**Inquiry 6.1**  
**Gravity’s effect on objects in motion**

**Directions:** Follow the procedures below. Write down the purpose, background information and answer any of the questions on your paper. Remember to include part of the question in all of your answers.

**Purpose:** How does gravity affect an object that is in motion?

**Background Info:**

- **Gravity:** a force that pulls objects towards each other and/or pulls all objects to the center of that object.
- **Law of Inertia:** Objects will not change their motion until an unbalanced force acts upon them.
- **Unbalanced forces:** a force that changes an object’s motion.

**Procedure:**

1. Hold the marble over the sand at height of 30 cm, with your fingers let it go.
   a. What happened to the marble?
2. Repeat step #1 for three more times.
   b. Did the marble fall the same way each time?
   c. What force is acting on the marble?
   d. If the sand were not there to stop the marble, what would the marble continue to do?
   e. Where would the marble eventually go if there were nothing underneath it?
   f. How does dropping the marble show the law of inertia?
3. Roll the marble gently down the center of the ruler (into the sand) at a low angle (nearly flat) so that it moves very slowly.
   g. Where does the marble go as it falls off the ruler? (Straight down or at an angle?)
4. Copy the data table below

<table>
<thead>
<tr>
<th>Speed</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Average distance marble traveled in centimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Slow</strong> (Just let it go)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Medium</strong> (Small finger flick)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>High</strong> (Strong finger flick)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5. Keep the ruler nearly flat and at the same angle for ALL trials. Mark a line directly under the edge of the ruler (like a starting line) in the sand. Let the marble go at the 30 cm mark of the ruler. Record the marble’s distance in the table using the measuring tape. Smooth out the surface of the sand after each of the 3 trials. Repeat these steps again but with a small flick of the marble from the 30 cm line and record the distance. Remember to try and use the same amount of force for all 3 trials and smooth out the surface after each trial. Repeat these steps a final time by flicking the marble stronger at the 30 cm line and record the distance.

h. How does the forward speed of the marble affect the motion of the marble once it leaves the ruler?

i. How much farther did the marble travel at the high-speed average from the low speed average?

6. All planets that orbit the Sun are traveling forward due to inertia and are pulled towards the Sun due to gravity.

j. Describe the path of something that has forward motion (like the marble) but is also being pulled down by gravity.

Why Don’t You Feel the Sun’s Gravity?

You don't feel the sun's gravity because you and the earth are both in orbit around the sun. Being in orbit means that you are accelerating into the sun the same way you would be accelerating in a free fall.

Say you have a small marble. If you drop the marble, it accelerates towards the ground due to the pull of the Earth's gravity. Now say you are in an elevator at the top floor of a tall building and the elevator cable snaps. Assuming no friction or air resistance, if you tried to drop the marble as you and the elevator are falling, the marble would seem to float weightlessly - i.e. you cannot feel the force of gravity since you, the marble and the elevator are all accelerating at the same rate. Similarly, if you are in space orbiting the sun and you drop the marble, you and the marble are accelerating towards the sun at the same rate and you will not feel the force of the sun's gravity.

Things get a little tricky because the force of gravity varies with distance, so in the case of the marble, the bottom of the marble will feel a stronger pull than the top of the marble. What if the marble were as big as the earth? The sun's pull is stronger on the near side and weaker on the far side. This difference (gradient) in gravitational pull is what is responsible for tides. It turns out that even though the moon's gravitational force on the earth is much smaller than the sun, it has a larger gravitational gradient) and therefore a bigger effect on the Earth's tides.

Reading Questions:

k. Which part of an object (like a marble) falling towards the Earth feels the strongest gravitational pull?

l. Why don’t most space satellites come crashing back to Earth (from Earth’s gravity) or just float away into space?
Interactive 6.1
Gravity’s effect on objects in motion

Procedures:
1. Copy down both data tables below.
2. Cut and paste the following link: http://www.physicsclassroom.com/Physics-Interactives/Vectors-and-Projectiles/Projectile-Simulator/Projectile-Simulator-Interactive
3. When you are on the correct website - click on the top left box (like the image below).
4. Use the website to fill in the table below. You will have to change the settings each time and then click “reset” to run each experiment.

