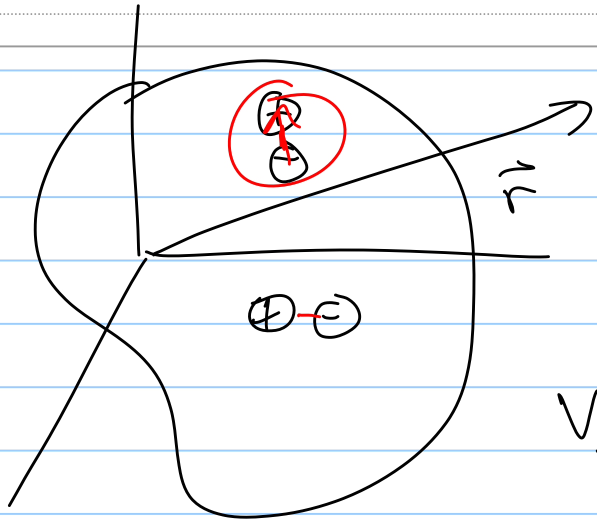


H_2O have electric dipole

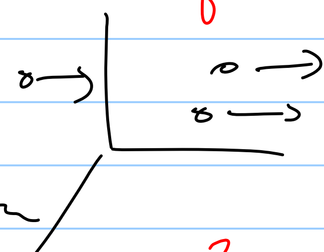
find $V(\vec{r}) = \int dV$

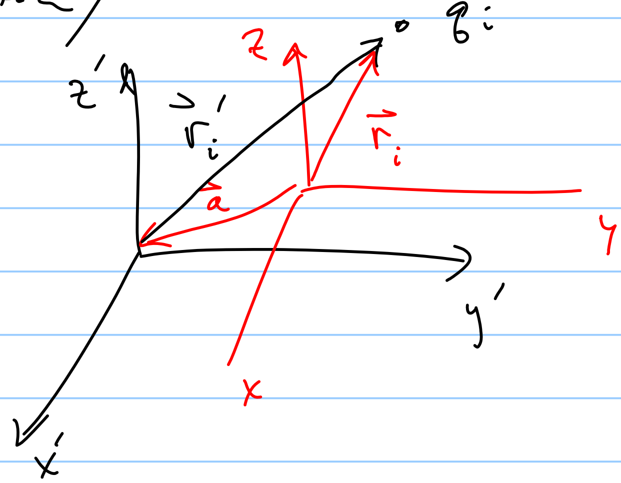
$$V_{\text{one dipol}} = \frac{1}{4\pi\epsilon_0} \frac{\vec{p}\cdot\hat{r}}{r^2}$$

$\vec{p}$ must not depend on location of coords

mom inertia

$$I = \sum_i' m_i r_i^2$$ depends on coord location





$$\vec{p} = \sum_i' q_i \vec{r}_i$$

$$\vec{r}_i = \vec{a} + \vec{r}_i'$$

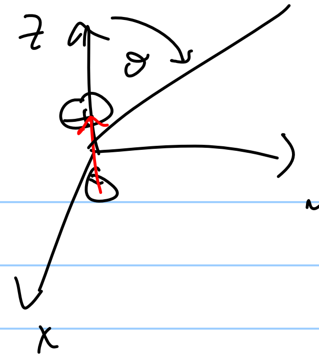
Is $\vec{p}' = \vec{p}$?

$$\vec{p}' = \sum_i' q_i \vec{r}_i' = \sum_i' q_i(\vec{r}_i - a) = -\sum q_i \vec{a} + \underbrace{\sum q_i \vec{r}_i}_{\vec{p}}$$

$$= -\vec{a} \underbrace{\sum_i' q_i}_{0} + \vec{p}$$

NO NET CHARGE $\vec{p}' = \vec{p}$

$$V_{\text{one dipol}} = \frac{1}{4\pi\epsilon_0}\frac{\vec{p}\cdot\hat{r}}{r^2}$$



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

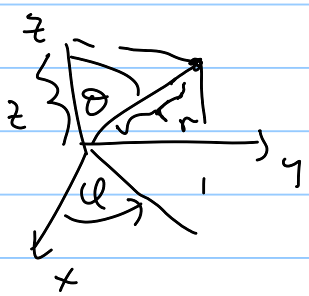
spherical $\quad E_r = -\frac{\partial V}{\partial r} \qquad V = \frac{1}{4\pi\epsilon_0}\frac{p\cos\theta}{r^2}$

$$E_r = +\frac{2}{4\pi\epsilon_0}\frac{p\cos\theta}{r^3}$$

$$E_\theta = -\frac{1}{r}\frac{\partial V}{\partial \theta} = \frac{-1}{4\pi\epsilon_0 r}\,\frac{-p\sin\theta}{r^2}$$

$$= \frac{p\sin\theta}{4\pi\epsilon_0 r^3}$$

cartesian: $\quad V = \frac{1}{4\pi\epsilon_0}\frac{\vec{p}\cdot\hat{r}}{r^2} \qquad r = \sqrt{x^2+y^2+z^2}$

