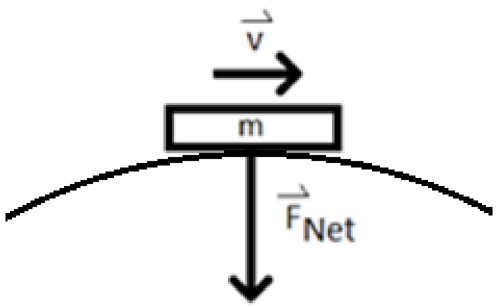
PHYSICS 20 **LAB 6: Centripetal Force** **2 HOURS**

INTRODUCTION;

<u>Uniform Circular Motion</u> describes an object traveling along a circular path with a constant radius at a constant speed. Given that over time, the object maintains its speed but changes its direction, its velocity changes and it said to have a non-zero acceleration and net force.

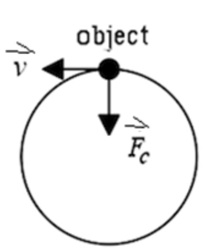
Uniform Circular Motion occurs when the direction of the <u>constant net force is</u> <u>always perpendicular</u> to the direction of the <u>object's velocity</u>, thus causing the object to maintain its speed and change its direction only.

This special net force that causes an object to travel along a circular path (and not fly off) is called a <u>centripetal force</u> or "center seeking force", and the special acceleration is called a <u>centripetal acceleration</u>. The direction of both of these constant quantities is always towards the center of the circle.

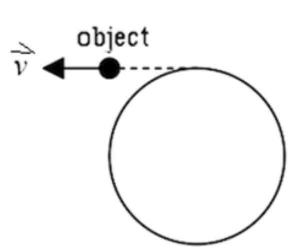


(Constant Speed, change direction)

If an object moving with uniform circular motion suddenly has its net force change to zero, the object will maintain its speed and travel in a straight line (ie. fly off). Given the object moves away from the center, this <u>phenomenon</u> is called a "centrifugal force" or "center fleeing force". This "centrifugal force" is not a real force but describes the sudden absence of the centripetal force which was keeping the object moving in a circle.



With centripetal force applied, the object moves along a circular path with a constant speed v.



If centripetal force is removed, the object will move along a tangent (in a straight line) with a constant speed v.

OBJECTIVE:

- To gather experimental evidence that supports the concept of centripetal force by comparing the experimental and accepted values of centripetal force.

  Avg % Error < 10 %

APPARATUS:

1	**Centripetal Force Apparatus**
1	**10.0 Newton Scale**
1	**Photogate Head**
1	**Lab Stand with adjustable feet**
1	**90º Bracket for lab stand**
1	**Pasco Smart Timer**
1	**12.0 Volt Power Source**
2	**Leads for Power Source**
1	**Ball Bearing Leader #30**
1	**Level**
1	**Set of Newton's weights**

Theory:

An object undergoing uniform circular motion (motion in a circle at constant speed where the angle is constantly changing) must be acted on by a non-zero net force. That net force is called the centripetal force. It must point toward the center of the circle and have a constant magnitude given by the following formulas:

$$F_c = m \cdot r \cdot \omega^2 \quad \text{where } \omega = 2\pi/T \text{ in rad/s}$$

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

Some example of systems with a centripetal force include: the tension in a string attached to a can twirled in a circular path; the friction between the road and the tires of a car on an unbanked curve; or the force of gravity pulling a satellite toward the center of Earth as the satellite moves in a circular orbit at a constant speed.

PROCEDURE:

1. Remove the black nut from the post with the attached leader. Measure and record the mass of the black nut and bolt, and 30.0 grams of the slotted mass. Place the leader then 30.0 grams back on the post. Place anther 30.0 grams on the opposite post as a counter-mass.

2. Plug the Photogate into the Pasco Smart Timer. The timer will be used to measure the number of revolutions in a 30.0 second time frame. This data will be used to calculate the period, T, for the apparatus.

3. Turn the Pasco smart timer on. Using Button 1, scroll to "Count". With Button 2, scroll over to 30 seconds. Button 3 will be used to turn the timer on and off. Push Button 3 until the * is displayed. The * tells you that the timer is ready to use.

4. Plug in the 12.0 volt source. Turn both the current and voltage off by turning all 4 knobs all the way to the left. With the 2 leads, plug the source into the centripetal force apparatus as shown in figure 1.

5. Pull the leader until 3.00 N is being measured on the spring scale. This will be the centripetal force (Fc) for the rotating system. Record the radius for the apparatus when Fc=3.0 N. Move the counter-mass to the same radius and lock in place.

6. Turn the source on. Turn the coarse current knob half-way on. With the coarse voltage knob, slowly turn the voltage up. Note: The voltage must remain below 12.0 V. Watch the scale as the turntable starts to turn.

7. Adjust the voltage using both the coarse and fine knob until the scale reads exactly 3.0 Newtons.

8. Start the Pasco smart timer by pushing Button 3. Allow the apparatus to continue rotating until the timer stops. Keep checking the spring scale to ensure it continues to read 3.0 Newton. If you adjust the speed you must restart the timer.