<table>
<thead>
<tr>
<th>Height</th>
<th>Angle</th>
<th>Speed</th>
<th>Displacement (Distance in meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>0</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>0</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>0</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>0</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>0</td>
<td>60</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Height</th>
<th>Angle</th>
<th>Speed</th>
<th>Displacement (Distance in meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>0</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>0</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>0</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>0</td>
<td>60</td>
<td></td>
</tr>
</tbody>
</table>

Questions:
A. What do you notice about the distance the ball travels when speed (independent variable) is increased and decreased?
B. What do you notice about the distance the ball travels when height (independent variable) is increased and decreased?
C. If the speed and height remains the same (the control variables), how does changing the angle (the independent variable) affect the distance the ball travels (the dependent variable)?
D. Write a couple of sentences answering the purpose question Inquiry 6.1.
Inquiry 6.2
Testing Balanced and Unbalanced Forces

Directions: Follow the procedures below. Write down the purpose, background information and answer any of the questions on your paper. Remember to include part of the question in all of your answers.

Purpose: How is an unbalanced force different from a balanced force?

Background Info:

Inertia: Objects will not change their motion until an unbalanced force acts on them.

Balanced forces: Forces that are the same but pull or push in opposite directions. Balanced forces do not change the motion of an object.

Unbalanced forces: Forces that cause a change in the motion of an object.

Procedure:

1. Place the white paper in the bottom of the plastic box. Put the metal ring on top of the paper as if you were putting the metal ring onto a jar. Trace the outside of the ring onto the paper. Remove the metal ring from the paper. Mark 4 points at an equal distance around the circle. Number the places 1 to 4 going clockwise, like in the image on the right.

2. Place the metal ring on the circle as you did before. Now place the marble inside the metal ring. Without moving the metal ring, describe the motion of the marble.
   a. How is the marble moving right now? (Don’t over think your answer)

3. Now make the marble move in a clockwise circle (inside the ring). Keep the ring on the paper at all times. Record your observations:
   b. What is happening to the marble as you move the metal ring?
   c. How does the metal ring produce an unbalanced force that influences the marble’s motion?
   d. Why is the marble not moving to the sides of the plastic container?

4. Discuss as a group what would happen if you lifted the ring while the marble was moving inside. (This would be removing the unbalanced force.) Move the marble in clockwise circle again by lifting the ring.
   e. What happened to the marble?

5. While having the marble move in a clockwise circle, try to pick up the ring when the marble at mark #2. Record in Table A which mark # the marble actually left the hand drawn circle. Then draw the path of the marble (on the sheet of paper in the box) as it left the circle and hit the wall of the container. Discuss what you noticed about the path of the marble.
   g. Did the marble leave the circle exactly at number 2?

<table>
<thead>
<tr>
<th>Table A</th>
<th>Number the marble left the circle at</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
6. Discuss what you noticed about the path of the marble.

7. Just like the marble, the planets move forward due to inertia and inward due to an unbalanced force. Together, these forces cause the planets’ paths to curve.

   h. What is the unbalanced force that keeps the planets in orbit?
   i. What would happen to the planets without this unbalanced force?
   j. What evidence do you have to support your answer to question h above?

**Orbital Motion**

How does gravity affect orbital motion in the solar system? The Sun’s gravity continuously pulls the planets toward the Sun. But the planets also have a natural tendency to move forward in their orbits at a constant speed and in a straight line until acted upon by an outside force. These two motions – forward motion and motion toward the Sun under the influence of gravity – keep the planets traveling in curved paths in elliptical (oval shaped) orbits around the Sun. If the gravitational force pulling on a planet is bigger, in addition to the planet’s tendency to continue moving forward, then its orbital velocity will be bigger too. Without the Sun’s gravity, all objects in the solar system would move a straight line into outer space.

