ASTRONOMY 822
Electromagnetic Radiation
Problem Set 3
due Wednesday, October 19
at class time

1) A particle of charge q is moving at a constant speed v_q along a straight line. You are located so that the particle's distance at closest approach is b (see the figure below).

Let $t = 0$ be the instant when the particle is at its closest approach.

a) What is $\vec{E}$ at your position at $t = 0$? What is $\vec{E}$ at your position in the limit $t \gg b/c$?

b) What is $\vec{B}$ at your position at $t = 0$? What is $\vec{B}$ at your position in the limit $t \gg b/c$?

2) Suppose that a particle of charge q is oscillating along the z axis, such that

$$\vec{r}_q(t) = \hat{e}_z z_0 \cos(\omega t) \ .$$

a) What is the power emitted per unit solid angle, $dP/d\Omega$, in a direction at angle θ to the z axis?

b) What is the polarization of the emitted radiation at $\theta = 0$? What is the polarization of the emitted radiation at $\theta = \pi/2$?

(Hint: This problem was inspired by problem 3.2 in the textbook. You may assume nonrelativistic motion.)

[continued on back]

3) Consider an electric dipole consisting of a charge $-q$ and a charge $+q$ separated by a constant distance D.

a) If the dipole is stationary, what is $\vec{E}(\vec{r})$, where $\vec{r}$ is measured from the point midway between the charges? What is $\vec{E}$ in the limit that $r \to \infty$?

b) Suppose that the dipole is rotating about the point midway between the charges, with angular frequency ω (see figure).

What is $\vec{E}(\vec{r}, t)$? What is $\vec{B}(\vec{r}, t)$? What is the power emitted per unit angle, $dP/d\Omega$, in a direction at angle θ to the axis of rotation?

(Hint: Problem 3.2 of the textbook might be useful for this problem, too. You may assume nonrelativistic motion.)