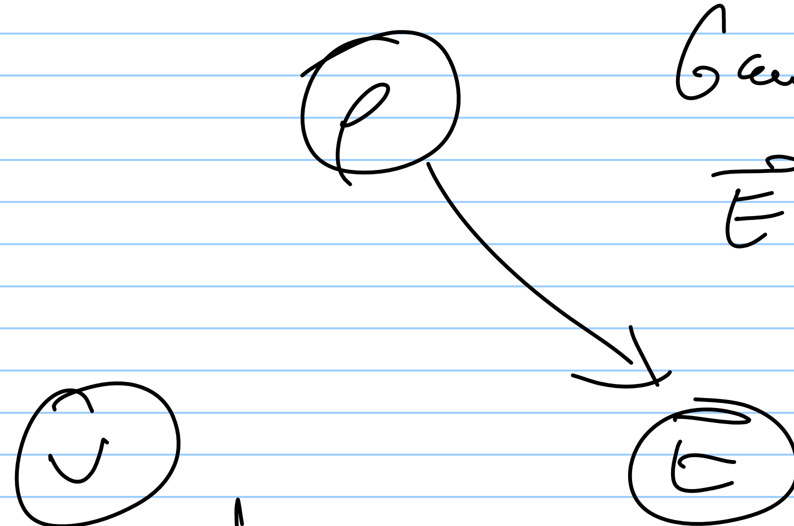
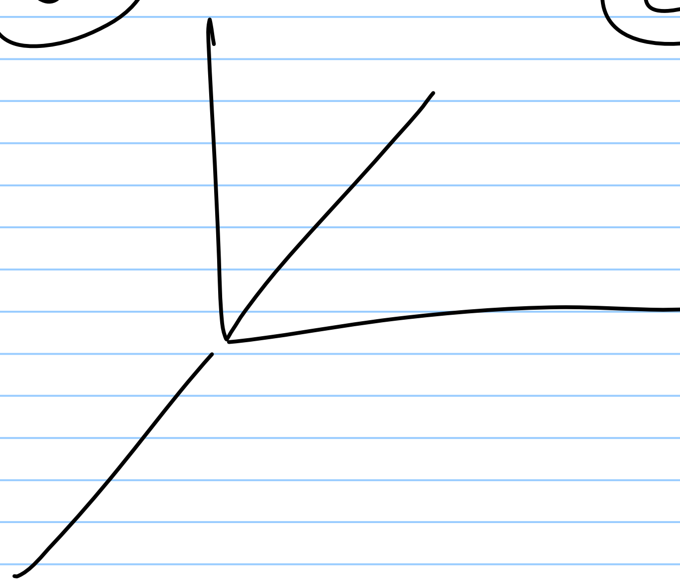
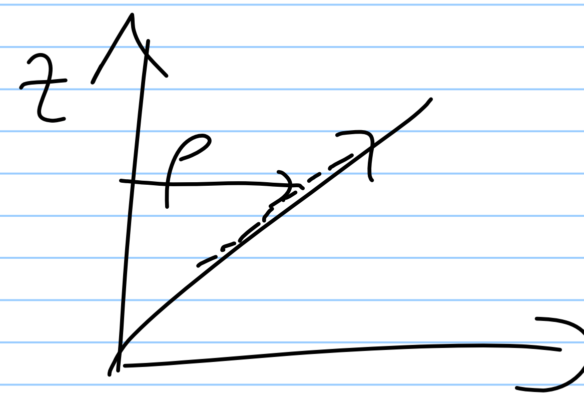
Ex: find $\vec{E}$ given ρ