All planets orbit the Sun in a counterclockwise direction (as seen from Earth’s North Pole) with those planets closest to the Sun traveling the shortest distance. Because the planets and the Sun originally were formed from the same rotating disk of dust and gas, it is logical that the counterclockwise direction of planetary revolution coincides with the Sun’s counterclockwise rotation. Most of the planets rotate in a counterclockwise direction as well. Venus is an exception because it is tilted nearly 180˚ on its axis. This means that from the Earth’s North Pole, Venus appears to rotate in a clockwise, or retrograde, direction.

**Unbalanced Forces Defined**

Unbalanced forces are forces that cause a change in the motion of an object. Any push or pull is a force. A force can do three things to an object: cause an object to start moving, stop moving or change direction. To describe a force, you must know two things. You must know the size of the force and the direction of the force. Suppose two teams are playing tug of war. Each team is pulling with equal force, but in opposite directions. Neither team can make the other team move. Forces that are equal in size but opposite in direction are called balanced forces.

Balanced forces do not cause a change in motion. When balanced forces act on an object at rest, the object will not move. If you push against a wall, the wall pushes back with an equal but opposite force. Neither you nor the wall will move. Forces that cause a change in the motion of an object are unbalanced forces. Unbalanced forces are not equal and opposite. Suppose that one of the teams in tug of war pulls harder than the other team. The forces would no longer be equal. One team would be able to pull the other team in the direction of the larger force.

**Force and Motion**

More than one force can act on an object at the same time. If you hold a paper clip near a magnet, you, the magnet and gravity all exert forces on the paper clip. The combination of all the forces acting on an object is the net force. When more than one force is acting on an object, the net force determines the motion of the object. In this example, the paper clip is not moving, so the net force is zero.
How do forces combine to form the “net force”? If the forces are in the same direction, they add up together to form the net force. Suppose you and a friend are asked to move a piano for the music teacher. To do this, you pull on one end of the piano, and your friend pushes on the other end. Together, your forces add up to enough force to move the piano. This is because your forces are in the same direction. Because the forces are in the same direction, they can be added together to determine the net force.

If two forces are in opposite directions, then the net force is the difference between the two forces, and it is in the direction of the larger force. Consider two dogs playing tug of war with a short piece of rope. Each is exerting a force, but in opposite directions. Notice that the dog on the left is pulling with a force of 10 N, and the dog on the right is pulling with a force of 12 N. Because the forces are in opposite directions, the net force is determined by subtracting the smaller force from the larger one. In this case, the net force is 2 N in the direction of the dog on the right. Give that dog a treat!

Unbalanced Forces in Action

Unbalanced forces can change the motion of an object in two ways. When unbalanced forces act on an object at rest, the object will move. Unbalanced forces are necessary to cause a non-moving object to start moving. Second, when unbalanced forces act on a moving object, the velocity of the object will change. Remember that a change in velocity means a change in speed, direction, or both speed and direction.

For example, consider a soccer game. The soccer ball is already moving when it is passed from one player to another. When the ball reaches the second player, the player exerts an unbalanced force - a kick - on the ball. After the kick, the ball moves in a new direction and with a new speed.

Reading Questions:

i. Describe a “balanced force” and give an example of one?

ii. Describe an “unbalanced force” and give an example of one?

iii. What is the definition of “force”?

iv. List 3 things that a force can do to an object?
Interactive 6.2
Testing Balanced and Unbalanced Forces

Procedures:


2) Click on “net forces”

3) In the upper right hand corner of the screen, put a check in the boxes for both “sum of forces” and “values” before having each tug-of-war challenge. Make sure to record your answers in the table.

