PROBLEM SET 1

Due 2:40pm Wednesday 16 July 2008

Astro/EPS C12 -- Mike Wong

Write your name at the top of your problem set solutions. Feel free to collaborate with other students to figure things out, but turn in your own unique, legible, handwritten solutions (DO NOT COPY). Showing your work is more important than having the right final answer. You will need information found in the C12 Data Sheet and the C12 Technical Supplement.

1. Surface gravity. 10 points + 1 point extra credit.

A. You've probably seen video clips of astronauts bounding across the lunar surface. In this problem, we'll calculate just how different the gravitational acceleration is there, and in some other exotic places.

To start, consider Newton's second law of motion, which says that force is equal to mass times acceleration: $F = m\,a$. If we're talking about the force of gravity, then the acceleration is the gravitational acceleration: $F = m\,g$. We earthlings are accustomed to $g = 9.8$ m s^{-1}, but to calculate g for other locations, use Newton's Law of Gravitation.

Because most of the objects below are not described in your C12 Data Sheet, I have filled values for the radius and mass of the Moon, Pluto, Ceres, and the fictional object Enchilladus to get you started. Please use these values to solve the problems below.

Location	Distance to center of planet/object (m)	Mass of planet/ object (kg)	Gravitational acceleration (m s^{-2})	(% of Earth surface gravity)
Surface of the Moon	1.74×10^{6}	7.35×10^{22}		
Surface of Pluto	1.18×10^{6} (p.75)	1.3×10^{22}		
Surface of Ceres	4.57×10^{5}	9.4×10^{20}		
Surface of Enchilladus	5.4×10^{5}	1.1×10^{21}		
International Space Station orbiting 350 km above Earth's surface				

B. Junior goes to the American doctor's office and is told that he "weighs" 150 pounds. Weight is actually a measure of gravitational force. Junior's mass is also 150 pounds, but mass is an intrinsic property of the object. If Junior were transported to Pluto, he would still have a mass of 150 pounds, but his weight would be much less.

What would Junior's weight be (in pounds) on Pluto's surface?

C. In the equation $F = m\,g$, valid at the Earth's surface, if weight (gravitational force) and mass are both expressed in pounds, then what is the value of the gravitational acceleration g?

D. In part A, you should have found that the gravitational acceleration at the location of the International Space Station is non-zero. However, space station astronauts experience a zero-gravity environment. Explain why, using a diagram if desired. (Part D is 1 point extra credit.)

2. **Density.** 10 points.

Density is an important material property that keeps popping up in planetary science. For this problem, imagine that a spacecraft encounters an imaginary satellite called Enchilladus. For this problem, you will need to understand density (p. 3 in the C12 Technical Supplement) and the formula for the volume of a sphere (p. 9, with $\pi \approx 3.14159$). As always, drawing a nice big picture will be helpful.

A. From imaging studies, the spacecraft determines that the radius of Enchilladus is 540 km. Based on the gravitational effect of Enchilladus on the trajectory of the spacecraft, scientists determine that the mass of Enchilladus is 1.1×10^{21} kg. What is the density of Enchilladus in kg/m^3? What is the density in g/cm^3?

B. A scientist claims that Enchilladus has a composition of iron + rock. Referring to the material densities given on page 3 of the C12 Technical Supplement, and based on the result you calculated for part A, would you say this scientist is correct? Why or why not?

C. Another scientist claims that Enchilladus has an inner rocky core, covered by a shell of ice. The scientist estimates that the ice shell has a thickness of 220 km. Would you say she is correct? If not, would you suggest that the ice shell is actually thicker or thinner than 220 km?