Name________________

Exam #2

Physics 248

March 14, 2007

Each problem is worth 25 points

Problem	Score
1	
2	
3	
4	
Total	

Physical constants: $h = 6.626 \times 10^{-34} Js$ | $c = 2.998 \times 10^{8} m/s$ | 1 eV=$1.602 \times 10^{-19} J$ | $\hbar c = 1973 eV\AA$

1. **Multiple choice question** (circle your answer):

   Consider two sources S_1 and S_2 emitting waves with equal amplitude A, frequency $f = 2$ Hz and velocity $v = 3$m/s.

   (i) What is the wavelength λ?

   (A) 6 m (B) 2/3 m (C) 3/2 m (D) 1/6 m (E) 3π m

   (ii) Suppose the wave source S_1 is 5 m directly to your right while S_2 is 5.75 m directly to your left, the result is

   (A) a wave with the same frequency but twice the amplitude
   (B) a wave with the same amplitude but twice the frequency
   (C) a wave with twice the frequency and twice the amplitude
   (D) a wave with zero amplitude
   (E) a wave with an intensity equal to the sum of the intensities of the two waves

   (iii) Now, increase the amplitude of S_1 to $2A$ while keeping the amplitude of S_2 fixed, the amplitude of the resulting wave is

   (A) zero (B) A (C) 2 A (D) 3A (E) 9A

2. A new particle, Montarulino, was recently discovered at an accelerator in Bari, Italy. The rest mass of Montarulino is 1 TeV/c^2. Usually, particles at accelerators are highly energetic, but Jim the God on Earth found a way to slow Montarulino down to a kinetic energy of 10 eV.

   (i) What is the wavelength of Montarulino in $\AA$?

   (ii) In order to see a diffraction pattern of Montarulino in a single slit experiment, what order of magnitude is size of the slit needed?

3. In a different universe, the electric potential between an electron and a proton in a "hydrogen atom" is

$$V(r) = -ke^2/r^{n+1}$$

where $n > 0$, instead of the familiar Coulomb potential $V(r) = -ke^2/r$ we discussed in class. Use uncertainty principle arguments to estimate the ground state energy. Don't worry about the overall numerical factor.

4. The wavefunction for a particle of mass m is $\psi(x) = \psi_0 e^{-\frac{|x|}{2a}}$ for some constant a, and where $-\infty < x < +\infty$. You may find the following integral helpful: $\int_0^\infty x^n e^{-x} dx = n!$ for any non-negative integer n.

(i) Normalize this wavefunction. That is, find the coefficient ψ_0 such that the probability of finding the particle between $\pm\infty$ is one.

(ii) Assuming the total energy of the particle is $E = -\frac{\hbar^2}{8ma^2}$, use the time independent Schrodinger equation to show that $V(x)$ is constant for $x > 0$ and $x < 0$, and find this constant. Don't worry about $V(x)$ at $x = 0$.

(iii) Calculate $< x^2 >$ and $< x >^2$.