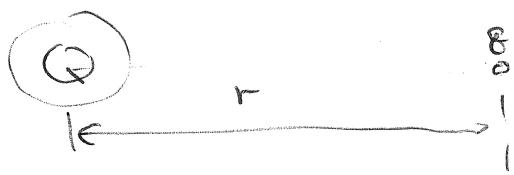
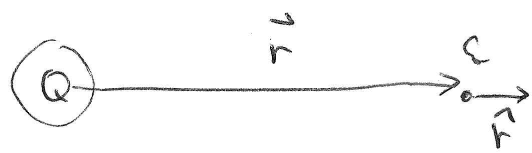
WEEK 2 (FALL 2010)

[LAST WEEK 23.1 23.4
23.2 23.6
23.3 23.7]

[THIS WEEK 24]

LAST TIME





$$\vec{F}_{Qq} = \frac{1}{4\pi\varepsilon_0} \frac{Qq}{|\vec{r}|^2} \hat{r}$$

$$\vec{E}_Q = \frac{\vec{F}_{Qq}}{q} = \frac{1}{4\pi\varepsilon_0} \frac{Q}{|\vec{r}|^2} \hat{r}$$ ELECTRIC FIELD

ACTIVE FIGURE 23.11

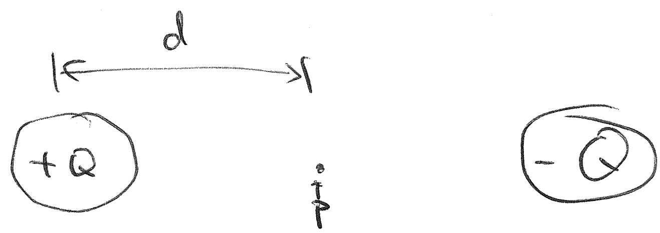
POINTS "RADIALLY OUTWARD"

ACTIVE FIGURE 23.22 ALSO

O.K. ONE CHARGE ONLY IS EASY. BUT WHAT HAPPENS IF THERE ARE MORE CHARGES

EXAMPLE

#1



WHAT IS $\vec{E}$ AT POINT P

TEST CHARGE

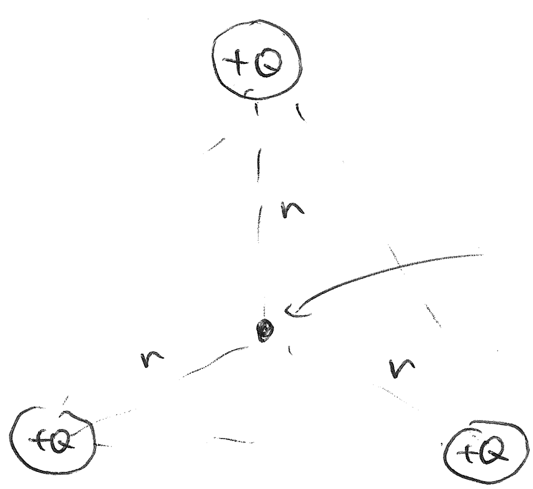
q

This is a mistake. These fields add rather than cancel because the sign of electric field is the same

$$\vec{E}_{TOTAL} = \frac{1}{4\pi\epsilon_0}\frac{Qq}{d^2}\hat{x} + \frac{1}{4\pi\epsilon_0}\frac{-Qq}{d^2}\hat{x}$$

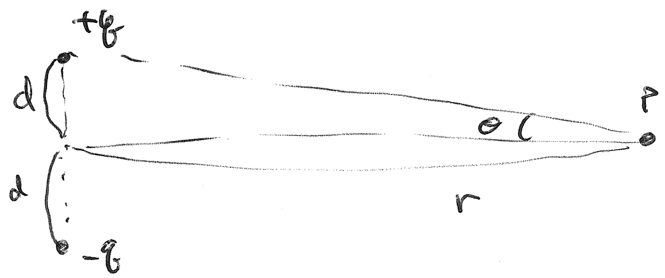
$$\vec{E}_{TOTAL} = 0 \Rightarrow \vec{E} = 0$$

#2

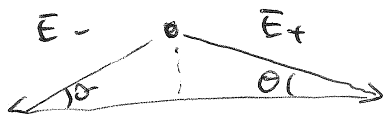


0 FIELD HERE TOO

#3



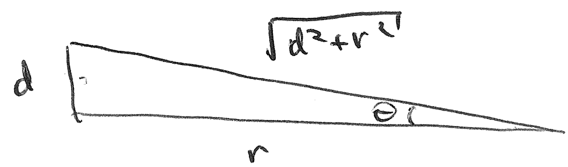
WHAT IS THE ELECTRIC FIELD AT POINT P?



