Physics 111
Fall 2007
Light

1. The human eye is most sensitive to light having a wavelength of 5.50×10^{-7} m, which is in the green–yellow region of the visible electromagnetic spectrum. What is the frequency of this light?

2. A diathermy machine, used in physiotherapy, generates electromagnetic radiation that gives the effect of "deep heat" when absorbed in tissue. One assigned frequency for diathermy is 27.33 MHz. What is the wavelength of this radiation?

3. A neodymium–yttrium–aluminum garnet laser used in eye surgery emits a 3.00-mJ pulse in 1.00 ns, focused to a spot 30.0 μm in diameter on the retina.
   (a) Find (in SI units) the power per unit area at the retina. (This quantity is called the *irradiance* in the optics industry.)
   (b) What energy is delivered to an area of molecular size, taken as a circular area 0.600 nm in diameter?

4. A handheld cellular telephone operates in the 860- to 900-MHz band and has a power output of 0.600 W from an antenna 10.0 cm long.
   (a) Find the average magnitude of the Poynting vector 4.00 cm from the antenna, at the location of a typical person's head. Assume that the antenna emits energy with cylindrical wave fronts. (The actual radiation from antennas follows a more complicated pattern.)
   (b) The ANSI/IEEE C95.1-1991 maximum exposure standard is 0.57 mW/cm^2 for persons living near cellular telephone base stations, who would be continuously exposed to the radiation. Compare the answer to part (a) with this standard.

5. A plane electromagnetic wave is traveling along the x-axis. If the electric field of the wave has a maximum value of 2×10^{-4} N/C and lies along the y-axis, find the wave's maximum magnetic field and its direction.

6. Unpolarized light of intensity I_o passes through a Polaroid with its transmission axis vertically oriented. What intensity emerges? If the transmitted light passes through a second Polaroid sheet with its transmission axis 60^o to the vertical what fraction of the original incident light intensity I_o emerges?

7. Three polarizers arranged in series are each oriented at 30^o from the previous one. If an unpolarized light beam travels through the three polarizers and emerges with an intensity of 0.2 W/m^2, what was the intensity of the beam incident on the first polarizer?

8. Suppose a 50-kW radio station emits EM waves uniformly in all directions.
   (a) How much energy per second crosses a 1.0-m^2 area 100 m from the transmitting antenna?
   (b) What is the rms magnitude of the $\vec{\mathbf{E}}$ field at this point, assuming the station is operating at full power?
   (c) What is the voltage induced in a 1.0-m-long vertical car antenna at this distance?

9. Repeat problem #8 for a distance of 100 km from the station.

10. What is the maximum power level of the radio station of Problem #8 so as to avoid electrical breakdown of air at a distance of 1.0 m from the antenna? Assume the antenna is a point source. Air breaks down in an electric field of about $3\times10^6\ \text{V/m}$.

11. An EM wave has frequency $9.66\times10^{14}\ \text{Hz}$. What is its wavelength, and how would we classify it?

12. Our nearest star (other than the Sun) is 4.2 light-years away. That is, it takes 4.2 years for the light it emits to reach Earth. How far away is it in meters?