**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 2: Kepler's Second Law***

* Use the “clear optional features” button to remove the 1st Law features.
* Click on the Kepler's 2nd Law tab
* Press the “start sweeping” button. Adjust the semi-major axis and animation rate so that the planet moves at a reasonable speed.
* Adjust the size of the sweep using the “adjust size” slider.
* Click and drag the sweep segment around. Note how the shape of the sweep segment changes, but the area does not.
* Add more sweeps. Erase all sweeps with the “erase sweeps” button.
* The “sweep continuously” check box will cause sweeps to be created continuously when sweeping. Test this option.

1. Erase all sweeps and create an ellipse with a = 1 AU and e = 0. Set the fractional sweep size to one-twelfth of the period and create a sweep segment. Drag the sweep segment around. Does its size or shape of the sweep segment change as it moves around the orbit? Why or why not?
2. Select the orbit preset for the planet Mercury. Where in its orbit does Mercury move the fastest? Where in its orbit does Mercury spend the most time?
3. Set the semi-major axis back to 1 AU and change the eccentricity to e = 0.5. Drag the sweep segment around and note that its size and shape change. Where is the sweep segment the “skinniest?” Where is it the “fattest?” Where is the planet when it is sweeping out each of these segments? What names do astronomers use for these positions?
4. What eccentricity in the simulator gives the greatest variation of sweep segment shape?
5. Halley’s comet has a semi-major axis of about 18.5 AU, a period of 76 years, and an eccentricity of about 0.97 (Halley’s orbit cannot be shown in this simulator but you can use the interactive comet animation at the website below to get closer).

<http://www.windows2universe.org/comets/comet_model_interactive.html>

The orbit of Halley’s Comet, the Earth’s Orbit, and the Sun are shown in the diagram below (not exactly to scale). Based upon what you know about Kepler’s 2nd Law, explain why we can only see the comet for about 6 months every orbit (76 years)?