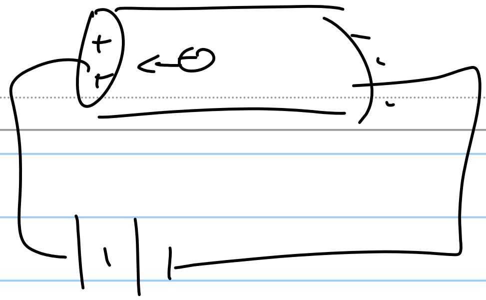


$E \neq 0$ inside

skydiver at term. vel

$\sum F = ma = 0$

$mg - \alpha v = 0$

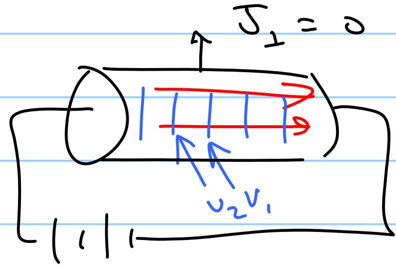
$v = \frac{mg}{\alpha}$ ← force/mass

$\vec{J} = \rho \vec{v} = \sigma \vec{E}$ ← force/charge   OHMS

$$\vec{\nabla}\cdot\vec{E} = \vec{\nabla}\cdot\frac{\vec{J}}{\sigma} \xrightarrow[\text{const } \sigma]{} \underbrace{\vec{\nabla}\cdot\vec{J}}_{-\frac{\partial\rho}{\partial t}} \longrightarrow 0 \quad \text{magnetostatics}$$

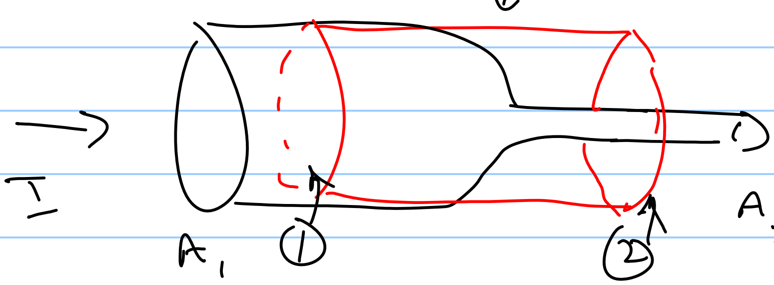
fields in conductor $\vec{\nabla}\cdot\vec{E} = 0$ $\nabla^2 V = 0$

$J = \sigma E$ so $E_\perp = 0$



$\vec{E} = -\vec{\nabla} V$

$\int \vec{J}\cdot d\vec{a} = 0$



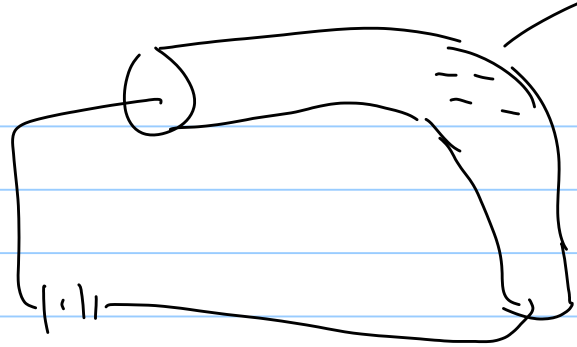
$\vec{\nabla}\cdot\vec{J} = -\frac{\partial\rho}{\partial t} = 0$

magnetostatics

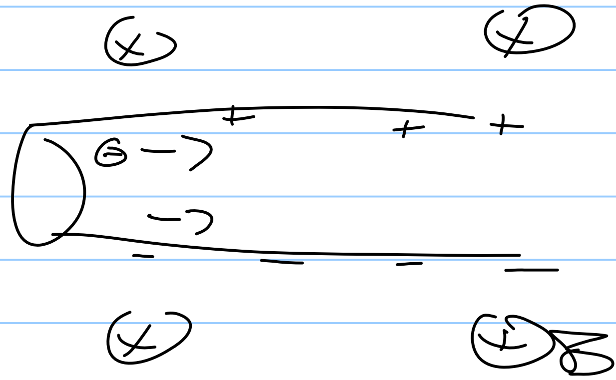
$$\int \vec{\nabla}\cdot\vec{J}\, d\tau = \underbrace{\oint \vec{J}\cdot d\vec{a}}$$

$$I = \int_{①} \vec{J}\cdot da = J_1 A_1 \qquad \int_{②} \vec{J}\cdot da = J_2 A_2 = I$$

