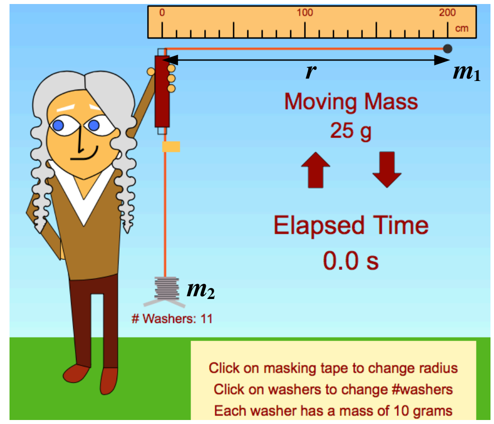
Centripetal Force Simulation

PURPOSE

To calculate the centripetal force acting on a mass moving in uniform circular motion.

PROCEDURE (PART A)



1. Go to physicsaviary.com and click on the Labs menu and then look for Classic Circular Force Lab. (Or just google "classic circular force lab" and it should be the first hit.)

2. This is truly a classic lab invented decades ago using common classroom or household materials. The moving mass, m_1, is varied by clicking the up/down arrows. The hanging mass, m_2, is varied by clicking the # Washers. (Each washer is 10 grams). Radius, r, is varied by clicking the masking tape below the tube held by the person's hand.

3. Refresh the web page, click Begin so the number of washers is 10, the moving mass is 25 g, and the radius is 200 cm.

4 The "Elapsed Time" is the stopwatch. You'll be timing 10 revolutions for the moving mass, m_1.

5. Click "Start" to measure and then record the time for the Moving Mass to go through 10 revolutions. Do this *carefully* four times, discarding any obvious outliers.

DATA

Moving mass, m_1: ________ kg Hanging mass, m_2: ________ kg Radius, r: ________ m

Time for 10 revolutions (s)				

Average time for 10 revolutions: ___________ Period, T: ___________

CALCULATIONS (Show all work)

1. Calculate the weight of the hanging mass, F_{g2}.

2. The weight you calculated in the last question equals the centripetal force on the moving mass because the tension in the string is acting equally on both masses. With the force F_c, the radius, r, and the period, T, solve for the experimental moving mass, m_1, using the equation:

$$F_c = \frac{4\pi^2 m_1 r}{T^2}$$

3. Calculate the percent error between experimental moving mass you found in the last step and the known moving mass of 25 g.

PROCEDURE (PART B)

1. Set new values for the hanging mass and moving mass. Any values are ok. Record below.
2. Set a new value for the radius. This can be finicky, but if you click a few times on the yellow masking tape below the tube held by the person's hand you can get the small black dot that represents the moving mass to align with one of the ruler markings. Be patient!

Moving mass, m_1: ________ kg Hanging mass, m_2: ________ kg Radius, r: ________ m

Time for 10 revolutions (s)				

Average time for 10 revolutions: ___________ Period, T: ___________

CALCULATIONS (Show all work)

1. Calculate the weight of the hanging mass, F_{g2}.
2. The weight you calculated in the last question equals the centripetal force on the moving mass because the tension in the string is acting equally on both masses. With the force F_c, the radius, r, and the period, T, solve for the experimental moving mass, m_1, using the equation:
3. Calculate the percent error between experimental moving mass you found in the last step and the known moving mass you recorded above.

QUESTIONS

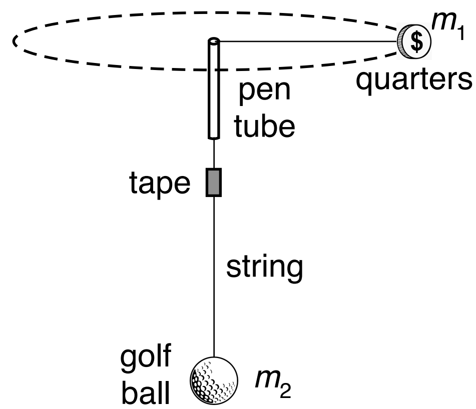
1. If the radius of the string is increased, (and nothing else changed) would the period of the rubber stopper increase, decrease, or stay the same? (Rearrange the F_c equation to get r in terms of T.)
2. Using your answer to the last questions, how would the period of a planet depend on its orbital distance from a star? In this comparison, m_2 is the star, and m_1 is a planet.

