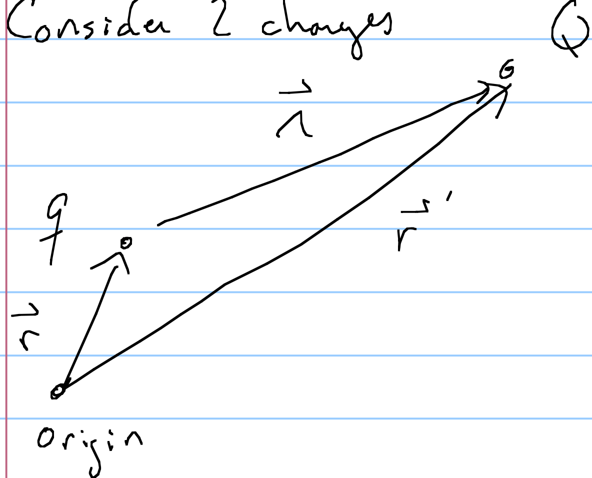
Lecture 4: Electric fields from Charge distributions.

Note Title 9/17/2009

Consider 2 charges



$$\vec{\mathscr{r}} = \vec{r} - \vec{r}\,'$$

then Coulomb's Law is

$$\vec{F} = \frac{1}{4\pi\epsilon_0}\,\frac{qQ}{\mathscr{r}^2}\,\hat{\mathscr{r}}$$

is the force on Q, due to the electric field of q.

$\epsilon_0 = 8.85 \times 10^{-12}\ \frac{C^2}{Nm^2}$ ← permitivity of free space

$$\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^{9}\ \frac{Nm^2}{C^2}$$

$\vec{F} = Q\vec{E}$ in this case where q creates an electric field $\vec{E}$ at $\vec{r}\,'$.

For point charges $$\vec{E}(\vec{r}) = \frac{1}{4\pi\epsilon_0}\sum_{i=1}^{N}\frac{q_i}{\mathscr{r}_i^2}\,\hat{\mathscr{r}}_i$$

where $\vec{\mathscr{r}}_i$ points from $\vec{r}_i$ (the location of q_i) to $\vec{r}$: $\vec{\mathscr{r}}_i = \vec{r} - \vec{r}_i$

More generally, the charge is given by a charge distribution

- along a 1-D line or curve: $\lambda = \frac{dq}{d\ell}$
- on a 2-D surface: $\sigma = \frac{dq}{dA}$
- in a 3-D volume: $\rho = \frac{dq}{d\tau}$

↳ so that
$$dq = \lambda \, d\ell$$
$$dq = \sigma \, dA$$
$$dq = \rho \, d\tau$$

The sum for pt. charges becomes an integral

$$\vec{E}(\vec{r}) = \frac{1}{4\pi\epsilon_0} \int \frac{dq}{\mathscr{r}^2} \hat{\mathscr{r}}$$

<u>Homework:</u> Ch. 2: 1, 2, 3, 4, 5, 6