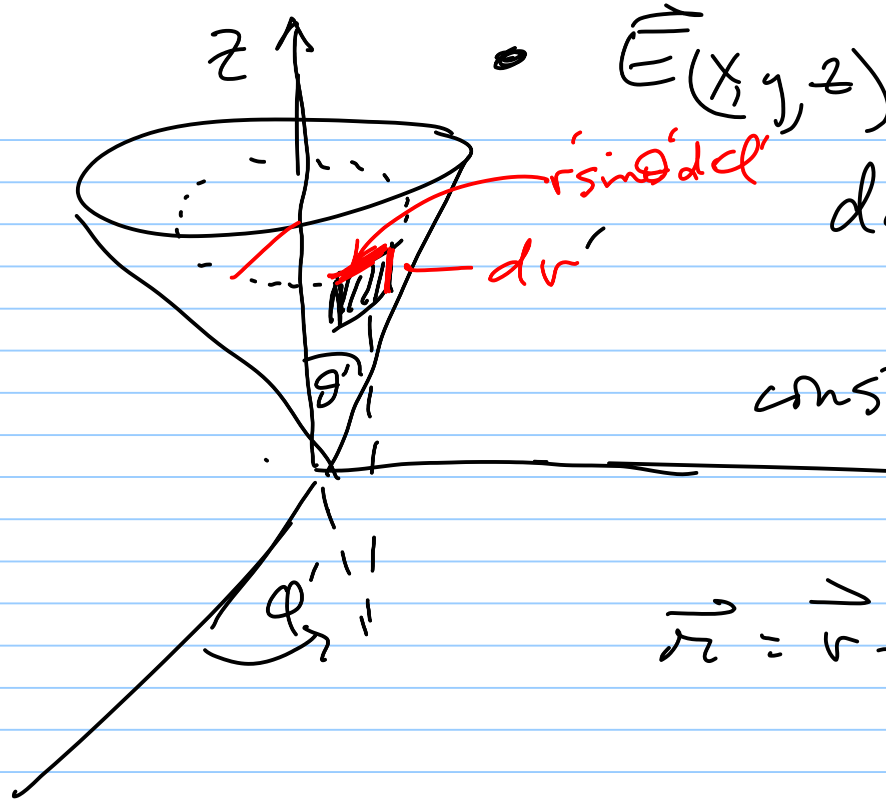
Gauss's law

$$\vec{E} = \int \frac{k\,dq}{r^2}\hat{r}$$





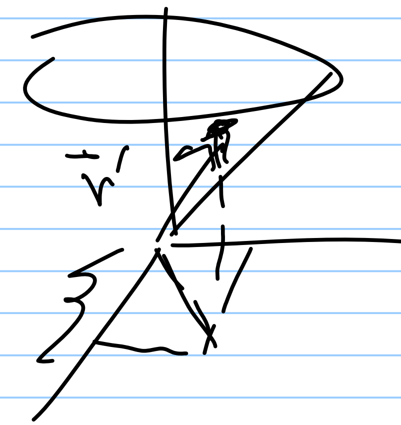




$$da' = r'\sin\theta'\, d\varphi'\, dr'$$

const on surface of cone

$$\vec{\mathscr{r}} = \vec{r} - \vec{r}\,'$$

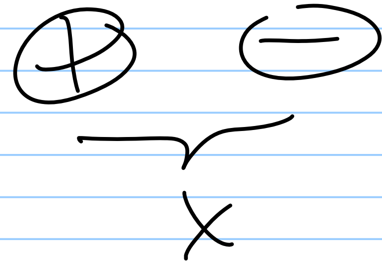


$$\vec{r}\,' = r'\cos\theta'\,\hat{z} + r'\sin\theta'\cos\varphi'\,\hat{x} + r'\sin\theta'\sin\varphi'\,\hat{y}$$

φ' goes from 0 to 2π

r' goes from 0 to R

Why doesn't hydrogen atom collapse?

