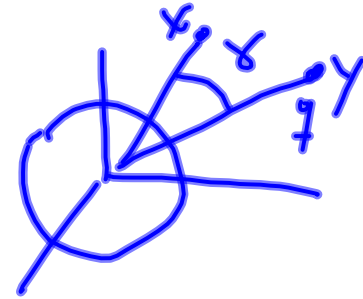


$$\Phi(x=a) = \frac{q/4\pi\epsilon_0}{a|\vec{n} - y\vec{n}'|} + \frac{q'/4\pi\epsilon_0}{y|\vec{n}' - \frac{a}{y}\vec{n}|} = 0$$

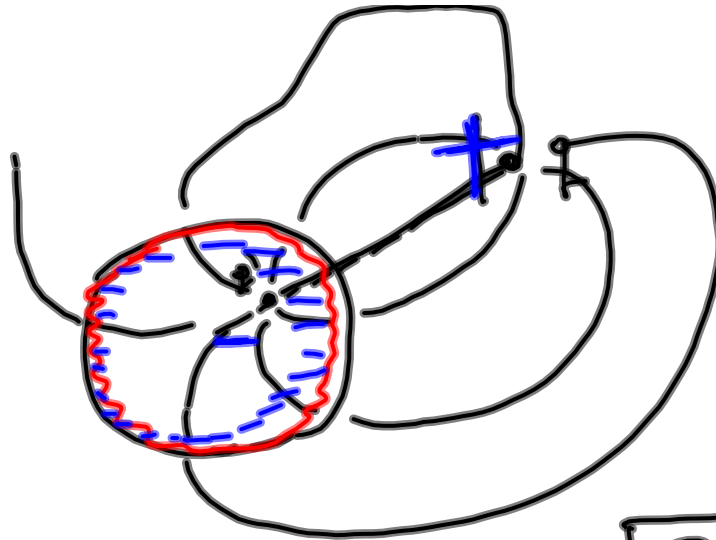
$$\boxed{\frac{q}{a} = -\frac{q'}{y'}} \quad , \quad \boxed{\frac{y}{a} = \frac{a}{y'}}$$

$$\vec{n} \cdot \vec{n}' = \vec{n}' \cdot \vec{n}$$



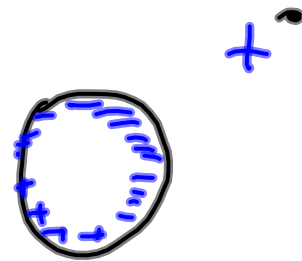
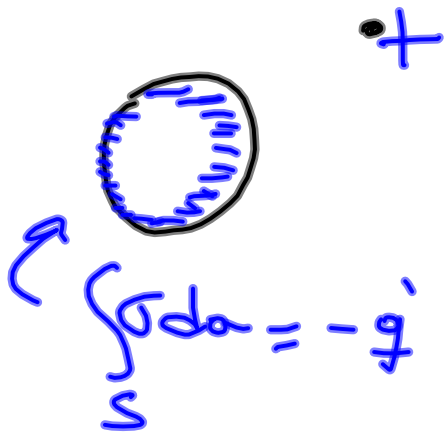
$$|\vec{n} - \frac{y}{a}\vec{n}'| = \sqrt{(\vec{n} - \frac{y}{a}\vec{n}') \cdot (\vec{n} - \frac{y}{a}\vec{n}')} = \sqrt{1 - 2\frac{y}{a}\underbrace{\vec{n} \cdot \vec{n}'}_{\cos \gamma} + \frac{y^2}{a^2}}$$

$\vec{n} \cdot \vec{n} = 1$
 $\vec{n}' \cdot \vec{n}' = 1$



$$\sigma = \epsilon_0 (-\nabla \cdot \Phi) \Big|_{x=a}$$

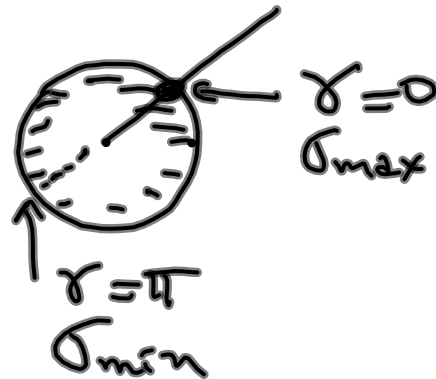
$$\frac{\sigma}{\epsilon_0} = (\vec{E}_2 - \vec{E}_1) \cdot \vec{n}$$

