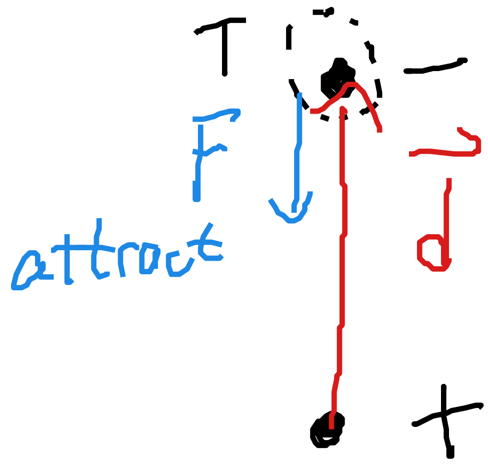
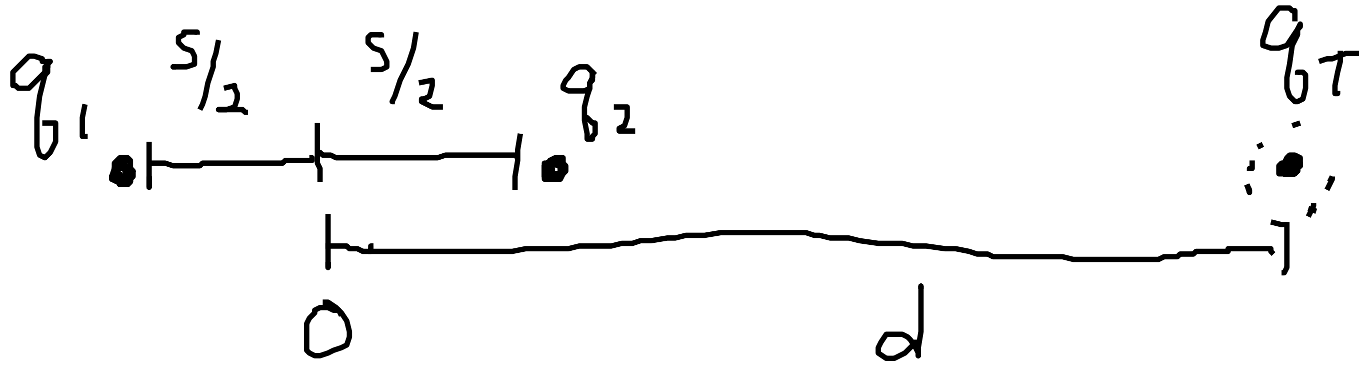
$$\vec{F} = k \frac{q_s q_t}{d^2} \hat{d} = k \frac{q_s q_t}{d^3} \vec{d}$$

$\vec{d}$ points from source to target

$|\vec{d}| = d$





$$\vec{F}_1 = k\frac{q_1 q_T}{\left(d+\frac{s}{2}\right)^3}\overbrace{\left(d+\frac{s}{2}\right)\hat{x}}^{\vec{d}}$$

$$= k\frac{q_1 q_T}{\left(d+\frac{s}{2}\right)^2}\left.\hat{x}\right]\hat{d}$$

$$\vec{F}_2 = k\frac{q_2 q_T}{\left(d-\frac{s}{2}\right)^2}\hat{x}$$

$$\vec{F}_{net} = k\frac{q_1 q_T}{\left(d+\frac{s}{2}\right)^2}\hat{x} + k\frac{q_2 q_T}{\left(d-\frac{s}{2}\right)^2}\hat{x}$$

Taylor Expansión

epsilon, $\epsilon << 1$

$$(1+\epsilon)^n \simeq 1 + n\epsilon$$

$$(1+\epsilon)^2 = 1 + 2\epsilon + \cancel{\epsilon^2}$$

$$\epsilon << 1, \quad \epsilon^2 <<<< 1$$

$$(1+\epsilon)^3 = \underline{1 + 3\epsilon} + \cancel{3\epsilon^2} + \cancel{\epsilon^3}$$