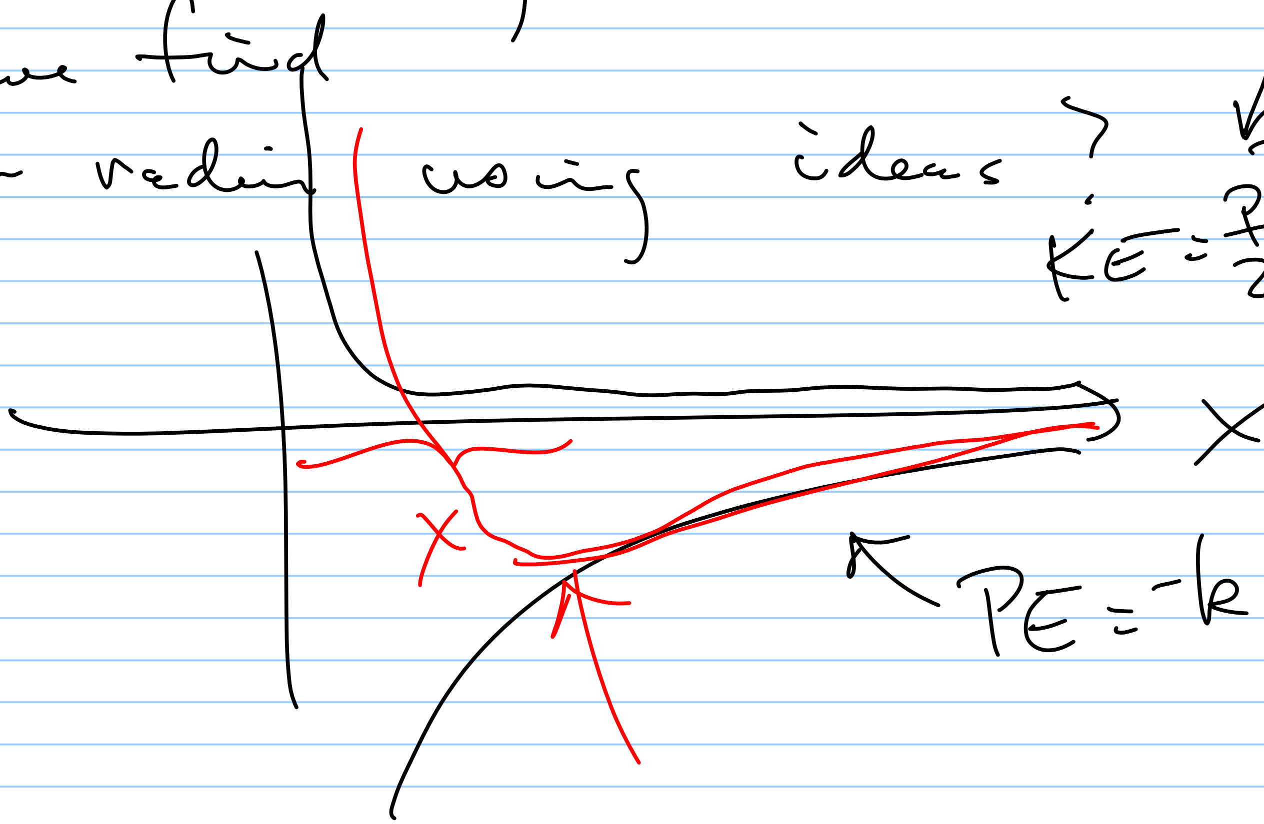


Ans: uncertainty

$\Delta p \Delta x \geq \hbar/2$ $\quad \Delta p = \frac{\hbar}{2\Delta x}$

Can we find Bohr radius using ideas?

