Vacuum diode relation to solve problem

$$\Rightarrow \nabla^2 V = -\rho/\epsilon_0 \qquad \boxed{\frac{d^2V}{dx^2} = -\rho(x)/\epsilon_0}$$

Assume steady state

⇒ conservation of charge

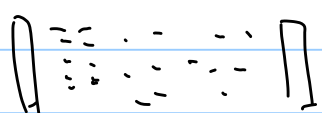
$$\vec{\nabla}\cdot\vec{J} = -\frac{\partial\rho}{\partial t} \qquad \underbrace{\int \vec{\nabla}\cdot\vec{J}\,d\tau} = -\frac{\partial}{\partial t}\underbrace{\int \rho\,d\tau}_{Q_{enc}}$$

$$J_x\hat{x} + J_y\hat{y} + J_z\hat{z}, \quad J_y = 0,\ J_z = 0 \qquad \frac{\partial\rho}{\partial t} = 0 \text{ steady state}$$

$$\underbrace{\oint \vec{J}\cdot d\vec{a}}_{\text{flow of charge out}} = -\frac{d}{dt}Q_{enc} \leftarrow \text{decrease of charge within}$$

$$\frac{d}{dx}J_x = 0 \qquad J_x = \frac{I}{A} = \rho v$$

$$\frac{d}{dx}(\rho v) = 0 \qquad \boxed{\rho v = \text{constant} = \frac{I}{A}}$$



$$\rho_1 v_1 = \rho_2 v_2$$

⇒ Newton Laws or cons $\left\{ \begin{array}{l} \text{mom: collisions} \\ \text{energy: } \Delta(KE+PE) = W_{\text{nonconservative}} = 0 \end{array} \right.$

$F = ma = qE + q\vec{v}\times\vec{B}$

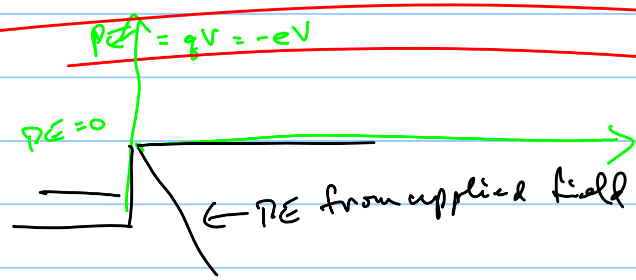
small neglect this term

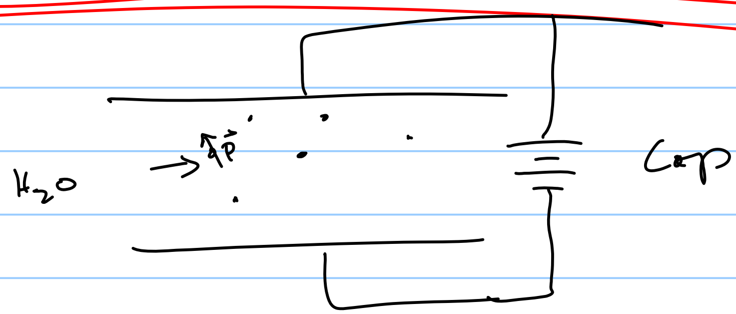
dynamics

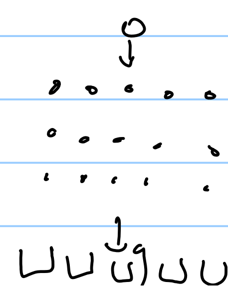
$$\boxed{\frac{1}{2} m v(x)^2 + q V(x) = \text{const}}$$

⇒ ODE 2^{nd} order in $V(x)$

\+ boundary conditions $\left\{ \begin{array}{l} V(x) = 0 \text{ at } x = 0 \text{ (gnd plate)} \\ V(x) = 12V \text{ at } x = L \\ -\left.\frac{dV}{dx}\right|_{x=0} = \left.E\right|_{x=0} = 0 \end{array} \right.$







$\vec{P}$

excited states

$$\frac{N_2}{N_1} = \frac{g_2}{g_1} \frac{N e^{-E_2/kT}}{N e^{-E_1/kT}} \hat{=} e^{-(E_2 - E_1)/kT}$$

Boltzmann factor

n=2 n=1 Boltzmann const

gnd states

$kT = .0259 eV$ $E = -\frac{13.6 eV}{n^2}$

$$\frac{N_2}{N_1} = 10^{-171}$$