

Calculating the dipole moment of an arbitrary charge distribution

$$\vec{p} = \int \vec{r}' \rho(\vec{r}') d^3\vec{r}' \quad \text{for a continuous } \rho(\vec{r}') \\ \text{see chp 3 of Griffiths for derivation.}$$

$$\vec{p} = \sum_{i=1}^n q_i \vec{r}'_i \quad \text{for a collection of discrete charges.}$$

(See pop quiz)

Once you know \vec{p}

$$\Phi(\vec{r}) = \frac{1}{4\pi\epsilon_0} \frac{1}{r^2} \vec{p} \cdot \hat{r}$$



Note that $\vec{p} \cdot \hat{r} = p \cos\theta$

ELECTRIC FIELD OF A PERFECT DIPOLE

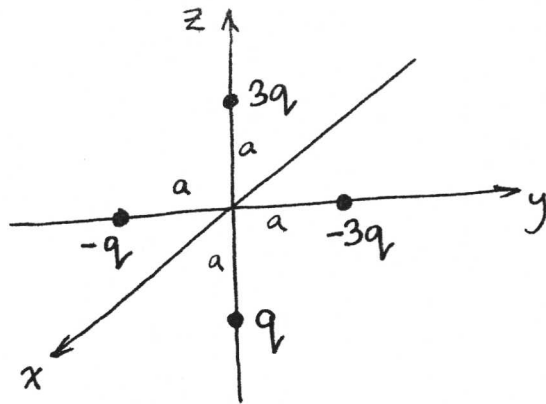
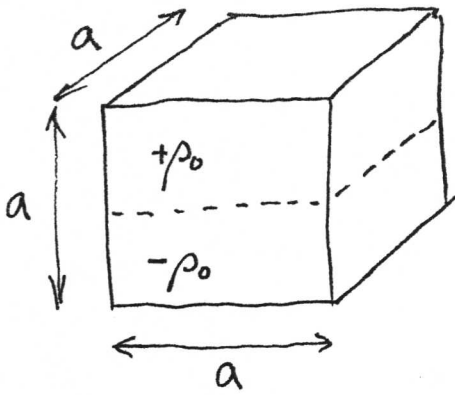
$$\vec{E} = -\nabla\Phi = -\nabla\left(\frac{1}{4\pi\epsilon_0} \frac{p \cos\theta}{r^2}\right) \quad \text{if I align z-axis with } \vec{p}.$$

In spherical coordinates $\nabla = \frac{\partial}{\partial r} \hat{r} + \frac{1}{r} \frac{\partial}{\partial \theta} \hat{\theta} + \frac{1}{r \sin\theta} \frac{\partial}{\partial \phi} \hat{\phi}$

DAY 19

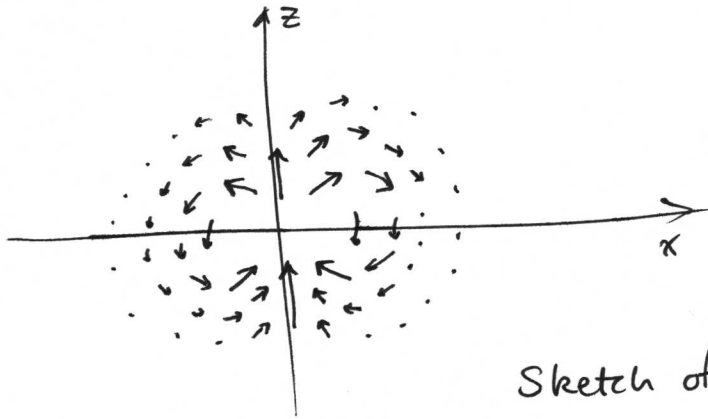
POP QUIZ

PH631



Find the dipole moment, \vec{p} , for these two charge distributions.

$$\Rightarrow \vec{E} = \frac{P}{4\pi\epsilon_0} \frac{1}{r^3} (2 \cos\theta \hat{r} + \sin\theta \hat{\theta})$$



Sketch of the vector field.

Why is the concept of a perfect dipole important?

- In conductors, the electrical properties are dominated by the free charges, the monopoles.
- In insulators, the electrical properties are dominated by the polarized atoms, dipoles.