Homework set #3 (assigned 23 February, due 4 March)

Instructions. As always, these questions have many parts to them. Please make sure you read all of each of these questions, and answer all the questions I ask you. Please remember that while I do not officially "count off" for grammar, spelling, and overall writing style, I do care about such things deeply. You should *definitely* proofread your homeworks not only to see if your answers make sense and have the correct units labeled, but also to see if your wording and spelling are correct.

Some of the math questions here are pretty straightforward and some require more creative thinking. I want to see how well you can do at each of those things. It will definitely help me to see what you have done if you write, in words, what it is that you are doing and trying to do (in addition to writing mathematical formulae).

1) Your weight is really the product of your mass and the acceleration due to gravity where you are, i.e., on the surface of the Earth (check out Newton's Second Law). In other words, weight is a **force**. Mass, in English units, is expressed in a unit called the slug. (a) What is your mass, in slugs? [Note: Acceleration due to gravity at the Earth's surface is around 32 feet/sec^2.] Now consider Newton's universal law of gravity, and switch to metric units (1 slug = 14.6 kg). (b) What is your mass in kg? (c) What is your mass 1000 km above the Earth's surface? (The radius of the Earth is around 6400 km, and the mass of the Earth is around 6×10^{24} kg.) (d) What is your weight, in Newtons, at 1000 km above the Earth's surface? Note that 1 Newton (the metric unit of force) is the amount of force required to accelerate 1 kg by 1 m/sec^2.

Now you can figure out how much you would weigh on the moon. (e) What is your mass (in kg) on the moon? (f) Now find your weight (in Newtons) on the moon, using $M_{moon} = 7 \times 10^{22}$ kg and $r_{moon} = 1700$ km. (g) What would your weight be, in pounds, on the Moon?

Lastly, here are the same questions for Mars: (h) What would your weight be, in pounds and in Newtons, on Mars? The mass of Mars is around 6×10^{23} kg and its radius is around 3400 km.

2) The magnitude of the tides raised on the Earth by the Moon and by the Sun is proportional to m^2/r^6, where m is the mass of the other body and r is the distance to the other body. Which is greater, tides raised on the Earth by the Moon or by the Sun? How much bigger? Explain, using this information, the difference between neap and spring tides.

3) The planet Uranus has an unusual orientation: its rotation pole is in the ecliptic plane[1]. What are seasons like on Uranus? Feel free to draw some pictures in your answer. I am looking for a fairly complete discussion here (more like a paragraph than a sentence, though you shouldn't feel like this guideline is absolute). Additional fact if you feel like doing a calculation: Uranus' orbital distance from the Sun is around 19 AU, that is, you might discuss how long seasons last on Uranus.

4) It turns out that the mass of 1 **mole** of a substance is simply the *atomic weight*, expressed in grams. The *atomic weight* of an atom is the simply the number of protons plus the number of neutrons of that atom. Examples: one mole of hydrogen has a mass of 1 g; one mole of helium has a mass of 4 g (because the atomic weight of helium is 4: two protons and two neutrons, each of which has an atomic weight of 1).

The amount of energy released by metabolizing one mole of glucose ($C_6H_{12}O_6$) is 2870 kJ (a Joule (J) is the metric unit of energy; 1 J is equal to 1 Newton times 1 meter or 1 Newton meter or 1 kg m^2/sec^2; and 1 kiloJoule is equal to 1000 Joules).

To climb a set of stairs is to do **work** (in the technical, mechanical definition; vertical motion turns out to be

[1] The ecliptic plane is the plane in which the planets of the Solar System orbit.

the only part that matters, not horizontal distance). Work is defined this way: $W = F \times d$ where W is the amount of work done (units: Joules), F is the force (units: Newtons), and d is the distance (units: meters) over which the force is applied.

The US RDA (Recommended Dietary Allowance, published by the Food and Drug Administration) suggests that young, active, adult males and females require something like 2500 and 2000 calories, respectively, for their daily intakes (your mileage may vary, of course). These FDA/RDA calories are actually kilocalories by the scientific definition, and 1 calorie (really kilocalorie) is equal to 4.184 kJ or 4184 J.

What percentage of your RDA do you expend climbing the stairs to my office? You can assume that all your caloric intake for the day is in pure glucose, which is (probably) not true, but makes the problem easier. How many grams of glucose do you have to eat to power the climb to my office? How much of a candy bar is this?

Other information you might want to know: 1 slug is equal to 14.6 kg. I have given you a lot of different kinds of information here without a specific road map. I want to see how you take apart this problem. I suggest you start by writing down what you know and what you are trying to find, identify the steps you need to take, and proceed from there. I wouldn't waste too much time trying to find some magical formula that will solve this for you. Instead, try thinking about the problem, writing down what you know and what you are trying to find out, and attacking the problem one logical step at a time.