AST 301
Homework #3
Due Friday Sep. 24

1. Newton's version of Kepler's 3rd law doesn't just apply to the planets orbiting the Sun. It also applies to moons orbiting a planet. If we use the year as the unit of time, the AU as the unit of distance, and the Sun's mass as the unit of mass, Kepler's 3rd law becomes:

$$P^2(\text{in years}) = a^3(\text{in AU})/M(\text{in solar masses}),$$

where P is the orbital period, a is the semimajor axis of the orbit, and M is the sum of the masses of the two objects.

a) Find a table in your book that gives the orbital periods and distances from Jupiter of the moons of Jupiter. Pick one of Jupiter's moons (say which one). Convert the moon's orbital period into years and its distance from Jupiter into AU and put them into this formula to calculate M, which is approximately the mass of Jupiter (in solar masses).

b) Multiply your answer to part a by the mass of the Sun to get the mass of Jupiter in kg. Compare your answer to the mass of Jupiter given in the book.

c) The mass in Newton's version of Kepler's 3rd law is actually the sum of the masses of the two bodies (the Sun plus a planet orbiting it, or Jupiter plus a moon). But your answer should have come out very close to the mass of Jupiter given in the book. Why didn't the mass of the moon matter?

2. Go to http://phet.colorado.edu. Choose Play with sims. On the left, choose Physics, then Motion. Choose My Solar System. Choose Run now.
For body 1 set the numbers at 100 0 0 0 0. For body 2 set them at 1 100 0 0 100.
Hit start. The planet should go in a circular orbit around the Sun. Hit Stop and Reset.

a) Change Position x for body 2 to 200. Try running again. You will find that the planet is going too fast and never comes back. Try a smaller value for Velocity y. Experiment with different velocities until you find one that results in a nearly circular orbit.
From your experiment, what can you conclude about how the speed of a planet in a circular orbit depends on its distance from the Sun? How about the square of the speed? Does it obey a simpler rule?

b) Measure the times to go around the orbit with Position x = 100 and your orbit with Position x = 200. Do your results obey Kepler's 3rd law?

c) While you were experimenting with different values of Velocity y, you should have seen some elliptical (non-circular) orbits. Did it look like Kepler's 2nd law was being obeyed?

d) Try changing some other Initial Settings, like the masses or other Positions or Velocities. Or try running with 3 bodies, with orbits of the planets that cross each other. Describe what you found.