8.022 at ESG **Fall 2004**

Problem Set 02 **due Friday September 24**

Reading

Finish Chapter 1 of Purcell

Problems from the text

- **1.21**
- **1.27** (optional; you could spend a lot of time on this one if you wanted)
- **1.30**
- **1.34**
- **1.35** A useful, interesting and amusing calculation; use the text's hint to do the radial integral first. A picture is of great use. A further hint; put your origin at one of the charges, not at the midpoint of the line segment seperating them. If you check our web page, you'll see under "**Supplemental Class Notes**" some links to possibly helpful hints.

More With Dipole Fields

We will rederive in class on **Friday September 17** the proper expression for the electric potential due to a dipole $\mathbf{p} = p\,\hat{\mathbf{z}}$,

$$\varphi_{\mathrm{d}} = p\,\frac{\cos\theta}{r^2}, \qquad r > 0$$

in spherical coordinates.

(A) Find the electric field $\mathbf{E} = -\boldsymbol{\nabla}\,\varphi_{\mathrm{d}}$. Of course, you still have your table of vector operators handy. You have your choice of coordinate systems. However, you are asked to express your answer in a "hybrid" form (that's my own terminology); you're shooting for

$$\mathbf{E} = \frac{1}{r^3}\left[3\,\hat{\mathbf{r}}\,(\mathbf{p}\cdot\hat{\mathbf{r}}) - \mathbf{p}\right];$$

this form is a common one for the electric field due to an ideal dipole.

(B) Sketch a few field lines in the x-z plane; use a plotting program if you wish. The main thing is to show proper directions for $r > 0$, $\theta = 0$, $r > 0$, $\theta = \pi/2$ and $\theta = \pi$. Also, from your analytic result, find the value(s) of θ for which $E_z = 0$.

(C) Find the energy density corresponding to this field and the total energy in the region $r > R_0$ where R_0 is some constant radius. We'll deal with $r < R_0$ in due time.