Assignment #1
Physics 201 (Mureika)
Due: Wednesday 06 September 2006

Answer all problems with complete solutions. Homework which gives only the final answer with no indication of how it was obtained will receive a 0. Solutions must be written clearly, and steps must be explained.

1. In class, we saw that Coulomb’s constant is “much bigger” than Newton’s gravitational constant \( k = 8.99 \times 10^9 \text{ N m}^2/\text{C}^2 \), \( G = 6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2 \). The conclusion was that the Coulomb force was probably “stronger” than the gravitational one. However, saying one is “bigger” and one is “smaller” is sort of like comparing apples to oranges, since they have different units. So, you need to convince yourself of this fact!

   (a) Determine both the gravitational and electrostatic forces of attraction between the proton and electron in the ground state of the hydrogen atom \( a_0 = 5 \times 10^{-11} \text{ m} \), and calculate the ratio between the forces. Recall that the proton has a mass \( m_p = 1.6 \times 10^{-27} \text{ kg} \), and the electron \( m_e = 9.1 \times 10^{-31} \text{ kg} \).

   (b) According to simple planetary models of the atom, the electron is held in its orbit by centrifugal forces (which overcomes the coulomb attraction between the charges). However, the nucleus is a different story, since it is made up exclusively of like charges. Estimate the force of repulsion between two protons in the nucleus. Assume the protons are separated by a distance of \( 10^{-15} \text{ m} \) (roughly the diameter of a proton).

   (c) Is the gravitational force of attraction between the protons enough to overcome the repulsive coulomb force? If not, how do you suppose nuclei are held together?

2. Problem 23-3.3

3. Problem 23-3.6

4. Problem 23-3.7