33-331 Physical Mechanics I. Fall Semester, 2009
Assignment No. 10
Due Friday, November 13

ANNOUNCEMENT: There will be an hour exam on Wednesday, Nov. 18 at 6:30 pm. It will be closed book and closed notes and no calculators. Bring a pencil or equivalent.

The exam will cover material from Sec. 7.5 through Sec. 7.12 in Ch. 7 of Thornton and Marion (we did not take up Sec. 7.13), and all of Ch. 8 with the exception of Sec. 8.9. The corresponding problem assignments are 7, 8, 9, and 10. Of course you are expected to know the material from earlier parts of the course, but it will not be the main focus.

READING Thornton and Marion Secs. 8.8 and 8.10. (We will not take up Sec. 8.9, apart from the definition of an apside.)

Excerpt from Physics Today on slingshot

Thornton and Marion Secs. 9.1 through 9.5

READING AHEAD:

Thornton and Marion Ch. 9.11; following that Secs. 9.6 through 9.10.

EXERCISES

1. Turn in at most one page, and not less than a third of a page, indicating what you have read, examples or exercises (apart from those assigned below) that you worked out, difficulties you encountered, questions that came to mind, etc.

2. Two stars with masses M_1 and $M_2 < M_1$ are circling each other in an elliptical orbit, where the ellipse describing $\vec{r} = \vec{r}_2 - \vec{r}_1$ has semimajor and semiminor axes a and b and eccentricity ϵ. In a coordinate system in which the center of mass is fixed at the origin each star is moving in its own elliptical orbit about the center of mass.

a) Describe the (real) elliptical orbits traced out by the two stars moving around the center of mass at the origin, including their semimajor and semiminor axes, and eccentricities. What about the focuses of these ellipses? What about the periods? You may find it helpful to make a sketch showing the two ellipses along with the imaginary orbit traced out by $\vec{r}$.

b) Relate the angular momentum and kinetic energy of each star, and their sum, to the corresponding quantities for an object with reduced mass μ traveling along the imaginary orbit traced out by $\vec{r}$.

3. For a hyperbolic orbit in the presence of a $1/r^2$ force, either attractive or repulsive, let r_m be the closest approach of the particle to the focus which is at the center of the symmetrical potential, v_m its speed at this point, and v_a the limiting speed as r tends to infinity. Find expressions for v_m/v_a in terms of the eccentricity ϵ of the orbit for both the attractive and repulsive cases using conservation of angular momentum, and checking that you get the same result by conservation of energy. (Or get the result using conservation of energy and check using angular momentum.) You may assume without further justification any of the formulas on the “Hyperbolic Orbits” handout. Discuss whether your results are reasonable in the sense that v_m/v_a is less than or greater than 1, and has the expected limit as ϵ goes to 1 or to infinity.

4. Thornton and Marion 8-35

5. Thornton and Marion 8-38. Assume a Hohmann transfer; calculate both the Δv at Earth radius and the one at Venus radius, and indicate their directions relative to the corresponding circular orbits on a sketch in which you show the orbits and indicate by arrows the directions of motion, as well as the directions of the Δv's.