**Motion Due to Gravity**

Although gravity is the weakest of the known forces, it dominates the Universe on large scales. The sub-atomic “strong” and “weak” forces work only over very small distances, and the electromagnetic force is weak because most mass in the Universe is electrically neutral. Understanding gravity is essential to understanding the Universe.

In the exploration, use the NAAP *Planetary Orbit Simulator* available from the University of Nebraska Lincoln at: <http://astro.unl.edu/naap/pos/animations/>.

**Part 1: Kepler’s First Law *-*** Launch the *Planetary Orbit Simulator* and play around a bit...

* Open the Kepler’s 1st Law tab if it is not already open (it opens by default)
* Enable all five check boxes (empty focus, center, semi-major axis, semi-minor axis, and radial lines)
* The white dot is the “simulated planet.” Click on it to drag it around the orbit.
* Change the size of the orbit with the semi-major axis slider. Note how the background grid indicates change in scale while the displayed orbit size remains the same (for this simulation, the size of the semi-major axis is limited to 50 AU).

**Tip:** You can change the value of a slider by clicking on the slider bar or by entering a number in the value box.

* Change the eccentricity and note how it affects the shape of the orbit (eccentricities are limited to be 0.7 or less, and the semi-major axis is always aligned horizontally, unlike real planets).
* Animate the simulated planet. You may need to increase the animation rate for very large orbits or decrease it for small ones.
* Compare the orbits of the planets of our solar system using the planet presets.

1. For what eccentricity is the secondary focus (which is usually empty) located at the sun? What is the shape of this orbit?
2. Create an orbit with a = 20 AU and e = 0. Drag the planet first to the far left of the ellipse and then to the far right. What are the values of r1 and r2 at these locations?
3. Create an orbit with a = 20 AU and e = 0.5. Drag the planet first to the far left of the ellipse and then to the far right. What are the values of r1 and r2 at these locations?
4. For the ellipse with a = 20 AU and e = 0.5, can you find a point in the orbit where r1 and r2 are equal? Sketch the ellipse, the location of this point, and r1 and r2 in the space below.
5. What is the value of the sum of r1 and r2 and how does it relate to the ellipse properties? Is this true for all ellipses?
6. Which preset object has the smallest eccentricity? How do the perihelion to aphelion distances compare for this planet? (Perihelion is the point where the planet is closest to the Sun; aphelion is the point furthest from the Sun).
7. Which preset object has the largest eccentricity? How do the perihelion and aphelion distances compare for this object?