DAY 19

PH 631

Instructor
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Calculating the dipole moment of an arbitrary charge distribution

$$\vec{p} = \int \vec{r}\,'\rho(\vec{r}\,')\,d^3\vec{r}\,'$$ for a continuous $\rho(\vec{r}\,')$

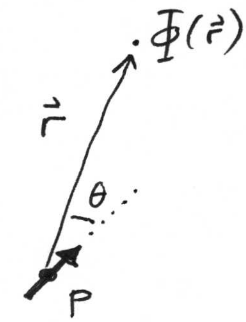
see Chp3 of Griffiths for derivation.

$$\vec{p} = \sum_{i=1}^{n} q_i \vec{r}_i\,'$$ 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

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

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

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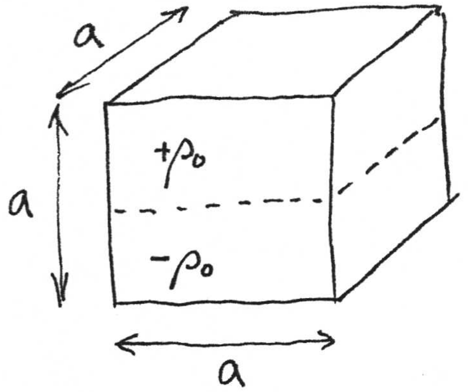
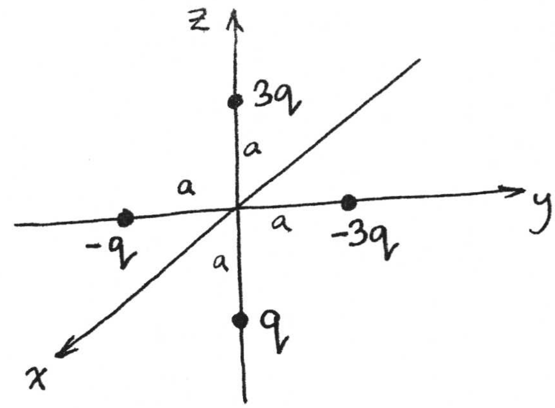
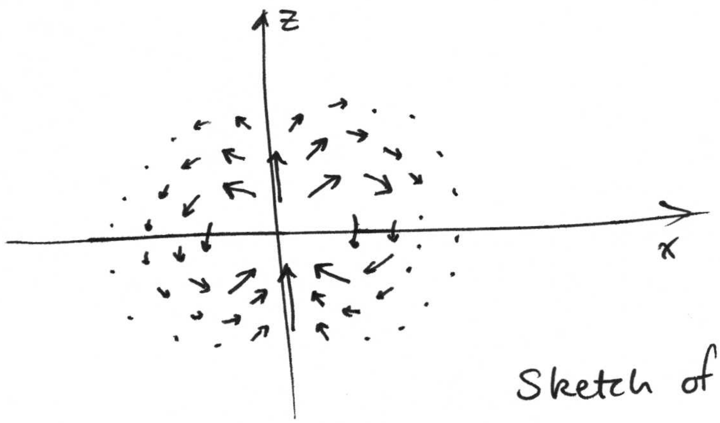
POP QUIZ PH631





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

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



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.