$KE = \frac{p^2}{2m} = \frac{\hbar^2}{4\Delta x^2}\frac{1}{2m}$

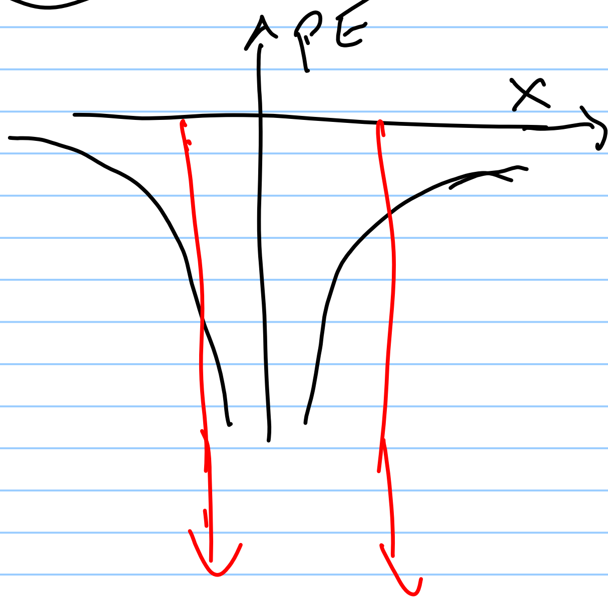


$PE = -k\frac{qq}{x}$

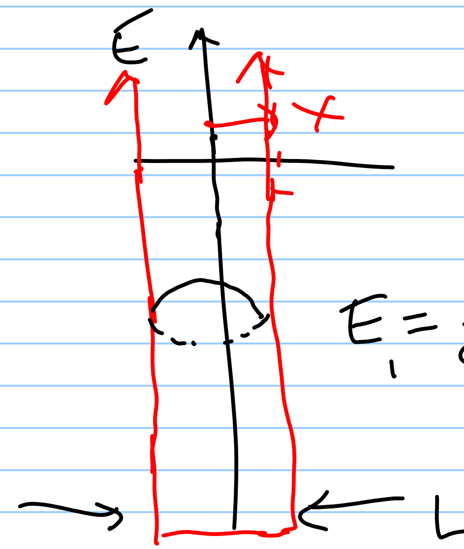
$$\text{Total energy} = \frac{\hbar^2}{4x^2}\frac{1}{2m} - \frac{kq^2}{x}$$

