PHY6938 Modern Physics and Quantum Mechanics, Spring 2000

1. A boy standing on a ladder drops marbles of mass M from a height H. He tries to hit a point on the ground. Show that even if he is very careful, the marbles are going to miss the point by an average distance Δx which is proportional to

$$\left(\frac{\hbar}{M}\right)^{1/2}\left(\frac{H}{g}\right)^{1/4},$$

where g is the gravitational acceleration. How large is the average distance for $M = 1$ g and $H = 2$ m? Compare this distance to the radius of an atom and the radius of a nucleus. *Hint:* Use Heisenberg's uncertainty principle.

2. A vessel holds 2 μg of tritium. The half life of tritium is $t_{\frac{1}{2}}({}^3_1H) = 12.3$ y, and its mass is $m({}^3_1H) = 3.02$ u $= 5.01 \times 10^{-27}$ kg.

a) What is the initial decay rate of the tritium?

b) How much time will elapse before the amount of tritium falls to 1% of its initial value?

3. Cosmic ray photons from space are bombarding your laboratory and smashing massive objects to pieces! Your detectors indicate that two fragments, each of mass m_0, depart such a collision (between a photon and a particle of mass M) moving at speed 0.6 c at 60° to the photon's original direction of motion.

a) In terms of m_0 and c, what is the energy of the cosmic ray photon?

b) In terms of m_0, what is the mass M of the particle being struck (assumed originally stationary)?

4. A particle of mass m moves in a one-dimensional potential

$$V(x) = \begin{cases} V_0\,\delta(x) & \text{for } |x| < a \\ \infty & \text{for } |x| \geq a \end{cases}$$

(i.e an infinite potential well with a δ-potential at the center). Find the energy levels for this particle and discuss the cases of very large and very small V_0. .