Maxwell's Eqns (up to now)

$\vec{\nabla}\cdot\vec{E} = \rho/\epsilon_0$ $\qquad$ $\vec{\nabla}\times\vec{E} = 0$

$\vec{\nabla}\cdot\vec{B} = 0$ $\qquad$ $\vec{\nabla}\times\vec{B} = \mu_0\vec{J}$

Triangle diagrams $\qquad$ $\vec{F} = q\vec{E} + q\vec{v}\times\vec{B}$

$\boxed{\vec{\nabla}\cdot\vec{J} = -\frac{\partial\rho}{\partial t} \text{ cons charge}}$ $\qquad$ $W = \Delta PE = q\Delta V$

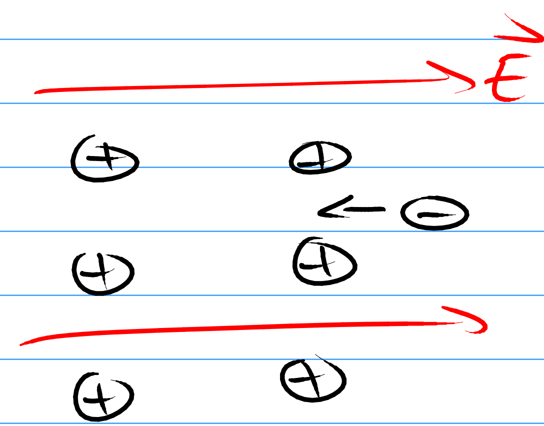
OHM'S LAW: $\qquad$ $\vec{J} = \sigma\vec{E}$

conductivity

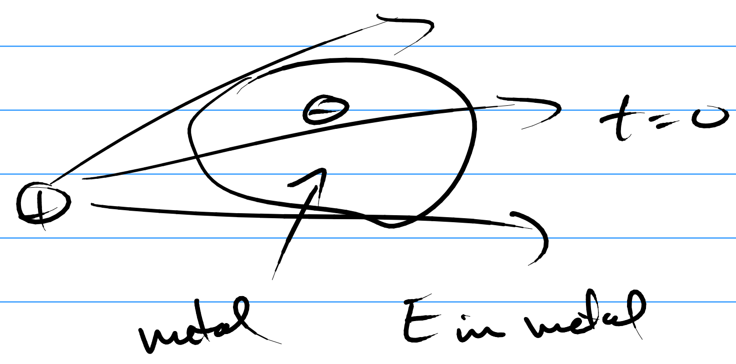
① NOT UNIVERSAL

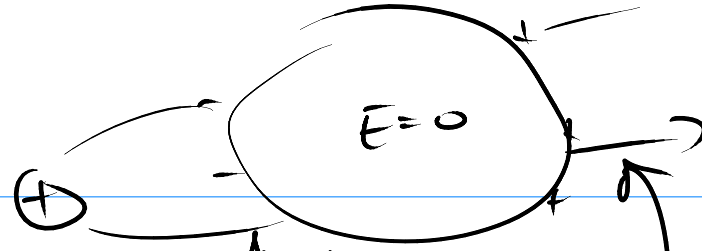
$\vec{J} = \rho\vec{v}$

Microscopic model tells more



② $\vec{E}$ in metal ?





grab charge move

$\vec{E} \neq 0$ in metal

(3) $\vec{J} = \rho \vec{v}$

const $\Rightarrow$ flow of current is analogous to incompressible fluid flow

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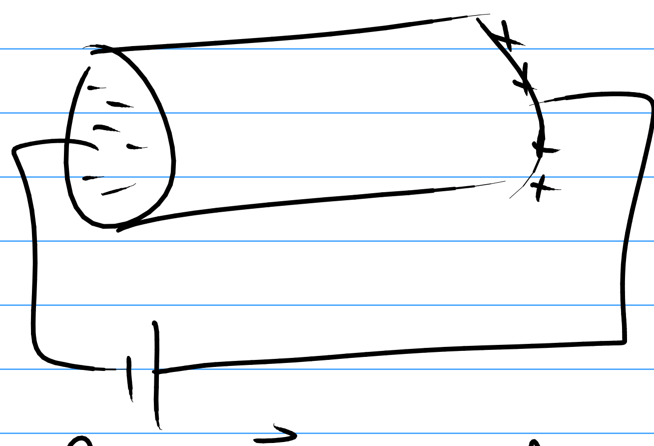
Uniform conductive $\quad \sigma$ is constant