$$|\vec{E_+}| = \frac{1}{4\pi\varepsilon_0} \frac{q}{(\sqrt{r^2+d^2})^2} = |\vec{E_-}|$$

SO X COMPONENTS CANCEL EACH OTHER

ONLY y COMPONENTS ADD



$\therefore$ y COMPONENT

$$E_{+y} = |\vec{E_+}| \frac{d}{\sqrt{d^2+r^2}}$$

$$|\vec{E_+} + \vec{E_y}| = 2E_{+y} = 2 \cdot \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2+d^2} \frac{d}{\sqrt{r^2+d^2}}$$

$$= \frac{1}{2\pi\varepsilon_0} \frac{qd}{(r^2+d^2)^{3/2}}$$

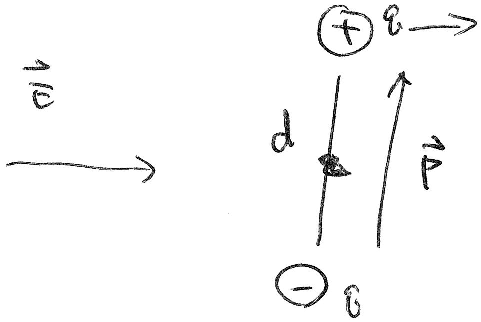
WHAT HAPPENS IF $|\vec{r}| \to \infty$?

$$\lim_{r \to \infty} |E_{TOTAL}| = \frac{1}{2\pi\varepsilon_0} \frac{qd}{r^3}$$

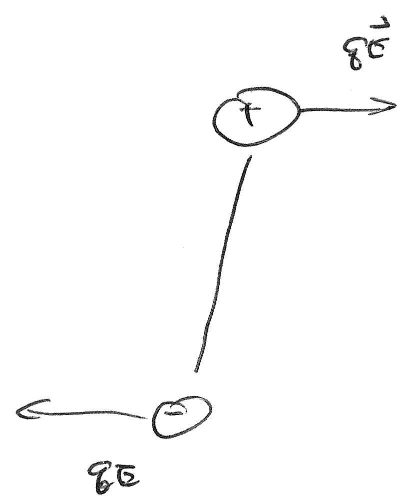
$$E \sim \frac{1}{r^3}$$

ELECTRIC FIELD (MAGNITUDE) GO AS $\frac{1}{r^3}$ AT LARGE DISTANCES

ELECTRIC DIPOLE

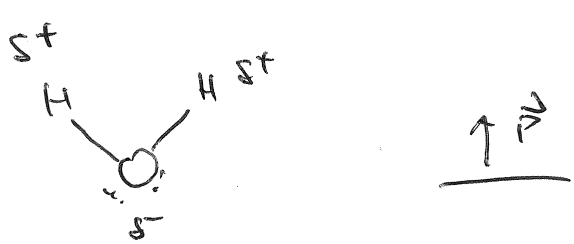


$|\vec{p}| = qd$

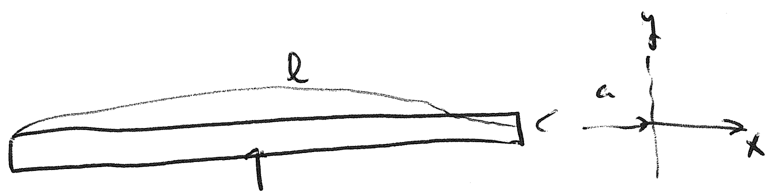


APPLIES TORQUE $\vec{\tau} = \vec{p} \times \vec{E}$

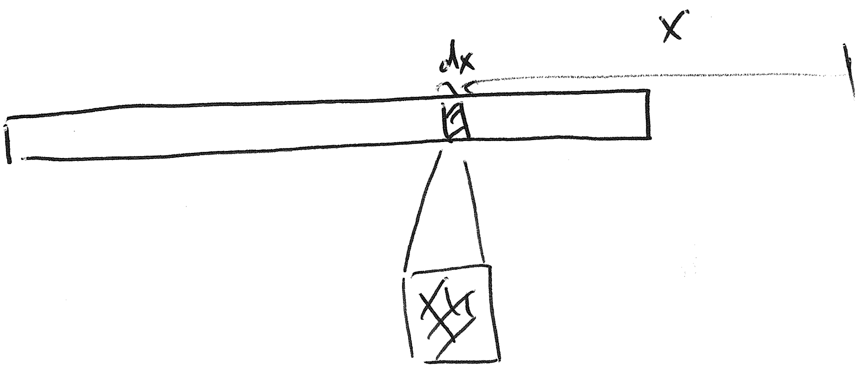
EXAMPLE WATER



MORE COMPLEX EXAMPLE



Q UNIFORM CHARGE



CHARGE ON SEGMENT $= \frac{dx}{l} Q$

$$\vec{dE} = \frac{1}{4\pi\epsilon_0} \frac{\frac{dx}{l} Q}{x^2} \hat{x}$$

$$\vec{dE} = \frac{1}{4\pi\epsilon_0} \frac{Q}{l} \frac{dx}{x^2} \hat{x}$$

$$\vec{E} = \int_{-(l+a)}^{-a} \frac{1}{4\pi\epsilon_0} \frac{Q}{l} \frac{dx}{x^2} \hat{x}$$

