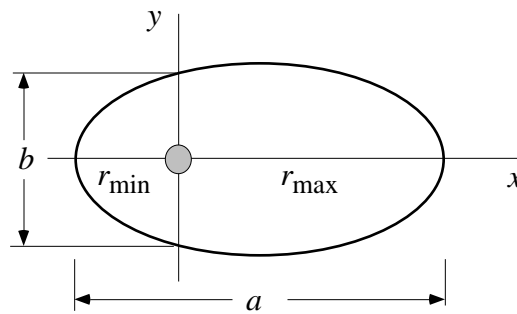


Physics 152
Problem Set #3
Due: Friday, February 6, 1998

1. Properties of Elliptical Orbits: A satellite of mass m is in an elliptical orbit about a body of mass $M \gg m$.

a.) Show that the major axis $a = r_{\max} + r_{\min}$ is related to the energy E by $a = (GMm)/(-E)$, where $E < 0$. (Hint: this is easier using the orbit equation in polar coordinates.)

b.) Show that the y -axis width b shown below is related to the angular momentum L by $b = 2L^2/m(GMm)$.



2. Circular and Elliptical Orbits: Tipler Ch. 10, Prob. 37.

3. Putting the Space Shuttle into Orbit: You are in charge of calculating how to put the Space Shuttle (mass $m = 1.2 \times 10^6$ kg) into an elliptical orbit around the earth. At apogee you want the shuttle to be 1,000 km above the earth's surface, and you want the eccentricity to be 0.06. The earth's radius is $R_e = 6,370$ km.

a.) To save on fuel weight, you want to launch the shuttle to as low an altitude (distance above the earth's surface) as possible. Find the minimum altitude the shuttle must reach and still be able to enter the desired orbit.

b.) After attaining this minimum altitude, the pilot fires the shuttle's maneuvering engines for a short time. What velocity (magnitude and direction) should the pilot reach before turning off the engines?

4. Gravitational Field of Two Masses: Tipler Ch. 10, Prob. 39.

5. Gravitational Potential Energy of the Earth: Treat the earth as spherical with uniform mass density (*i.e.* mass per unit volume) ρ , so that the total mass of the earth is $M = (4/3) \rho R^3$,

(continued on other side of paper)

where R is the earth's radius. Calculate the gravitational potential energy $U(r)$ due to the earth for a small test mass m located at any distance r from the center of the earth, including both inside the earth ($0 < r < R$) and outside the earth ($R < r < \infty$). Sketch this function $U(r)$ for distances from $r = 0$ to $r = 2R$. (Hint: use the results stated in lecture and proved in Tipler about the forces and fields outside and inside a hollow spherical shell and outside a solid sphere.)

