Homework 8 Solutions

1. An Uncharged Rotator

Two equal and opposite charges are attached to the ends of a rod of length s. The rod rotates counterclockwise with angular speed $\omega = ck$. The electric dipole moment of the system at time $t = 0$ has the value $\mathbf{p}_0 = qs\hat{\mathbf{y}}$.

(a) Show that the electric field in the radiation zone is:

$$\mathbf{E_{rad}}(r, \theta, \phi, t) = \frac{k^2 p_0}{4\pi\epsilon_0}(i\cos\theta\hat{\theta} - \hat{\phi})\frac{e^{i(kr-\omega t-\phi)}}{r}$$

. Explain why the observers' azimuth angle ϕ appears in the phase.

(b) Write out the (real) electric field on the positive x y and z axes. Identify the state of polarization observed in each case and make a physical argument why each might be expected.

(c) Find the time-averaged rate at which energy is radiated per unit solid angle and the total rate at which energy is radiated to infinity.

2. Radiation Recoil

(a) Explain why a localized (and entirely classical) source of charge and current does not recoil when it emits dipole radiation.

(b) Is recoil ever possible for a classical radiation source? If not, explain why not. If so, give an example.