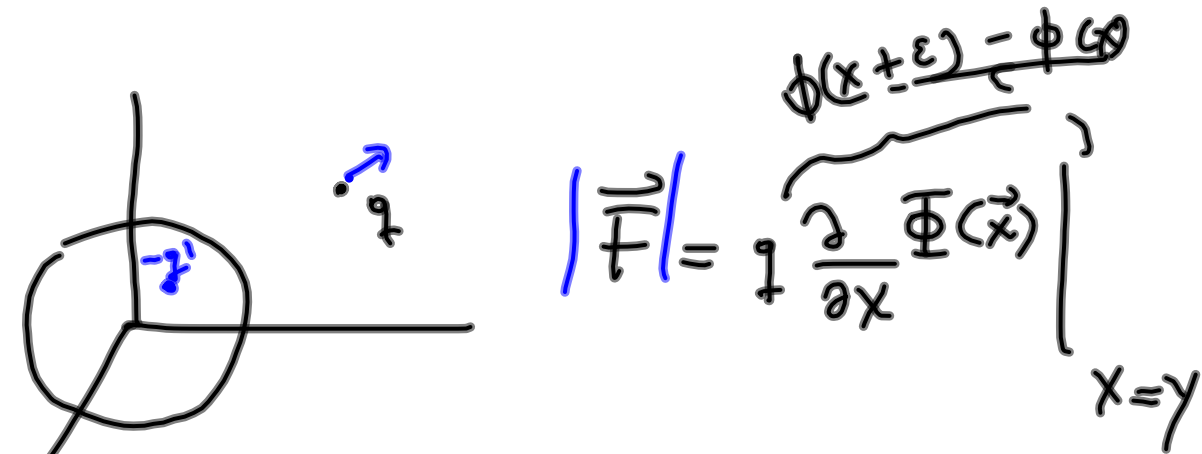


$$\nabla \psi = \hat{e}_r \frac{\partial \psi}{\partial r} + \hat{e}_\theta \frac{1}{r} \frac{\partial \psi}{\partial \theta} + \hat{e}_z \frac{1}{r \sin \theta} \frac{\partial \psi}{\partial \theta}$$

$$G = \frac{-q}{4\pi a y} \frac{\left(1 - \frac{a^2}{y^2}\right)}{\left[1 + \frac{a^2}{y^2} - \frac{2a}{y} \cos \delta\right]^{3/2}}$$

