Recitation Problems for Week 1, Tuesday

Work each of the following problems on your white board. When you have completed a problem, please have an instructor come and sign off that you have done it correctly.

$$| F_{grav} | = G\frac{m_1 m_2}{r^2} \quad (1)$$

$$G = 6.67 \times 10^{-11}\, Nm^2/kg^2 \quad (2)$$

$$| F_{ele} | = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2} \quad (3)$$

$$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 Nm^2/C^2 \quad (4)$$

$$r_{atom} \approx 0.5 \times 10^{-10}\, m \quad (5)$$

$$r_{nucleus} \approx 1 \times 10^{-15}\, m \quad (6)$$

$$e = 1.6 \times 10^{-19}\, C \quad (7)$$

$$m_p \approx 1.7 \times 10^{-27}\, kg \quad (8)$$

$$m_e \approx 9 \times 10^{-31}\, kg \quad (9)$$

$$m_{moon} \approx 7 \times 10^{22}\, kg \quad (10)$$

$$m_{earth} \approx 6 \times 10^{24}\, kg \quad (11)$$

$$m_{sun} \approx 2 \times 10^{30}\, kg \quad (12)$$

$$r_{earth.moon} \approx 3.84 \times 10^8\, m \quad (13)$$

$$r_{earth.sun} \approx 1.5 \times 10^{11}\, m \quad (14)$$

$$c = 3 \times 10^8\, m/s \quad (15)$$

(1) What is the force (in Newtons) that binds an electron to a proton in a hydrogen atom?

(2) Estimate the weight of a flea (in Newtons).

(3) What is the force between the Earth and the Moon? How about the Earth and the Sun?

(4) The Milky Way and the Andromeda galaxies are each about 10^{11} solar masses. They are also roughly 2.5×10^6 light-years apart (the distance light travels in a year). What is the force between the galaxies?

(5) What is the repulsive force between two protons in a helium nucleus?

(6) What is the gravitational force between two protons in a helium nucleus?

(7) The two protons in helium are bound by the strong nuclear force. What is the minimum value of this force?

Another piece of information about helium is that the energy required to remove one of the protons from the helium is about $3 \times 10^{-12}\,J$. We can try to use this to determine the magnitude of the strong nuclear force. The simplest form is to assume that the force is constant from $10^{-15}\,m$ to $2 \times 10^{-15}\,m$ and zero after that. Consider that the two protons start with a separation of $10^{-15}\,m$.

(8) Estimate the size of the strong force.

(9) Assume that the force is of the form $F = a - bx$ such that at $x = 2 \times 10^{-15}\,m$, $F = 0$. Estimate a and b and the force at $10^{-15}\,m$.

The tail of a vector is located at the point $(-2\,m, 1\,m)$, while the tip of the vector is located at the point $(6\,m, -3\,m)$. Answer the following questions about this vector in the $x - y$plane.

(10) Sketch the vector on your white board.

(11) What is the length of the vector?

(12) What angle does the vector make with the x-axis?

(13) What is the unit vector in the direction of the vector?

(14) What are the two unit vectors in the $x - y$ plane that are normal to the vector?

(15) If you rotate the vector such that it is pointing along the $45°$ line between the x and y axis, and then place its tail on the origin, at what point will you find the tip of the vector?