ASTR430 Homework 1 (due 9/28/05)

1. Dimensional analysis.

   (a) Use dimensional analysis to derive the functional dependence of the pressure P exerted by a fluid of bulk density ρ moving at speed v.

   (b) Derive, look up in a textbook, or do a `google` search to find the true expression for this dynamic pressure.

2. Kepler's laws.

   (a) By using the geometrical properties of an ellipse, derive Kepler's third law in the form $P^2 = 4\pi^2 a^3/GM$. *Hint:* express the areal speed in terms of the angular momentum.

   (b) According to the Japan Aerospace Exploration Agency, the spacecraft Hayabusa (formerly MUSES-C) successfully entered a station-keeping heliocentric orbit 20 km from asteroid (25143) Itokawa on Sept. 12, 2005. Do a `google` search to get the latest data from the mission. What is the estimated mass of the asteroid? (You may need to do your own calculation.) What would Hayabusa's period be if the spacecraft were to enter into orbit at that distance?

3. Orbits.

   A comet is measured to have a speed relative to Earth of 20 km/s while it is still far away. The estimated impact parameter with Earth is $2R_\oplus$ at that distance. For the following calculations, neglect solar tides and other perturbations.

   (a) How fast will the comet be moving relative to Earth at encounter (in km/s)?

   (b) What will the actual close approach distance be at encounter (in units of $R_\oplus$)?

   (c) What would the impact parameter (in $R_\oplus$) at its observed distance need to be in order to just graze the Earth at encounter?

   (d) If the comet is actually 0.1 AU away and is a sphere of radius 1 km and bulk density 0.5 g/cc, how much energy would Dr. Evil have to deliver to the comet now in order for it to just graze the Earth at encounter? Express your answer in units equivalent to the energy released by the Hiroshima bomb.