y_s,0)$$

$$\vec{R} = (0,-y_s,0)$$

Solve

$$\frac{\vec{A}_r}{\vec{R}^2} = \frac{\vec{R}}{|\vec{R}|^3} = -\frac{1}{y_s}\hat{y}$$

$$\vec{E} = \int_{-\infty}^{a} \frac{d_0}{4\pi\varepsilon_0}\left(-\frac{1}{y_s}\right) dy_s \,\hat{y}$$

$$= \frac{-d_0}{4\pi\varepsilon_0 a}\hat{y}$$

for wire 2

so on sub the totals.