

Problem Set 1
due Jan. 31, 2003

Reading assignment: Giancoli, chapter 32.

1. Giancoli 32-7. There is no proof that magnetic monopoles cannot exist—it's just that they have not been observed (and people have been looking)!
2. (Similar to Giancoli 32-11) An electromagnetic wave is travelling in vacuum. The magnetic field component of the electromagnetic wave is $\mathbf{B} = B_0 \sin(kz - \omega t)\hat{x} = B_x(z, t)\hat{x}$.
 - Show by substituting into the wave equation that $B_x(z, t)$ satisfies the wave equation. What is the relation between k, ω and the speed of the wave c ?
 - What direction is the wave travelling?
 - Show that \mathbf{B} satisfies $\nabla \cdot \mathbf{B} = 0$.
 - Using the Maxwell's equations find \mathbf{E} . That is, if $\mathbf{E} = E_x\hat{x} + E_y\hat{y} + E_z\hat{z}$, what are E_x, E_y, E_z ?
3. What is the wavelength of a wave with frequency 10^4 Hz and how would we classify it? How about a wave with frequency 10^{16} Hz?
4. (Variant of Giancoli 32-26) A high energy pulsed laser emits a 10 ns long pulse of average power P . The beam has radius R .
 - What is the energy delivered in each pulse?
 - What is the rms value of the electric field?
 - For $P = 2.5 \times 10^{11}$ W, and $R = 2.2 \times 10^{-3}$ m, what is the energy delivered in each pulse?
5. The finite speed of electromagnetic waves introduces a time lag between when we see things in the sky and when they happened.

- The moon is 3.84×10^5 km away. When we see something on the moon, how much earlier did it happen?
 - A light year is the distance light travels in a year. How many meters are in a light year?
 - Astronomers use parsecs (3.26 light years), kiloparsecs (3.26×10^3 light years) and megaparsecs (3.26×10^6 light years) to describe astronomical distances. Our solar system is about 8.5 kiloparsecs from the center of the galaxy– when was the light emitted from the center of the galaxy that we see now?
 - A member of our “local group” of galaxies is the Andromeda Galaxy (also called m31), about 700 kpc away from earth. It is one of the farthest away objects that can be seen with the naked eye. How long ago did the light we are seeing today leave the galaxy?
6. (Variant of Giancoli 32-42) What are E_0 and B_0 2.00 meters from a 75 W light source? Assume that the bulb emits radiation of a single frequency uniformly in all directions.
7. Giancoli 32-44
8. (Variant of Giancoli 32-47) Suppose a 100 kW radio station emits EM waves uniformly in all directions.
- How much energy per second crosses a 1.0 m^2 area 100 m from the transmitting antenna?
 - What is the rms magnitude of the \mathbf{E} field at this point, assuming the station is operating at full power?
 - What is the voltage induced in a 1 m long vertical car antenna at this distance?

For an idea of the ranges of power output for FM radio stations, you can look at <http://www.radio-info.com/goldenstate/sf-fm.htm>

9. Giancoli 32-52. For part (a), look at example 25-13 for a hint.

Please show your work so that the grader can give you credit for effort even if you get the wrong answer. For keeping track of your own work it is usually helpful to only plug in numbers at the end. Also, please try to make your work readable!