Physics 114 - January 27, 2015

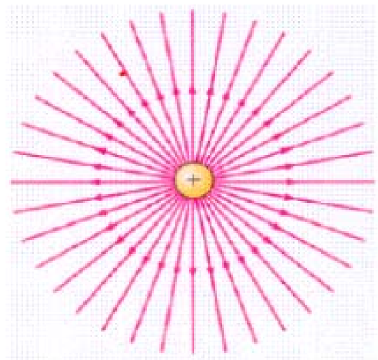
- Workshops happening
- TA office hours

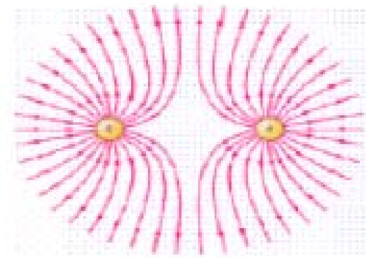
~~TA abuse~~

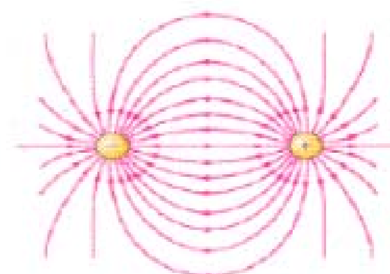
- Next week's Lectures + my office hour

The Electric Field

$$\vec{E} = \vec{F}/q_0$$



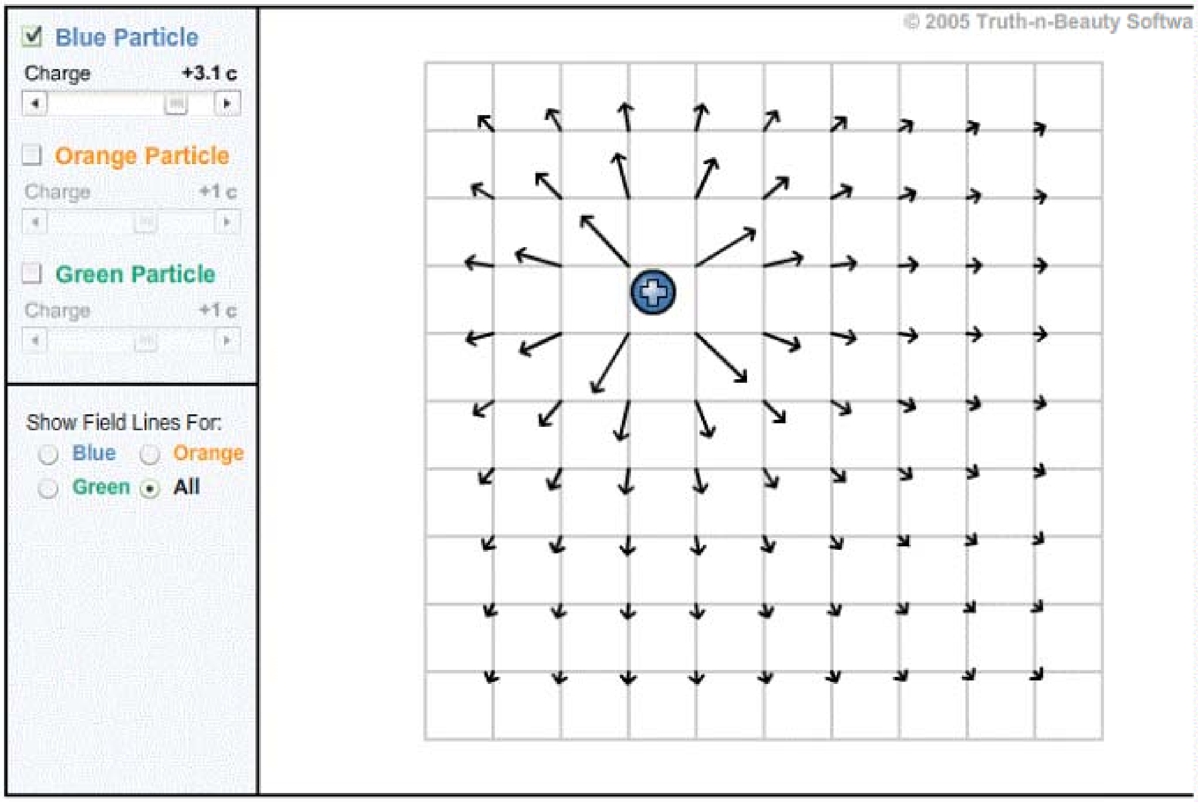