How do we find $\vec{E}$ in metal

$\vec{J} = \sigma \vec{E}$ Ohm's Law

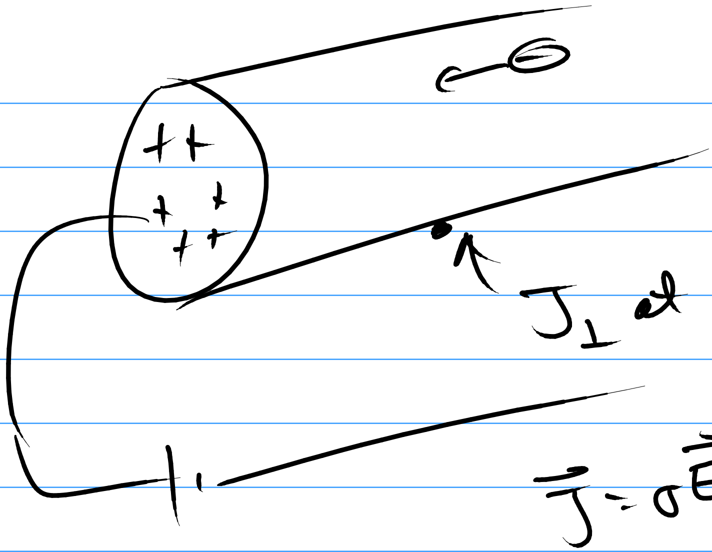
Bndry cond

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

$\vec{\nabla} \cdot \vec{E} = \rho / \epsilon_0$

steady state

$\vec{\nabla} \cdot \frac{\vec{J}}{\sigma} = \frac{1}{\sigma} \vec{\nabla} \cdot \vec{J} = \frac{1}{\sigma}\left(-\frac{\partial \rho}{\partial t}\right) = 0$



$\vec{J} = \rho \vec{v}$

$J_\perp$ at bndry $= 0$

$\vec{J} = \sigma \vec{E} \Rightarrow E_\perp$ bndry $= 0$

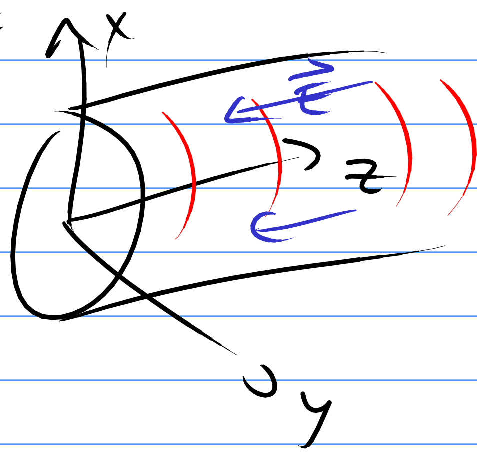
$$\vec{\nabla} \cdot \underbrace{\vec{E}}_{-\vec{\nabla} V} = 0 \quad \Rightarrow \quad \nabla^2 V = 0$$ Laplaces Eqn

