ASTR 101. Assignment 2. Oct. 2/2006

Due: Wednesday Oct. 11th/2006 at 5 PM, in your Hennings 312 lab slot (in corridor).
Late Penalty: -30% if in slot by 5 PM Oct. 12th, -50% by 5 PM Oct. 13th. Zero after.

Format: Normal lined 8.5x11" paper . Pages STAPLED or paper-clipped (-0.5 points if not!).
Upper right corner contains: Last name, First name and the student ID#.
Grading: Only 1 question of the 3 will be graded, determined randomly.

EXPLAIN YOUR REASONING in a few words in each case.

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1. **Roche stability.** Consider two boulders near a planet. The planet has mass M and each boulder has mass m and radius r. The two boulders touch along a line which comes from the planet to the boulders (one has a center that is thus $2r$ further from the planet than the inner one). Draw the diagram. The point of contact between the two boulders is a distance 'a' from the planet. Start by saying that an equilibrium will occur when the mutual gravitational pull of the two boulders together is equal to the DIFFERENCE of the gravitational pull of the planet on the two of them.
   a) Prove that the 'Roche limit' distance from the planet where these two forces balance obeys the relation $a^3 = 16Mr^3/m$. Pairs of boulders closer than 'a' are pulled apart by tidal effects. Note that you will have to use the approximation that $r \ll a$ at some point.
   b) Now assume that the density of the planet (D) and the density of the boulders (d) is uniform in each case (but D does not equal d). Produce an expression for the quantity (a/R) , where R is the radius of the planet, and make sure this expression contains ONLY constants and the densities. Evaluate this for the case of Saturn, where D=0.70 g/cc and d for ice is taken to be 1.0 g/cc. (1 cc = 1 cubic centimeter).

2. The Messenger mission to Mercury was launched Aug. 4, 2004. Although the trajectory actually involves a Venus gravity assist, assume that the interplanetary trajectory is a Hohman transfer ellipse with aphelion at 1.0 AU (Earth's orbit) and perihelion at the same distance from the Sun as Mercury's aphelion (see Appendix in text for Mercury's orbital parameters). Ignore Mercury's orbital inclination here. How long will it require for the journey assuming that Mercury is at its aphelion when the spacecraft arrives? Thus, what month and year would the spacecraft arrive (accurate to a month)? How many times will Mercury orbit the Sun during the period between Messenger leaving the Earth and arriving at the rendezvous?

3. A newspaper article claims that the wealthy Hollywood director Ima Helluvaguy (while looking through his private observatory's 75-cm diameter optical reflecting telescope at his mansion in northern California) has observed that the Apollo 17 lunar mission's lander (left on the surface of the Moon in the 1970s) has been struck by a meteoroid and broken into two roughly equal-sized 2m-diatmeter hunks which are lying about 10 m apart on the lunar surface. Provide a quantitative argument of why this claim is impossible. Then explain what instrumentation *would* be need to observe this.