$$y > a$$

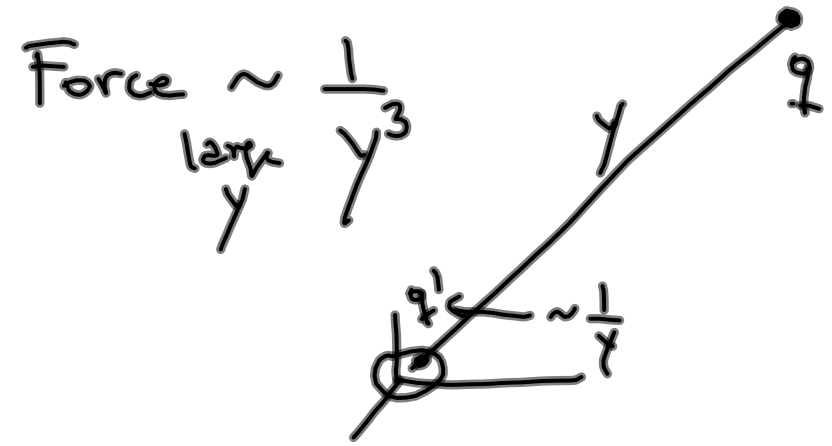




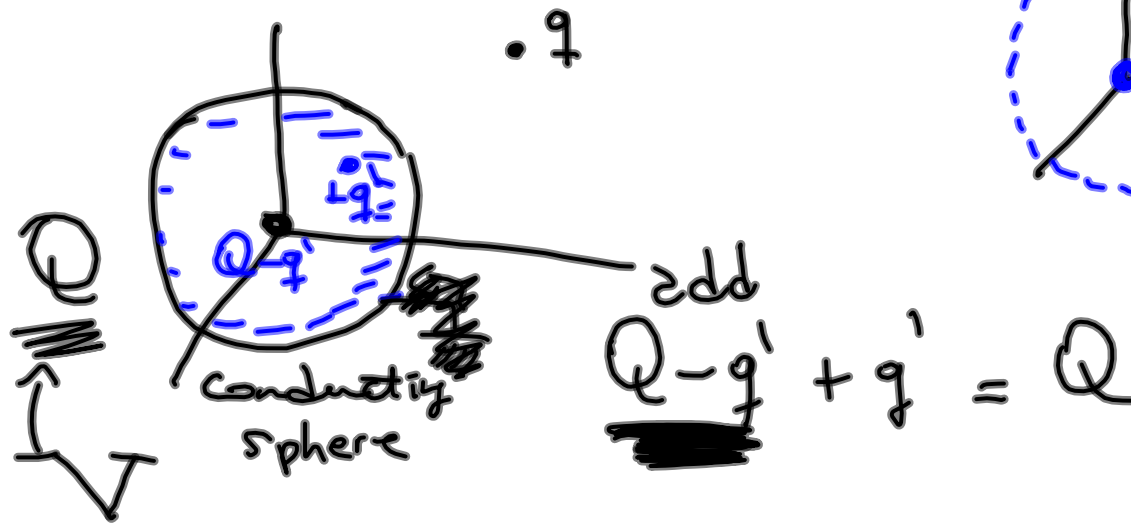
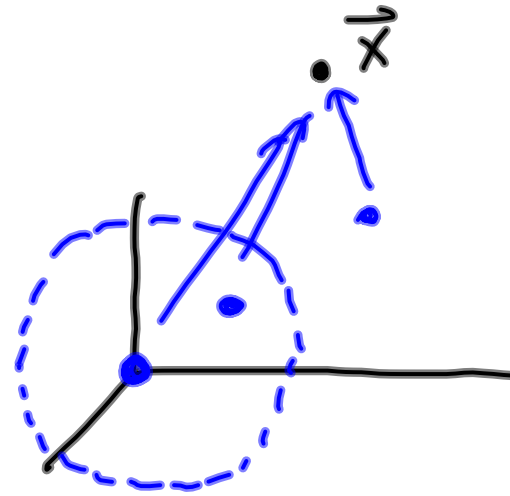
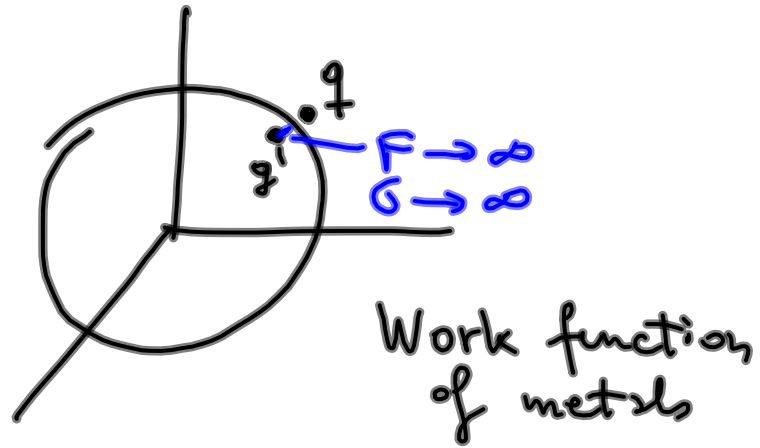
$$|\vec{F}| = q \left. \frac{\partial \Phi(\vec{x})}{\partial x} \right|_{x=y}$$

$\phi(x+\epsilon) - \phi(x)$

$$= \frac{1}{4\pi\epsilon_0} \cdot \frac{q^2}{a^2} \cdot \left(\frac{a}{y}\right)^3 \left(1 - \frac{a^2}{y^2}\right)^{-2}$$



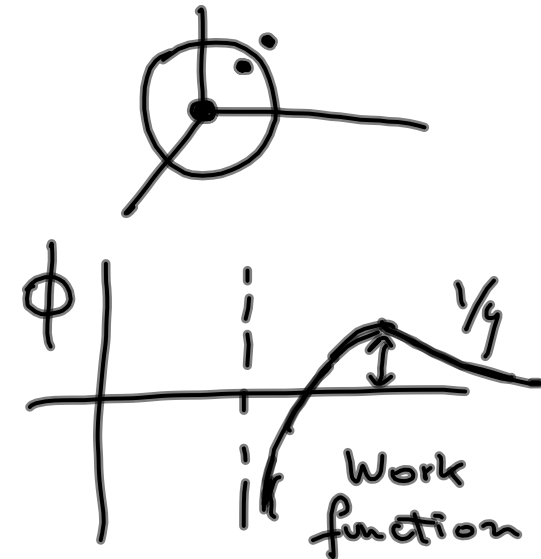
Force $\sim \frac{1}{y^3}$
 large y



$$\vec{F} = \frac{q}{4\pi\epsilon_0 y^2} \left[Q - \frac{qa^3(2y^2 - a^2)}{y(y^2 - a^2)^2} \right] \frac{\vec{y}}{y}$$

$y \rightarrow \infty$ repulsive if $Q > 0$

$y \rightarrow a$ attractive



$W_{Cu} \sim 5\text{eV}$

