PHYS 114

Rec. Assignment #5

February 21, 2007

Dipoles - Taylor expansions for dummies

You've learned about electric fields of point charges:

$$\Phi = \frac{1}{4\pi\epsilon_0}\frac{q}{r} \tag{1}$$

And thus you could calculate the potential due to any number of given point charges. You also learned that the same principle can be applied to dipoles, except that in the limit where this distance from the dipole is much greater than the dipole separation, a simplification exists (via a Taylor expansion):

$$\Phi = \frac{1}{4\pi\epsilon_0}\frac{qs\cos\theta}{r^2} \tag{2}$$

You are going to plot this approximation against the exact value.

To make life simple, let's plot everything in units of $\frac{1}{4\pi\epsilon_0}$, that is you can ignore the constant term. Let all the charges described have $q = 1C$ and the dipole separation $s = 1m$. There will be two charges located at:

$$\vec{r_1} =< -d, 0, 0 >$$
$$\vec{r_2} =< +d, 0, 0 >$$

Each plot should contain two curves, the magnitude of the exact Φ, and the approximation your that goes as $\frac{1}{r^2}$.

1. Plot these two curves along the x-axis in the range of x=[1.5,10].

2. Plot these two curves along the line r, from the center of the dipole at an angle from the positive x-axis $\theta = 20°$ for r = [1.5,10].

3. Plot these two curves along the line r, from the center of the dipole at an angle from the positive x-axis $\theta = 90°$ for r = [1.5,10]. Think about this one before you do it!

Feel free to use any program you feel comfortable to do this (MAPLE, MAT LAB, Mathematica, etc...) but if you want to use python you need to learn a few simple plotting commands. Some example code:

```
# Quadratic in the interval [1.5, 10] with an x-precision of .01
from pylab import *
X = arange(1.5, 10, 0.01)
Y = [ x**2 for x in X ]
plot(X,Y)
show()
```

The plot command takes in two lists (of the same size) as the X and Y values of a plot. It is your job to compute the proper Y values for this assignment. Multiple plot commands will put multiple curves on the same graph.

As a requirement to this assignment, please turn in your code and the three graphs via email attachments.