Due date: Wednesday, Nov. 7

Reading: Griffiths 3.4, Handout #3, and Griffiths 4.1-2.
Note that the second hour exam will be on Wed. Nov. 14. No new homework will be handed out next week. This homework is a little bit long to compensate.

The first three problems refer to the multipole expansion for systems with axial symmetry (the charge density is independent of $\phi$ in radial coordinates). See Handout #4 for reference in solving these three problems. (We don’t quite follow Griffiths here.) The idea in these problems is to think about which of the constants $I_0$, $I_1$, and $I_2$ is the first to be non-zero; that will determine the “leading behavior” at large $r$. Then calculate the relevant constant $I_n$ to answer the question. Note that the integrals appearing in the last column of the handout might need to turn into sums, or line integrals, or surface integrals depending on what kind of charge distribution is specified.

1. [4 points] Three charges are arranged on the $z$ axis as follows.
   a) Charges $q_0$, $-3q_0$, and $2q_0$ are located at $z = -1$, $z = 0$, and $z = +2$, respectively. What is the leading behavior of $V(r, \theta)$ at large $r$?
   b) Now the $-3q_0$ charge is located at $z = 1$ instead of $z = 0$. What is now the leading behavior at large $r$?

2. [4 points] A sphere of radius $R$ has a uniform charge density $\rho_0$ inside the “northern hemisphere” ($z > 0$) and an opposite charge density $-\rho_0$ inside the “southern hemisphere” ($z < 0$). What is the leading behavior of $V(r, \theta)$ at large $r$?

3. [4 points] A loop with linear charge density $3\lambda_0$ and radius $a$ is centered on the origin in the $x$-$y$ plane, and a second loop with charge density $-\lambda_0$ is concentric with it and has radius $3a$. What is the leading behavior of $V(r, \theta)$ at large $r$?

The remaining problems are independent of the above.


6. [3 points]
   a) Starting from Eq. (3.103), show that the electric field from a point dipole $p = p\hat{z}$ located at the origin, evaluated on the positive $z$ axis, is $(p/2\pi\epsilon_0 z^3)\hat{z}$.
   b) Plug into (4.5) to find the force on an identical point dipole on the $z$ axis at $z = a$. Is the force attractive or repulsive?