UNIVERSITY OF ALABAMA
Department of Physics and Astronomy

PH 102 / LeClair Summer II 2010

Problem Set 7: Review

Instructions:

1. Answer all questions below. Show your work for full credit.
2. All problems are due at the start of your final exam.
3. You may collaborate, but everyone must turn in their own work.

1. In periods of peak demand, power companies lower their voltage. This saves them power (and saves you money)! To see the effect, consider a 1200 W toaster that draws 10 A when connected to 120 V. Suppose the voltage is lowered by 10% to 108 V. By how much does the current decrease? By how much does the power Decrease? On a related note, why do we use ac power instead of dc?

N.B. - the 1200 W label is valid only at 120 V applied. When the voltage is lowered, it is the *resistance* of the toaster, not its power, that remains constant.

2. The average lifetime of a pi meson in its own frame of reference (*i.e.*, the proper lifetime) is 2.6×10^{-8} s

(a) If the meson moves at 0.98c, what is its mean lifetime as measured by an observer on earth?
(b) What is the average distance it travels before decaying, as measured by an observer on Earth?
(c) What distance would it travel if time dilation did not occur?

3. An electron has a velocity of 3×10^6 m/s perpendicular to a magnetic field and is observed to move in a circle of radius 0.3 m.

(a) What is the strength of the B field?
(b) What E field could you apply (in addition to the B field) to cause the electron to move in a straight line instead? Give the magnitude and direction (relative to the B field and the electron's velocity).

4. *French & Taylor 1.8* A radio station broadcasts at a frequency of 1 MHz with a total radiated power of 5 kW. **(a)** What is the wavelength of this radiation? **(b)** What is the energy (in electron volts) of the individual quanta that compose the radiation? How many photons are emitted per second? Per cycle of oscillation? **(c)** A certain radio receiver must have 2 μW of radiation power incident on its antenna in order to provide an intelligible reception. How many 1 MHz photons does this require per second? Per cycle of oscillation? **(d)** Do your answers for parts (b) and (c) indicate that the granularity of electromagnetic radiation can be neglected in these circumstances?

5. You decide to roll a $0.1\,\text{kg}$ ball across the floor so slowly that it will have a small momentum and a large de Broglie wavelength. If you roll it at $0.001\,\text{m/s}$, what is its de Broglie wavelength? Compare this wavelength to the size of a proton.

6. The energy required to break one O=O bond in ozone (O_3, O=O=O) is about $500\,\text{kJ/mol}$. What is the maximum wavelength of the photon that has enough energy to photo-dissociate ozone by breaking one of the O=O bonds?

$$O_3 \xrightarrow{hf} O + O_2$$

Note Avagadro's number is $N_A = 6.02 \times 10^{23}$ things/mol.