$$= \frac{1}{4\pi\epsilon_0} \frac{Q}{l} \cdot \left(-\frac{1}{x}\right) \Big]_{l+a}^{-a} \hat{x}$$

$$E = \frac{1}{4\pi\varepsilon_0} \frac{Q}{l} \left(\frac{1}{a} - \frac{1}{l+a} \right) \hat{x}$$

$$E = \frac{1}{4\pi\varepsilon_0} \frac{Q}{l} \left(\frac{l}{a(l+a)} \right) \hat{x}$$

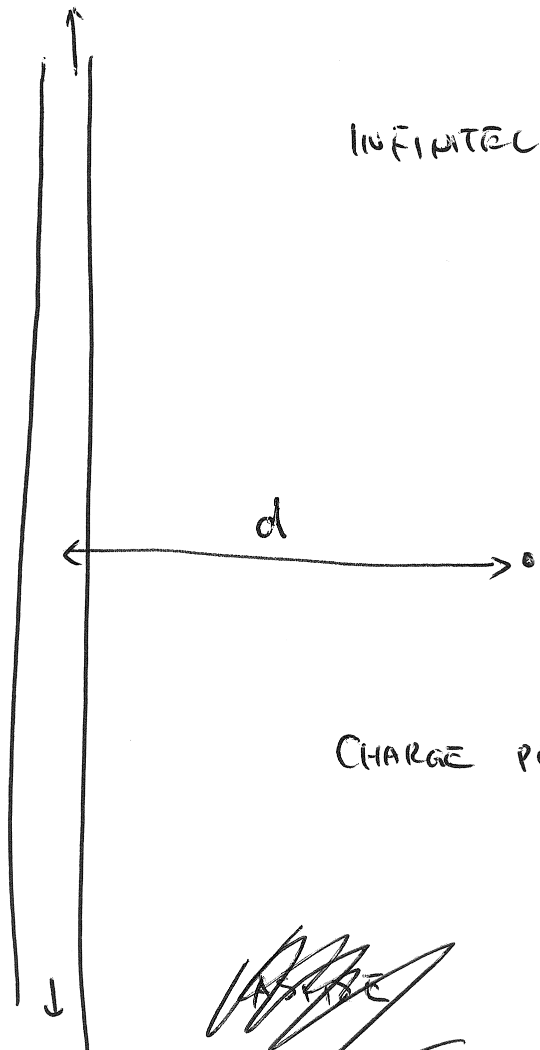
$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \frac{Q}{a(l+a)} \hat{x}$$

$a \to \infty$

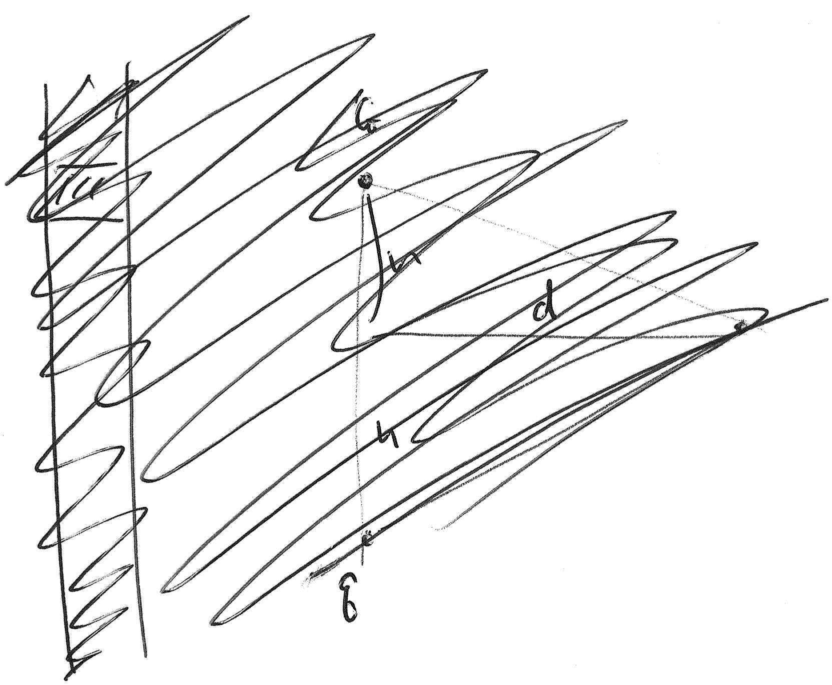
$$E = \frac{1}{4\pi\varepsilon_0} \frac{Q}{a^2} \checkmark$$

