AST101: Our Corner of the Universe
Lab 5: Kepler's Laws prelab

Name:

Student number (SUID):

Lab section:

1 Kepler's First Law

Kepler's first law of orbital motion says that planets orbit their stars in elliptical orbits, with the star at one focus of the ellipse.

Recall that in an ellipse the two foci lie along the major axis (long axis) of the ellipse. As the ellipse grows more eccentric the foci move closer to the edges; as the ellipse grows less eccentric the foci move closer together. A circle is a special case of an ellipse with both foci at the center.

In the space below, draw an elliptical orbit. Label the major axis, the minor axis, the position of the Sun, the perihelion (closest point to the Sun), and the aphelion (the furthest point from the Sun).

Is the orbit you have drawn more or less eccentric than that of Mars? More or less eccentric than that of Halley's comet?

2 Kepler's Second Law

Kepler's second law of orbital motion says that the line between the Sun and a planet (or other object!) orbiting the Sun sweeps out equal areas in equal times.

Suppose that a spacecraft is put in an orbit around the Sun whose major axis is twice as long as its minor axis, and that takes one year to go around the Sun. Draw this orbit and label the position of the Sun below.

On your orbit, label the following points:

- A: Perihelion
- B: The position of the spacecraft one month after perihelion
- C: Aphelion
- D: The position of the spacecraft one month after aphelion

At which point will the spacecraft be moving fastest?

3 Kepler's Third Law

Kepler's third law says that the orbital period (time it takes to go around the Sun) of a planet is proportional to the $3/2$ power of the length of its semimajor axis.

This means that if you multiply or divide the semimajor axis of a planet's orbit by x, its orbital period changes by a factor of $x^{3/2}$.

For orbits in the Solar System that are nearly circular, the length of the semimajor axis is essentially the distance from the Sun. So the Earth's orbit has a semimajor axis of 1 AU.

Suppose that another planet has a nearly-circular orbit that lies 4 AU from the Sun. How long does that planet take to orbit?

First, answer this question qualitatively. Is it:

- Less than $1/4$ year
- $1/4$ year
- Between $1/4$ year and 1 year
- Between 1 year and 4 years
- 4 years
- More than 4 years

Then, calculate an actual number.