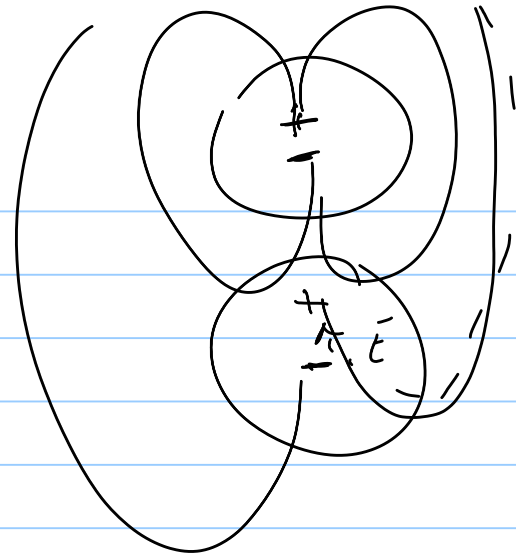


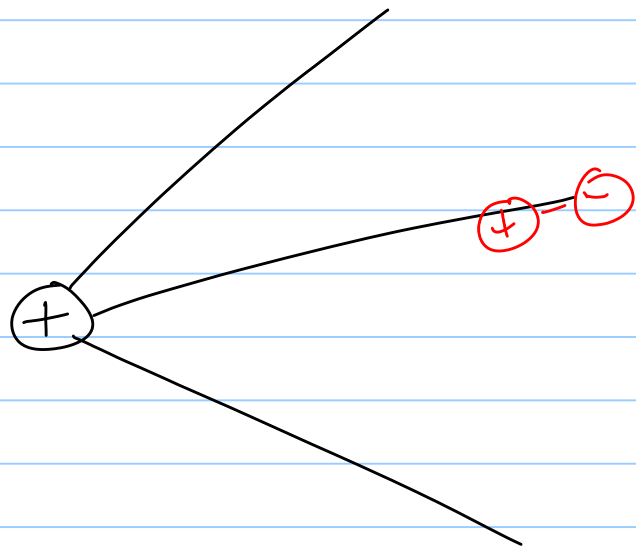
$$\cos\theta = \frac{z}{r} = \frac{z}{\sqrt{x^2+y^2+z^2}}$$

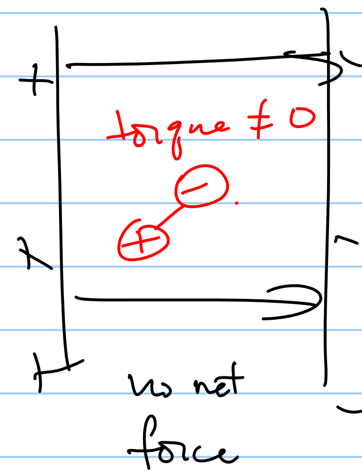
$$V = \frac{1}{4\pi\epsilon_0}\,p\,\frac{z}{(\sqrt{})^2\sqrt{}}$$

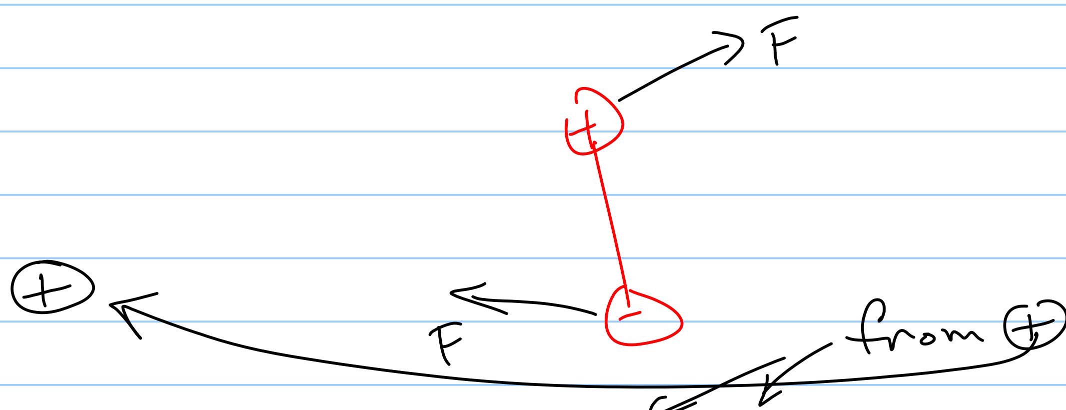
$$E_x = -\frac{\partial V}{\partial x}$$

Forces on a dipole









$$\vec{F}_{net} = \vec{F}_+ + \vec{F}_- = q\big(\underbrace{\vec{E}_+ - \vec{E}_-}_{\Delta \vec{E}}\big) = q\, d\vec{E}$$

$$d\vec{E} = dE_x\,\hat{x} + dE_y\,\hat{y} + dE_z\,\hat{z}$$

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

$$dE_x = \underbrace{\left(\frac{\partial E_x}{\partial x}\hat{x} + \frac{\partial E_x}{\partial y}\hat{y} + \frac{\partial E_x}{\partial z}\hat{z}\right)}_{\vec{\nabla} E_x} \cdot \underbrace{\left(dx\,\hat{x} + dy\,\hat{y} + dz\,\hat{z}\right)}_{d\vec{l} = \vec{s} \text{ sep. of charg dipol}}$$

$$d\vec{E} = dE_x\,\hat{x} + dE_y\,\hat{y} + dE_z\,\hat{z}$$

$$\vec{F} = q\,d\vec{E} = \underbrace{q\,(d\vec{l}}_{\vec{p}} \cdot \vec{\nabla})\vec{E} = (\vec{p}\cdot\vec{\nabla})\vec{E}$$