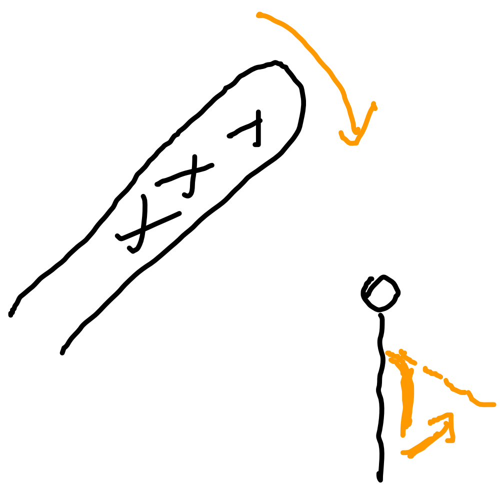


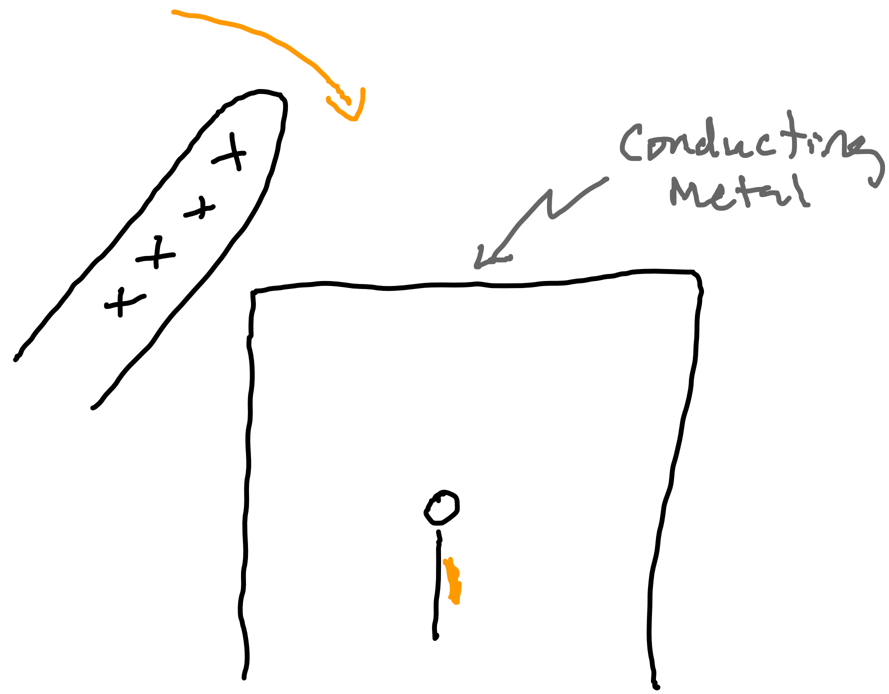
lines of force

- go from $\oplus$ to $\ominus$
- lines Never cross
- density $\propto |\vec{E}|$
- $\vec{F}, \vec{E}$ always Tangent to line of force

Check out electric field java applet ... link is on class website

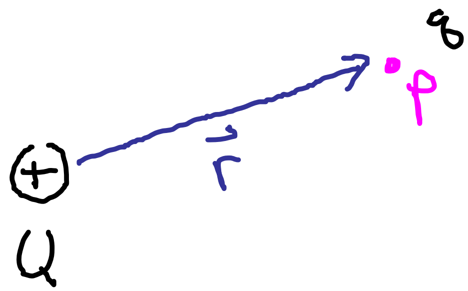






What happens when rod approaches?

