Observing Planetary Motion

Directions: Write down the title and purpose. Discuss all of the questions with your group.

Purpose: What happens to the speed of an object when the body it is orbiting has a greater gravitational pull (greater mass)?

Procedures:

1. Make sure the lip of the hoop is facing up so that the marble will not fall off the latex sheet.
    a. Predict where will the marble go when you roll a marble (carefully down a ruler) onto the latex circle?

Figure 15.3 *The Planetary Motion Model™ should be set up as shown. (A) Face the lip of the hoop up. (B) Hang the extra sheeting under the hoop. (C) Place the hoop on the edge of each box.*

2. Hold the ruler (as shown in the picture) so that it faces the edge of the hoop. The ruler should be close to flat. Roll the marble 3 times onto the circle and observe the marble.
    b. How did the marble move?

3. Place the water balloon in the center of the sheet so that the top of the mouthpiece of the balloon is facing the ceiling.
    c. What happened to the balloon on the latex circle?

4. Roll a marble onto the latex (towards the edge of the hoop) again using the ruler as you did before. Watch the balloon and marble closely as it revolves around the balloon.
    d. Describe the path of the marble. *Think about how long it took the marble to revolve on the circle.*

5. Now gently push down on the balloon. While keeping the same amount of pressure on the balloon (don't push harder then softer), have one of your partners roll the marble onto the latex circle and repeat a couple more times.

    e. Describe the path of the marble. *Think about how long it took the marble to revolve on the latex circle until it reached the middle compared to how long the marble took before.*

    f. How does the motion (speed) of the marble change as the marble nears the balloon in the middle of the latex?

6. Now "wobble" (move back and forth while lightly pressing down) the balloon very gently as the marble orbits the balloon.

    g. What happened to the marble?

    h. What was the path of the marble like? *Think about how long it took for the marble to revolve.*

    i. Based on your observations from this inquiry, which planet do you think would have the fastest orbital speed?

    j. What evidence do you have to support your answer to question i? *Explain in detail.*

STARS WOBBLE

There are many stars like our Sun. Some of these other stars also may have planets that orbit them. Even though Earth-based astronomers may not have yet seen a planet orbiting another star, they know such orbiting planets exist. How do they know? Because when a planet orbits a star, it makes the star "wobble". Astronomers can examine a star's wobble and figure out how big, how massive, and how far away from its star the planet is. At the start of the new millennium, there were nearly 60 planets that had been discovered by using the "wobble" method.

It all begins with gravity. Because of gravity, the Sun pulls on the planets, but it also means that the planets pull on the Sun (moons and planets tug at each other too). An orbiting planet exerts a gravitational force that makes the star wobble in a tiny circular (or oval) path. The star's wobbly path mirrors in miniature the planet's orbit. It's like two twirling dancers tugging at each other in circles.

Scientists use powerful space-based telescopes that orbit Earth to look for wobbling stars. Since they are outside of Earth's atmosphere, these telescopes can see the stars more clearly than telescopes on Earth's surface. Who knows? Someday scientists may use the wobble method to discover another solar system just like ours.

Laws of Planetary Motion

German astronomer Johannes Kepler (1571-1630) created a simple, precise description of planetary motion using records from Tycho Brahe, a Danish astronomer who had recorded the positions of the stars and planets with unprecedented accuracy. Kepler stated that each planet moves around the Sun in an elliptical orbit. He also started that a planet moves slower when it is farthest from the Sun, and fastest when it is closest to the Sun.

Kepler observed that each planet moves in such a way that if an imaginary line were drawn between the Sun and a particular planet, the planet "sweeps out" equal areas in equal times. This means that no matter where a planet is in its orbit around the Sun, the area of its triangular "sweep" remains the same for the same interval of time. Therefore, when a planet or satellite travels in an elliptical orbit, its orbital velocity is fastest when it is closest to the body it is orbiting, since the distance the planet must "sweep out" or cover in a given time is greatest. Its orbital velocity is slowest when it is farthest from the body it is orbiting, since the distance the planet must cover in a given time is less.

The speed at which a planet travels in its orbit is called its orbital velocity. The amount of time required by a planet to complete one solar orbit is called its orbital period (or period of revolution). Both are affected by a planet's distance from the Sun.

Newton's Law of Universal Gravitation

Newton's law of universal gravitation states that every object in the Universe attracts every other object in the Universe. The more massive the object, the stronger the gravitational pull. For example, Jupiter is larger than the Earth, so Jupiter has more moons because it is able to attract (capture) and keep more moons orbiting itself. The strength of gravity also depends on the distance of the objects. If the distance is greater, then the force is weaker. The Sun pulls less on Saturn than it does on the Earth because Saturn is farther away from the Sun than the Earth.

Reading Questions:

k) How do we know that planets circle other stars?

l) Why do Stars wobble?

m) Why does the Sun pull less on Neptune than it does on Mercury?

Interactive Part of Inquiry 6.3
Observing Planetary Motion

Procedures:

4. Copy and paste the link: http://lasp.colorado.edu/education/outerplanets/orbit_simulator/
4. Click the "close" button in the middle of the screen.
4. Click on the "zoom out" button on the right side 8-9 times *(so you can see the entire Solar System).*

A. What do you notice about the speed of all the planets as they orbit the Sun?

B. Look at the comet with the blue orbit. What happens to the comet as it gets closer to the Sun?

C. Why do you think the speed of the comet increases as it gets closer to the Sun?

4. Use the data table at the bottom of the webpage and the "average distance" slider for Planet X (on the top right side of the webpage) to answer the following questions:

D. What pattern do you see with the planets Mercury through Neptune regarding their "average velocity"?

E. What pattern do you see in the "period" column with the planets Mercury through Neptune?

F. What 2 planets would you have to put "Planet X" between to get an average velocity of 11.9 km/s?

G. Answer the purpose question. *(What happens to the speed of an object when the body it is orbiting has a greater gravitational pull (greater mass)?*