9. Record the number of revolutions for 30 revolutions in the Initial Data Table provided.

10. Repeat steps 5 – 9 for 4.00 Newtons, 5.00 Newtons and 6.00 Newtons and record the number of revolutions in 30 s for each.

11. Create a Title section named: Calculations and show "sample calculations" using the first row.

12. Complete the Final Results Table provided.

13. Write a conclusion.

14. Compile and submit your completed lab to your instructor by the due date. A Conclusion is needed for this lab!

    Your completed lab should contain:

    - Initial Data Tables
    - Calculations
    - Final Results Tables
    - Conclusion

See your lab instructor for a more detailed format for the completed lab submission.

Initial Data Table

Note: For the online course, use the common data given below.

Mass (m) = ________

Scale Reading (N)	Radius (m)	# Revolutions in 30.0 s

<u>Final Results Table</u>

Mass (m) = _______

Accepted Force - F_C (N)	Radius - r (m)	Period - T (s)	Experimental Force - F_C (N)	% Error (%)

Average % Error = _________

CALCULATIONS:

Determining Period

$$T = \frac{30.0\ s}{Revs}$$

Determining Theoretical Centripetal Force

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

Determining % Error

$$\%\ Error = \frac{|Experimental\ F_C - Accepted\ F_C\ |}{Accepted\ F_C} x100\ \%$$

Determining Average % Error

$$Avg\ \%\ Error = \frac{(\%_1 + \cdots + \%_4)}{4}$$

PHY20 **Lab 6 Data Sets**

Data Set 1

Force	Radius	# Revs/30 s
3.00 N	0.092 m	164 Revs
4.00 N	0.104 m	181 Revs
5.00 N	0.113 m	189 Revs
6.00 N	0.128 m	196 Revs

Data Set 2

Force	Radius	# Revs/30 s
3.00 N	0.090 m	169 Revs
4.00 N	0.096 m	179 Revs
5.00 N	0.106 m	189 Revs
6.00 N	0.119 m	193 Revs

Data Set 3

Force	Radius	# Revs/30 s
3.00 N	0.086 m	168 Revs
4.00 N	0.093 m	178 Revs
5.00 N	0.108 m	184 Revs
6.00 N	0.116 m	192 Revs

Data Set 4

Force	Radius	# Revs/30 s
3.00 N	0.076 m	165 Revs
4.00 N	0.106 m	178 Revs
5.00 N	0.116 m	189 Revs
6.00 N	0.121 m	191 Revs

Data Set	5

Force		Radius		# Revs/30 s	
3.00	N	0.081	m	165	Revs
4.00	N	0.102	m	179	Revs
5.00	N	0.108	m	192	Revs
6.00	N	0.133	m	197	Revs

Data Set	6

Force		Radius		# Revs/30 s	
3.00	N	0.074	m	167	Revs
4.00	N	0.087	m	177	Revs
5.00	N	0.101	m	187	Revs
6.00	N	0.104	m	193	Revs

Data Set	7

Force		Radius		# Revs/30 s	
3.00	N	0.083	m	170	Revs
4.00	N	0.087	m	182	Revs
5.00	N	0.104	m	185	Revs
6.00	N	0.118	m	194	Revs

Data Set	8

Force		Radius		# Revs/30 s	
3.00	N	0.069	m	167	Revs
4.00	N	0.087	m	179	Revs
5.00	N	0.104	m	188	Revs
6.00	N	0.123	m	192	Revs

Data Set	9

Force		Radius		# Revs/30 s	
3.00	N	0.080	m	168	Revs
4.00	N	0.096	m	180	Revs
5.00	N	0.108	m	187	Revs
6.00	N	0.128	m	193	Revs

Data Set	10

Force		Radius		# Revs/30 s	
3.00	N	0.078	m	167	Revs
4.00	N	0.091	m	176	Revs
5.00	N	0.099	m	185	Revs
6.00	N	0.130	m	198	Revs

Data Set	11

Force		Radius		# Revs/30 s	
3.00	N	0.075	m	168	Revs
4.00	N	0.078	m	180	Revs
5.00	N	0.108	m	189	Revs
6.00	N	0.137	m	193	Revs

Data Set	12

Force		Radius		# Revs/30 s	
3.00	N	0.070	m	170	Revs
4.00	N	0.095	m	178	Revs
5.00	N	0.112	m	185	Revs
6.00	N	0.130	m	194	Revs

Data Set	13

Force		Radius		# Revs/30 s	
3.00	N	0.076	m	168	Revs
4.00	N	0.091	m	181	Revs
5.00	N	0.094	m	185	Revs
6.00	N	0.109	m	195	Revs

Data Set	14

Force		Radius		# Revs/30 s	
3.00	N	0.083	m	170	Revs
4.00	N	0.111	m	177	Revs
5.00	N	0.115	m	187	Revs
6.00	N	0.121	m	194	Revs

Data Set	15

Force		Radius		# Revs/30 s	
3.00	N	0.067	m	169	Revs
4.00	N	0.095	m	180	Revs
5.00	N	0.113	m	187	Revs
6.00	N	0.124	m	197	Revs