very very small

$$\frac{1}{1+\epsilon} = (1+\epsilon)^{-1} \simeq 1 - \epsilon$$

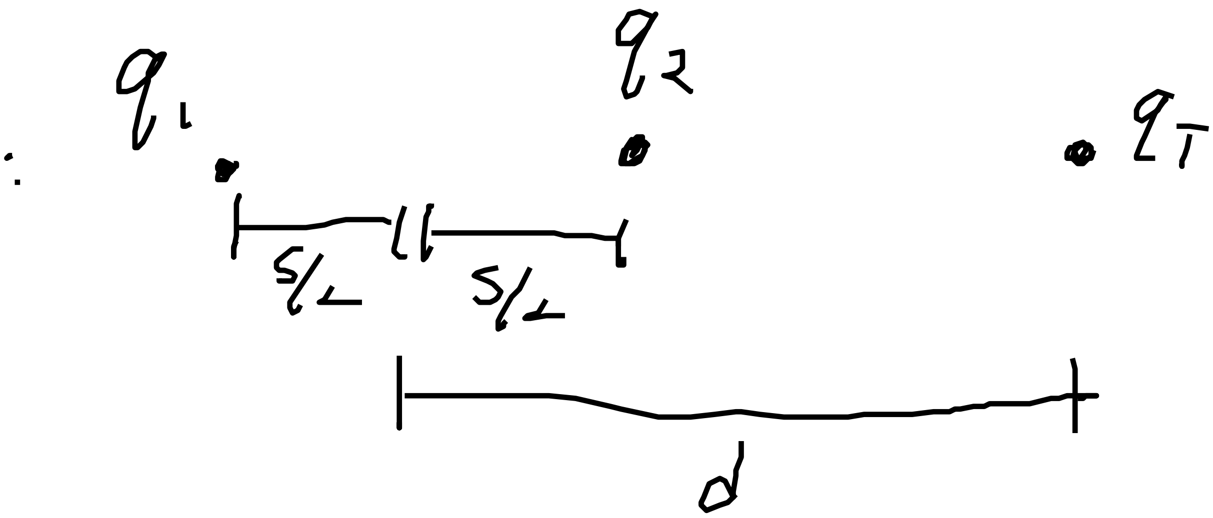
$$\sqrt{1+\epsilon} \simeq 1 + \frac{1}{2}\epsilon$$

$$(a+\epsilon)^n = a^n\left(1+\frac{\epsilon}{a}\right)^n =$$

$$(a+\epsilon)^n = a^n\left(1+\frac{\epsilon}{a}\right)^n$$

$$\approx a^n\left(1+n\frac{\epsilon}{a}\right)$$

$$= a^n + n a^{n-1}\epsilon$$



$$\vec{F}_{net} = k\frac{q_1 q_T}{(d+s/2)^2}\hat{x} + k\frac{q_2 q_T}{(d-s/2)^2}\hat{x}$$

$$= k q_T \hat{x}\left[\frac{q_1}{(d+s/2)^2} + \frac{q_2}{(d-s/2)^2}\right]$$

$$= k q_T \hat{x}\left[q_1\left(d+\frac{s}{2}\right)^{-2} + q_2\left(d-\frac{s}{2}\right)^{-2}\right]$$

Suppose $s << d$

$a = d \quad n = -2 \quad \epsilon = \frac{s}{2}$

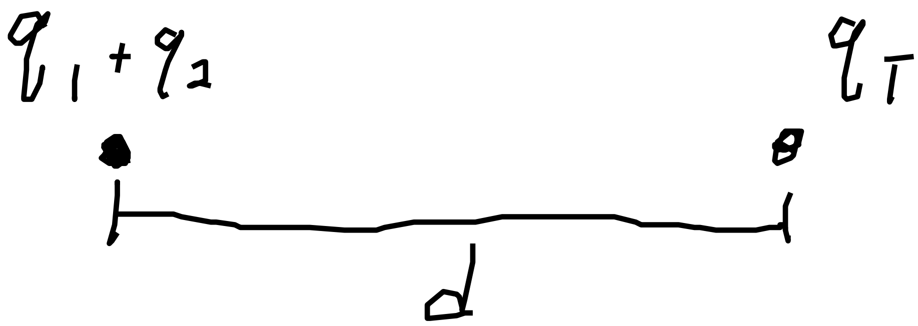
$$\vec{F}_{net} \approx k q_T \hat{x} \left[q_1 \left(d^{-2} - 2d^{-3} \frac{s}{2} \right) + q_2 \left(d^{-2} - 2d^{-3} \left(-\frac{s}{2} \right) \right) \right]$$

$\epsilon = -\frac{s}{2}$

$$= k q_T \hat{x} \left[\frac{q_1}{d^2} + \frac{q_2}{d^2} - \frac{2}{d^3} \frac{s}{2} (q_1 - q_2) \right]$$

If we ignore s term completely

$$\vec{F}_{net} = k \frac{(q_1 + q_2) q_T}{d^2} \hat{x}$$



For enough away, treat q_1 & q_2 as a single charge

Any collection of charges acts like a single charge if you're far enough away

except . . . :

$$q_1 = q \qquad q_2 = -q$$

red term is zero

$$\vec{F}_{net} \approx kq_T \hat{x} \left[- \frac{s}{d^3} (q - -q) \right]$$

$$= kq_T \frac{2qs}{d^3} (-\hat{x})$$

+ -

Electric dipole

two opposite charges

$$F_{net} \sim \frac{1}{d^3}$$

dies away faster than point charge