DIY Centripetal Force Kit Lab

PURPOSE

To use the ideas of uniform circular motion to calculate the centripetal force acting on a rubber stopper moving in a circle using the equation $F_c = \dfrac{4\pi^2 m_1 r}{T^2}$

DIY – MAKE YOUR OWN LAB KIT



1. You will need the following household items:
   - a golf ball (ask a neighbor if you don't have one)
   - two quarters (coins)
   - a ball point pen
   - sewing thread (or very thing string)
   - masking tape (or other tape)
   - a ruler or measuring tape
   - cell phone for stopwatch timer

2. Take apart the ball point pen by pulling on the plastic tip with a pliers. Then use a butter knife to pry the cap off the other end. You will use the outer pen tube only for the lab. (Don't use the inner tube with the ink!)

3. Cut about 5 feet (1.5 meters) of thread (*thick thread* is best).

4. Push the thread through tube. This can be a bit tricky – it might help to moisten the thread a bit Wrap one end of the thread around two quarters and then use about 4 inches of masking tape to secure the thread to the quarters. Quarters are 5.67 grams of mass each (don't use older silver quarters…they are more massive) and assume the 4 inches of tape is 0.25 gram of tape. **This is m_1.**

5. Loop the other end of the thread around the golf ball a couple of times. Then wrap 8 inches of tape around the golf ball and thread so that the thread will not come off the golf ball. Golf balls are about 46 grams, and assume you have used 0.5 gram of tape. **This is m_2.**

6. You have made your Centripetal Force Kit! Practice swinging the quarters into in a horizontal circle around the tube, while the golf ball hangs downward, as show in the diagram. It takes some practice to learn how to swing the quarters by slightly moving the pen tube in a tiny circle. Try watching YouTube video for help.

7. Once you are comfortable using the Centripetal Force Kit, you need to establish a fixed radius and measure it *carefully*. First, notice about how much thread is hanging below the tube, and how much is going around in circular motion. Place a piece of tape on the thread a little below the bottom of the tube and secure the tape by pressing on it firmly.

8. Now, again practice swinging the Centripetal Force Kit into motion and see if you have placed the tape in a good spot for making the motion. **Do not let the tape get pulled up into the tube. Instead, have the tape about one tape height below the tube for a good reference point.**

9. Carefully measure and record the radius from the edge of the pen tube to the center of the quarters. Usually about 70 cm radius works pretty well, but it can vary a bit.

10. Have a lab partner use a cell phone stopwatch to measure the time for the quarters to go through 10 revolutions. Do this *carefully* four times, discarding any obvious outliers.

DATA & ANALYSIS (Show all work)

Quarters mass, m_1: ________ kg golf ball mass, m_2: ________ kg radius, r: ________ m

Time for 10 revolutions (s)				

Average time for 10 revolutions: ___________ Period, T: ___________

1. Calculate the weight of the golf ball mass, F_{g2}.

2. The weight you calculated in the last question equals the centripetal force on the quarters mass because the tension in the thread is acting equally on both masses. With the force F_c, the radius, r, and the period, T, solve for the experimental moving mass, m_1, using the equation:

$$F_c = \frac{4\pi^2 m_1 r}{T^2}$$

3. Calculate the percent error between experimental quarters mass you found in the last step and the known quarters/tape mass. Careful with units since the mass is in kg from the last step.

Predicted (Exp) Mass: ________ Actual (Known) Mass, m_1: _______ Percent Error: _______

QUESTIONS & CALCULATIONS

1. If the radius of the thread is increased, would the period of the rubber stopper increase, decrease, or stay the same? (Assume that the mass m_2 is not changed).

2. Using your answer to the last questions, how would the period of a planet depend on its orbital distance from a star? In this comparison, m_1 is the star, and m_2 is a planet.