611-1800 (40-205) Centripetal Force Kit

Caution: Safety glasses are required for this experiment

Additional Materials Required

- Students (2-3)
- Stopwatch
- Laboratory balance
- Meter stick
- Safety glasses

Warranty, Replacement Parts:

We replace all defective or missing parts free of charge. Additional replacement parts may be ordered toll-free. We accept MasterCard, Visa, checks and School P.O.s. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse or normal wear and tear. Intended for children 13 years of age and up. This item is not a toy. It may contain small parts that can be choking hazards. Adult supervision is required.

Introduction:

Centripetal force is the "center seeking force" which causes an object to move toward the center of curvature of its path. Newton stated that F=MA. We will verify this by calculating the centripetal force of a rotating mass and comparing it to a known force caused by the accelleration due to gravity.

How to use:

1. Using a laboratory balance, record the mass of the rubber stopper and of the two paperclips.
2. Measrue a length of 1 meter of sting between the handle tube and the rubber stopper.
3. With the 1 meter of string extended, tie a paperclip onto the string 1cm from the other end of the handle tube.
4. Tie the other paperclip 30cm below the first paperclip.
5. Connect 30g of mass to the lower paper clip.
6. Hold the handle tube up into the air. At this point the rubber stopper should be hanging from the string from the top of the handle tube. The two paperclips should be attached below the handle tube with 30g of mass haning from the lower one.
7. Slowly begin to swing the rubber stopper in a circular motion over your head. Swing the stopper at a speed at which the upper paperclip maintains a position 1cm below the bottom of the handle tube. This ensures that there is a radius of 1 meter between the top of the handle tube and the rubber stopper. Do not swing the stopper so fast as to allow the paperclip to touch the handle tube.
8. Once a stable speed is maintained, have a second student start the stopwatch and count 20 revolutions. Record the time of 20 full revolutions.
9. Repeat step 7 two more times and record the average time. It is easiest to record the three times without stopping the stopper from rotating in between.
10. Carefully have the timing student catch the stopper, being sure not to tangle the string.
11. Add 5g to the mass hanging from the lower paperclip, and repeat steps 7 through 9. Keep adding masses until you have 10 separate data points. Record the results after each experiment.

Calculations:

Our experiment will allow us to verify Newtons theory by balancing a known force against centripetal force by using a balanced system. Force on an object is equal to its mass times its accelleration (F=MA). The force on the rotating stopper in our experiment may then be calculated using:

Where:
F = centripetal force (in Newtons)
M = mass of the object (the stopper in kg)
R = radius (in meters)
T = period (in seconds per revolution)

$$F = M\left(\frac{4\pi^2 R}{T^2}\right) \quad \text{vs. } F = MA$$

The opposing force which balances the system is the result of the force of gravity acting acting upon the masses at the bottom of the string. F=MA now allows us to calculate the downward force by multiplying the mass during each experiment times the acceleration due to gravity (9.8 N/Kg). Follow the calculations on the following page to verify:

T = Time (average time in seconds)	P = Period (time/20)	P^2 = Period Squared (P^2)	**1/ P^2**

M = Mass (masses + mass of clips)	**F** = Force F=MA (M x 9.8m/s²)

Mass of rubber stopper (in Kg) ____________ Mass of the two paperclips (in Kg) ____________

Plot a graph of **1/ P^2** vs. **F**. This graph represents the balancing force pulling against the centripetal force per revolution. Determine the slope of your graph. The slope of your graph should closely match the following calculation: $M(4\pi^2R)$

Where:
M = the mass of the stopper ____________
R = the radius of the circular motion (1 meter)

When the slope of your graph matches the centripetal calculation above, you have just verified the theoretical centripetal force formula: $F = M\left(\frac{4\pi^2R}{T^2}\right)$

Centripetal Force Kit Curriculum Fit:

Content: Physical Science, life science, and earth and space science standards

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Grades 5-8: *Motions & Forces*
Grades 9-12: *Motions & Forces*

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