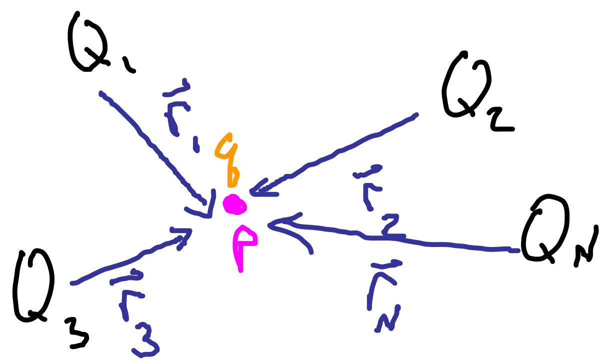
$\vec{E}$ calculations



$$\vec{F}_q = \frac{kqQ}{r^2}\hat{r}$$

$$\vec{E}_p = \frac{kQ}{r^2}\hat{r}$$

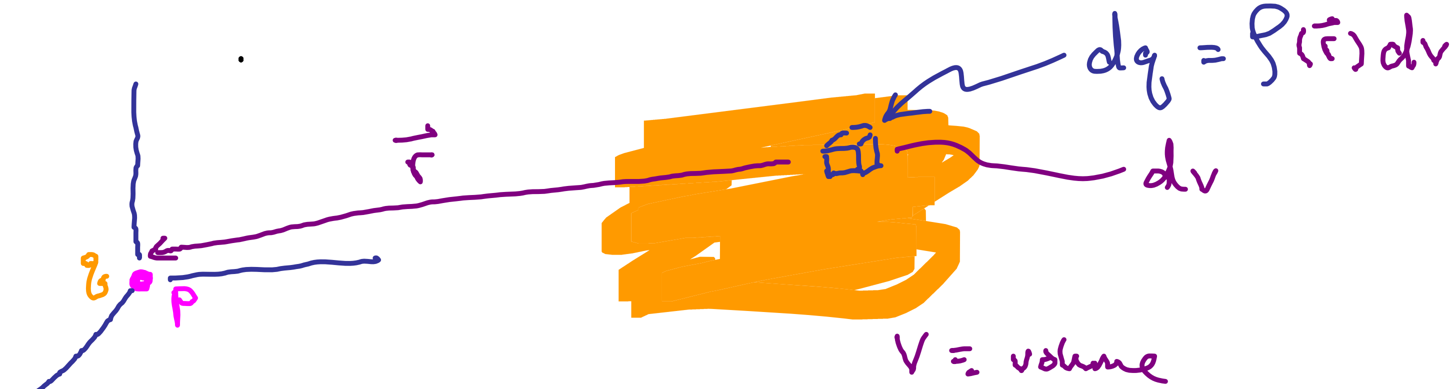
$q \to p$
due to Q



$$\vec{F}_{\text{on } q \text{ due to } Q_1 \cdots Q_N} = \frac{kQ_1 q}{r_1^2}\hat{r}_1 + \frac{kQ_2 q}{r_2^2}\hat{r}_2 + \cdots + \frac{kQ_N q}{r_N^2}\hat{r}_N$$

$$\vec{E}_{\text{at } P \text{ due to } Q_1 \cdots Q_N} = \frac{kQ_1}{r_1^2}\hat{r}_1 + \cdots + \frac{kQ_N}{r_N^2}\hat{r}_N$$

