PHYS 102- Concepts of Physics II- Spring 2007
Homework #3
Due in class Wednesday April 4th

You must mostly type the text part of your work. But hand-write equations and drawings as needed; just please be neat. [Late work will not be carefully graded, but will be given a moderate amount of credit if it's generally satisfactory. If submitting late work, you must keep a back-up copy for yourself.]

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1. In this problem you will measure your reaction time, and then apply it to a question about the speed of light.

(a) To measure your reaction time, have a friend hold a pencil or pen between your opened thumb and index finger, which should be spaced a bit wider than the pencil or pen. At a surprise moment, your friend should let go of the object, and then you should close your thumb and index finger to catch it. Do this twice, and each time measure the distance the object fell (i.e. the difference between starting and ending positions of the object). Convert your answers to meters. What were your two measurements of the distance it fell?

(b) Average your two numbers from part (a). Now using what you know about falling objects, find the time, in seconds, that an object takes to fall that height, starting from rest. Be sure to show your work. We will call this your "reaction time."

(c) Imagine turning on, and then off, a laser as fast as you can, with the time difference being your reaction time. How far does light travel during that time, in meters? In miles?

(d) In order to further illustrate how extremely fast light travels, imagine that someone has a very short reaction time of only $1/100^{th}$ of a second. If this person were to climb a mountain in central Virginia and point a laser toward San Francisco and turn it on, to what point in the U.S. would the leading edge of the light pulse reach before the laser could be turned off? Draw a thick line on the provided map (see last page) to show this path. Cut out the map and include it within this problem on your submitted paper. Be sure to justify your answer.(The distance from central Virginia to San Francisco is about 2400 miles).

2. Conceptual exercise # 1 on page 216 (of Hobson, 4^{th} edition). [What evidence is there…] This answer can be brief—2 or 3 sentences, but add something beyond the answer in the back of the book.

3. Conceptual exercise # 4 on page 216. [It takes light 20 minutes…]

4. Conceptual exercise #12 on page 216. [You do not get a sunburn…]

5. Conceptual exercise #14 on page 216. [Suppose you viewed Earth's dark side…]

6. These questions concern electromagnetic waves.

   (a) If you stand in the shade on a hot summer day, your face feels warm. Holding an object such as a piece of cardboard several inches from your face does not change that. On the other hand, if you are in close proximity to a fire or a bright tungsten lamp, your face also feels warm, but holding an object between your face and the fire/lamp will make your face instantly cooler. Explain.

   (b) A typical medical or dental X-ray machine accelerates electrons through 70,000 volts, giving each electron an energy of 70,000 electron-volts (eV). These electrons then smash into a metal target. The electrons in the atoms of the metal target are boosted to a higher orbit, and then decay, emitting a photon. Assuming that all of the energy of the original accelerated electron is converted to the energy of the photon, find the frequency and the wavelength of the photon, and where it lies in the electromagnetic spectrum (see chart on page 196). You will need this conversion: 1 eV = 1.6×10^{-19} Joules.

   (c) Most large objects emit a range of electromagnetic waves, and the details depend on the surface temperature of the object. The higher the temperature, the higher the average energy of the radiation emitted. The peak wavelength of that range is given by the following formula:

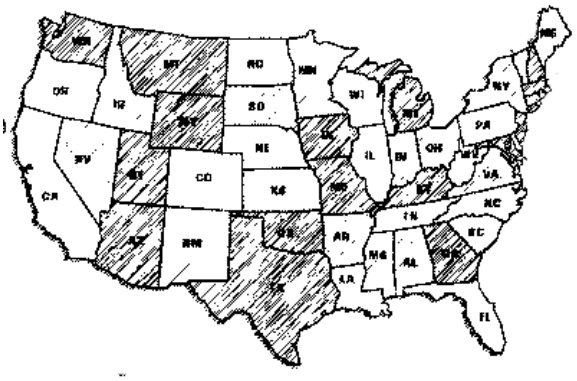
$$\text{Peak Wavelength (in meters)} = \frac{0.0029}{(\frac{5}{9}T_{Fahrenheit} + 255)}$$

   The surface temperature of the sun is about 10,000 degrees Fahrenheit, and that of the human body is about 90 degrees Fahrenheit. Find the peak wavelength emitted by these two objects, compare to the information in sections 9.3 and 9.4 of your text, and explain whether or not your answers make sense.

7. For this problem, you will need to refer to the following frequency allocation chart:

   http://www.ntia.doc.gov/osmhome/allochrt.pdf

(a) What is one of your favorite AM radio stations? It does not have to be in Charlottesville, or even in Virginia. Look up the frequency of this station. What is it? How is this frequency labelled on the allocation chart?
(b) What is one of your favorite FM radio stations? It does not have to be in Charlottesville, or even in Virginia. Look up the frequency of this station. What is it? How is this frequency labelled on the allocation chart?
(c) One set of frequencies set aside for cell phones is 866 to 869 MHz. How is this band of frequencies labelled on the allocation chart?
(d) One frequency used by the Global Positioning System is 1575 MHz. How is this frequency labelled on the allocation chart?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