LECTURE 3. CENTIPETAL FORCES

1. Purpose:

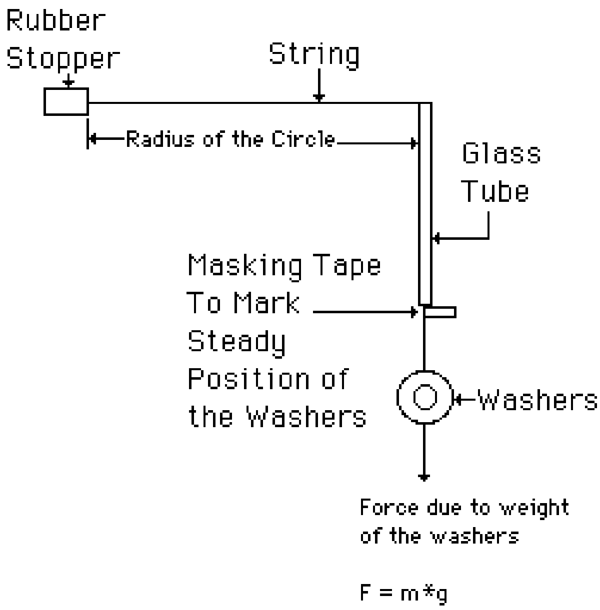
- To study the nature of Centripetal Force
- To measure the relationship between Centripetal Force, mass, and velocity.

2. Equipment

- 4 Rubber stoppers (size 6, 8, 11.5, and 13)
- 1 Hollow tube
- 1 Plastic ties
- 1 Yellow string
- Masses hanger
- 1 meter stick.
- 1 Weight set

3. Background

The rubber stopper that will be swinging around in a circle for this lab travels a distance equal to the circumference of a circle. Because the rubber stopper will be traveling more than once around the circle, the total distance will be equal to the number or revolutions times the circumference. The "velocity" of the stopper is calculated then as the distance divided by the time:



$$V = \frac{(2 * \pi * r)(N)}{t}$$

Equation 1

Where V = Velocity, r = radius (see diagram), N = Number of revolutions counted in 60 seconds, t = 60 seconds (length of one trial).

The **experimental** centripetal force (F_c) of the **rubber stopper** swinging around is calculated by using:

$$F_c = \frac{m_s V^2}{r} = \frac{m_s}{r}\left(\frac{(2 * \pi * r)(N)}{t}\right)^2 = \frac{m_s * 4 * \pi^2 * r * N^2}{t^2} \qquad \text{Equation 2}$$

where m_s is the mass of the **rubber stopper**, and the other variables as before.

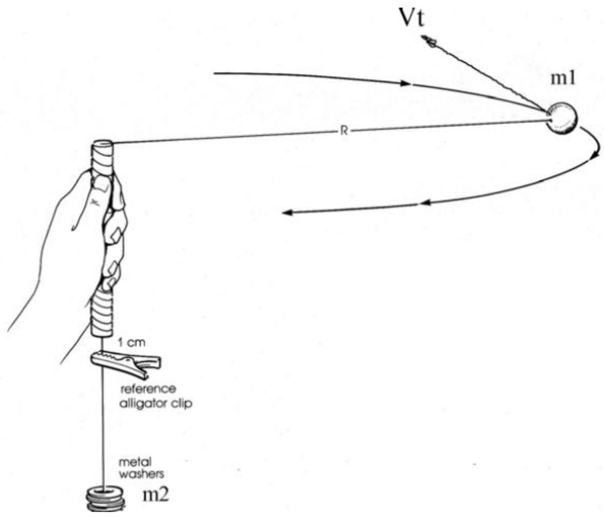
Centripetal means "center seeking". There are two main forces at work in this laboratory exercise. "Opposing" the centripetal force is the theoretical, accepted force due to the weight of the washers pulling the string down through the bottom of the hollow glass tube:

$$F_w = m_w * g \qquad \text{Equation 3}$$

where g = 9.8 m/s^2, the accel. due to gravity, and m_w is the mass of the **washers**.

During this experiment, $F_c = F_w$.. The centripetal force is equal to the weight of the washers.

4. Procedure:



1) Weigh the rubber stopper, and the washers (separately). Record their masses in the data table on page 31. Convert these masses from grams to kilograms (move the decimal over 3 places)

2) Lay out the apparatus as it appears above and measure the radius. Record this distance in centimeters and meters in the appropriately labeled data table.

3) Rearrange equation 2 so the variable N^2 is on one side of the equation. Take the square root of the entire other side of the equation. This will provide you with the number of revolutions that you are supposed to have if this experiment was perfect. Calculate this number of revolutions, showing the equation with all of the variables first, then putting in the actual numbers, just to the right of it, to show the sequence of working the problem. DO NOT CONFUSE THIS "N" WITH THE LETTER N THAT REPRESENTS THE UNITS OF FORCE (NEWTONS). They are two entirely different quantities. Keep them straight.

4) Calculate the theoretical force caused by the washers, using equation 3. Put this value at the bottom of the column on the far right side of the data table.

5) Pick up the apparatus. Put the washers in one hand and carefully start swinging the rubber stopper around in a **HORIZONTAL** circle. Slowly increase the speed until the rubber stopper can "lift" the weight of the washers. Practice until the circle is a horizontal as possible, and the flag on the string is just below the bottom of the hollow glass tube. Don't swing the rubber stopper too fast, as it will push the flag up against the glass tube, and the forces will no longer be in balance. Keep the washers from swinging too much by giving them a gentle nudge occasionally with the now free hand. Count the number of revolutions done in 60 seconds. Repeat this 9 more times for a total of 10 trials.

6) Compute the individual centripetal forces for the ten trials.

7) Compute the average centripetal force. Do not compute the average number of revolutions counted.

8) Use the "percent error formula" and compare the experimental and theoretical forces at work during this experiment, using the average centripetal force.

LECTURE 3. CENTIPETAL FORCES

REPORTS

Name:……………………………………………………………….

Class:……………………………………………………………..

1. **Purpose::……………………………………………………………………………………**
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2. **Results:**

m_s =…………………. kg (rubber stopper mass)

r = ……………………m

Trial	t (s) for 10 revolutions
1	
2	
3	
4	

5	
6	
7	
8	
9	
10	
Avg.	

run	m_w (kg)	avg. t (s) for 10 rev.	avg. t (s) for 1 rev.	ω (rad/s) $\omega = \frac{2\pi}{t}$	Meas V(m/s) $V = \omega r$	Calc.V(m/s) $V = \sqrt{\frac{m_w}{m_s} rg}$	F_C (N) $F_C = F_w = m_w g$
50 g							
100g							
150g							
200g							

Notes:

1. m_w = slotted mass (50g, 100g, 150g, 200g) + mass of hanger
2. Percent error calculation is: $\frac{cal. - meas}{cal.} \cdot 100\%$

3. Discussion of results

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