$\vec{E}$ due to continuous distribution

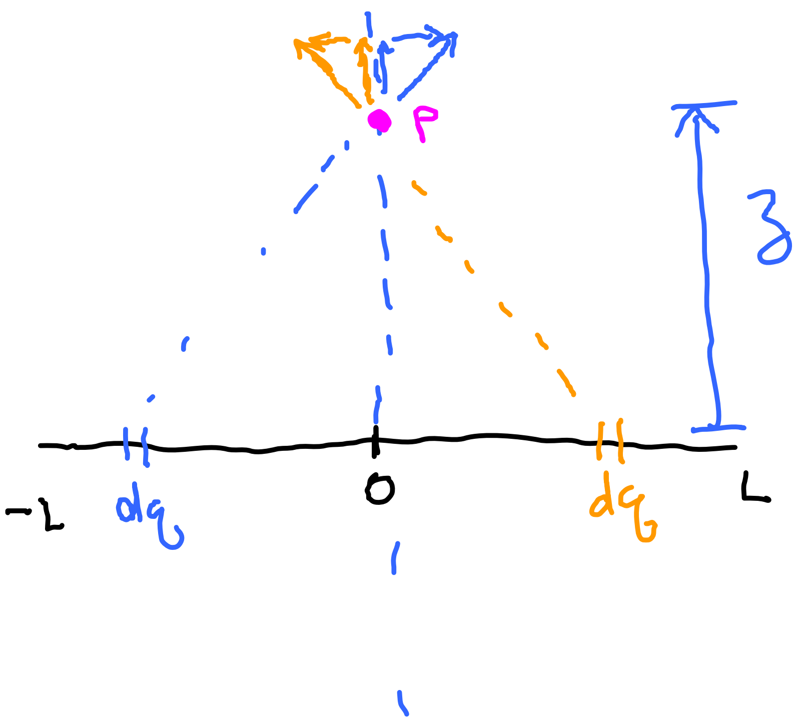


$$d\vec{F}_{\substack{\text{on } q \\ \text{at } P \\ \text{due to } dq}} = \frac{k\,q\,dq}{r^2}\,\hat{r} = \frac{k\,q\,\rho\,dv}{r^2}\,\hat{r}$$

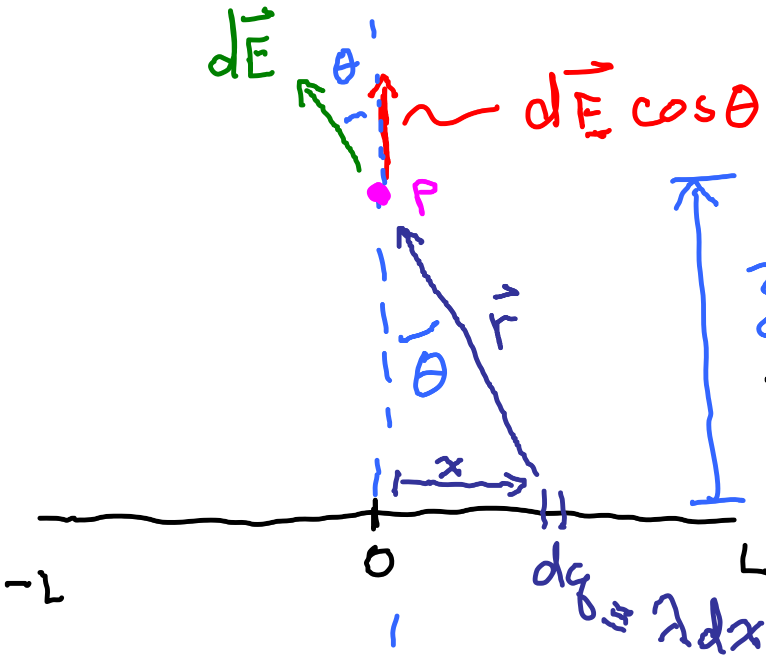
$$d\vec{E}_{\substack{\text{at } P \text{ due to} \\ dq}} = \frac{d\vec{F}}{q} = \frac{k\,\rho\,dv}{r^2}\,\hat{r}$$

$$\vec{E}_P = \int_{\text{volume}} \frac{k\,\rho(\vec{r})\,dv}{r^2}\,\hat{r}$$

Find $\vec{E}$ at distance z above midpoint of a line segment of length $2L$ that carries a uniform charge density $+\lambda$



