**Gravity, Orbits and Kepler’s Laws**

**LEARNING OBJECTIVES**

* To learn how the shape and period of a planet orbiting a star depend on the mass of the star and the mass of the planet
* To learn how the shape of the orbit depends on the speed and orbital radius of the planet.
* To observe Kepler’s laws

**INTRODUCTION**

Planets or other objects orbiting a star are accelerating -- they are continually changing direction. The force that produces this acceleration is the gravitational attraction to the star. In this activity we will use a simulation to observe and learn about these orbits and relate them to Kepler’s laws.

**PROCEDURE**

Go to <http://phet.colorado.edu>, click on “play with sims,” then click “physics” and open the “Gravity and Orbits” simulation.

Use the “cartoon” tab. The settings on the right should be for Earth and Our Sun. Begin the activity with original values. Hit Reset if they’ve shifted. Click on: Gravity Force, Velocity, Path and Grid.

Follow all the procedures described below. Write answers on a separate sheet or enter your descriptions and answers directly below the questions using italics or bold.

Descriptions and answers must be *in complete sentences.*

**1.** Note that the blue force arrow on Earth is the same size as the blue force arrow on the Sun. Why is this so? What law(s) is (are) being illustrated?

**2.** Hit the start arrow and observe the path.

2a. Describe the shape of the orbit.

2b. Which of Kepler’s laws did this illustrate? (State the law – don’t simply give the number of the law.)

2c. Measure the time for one period of revolution. (You may have to practice stopping at “one period” and you may want to slow the Sim speed.)

**3.** Slide the “Planet” selector to the left. You will be maintaining the distance to the Sun but replacing Earth with a planet having a smaller mass.

3a. *Before hitting start,* what changes do you notice? Why do think things changed?

3b. Hit start and carefully observe the orbit and determine the period.

**RESET**

**4.** Slide the “Planet” selector to the right – maintaining the distance to the Sun but replacing Earth with a planet with a larger mass.

4a. *Before hitting start,* what changes do you notice? Why do think things changed? What law(s) is being illustrated?

4b. Hit start and carefully observe the orbit and determine the period.

4c.What do you learn from your measurements in parts 2,3 and 4?

**RESET**

Slide the “star” tab one notch to the right, thus replacing the Sun with a star of greater mass.

5a. *Before hitting start,* what changes do you notice?

* Why do think things changed?
* What law(s) is being illustrated?

5b. Hit start and carefully observe the orbit and determine the period.

5c. Carefully observe the speed (the length of the velocity arrow). Describe what you observe about the speed at different locations in the orbit. Which of Kepler’s laws did this illustrate? (State the law – don’t simply give the number of the law.)

5d. Carefully observe the force vector. Describe what you observe about the force at different locations in the orbit. Why do you think the force changes? Which of Newton’s laws did this illustrate?

In conclusion…

Summarize what you learned from this activity by:

1. listing the key scientific terms encountered in the activity.
2. constructing a bulleted list that utilizes these key words (and, as needed, words from previous activities) in summarizing what you learned.

**Additional Questions**

1. T/F explain your choice based on your observations in this activity: Earth is accelerating.
2. Earth exerts a gravitational force on the Sun and the Sun exerts a gravitational force on Earth.
3. Which exerts the larger force? Explain your choice.
4. Which has the greater acceleration? Explain your choice.

3. Imagine another solar system with a star of the same mass as the Sun. In this solar system there is a planet with a mass twice that of Earth orbiting at a distance of 1 AU from the star. What is the orbital period of that planet? Explain your answer *based on what you observed in this activity*.

4. T/F explain your choice based on your observations in this activity:

Doubling the mass of the Sun would have no effect on the period of Earth.

5. As a planet orbits the Sun in an ellipse, at what point on the ellipse is the Sun’s gravitational force on it greatest? Explain your reasoning. At what point is the acceleration the greatest? Explain.