$$W_{noncon} = 0$$

$$\frac{d\,\text{total energy}}{dx} = 0$$



$\approx$

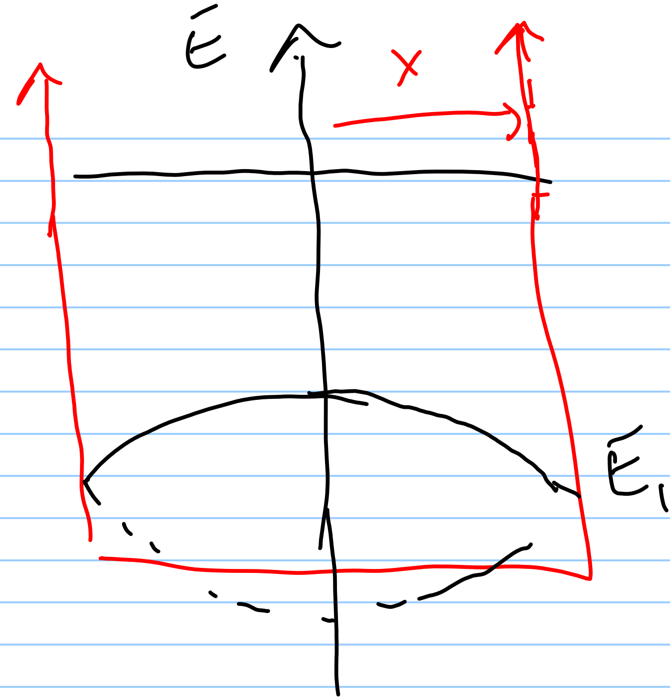


$$E_1 = \frac{h^2}{8mL^2}$$

$$H\psi = E\psi$$

$$-\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2}\psi = E\psi$$

$$\psi_0 \sin(kx - \omega t) + \psi_0 \sin(kx + \omega t)$$



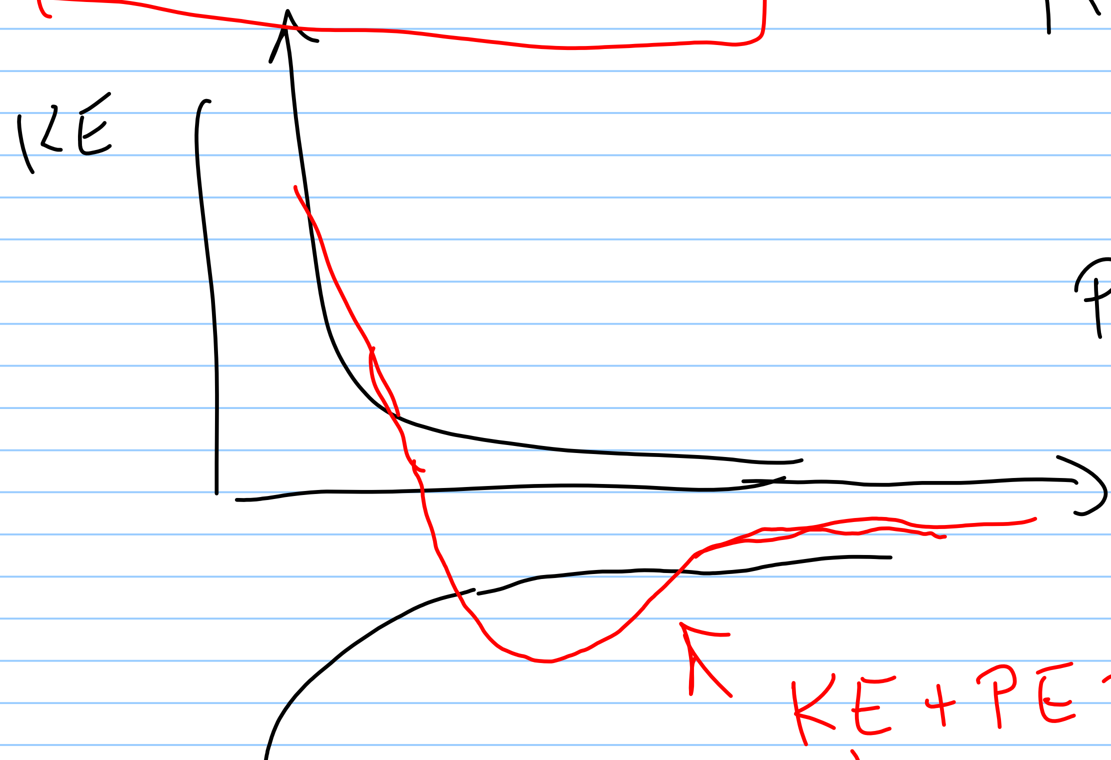
(remember acoustic modes of a pipe)

$$p = \hbar k$$

$$KE = \frac{p^2}{2m} = \frac{\hbar^2 k^2}{2m} = \frac{\hbar^2\left(\frac{2\pi}{2L}\right)^2}{2m}$$

$$= \frac{h^2}{(2\pi)^2}\frac{(2\pi)^2}{4L^2}\frac{1}{2m} = \frac{h^2}{8mL^2}$$

Plop an electron in the square well of width $L = 2x$ $\Rightarrow$ $KE = \frac{h^2}{8m4x^2} = \frac{\alpha}{x^2}$



$PE \approx -\frac{1}{4\pi\epsilon_0}\frac{q^2}{x} = -\frac{\beta}{x}$

KE + PE = Total Energy

Assume electron goes to position where total energy is minimized!

$\frac{d}{dx}TE = -2\frac{\alpha}{x^3} + \frac{\beta}{x^2} = 0$

$x = \frac{2\alpha}{\beta} = 2\frac{h^2 4\pi\epsilon_0}{8m4q^2}$

$$X = \frac{\epsilon_0 h^2}{m q^2} \frac{\pi}{4}$$

Conservation laws don't often explain why something happens but rather just what happens.