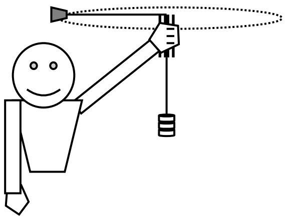
Circular Motion Lab



Name______________________________**Period** _______

Lab Partners: _______________________

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Purpose: To demonstrate the relationship between centripetal force and other forces.

Discussion: We have been studying circular motion and have talked about what causes circular motion. Our discussion led us to the conclusion that centripetal forces (forces that redirect an object so that it will turn continuously and end up in circular motion) are really other forces such as normal force, gravity, tension in a cord, or friction.

We will be exploring this idea in this lab by comparing the centripetal force $\mathbf{F_c}$ that we find acting on a horizontally revolving stopper to the string tension $\mathbf{F_T}$ that we suspect is the source of that centripetal force. Since we will be using a measured weight $\mathbf{F_g}$ to cause the string tension, we are expecting that the weight will be equal to the centripetal force.

$$\mathbf{F_c = F_T = F_g}$$

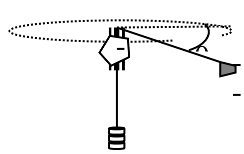
Since the tension is equal to both $\mathbf{F_g}$ and $\mathbf{F_c}$ **,** we can set $\mathbf{F_g}$ and $\mathbf{F_c}$ directly equal to each other.

$$\mathbf{F_c = F_g}$$

$$\mathbf{\frac{mv^2}{R} = Mg}$$

<u>It is important to note that the masses cannot be cancelled because they are different</u>. The **m** of the centripetal force $\mathbf{F_c}$ side is the mass of the whirling stopper, while the **M** of the weight $\mathbf{F_g}$ side is the mass hanging from the cord that causes the tension in the cord.

It is also important to note that the radius **R** will not be exactly the same as the length of string from the stopper to the top of the tube. Gravity will pull the stopper slightly down at an angle θ from horizontal, so that the radius will be the horizontal component of the string length.



The measurements that need to be taken are those that will allow us to calculate the centripetal force side (**$m_{stopper}$, v,** and **R**), and the measurement that will allow us to calculate the tension-causing weight (**$M_{hanging}$**). The velocity of the revolving stopper can be found by measuring the period for its revolution and the radius of its revolution and using $\mathbf{v = \frac{2\pi R}{T}}$

Testable Question: Will the hanging weight $\mathbf{F_g}$ be equal to the calculated centripetal force $\mathbf{F_c}$ **?**

Hypothesis: ____

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Materials: gram scale, set of masses or washers, string, paper clip, rubber stopper, tube, protractor, meter stick, stopwatch

Procedure:

1. Measure the mass of the stopper and convert this mass to kilograms

2. For each trial **measure**:
   - the mass that you are hanging off the end of the string in kilograms
   - the time it takes to swing the stopper in 10 complete circles at a constant radius (this will be divided by 10 to obtain the period **T** of the swing)
   - the angle **θ** from horizontal that the string swings ***(best done while viewing the revolving stopper from a distance while holding up the protractor)***
   - the length (in meters) of the string for each particular swing (this will be done at the end of each 10 swings by placing your finger over the top of the tube to pinch the string against that edge as you complete the swings. You will measure the length from the center of the stopper to the top of the tube.

3. Convert all gram measurements to kilograms, and all centimeter measurements to meters.

4. For each trial **calculate**:
   - The weight $\mathbf{F_g}$ of the hanging mass, paper clip and string
   - the period **T** of the swings
   - the radius **R** of the swing as a component of the length of the string
   - the speed **v** of the stopper
   - the centripetal force $\mathbf{F_c}$ acting on the stopper
   - the percent difference between $\mathbf{F_g}$ and $\mathbf{F_c}$

5. Answer the questions at the end of the lab, **making sure that each lab group member chooses a different source of error to analyze.**

Data: mass of stopper (g) ____________ mass of stopper (kg) _____________

Trial	Hanging Mass **M** (kg)	Hanging Weight $\mathbf{F_g}$ (N)	**t** (sec) for 10 swings	Period **T** (sec)	Length of string **L** (m)	Radius **R** (m)	Speed **v** (m/s)	$\mathbf{F_c}$ (N)	% Diff of $\mathbf{F_g}$ and $\mathbf{F_c}$

Sample Calculations:

Quantity Calculated	**Formula Used**	**Substitution**	**Solution With Units**
g to **kg**			
cm to **m**			
t to **T**			
R from **L**			
v			
$\mathbf{F_g}$			
$\mathbf{F_c}$			
% Difference $\mathbf{F_g}$ and $\mathbf{F_c}$			

Questions:

1. What are three experimental factors that might have contributed to the percent difference between $\mathbf{F_g}$ and $\mathbf{F_c}$?

   a. ____

   b. ____

   c. ____

2. Explain the effect of one of the three factors you listed above, making sure to :

- Describe exactly what the error may have been
- Estimate and state a reasonable amount of error for the factor
- **quantitatively** demonstrate the effect a reasonable amount of change in that factor would have caused,
    - showing the before and after calculations for a particular trial
    - showing the effect in terms of how much the percent difference between $\mathbf{F_g}$ and $\mathbf{F_c}$ would *change*.
- Diagram the error if appropriate