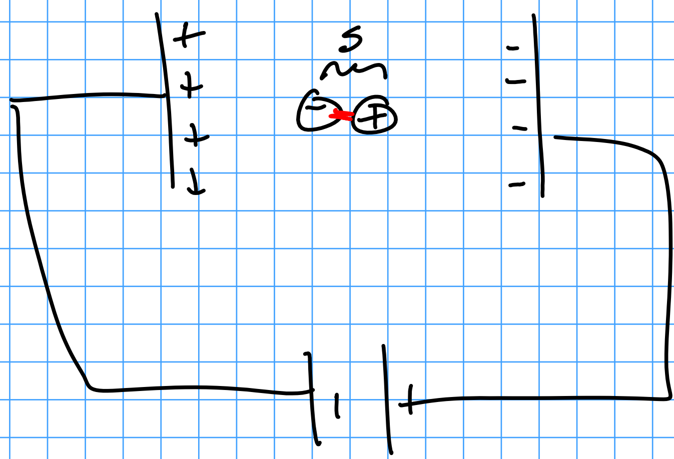


$p = qs = \alpha E$

Quantum treatment

Principle: Schrodinger Eqn   Find $\psi_{electron}$

Method: $x = 0$ at proton $PE = q\Delta V = -q\int \vec{E}\cdot d\vec{l}$

$E_{proton} + E_{applied}$

No exact soln. Approx effect of $E_{applied}$

$E_{proton} >> E_{applied}$

$$PE = \frac{kq^2}{x} + qEx$$

change in PE: $x - x_{initial}$, where $x_{initial} = 0$

expectation value

$$\langle p \rangle = \int \psi^* q x \psi \, dx = \alpha E$$

solve for

dipole moment

Inhomog $\boxed{\vec{P} = k\vec{r}}$ find σ_b & ρ_b

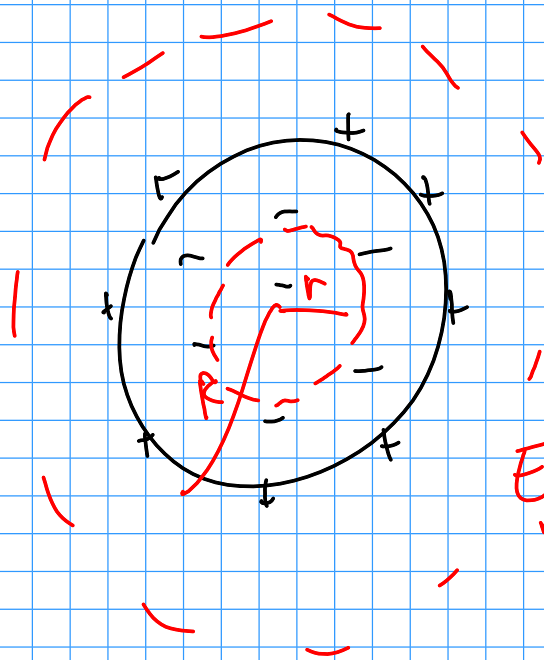
$$\vec{\nabla}\cdot \rightarrow \frac{1}{r^2}\frac{\partial}{\partial r} r^2$$

$$\sigma_b = \vec{P}\cdot\hat{n} = k\vec{r}\cdot\hat{r}\Big|_{r=R} = kR$$

$$\rho_b = -\vec{\nabla}\cdot\vec{P} = -\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 kr\right) = -\frac{1}{r^2}3kr^2$$

$$= -3k$$

find E_{inside}



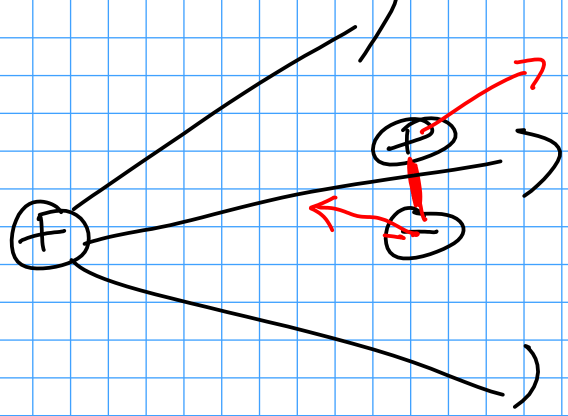
$$E 4\pi r^2 = \frac{\rho \frac{4}{3}\pi r^3}{\epsilon_0}$$

$$E_{r<R} = -\frac{kr}{\epsilon_0}\hat{r}$$

$E_{r>R} \Rightarrow$

$$E 4\pi r^2 = \frac{Q_{encl}}{\epsilon_0} = \frac{1}{\epsilon_0}\left(\underset{-3k}{\rho}\frac{4}{3}\pi R^3 + \underset{kR}{\sigma} 4\pi R^2\right)$$

$$= \emptyset$$



net force up & torque

$$\vec{F} = \vec{F}_+ + \vec{F}_- = q(\vec{E}_+ - \vec{E}_-) = q\,d\vec{E} = q\left(dE_x\hat{x} + dE_y\hat{y} + dE_z\hat{z}\right)$$

difference in E at + & − charges

from + charge at origin

$$\vec{E} = E_x(x,y,z)\,\hat{x} + E_y(x,y,z)\,\hat{y} + E_z(x,y,z)\,\hat{z}$$

short dipole $\qquad dE_x = \frac{\partial E_x}{\partial x}dx + \frac{\partial E_x}{\partial y}dy + \frac{\partial E_x}{\partial z}dz$

$$dE_x = \left(\frac{\partial E_x}{\partial x}\hat{x} + \frac{\partial E_x}{\partial y}\hat{y} + \frac{\partial E_x}{\partial z}\hat{z}\right)\cdot\left(dx\,\hat{x} + dy\,\hat{y} + dz\,\hat{z}\right)$$

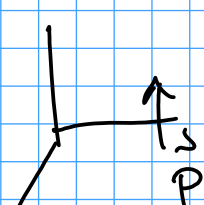
$$dE_x = \vec{\nabla}E_x \cdot \vec{s}$$

$d\vec{\ell}$

$$d\vec{E} = (\vec{s}\cdot\vec{\nabla})\vec{E}$$

good for all coordinate systems since it is now a vector relationship

$$\vec{F} = (\vec{p}\cdot\vec{\nabla})\vec{E}$$



$$(p\hat{z}\cdot\vec{\nabla})\vec{E}$$

$$\left(p\frac{\partial}{\partial z}\right)\vec{E}$$

$\Sigma \vec{F} \neq 0$