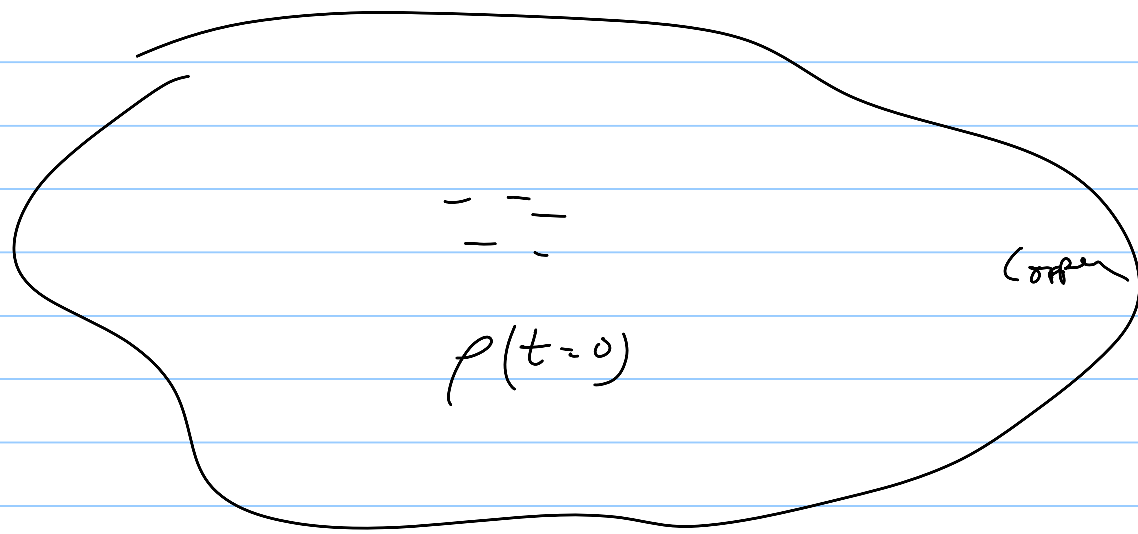
$$\cancel{\rho} v_1 A_1 = \cancel{\rho} v_2 A_2$$



assume a buildup of charge at the kink.
Left the field from kink slows down incoming charge.
Right the field from kink pushes outgoing charges away



$$\vec{F} = q\vec{v} \times \vec{B}$$



Using conservation of charge, Coulomb's law, and Ohm's law (all in differential form) derive an expression for the charge density in a conductor given its initial value.

$$\boxed{\vec{\nabla} \cdot \vec{J} = -\frac{\partial \rho}{\partial t}}$$

Cons of charge (continuity equation)

$$\boxed{\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\epsilon_0}}$$

Coulomb's law

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

const

Ohm's law

$$\vec{\nabla}\cdot\sigma\vec{E} = -\frac{\partial\rho}{\partial t} \Rightarrow \sigma\underbrace{\vec{\nabla}\cdot\vec{E}}_{\frac{\rho}{\epsilon_0}} = -\frac{\partial\rho}{\partial t}$$

$$\frac{\sigma}{\epsilon}\rho = -\frac{\partial\rho}{\partial t} \qquad \rho(t) = \rho(t=0)\,e^{-\sigma/\epsilon\, t} = \rho(0)\,e^{-t/\tau}$$

$$\tau = \frac{\epsilon}{\sigma} = \frac{10^{-11}}{10^{7}} \simeq 10^{-18} \text{ seconds}$$

collision time $\simeq 10^{-14}$ s

Because $10^{-14} \gg \tau$ conclude Ohm's law is not valid on these time scales, when measure $\tau \simeq 10^{-14}$ s & get exponential decay.

Takes longer for fields (E & B) & currents to dissipate need to add all Maxwell's eqn which relate fields to charges & currents.