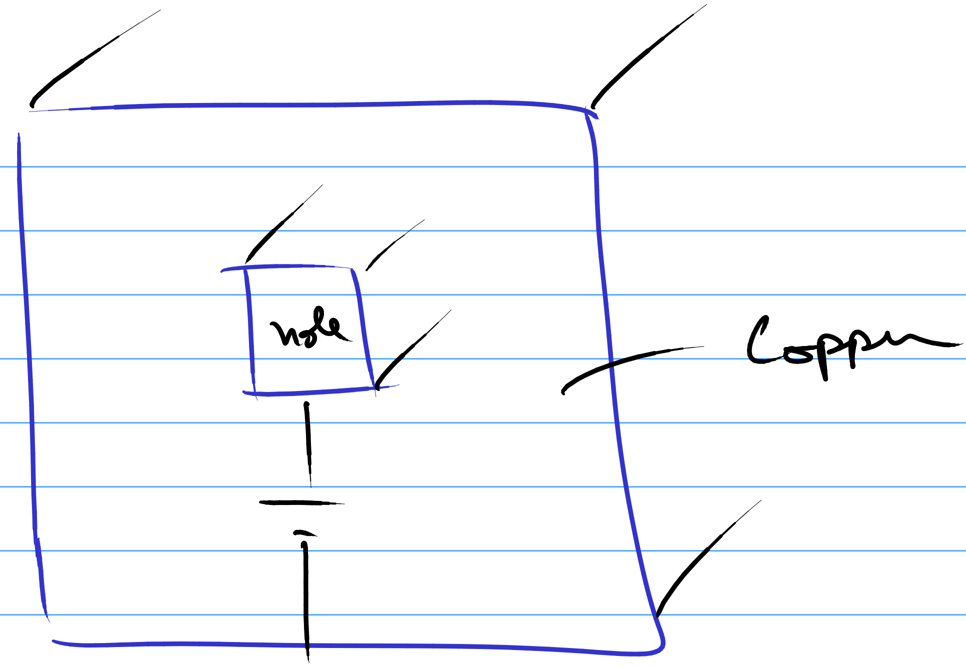
$$\frac{\partial V}{\partial n} = 0$$

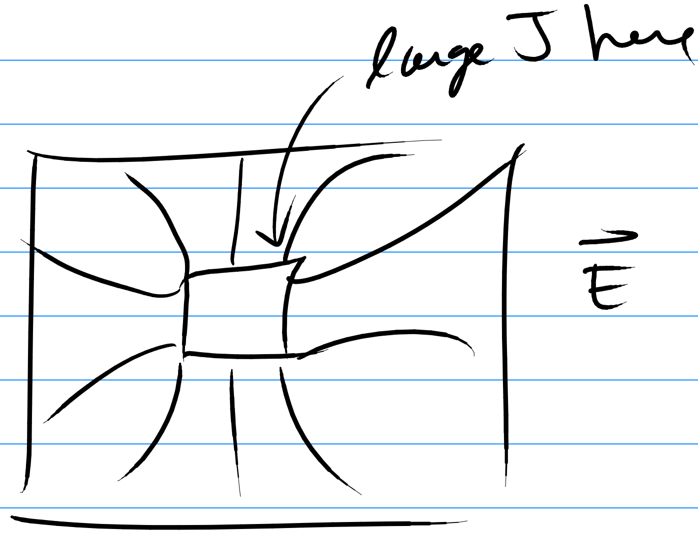
Uniqueness Th.

$$\nabla^2 V \to \underbrace{\cancel{\frac{\partial}{\partial \theta}}}_{0} + \underbrace{\cancel{\frac{\partial}{\partial r}}}_{0} + \frac{\partial^2 V}{\partial z^2} = 0$$

