Investigating the Effect of Planetary Mass on Moon's Orbit

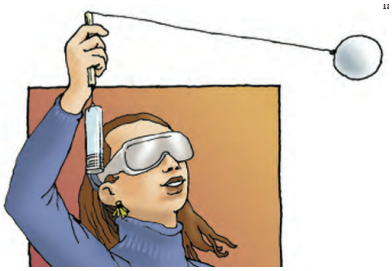
Directions: Write down the title and purpose of this lab. Discuss all the questions with your group.

Purpose: How does a planet's gravitational force (mass) affect a moon's orbital speed around it?

Procedures:

A. Carefully examine the Moon Orbiter. Briefly discuss how you think the orbiter works.

B. **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).



C. Copy the data table below:

Trial	Time in seconds for 5 washers (small mass)	Orbital Period (Divide time by 10)
1		
2		
3		
Ave		

D. Now increase the mass of the Moon orbiter 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. Make sure the moon moving smoothly over your head before timing.

E. 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.

F. Copy the second data table:

Trial	Time in seconds for 25 washers (larger mass)	Orbital Period (Divide time by 10)
1		
2		
3		
Ave		

Solar system Body	Approximate Mass (kg)	Diameter (km)	Distance from the planet (km)	Orbital speed (km/sec)	Orbital Period (days)
Jupiter	$189{,}000 \times 10^{22}$	142,984			
Earth	597×10^{22}	12,756			
Io	9×10^{22}	3643	421,600	17	About 2 days
Moon	7×10^{22}	3475	384,400	1	About 27 days

G. 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.

Use the table above to answer the following questions

1) Which has more mass – Earth or Jupiter?
2) Comparing Jupiter's moon "Io" with Earth's Moon - how are they alike?
3) Comparing Jupiter's moon "Io" with Earth's Moon - how are they different?
4) Comparing Io and the Moon, which planetary satellite travels faster (has a greater orbital speed)?
5) How do you know it travels faster?
6) Given the results from this inquiry, why do you think that one moon orbits faster than the other?
7) Orbital period is the time it takes a revolving object to orbit a central object. Which planetary satellite has a shorter orbital period?
8) 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.

Investigating the Effect of Planetary Mass on Moon's Orbit

Procedures:

A. 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

B. Increase the mass of the Sun by sliding the "Star Mass" from 1 to 4.

1) What happened to the orbital speed of the Earth as you moved Star mass from 1 to 4?

C. Move the "Orbit Radius" slider to 1.6 AU and the "Star Mass" slider back to 1.

D. What happened to the orbital speed as you changed the orbital radius from 1.6 to 1.

E. Now increase the "Star Mass" slider from 1 to 4 while leaving the Orbit Radius at 1.6 AU.

2) What happened to the orbital speed of the Earth this time?

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

3) What happened to the orbital speed of the Earth this time?

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

4) 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?

5) Answer the purpose question of this inquiry *(How does a planet's gravitational force (mass) affect a moon's orbital speed around it?).*