↓ START

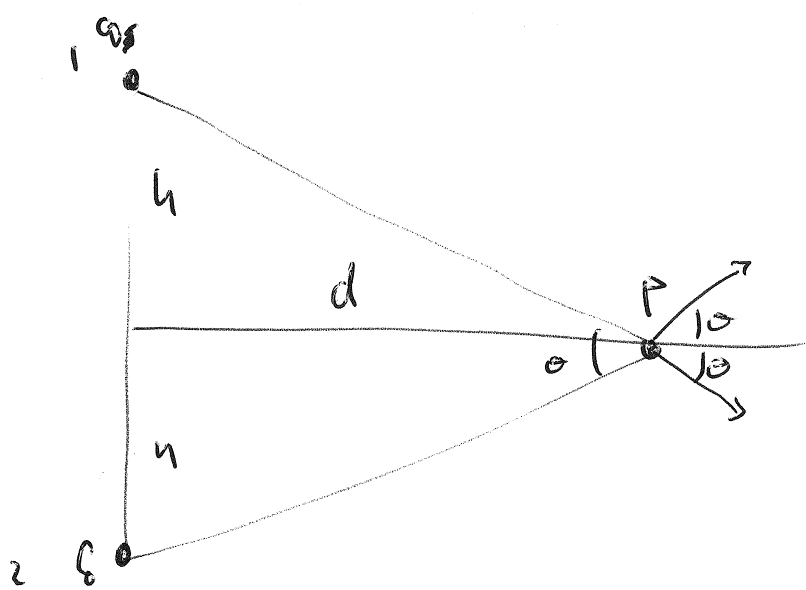
INFINITELY CHARGED LINE



CHARGE PER UNIT LENGTH = λ (COULOMB/m)



CONSIDER AN EXAMPLE



$$\vec{E}_T = E_1 + E_2$$

$$= 2E_x \hat{x}$$

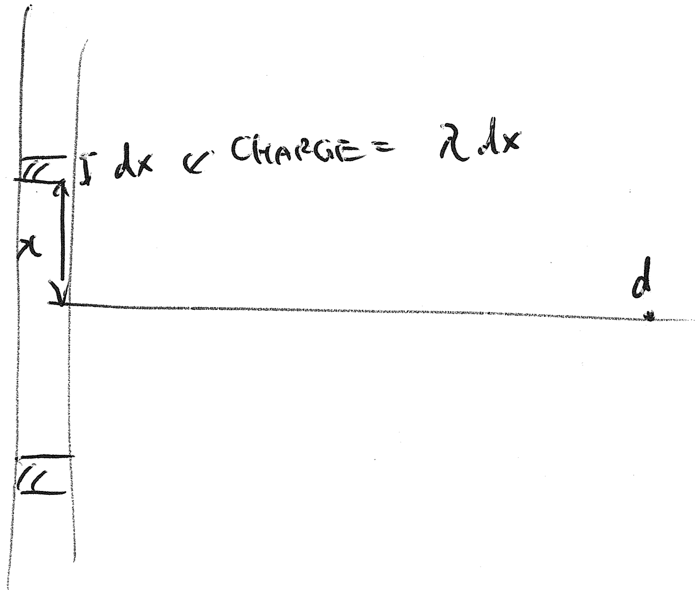
$$E_{1x} = \frac{1}{4\pi\varepsilon_0} \frac{q}{\sqrt{d^2+h^2}^{\,2}} \times \cos\theta$$

$$E_{2x} = \frac{1}{4\pi\varepsilon_0} \frac{q}{\sqrt{d^2+h^2}^{\,2}} \times \cos\theta$$

$$\cos\theta = \frac{d}{\sqrt{d^2+h^2}}$$

$$E_T = \frac{1}{2\pi\varepsilon_0} \frac{qd}{(d^2+h^2)^{3/2}}$$

NOW REPLACE q WITH $\lambda\, dx$



$$dE = \frac{1}{2\pi\varepsilon_0} \frac{\cancel{q}\, d\, \lambda\, dx}{(d^2+h^2)^{3/2}}$$

$$E = \int_0^{\infty} \frac{1}{2\pi\varepsilon_0} \frac{d\, \lambda\, dx}{(d^2+h^2)^{3/2}}$$

$$= \frac{\lambda d}{2\pi\varepsilon_0} \left[\frac{1}{d^2} \frac{x}{(d^2+x^2)^{1/2}} \right]_0^{\infty}$$

$$E = \frac{1}{2\pi\varepsilon_0} \frac{\lambda}{d}$$

~~STS UCP~~

~~3/0 80A~~

~~Kayla Lesker~~

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