Physics 100 HW 6 (Due 2/21/07 Wednesday) Name S. Olsen

1. In class we said that *absolute zero* (-273°C or -459°F) is the lowest temperature possible. Nothing can be made colder than something at a temperature corresponding to *absolute zero*. What happens at *absolute zero* that makes it the lowest possible temperature?

The random thermal motion of atoms & molecules goes to zero. The energy associated with this motion can't be any lower

2. A young man (mass = 80 kg) feels a strange attraction to the young woman (mass = 60 kg) sitting next to him (about 0.8 m away) in Physics 100. Could this be due to the gravitational force?

a) Compute the gravitational force exerted on the young man by the young woman.

$$F_G = G \frac{m_{♂} m_{♀}}{d^2} = 6.7 \times 10^{-11} \frac{Nm^2}{kg^2} \cdot \frac{(80\,kg)(60\,kg)}{(0.8\,m)^2} = 5.0 \times 10^{-7} N$$

b) What is the young man's weight?

$$W_{♂} = m_{♂} g = 80\,kg \cdot 10\,m/s^2 = 800\,N$$

c) How many times bigger is the young man's weight in comparison to the force exerted by the young woman? Is it likely that he would be aware of the presence of a force of this size?

$$\frac{W_{♂}}{F_G} = \frac{800\,N}{5 \times 10^{-7} N} = 1.6 \times 10^{9} \text{ times bigger.}$$ Probably not.

3. The Moon has a mass of $7.4 \times 10^{22} kg$ and a radius of $1.7 \times 10^{6} m$.

a) What is the acceleration of gravity on the surface of the Moon?

$$g_{Moon} = G \frac{M_{moon}}{R_{moon}^2} = 6.7 \times 10^{-11} \frac{N m^2}{kg^2} \frac{7.4 \times 10^{22} kg}{(1.7 \times 10^{6} m)^2} = 1.7 \frac{N}{kg} = 1.7\, m/s^2$$
$(.17 g)$

b) What would your weight be if you stood on the surface of the Moon?

$$W_{moon} = m\, g_{moon} = 90\,kg \cdot 1.7\,m/s^2 = 153\,N$$
$(\sim 34\ lbs)$

4. The Sun has a mass of $2 \times 10^{30} kg$ and a radius of $7 \times 10^{8} m$.

a) What is the acceleration of gravity on the surface of the Sun?

$$g_{\odot} = G \frac{M_{\odot}}{R_{\odot}^2} = 6.7 \times 10^{-11} \frac{N m^2}{kg^2} \frac{2 \times 10^{30} kg}{(7 \times 10^{8} m)^2} = 273\, m/s^2 \sim 27 g$$

b) What would your weight be if you stood on the surface of the Sun?

$$W_{\odot} = m\, g_{\odot} = 90\,kg \cdot 273\,m/s^2 = 24{,}600\,N$$
$(5{,}500\ lb)$

$= r_{moon}$

5. The distance from the Earth to the Moon is $3.8 \times 10^8 m$.)

   a) What is the gravitational force exerted on you by the Moon (while you are here on Earth)?

   $$F = G \frac{m M_{moon}}{r_{moon}^2} = 6.7\times10^{-11} \frac{Nm^2}{kg^2} \frac{90kg \cdot 7.4\times10^{22}kg}{(3.8\times10^8 m)^2} = 3.1\times10^{-3} N$$

   b) When the Moon is overhead, it pulls you upward, which reduces your weight; when the Moon is on the opposite side of the Earth, it pulls you downward, increasing your weight. By what percentage does your weight change between a time when the Moon is directly overhead and when it is on the other side of the Earth?

   $$\Delta W = 2F = 2\times3.1\times10^{-3}N = 6.2\times10^{-3}N$$

   $$\text{Percentage change} = \frac{\Delta W}{W}\times100 = \frac{6.2\times10^{-3}}{900N}\times100 = 0.0007\%$$

6. In a hydrogen atom, a negatively charged electron is held in orbit around a positively charged proton by the coulomb force. The charges of the electron and proton are $-1.6 \times 10^{-19}C$ and $+1.6 \times 10^{-19}C$, respectively, and the average distance between the electron and proton is $d = 5 \times 10^{-11}m$. (The mass of a proton is $1.7 \times 10^{-27}kg$; the mass of an electron is $9.1 \times 10^{-31}kg$.)

   a) What is the coulomb force between the electron and proton?

   $$F_{coul} = k\frac{q_e q_p}{d^2} = 9\times10^9 \frac{Nm^2}{C^2} \frac{(1.6\times10^{-19}c)^2}{(5\times10^{-11}m)^2} = 9.2\times10^{-8}N$$

   b) What is the gravitational force between the electron and proton?

   $$F_{Grav} = G\frac{m_e m_p}{d^2} = 6.7\times10^{-11}\frac{Nm^2}{kg^2} \frac{9.1\times10^{-31}kg \; 1.7\times10^{-27}kg}{(5\times10^{-11}m)^2} = 4.1\times10^{-47}N$$

   c) Which force is bigger? How many times bigger?

   Coulomb force is much, much bigger

   $$\text{factor} = \frac{F_{coul}}{F_{grav}} = \frac{9.2\times10^{-8}N}{4.1\times10^{-47}N} = 2.2\times10^{39}$$

7. Astrologists keep track of the positions of planets relative to the Earth and attribute events on Earth to the changes of the planet's graviational forces on us. Jupiter, the biggest planet ($M_{Jup} = 7\times10^{25}$ kg), goes around the Sun in a nearly circular orbit with a radius of 8×10^{11} m. The Earth orbits the Sun with a nearly circular orbit of 1.5×10^{11} km. The gravitational attraction of Jupiter is strongest when the Earth and Jupiter are closest and this happens when they are on the same side of the Sun and about 6.5×10^{11} m apart.

   a) What is the force of attraction between you and Jupiter when the Earth and Jupiter are closest?

   $$F_{Jup} = G\frac{m M_{Jup}}{r_{Jup}^2} = 6.7\times10^{-11}\frac{Nm^2}{kg^2} \frac{90kg \cdot 7\times10^{25}kg}{(6.5\times10^{11}m)^2} = 1.0\times10^{-6}N$$

   b) How does this compare with the gravitational force exerted on yoy by the Moon (determined in question # 5 above).

   F_{Moon} is much bigger : factor : $\frac{F_{moon}}{F_{Jup}} = \frac{3.1\times10^{-3}N}{1.0\times10^{-6}N} \Rightarrow 3100\times$ bigger

   c) Do you think that the gravitational force of Jupiter will have a big influence on events here on Earth?

   No