<table>
<thead>
<tr>
<th>Left Force (blue emos)</th>
<th>Right force (red emos)</th>
<th>Sum of the forces</th>
<th>Type of force: Balanced or unbalanced?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 large blue</td>
<td>1 large red</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 large blue + 1 small blue</td>
<td>2 small reds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 medium blue</td>
<td>2 small reds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 large blue + 1 med. blue</td>
<td>2 small reds + 1 med. red</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Questions:

A. If Mr. Kusibab pushes on a chair with a force of 10 N and Mr. Ragaller pushes the chair in the opposite direction with a force of 3 N, then which direction will the chair move?

B. If Mr. Glennon and Mr. Ragaller push a chair in the same direction, each with force of 6 N, and Mr. Kusibab pushes the chair in the opposite direction with a force of 10 N, which way will the chair move?

C. Write a couple of sentences answering the purpose question for Inquiry 6.2.

*(Hint: What are the differences between a balanced and an unbalanced force?)*
Inquiry 6.3
Observing Planetary Motion

Directions: Follow the procedures below. Write down the purpose and answer any of the questions on your paper. Remember to include part of the question in all of your answers.

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

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?

2. Hold the ruler (as shown in the picture) so that it faces the edge of the hoop. Roll the marble 3 times onto the circle and observe the marble.
   b. What happened to the marble?

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.
   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. Write a couple of sentences answering the purpose question to Inquiry 6.3.
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?
Inquiry 6.4
Investigating the Effect of Planetary Mass on Moon’s Orbit

Directions: Follow the procedures below. Write down the purpose and answer any of the questions on your paper. Remember to include part of the question in all of your answers.

Purpose: How does a planet’s gravitational force affect a moon’s orbital speed?

Procedures:
1. Carefully examine the Moon Orbiter. Briefly discuss how you think the orbiter works.
2. Make sure no one is within an arms length of you before twirling. Do not add any washers yet. Let every member practice using the Moon Orbiter for about 5 seconds by holding the narrow plastic tube in your hand like as shown. Slowly begin moving your hand in small circles to get the white sphere to orbit over your hand by using a steady and regular motion. When the sphere is in full orbit, the bottom of the tube should barely touch the cylinder (see image at right).
3. Copy the data table below:

<table>
<thead>
<tr>
<th>Trial</th>
<th>Time in seconds of 10 orbits for 5 washers</th>
<th>Orbital Period (Divide time by 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Now increase the mass of the Moon orbiter (independent variable) by adding five washers to the cylinder. Move your hand in circles over your head to get the white sphere orbiting your head as done before (a control variable). Make sure it moving smoothly over your head before timing.

5. Use a stopwatch to record the time it takes the sphere to orbit your hand with a mass of 5 washers “pulling” on it 10 times around. Record your answers on your data table.

6. Copy the second data table:

<table>
<thead>
<tr>
<th>Trial</th>
<th>Time in seconds of 10 orbits for 25 washers</th>
<th>Orbital Period (Divide time by 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. Discuss what would happen if you increased the mass of the Moon Orbit's cylinder to 25 washers? If I increased the mass of the orbiter then I think.... Don’t try it until everyone has made a guess.
8. Fill the cylinder of the Moon Orbiter with **25 washers**. Repeat procedures 3 - 4. Let everyone in your group have a turn. Discuss how fast the sphere had to move to stay in orbit over your hand and head.

9. Use the table below to answer the following questions:

<table>
<thead>
<tr>
<th>Solar system Body</th>
<th>Approximate Mass (kg)</th>
<th>Diameter (km)</th>
<th>Distance from the planet (km)</th>
<th>Orbital speed (km/sec)</th>
<th>Orbital Period (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jupiter</td>
<td>189,000 x 10^{22}</td>
<td>142,984</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earth</td>
<td>597 x 10^{22}</td>
<td>12,756</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Io</td>
<td>9 x 10^{22}</td>
<td>3643</td>
<td>421,600</td>
<td>17</td>
<td>About 2 days</td>
</tr>
<tr>
<td>Moon</td>
<td>7 x 10^{22}</td>
<td>3475</td>
<td>384,400</td>
<td>1</td>
<td>About 27 days</td>
</tr>
</tbody>
</table>