$\vec{E}$ is straight up at P due to symmetry



$$\cos\theta = z/r = \frac{z}{(x^2+z^2)^{1/2}}$$

$$\vec{E} = \int_{-L}^{L} \underbrace{d\vec{E}_p}_{\frac{k\,dq}{r^2}\hat{r} \,=\, \frac{k\lambda dx}{r^2}\hat{r}} \cos\theta = \int_0^L d\vec{E}_p \cos\theta$$

$$\vec{E} = \hat{z}\,2\int_0^L \frac{k\lambda dx}{r^2}\cos\theta = \hat{z}\,2\int_0^L \frac{k\lambda dx}{(x^2+z^2)}\,\frac{z}{(x^2+z^2)^{1/2}}$$

$$\vec{E}_p = \hat{z}\, 2k\lambda z \int_0^L \frac{dx}{(x^2+z^2)^{3/2}}$$

$$\int \frac{dx}{(x^2+a^2)^{3/2}} = \frac{x}{a^2(x^2+a^2)^{1/2}}$$

$$F = k\frac{qq}{r^2} \qquad \frac{N\,m^2}{C^2}$$

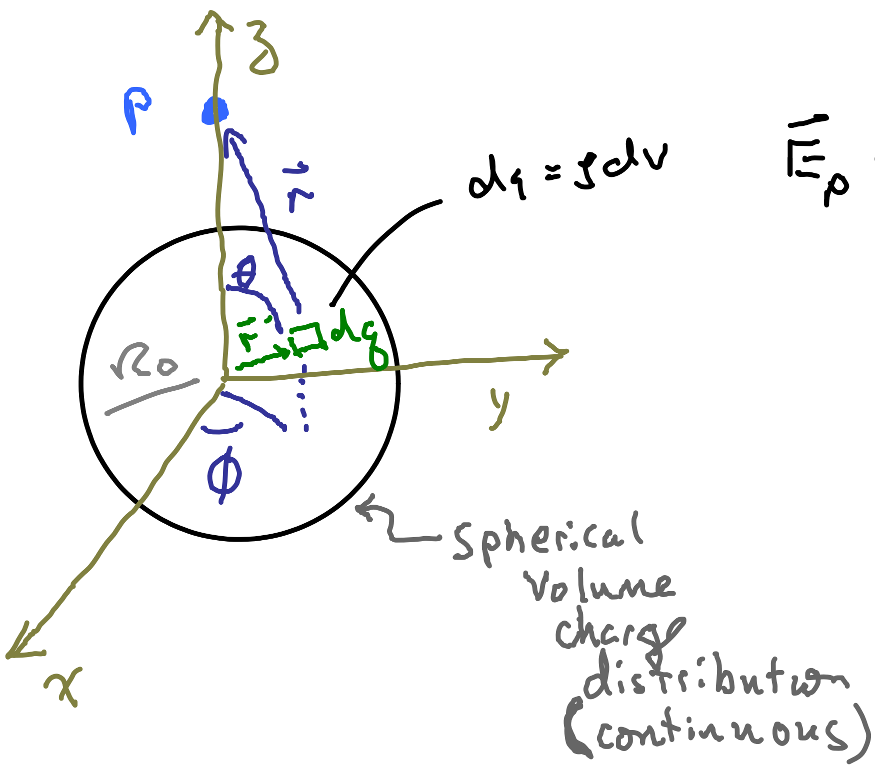
$$\vec{E}_p = \hat{z}\, 2k\lambda \left[\frac{x}{z(x^2+z^2)^{1/2}}\right]_0^L = \hat{z}\,\frac{2k\lambda\, L}{z(L^2+z^2)^{1/2}}$$

units

$$\frac{N}{C}$$

$$= \frac{N m^2}{C^2}\,\frac{C}{m}\,\frac{m}{m^2} = \frac{N}{C}$$ ✓

Limiting cases   Let $z \to$ large $\vec{E}_\rho \to \dfrac{k\,2L\lambda}{r^2}$



$$\vec{E}_p = \int_{chg} \frac{k\rho\, dv}{r^2}\,\hat{r}$$

$$\vec{E}_p = \int_0^{R_0}\int_0^{2\pi}\int_0^{\pi} \frac{k\rho\, r^2 \sin\theta\, d\theta\, d\phi\, dr}{r^2}$$

Holy Crap!!