Phys 2112, Spring 2011
Problem Set #1

1. The Earth goes around the Sun once a year in a nearly circular orbit of radius $R = 1.50 \times 10^{11}$ m. Find the speed of the Earth. Is relativity needed to describe its motion?

2. Find the speed of a proton with a kinetic energy of 2 MeV. (Assume that KE is given by $\frac{1}{2}mv^2$ and later decide if this was justified.) Is relativity needed to describe its motion?

3. Find the speed of a proton with a kinetic energy of 50 MeV. Is relativity needed to describe its motion?

4. Do the same as in 2 and 3 for a proton with a kinetic energy of 500 MeV.

5. Find the speed of an electron with a kinetic energy of 20.0 keV. Is relativity needed to describe its motion?

6. Find the wavelength of a baseball which has a mass of 0.15 kg and a speed of 10.0 $\frac{\text{m}}{\text{s}}$. Would we ever have to worry about quantum effects for a baseball? (Consider that the electron in a hydrogen atom can be considered to orbit the proton in a circular orbit of radius 5.26×10^{-11} m; you can take that as the "size" of an atom.)

7. The electron in a hydrogen atom can be considered to orbit the proton in a circular orbit of radius 5.26×10^{-11} m. Its kinetic energy is 13.6 eV.

a) Find the speed of the electron. (Assume the formula $K = \frac{1}{2}mv^2$ is correct.)

b) Is relativity needed to describe the motion of the electron?

c) Find the momentum p of the electron and its wavelength λ.

d) If the wavelength is comparable to (or bigger than) the size of its orbit then quantum theory is needed. Is this the case for the electron in the H atom?

$$p = mv \qquad K = \tfrac{1}{2}mv^2 \quad \text{(non-rel)} \qquad \lambda = \frac{h}{p} \quad \text{(quantum)}$$

$$c = 2.998 \times 10^8 \ \tfrac{\text{m}}{\text{s}} \qquad \hbar = \frac{h}{2\pi} = 1.0546 \times 10^{-34} \ \text{J} \cdot \text{s} \qquad h = 6.626 \times 10^{-34} \ \text{J} \cdot \text{s}$$

$$1 \text{ eV} = 1.602 \times 10^{-19} \text{ J} \qquad 1 \text{ MeV} = 10^6 \text{ eV} \qquad m_{\text{e}} = 9.11 \times 10^{-31} \text{ kg} \qquad m_{\text{prot}} = 1.67 \times 10^{-27} \text{ kg}$$