Physics 123 – Spring 2013 – Module 6

1. The light beam from a searchlight may have an electric-field magnitude of 1000 V/m, corresponding to a potential difference of 1500 V between the head and feet of a 1.5-m-tall person on whom the light is shone. Does this cause the person to feel a strong electric shock? Why or why not?

2. It turns out that electromagnetic radiation is emitted by accelerating charges. The rate at which energy is emitted from an accelerating charge that has charge q and acceleration a is given by

$$\frac{dE}{dt} = \frac{q^2 a^2}{6\pi\varepsilon_o c^3}$$

where c is the speed of light. Verify this equation is dimensionally correct.
Consider the classical hydrogen atom … The electron in a hydrogen atom can be considered to be in a circular orbit with a radius of 0.0529 nm and a kinetic energy of 13.6 eV. If the electron behaved classically, how much energy would it radiate per second? What does this tell you about the usefulness of classical physics to describe atoms?

3. The energy flow to the earth associated with sunlight is about 1.4 kW/m^2. a) find the maximum values of E and B for a sinusoidal wave with this intensity. b) The distance from the earth to the sun is about 1.5x10^{11} m. Find the total power radiated by the sun.

4. A beam of light is a mixture of polarized light and unpolarized light. When it is sent through a Polaroid sheet (a linearly polarizing sheet), it is found that the transmitted intensity can be varied by a factor of five depending on the orientation of the Polaroid sheet. Find the relative intensities of the two components of the incident beam.

5. An electromagnetic wave has a frequency of 100 MHz and is traveling in a vacuum. The magnetic field is given by

$$\vec{B}(z,t) = (10^{-8}\,\mathrm{T})\cos(kz - \omega t)\hat{i}$$

(a) find the wavelength and the direction of propagation of this wave
(b) find the electric field.

6. The radiation pressure from a laser beam supports a particle against the force of gravity. What power 654-nm laser is necessary to support a perfectly reflecting spherical particle having a diameter of 10 μm and a density of 0.2 g/cm^3?

7. An electromagnetic wave is described by

$$\vec{\mathrm{E}} = \mathrm{E}_0\sin(\mathrm{kx} - \varpi\mathrm{t})\hat{\mathrm{j}} + \mathrm{E}_0\cos(\mathrm{kx} - \varpi\mathrm{t})\hat{\mathrm{k}}$$

What direction does this wave propagate? What is the polarization of this wave?