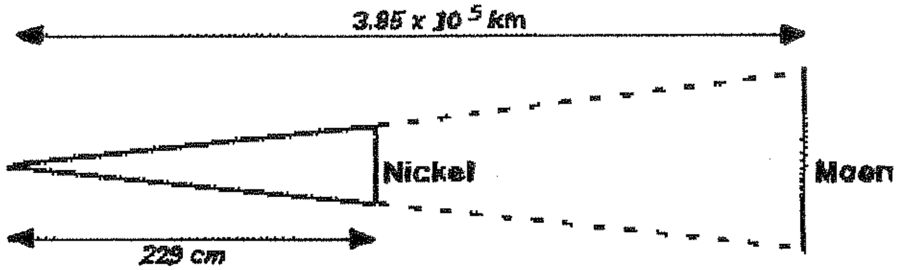
Earth 202 Problem Set 1

If you don't understand something on the problem set or if you find an error, e-mail Laura

1. (5 points) To determine the size of the moon, use the fact that it appears to be the same size as a nickel held 229 cm from the observer (this is called having the same *angular diameters).* If the moon is 3.85×10^5 *km* away, what is the *radius* of the moon? How does the moon compare in volume to the earth?



2. (5 points) The acceleration of gravity on the lunar surface is about 1/6 that on the earth's surface. Given the moon's radius from problem 1, find its mass and average mean density.

3. (3 points) Before actually working problem 2, you might be tempted to say that if the acceleration of gravity on the moon was 1/6 that on earth, its mean density is 1/6 that of earth. Why isn't this correct?

4. (3 points) A model often used for the moon is that it is made of (green) cheese. Test this model by comparing its density to a block of Monterey Jack with dimensions 3 cm x 12 cm x 7 cm and a mass of 255 grams.

5. (7 points) We saw in class that a body in earth's orbit has an orbital period which depends on its distance from the center of the earth. Communications satellites are often put in *synchronous orbit* - that is, with a period equal to one day so that they stay above the same point on the earth as the earth rotates. How large is the radius of this orbit? How high above the earth's *surface* is the satellite?

6. (4 points) Moment of inertia factors I/MR^2 (and other information) for the various planets can be found on the website *http://nssdc.gsfc.nasa.gov/planetary/planetfact.html* or on the class website *http://www.earth.northwestern.edu/people/seth/202* by clicking on the planet fact sheet, which is found underneath the problem set 1 link. Find the values for the Sun, Venus, Mars, the moon, Earth, and Jupiter. Put these in order from large to small and explain what they tell about the density distribution (the way that the density changes from the surface to the center of an object).

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C-1. (8 points) The moment of inertia ratio I/Ma^2 constrains a planet's density distribution. For a two-shell planet with radius a, a mantle of density ρ_m and a core of density ρ_c and radius r_c

$$I = \frac{8}{15}\pi\left[\rho_m a^5 + (\rho_c - \rho_m)r_c^5\right]$$

$$M = \frac{4\pi}{3}\left[\rho_m a^3 + (\rho_c - \rho_m)r_c^3\right]$$

a) Write a spreadsheet or program that takes as inputs a, ρ_m, ρ_c and r_c and computes r_c/a, I, M, and I/Ma^2. Hint: in Excel the symbol "^" is used to raise a quantity to a power.

b) Test this by setting $\rho_m = \rho_c$. What is I/Ma^2 and why?

c) Test this further by setting $\rho_c = 0$ and $r_c = 0.99a$. What is I/Ma^2 and why?

d) Derive a plausible two layer model for Mars, assuming $I/Ma^2 = 0.365$.