$V =$ cons z

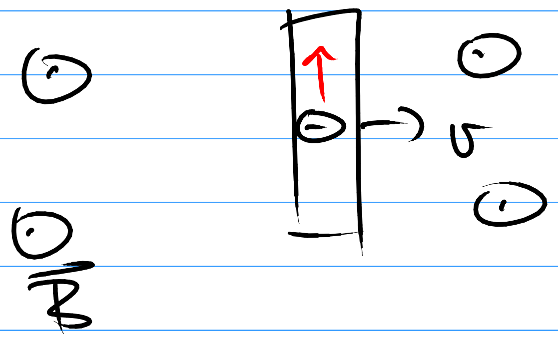


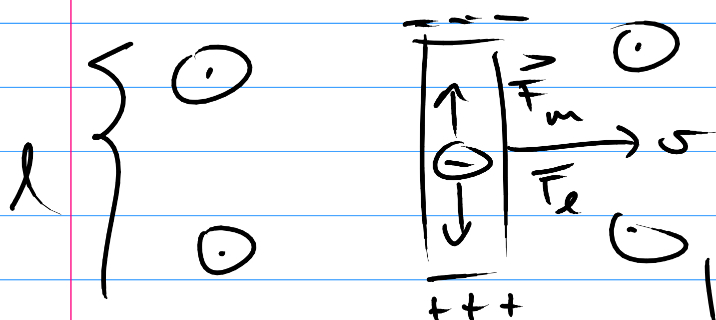




$$I^2 R \to \left(\int \vec{J} \cdot d\vec{a}\right)^2 R$$

batteries: chemical <u>electromechanical</u>

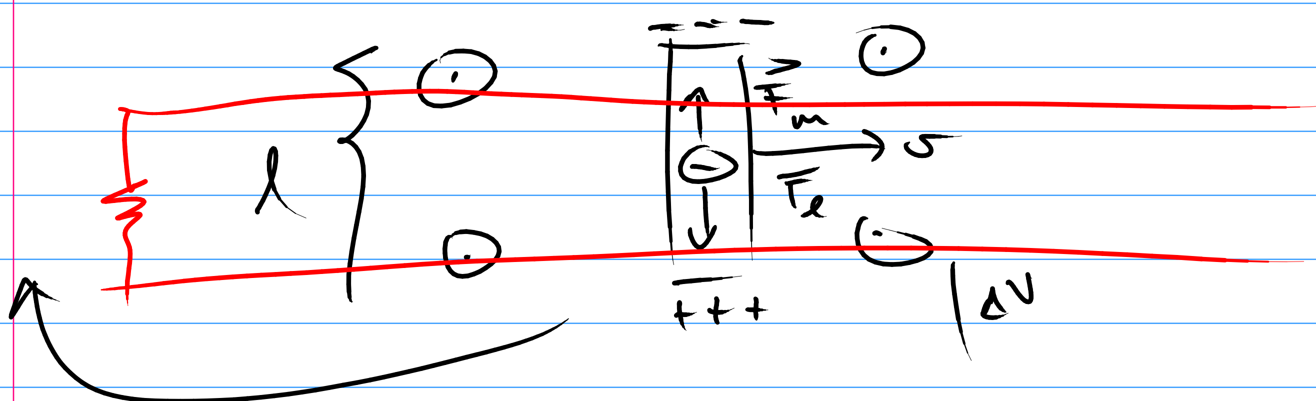


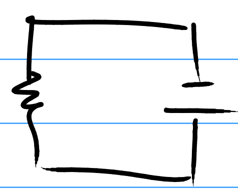


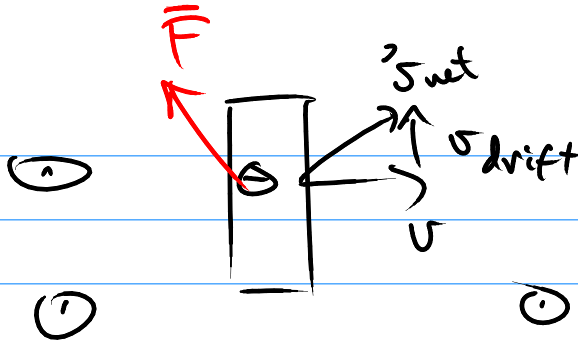
$$qvB = qE$$

$$E = vB$$

$$|\Delta V| = \int E \cdot dl = vBl$$

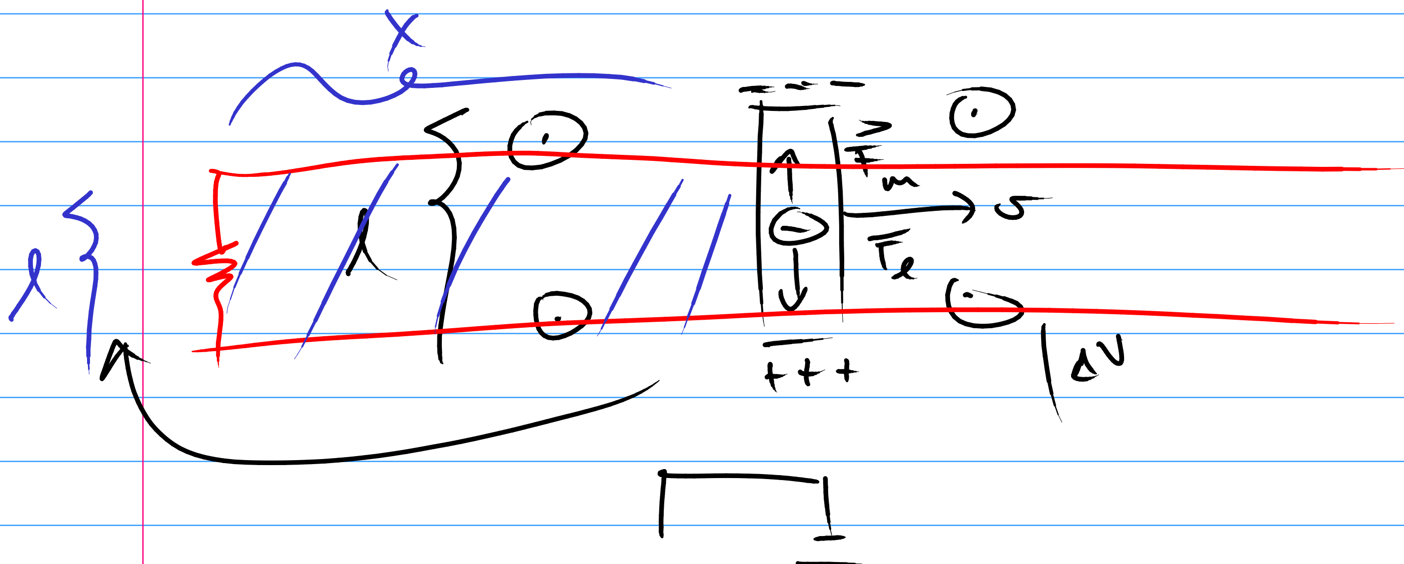






$q\vec{v}\times\vec{B}$

$$\text{Emf (voltage)} = vBl$$



$$\Phi_B = \int \vec{B}\cdot d\vec{a} = Blx$$

$$|\text{Emf}| = \frac{d\Phi_B}{dt}$$