a. Which has more mass – Earth or Jupiter?
b. Comparing Jupiter’s moon “Io” with Earth’s Moon - how are they alike?
c. Comparing Jupiter’s moon “Io” with Earth’s Moon - how are they different?
d. Given the results from this inquiry, why do you think that one moon orbits faster than the other?
e. Orbital period is the time it takes a revolving object to orbit a central object. Which planetary satellite has a shorter orbital period?
g. Explain the relationship between orbital speed and orbital period.

**Gravity and Planetary Motion**

Newton’s laws provide an explanation for the motions of planets around the Sun and of moons around planets. A simple analogy of how gravity controls the motion of a moon around a planet is demonstrated during this inquiry when you twirled a sphere at the end of a string. According to Newton’s First Law of Motion, the natural motion of an object (such as the sphere) is to move at a constant speed in a straight line. However, the sphere twirled on the end of a string travels in a circular path, which indicates that there is an outside force holding the sphere in a circular orbit and is directed toward the center of the orbit. As the sphere moves in its circular path, it moves with constant speed but constantly changes the direction of its motion. (Remember that an object whose direction of motion is changing is accelerating.) Similarly, a moon moves in a nearly circular orbit around a planet because there is a force that pulls it toward the center of its orbit. That force is the gravitational pull of the planet at the center of the moon’s orbit.

During this inquiry, you changed the mass of the central force pulling on the sphere by adding washers to the cylinder. The more mass added to the cylinder, the faster the sphere must move to remain in orbit. This is in accordance with Newton’s Second Law of Motion, which states that a moon will have greater accelerations (greater speed or direction) when it orbits a planet with greater gravitational force. Greater acceleration requires greater speeds to keep the moons from falling into the planets. An example of this idea is the moon “Io”, which is nearly identical in mass, diameter, and distance to Jupiter as our Moon is from Earth. Io, however, travels faster in its orbit around Jupiter than our Moon orbits Earth because Io orbits a more massive (bigger) planet. Scientists can also use the orbital speed of a satellite or moon as an indicator of the gravitational force exerted upon the Moon. Therefore, a moon’s orbital speed serves as an indicator of the mass of the planet exerting the gravitational force.
Interactive 6.4
Investigating the Effect of Planetary Mass on Moon’s Orbit

Procedures:

1. Copy and paste the link below:
   
   [http://highered.mheducation.com/olcweb/cgi/pluginpop.cgi?it=swf::800::600::/sites/dl/free/0072482621/78778/Orbital_Nav.swf::Orbital%20Velocity%20Interactive](http://highered.mheducation.com/olcweb/cgi/pluginpop.cgi?it=swf::800::600::/sites/dl/free/0072482621/78778/Orbital_Nav.swf::Orbital%20Velocity%20Interactive)

2. Increase the mass of the Sun by sliding the “Star Mass” from 1 to 4.
   
   A. What happened to the orbital speed of the Earth when it was at 1 AU?

3. Move the “Orbit Radius” slider to 1.6 AU and the “Star Mass” slider back to 1.

4. Observe the orbital speed of the Earth.

5. Now increase the “Star Mass” slider from 1 to 4 while leaving the Orbit Radius at 1.6 AU.

   B. What happened to the orbital speed of the Earth this time?

6. Now decrease the Orbit Radius slider to 0.3 AU.

   C. What happened to the orbital speed of the Earth this time?

7. Now increase the Orbit Radius slider back to its normal 1AU position.

   D. What trend or pattern do you observe when increasing the mass of the center object (like our star called the Sun) that something (like our Earth) revolves around?

7. Write a couple of sentences answering the purpose question to Inquiry 6.4.