Investigation 5.2
Centripetal Force

Tom Yue

November 2, 2003

Purpose

The purpose of this investigation is to determine the relationship between the ceentripetal force and the frequency, speed, and mass of a rotating object.

Materials

- 2 small rubber balls
- 28 steel washers
- 2 alligator clips (mass of one clip = mass of one washer)
- 1.5m of fishing line or strong cord
- reinforced glass tube with smooth ends
- metre ruler

Procedure

Refer to **Investigation 5.2: Centripetal Force** on pages 192 and 193, **Fundamentals of Physics: A Senior Course**.

Data, Tabulations, Calculations and Answers to Questions

All experiments have been performed with 20 rotations. Each power setting is used three times, and the times are averaged to arrive at the final data.

Step 5. Data harvested in the experiments

Force (washers)	6	10	14	18	22	26	30	12 *
Trial 1 (s)	25.68	20.79	18.40	16.19	13.67	12.42	11.64	24.78
Trial 2 (s)	25.87	21.27	18.60	16.61	13.71	12.42	11.80	24.37
Trial 3 (s)	25.76	20.65	18.86	17.34	14.16	12.90	11.57	26.16
Average (s)	25.77	20.90	18.62	16.71	13.85	12.58	11.65	25.10

*: the mass is doubled in this expriment (step 11).

Step 6. Observations and preliminary calculations

Number of units of force	Number of rotations	Time (s)	Frequency (Hz)
6	20	25.77	0.7761
10	20	20.90	0.9569
14	20	18.62	1.074
18	20	16.71	1.197
22	20	13.85	1.444
26	20	12.58	1.590
30	20	11.65	1.717
12 *	20	25.10	0.7968

*: the mass is doubled in this expriment (step 11).

(Graph)

It is apparent from the graph that there is a linear relationship between the force and the frequency. Using linear regression, we have determined the equation to be

$$f = 0.1592F + 0.4545 \ ,$$

where f is the frequency in Hertz, and F is the force in washers.

If we hold this equation to be true, then frequency varies directly with the amount of force applied. This can be expressed as

$$f \propto F \ ,$$

and the constant of proportionality is 0.1592.

Step 8. If we have a frequency of 6 Hz, then

$$6 = 0.1592F + 0.4545 \Longrightarrow F = 34.83N \ .$$

Step 11. The data gathered from this step have been combined in the previous tables - see steps 5 and 6.

Step 12. As shown in the experiment, as we doubled the mass of the ball and the magnitude of the centripetal force, the frequency stayed roughly the same. This means that, if the radius and the frequency are kept constant,

$$m \propto F \ ,$$

where m is the mass of the object, and F the centripetal force.

Conclusion

This investigation explored the relationship between the centripetal force of a system and its frequency and mass. However, this investigation is heavily handicapped (and thus not very accurate and leading to misleading results) in that it allows for a large room of error. This investigation could be improved upon if ...

- the string was made lighter and more flexible. This will minimise the magnitude of unnecessary forces acting upon the object during the experiment.
- a more reliable method of keeping the radius constant was used. One could seal off the top of the glass tube save for a small opening. Then, by routing the string through the opening, one would be able to eliminate much sideways motion of the string during the experiment.
- the metal washers were secured somehow during the experiment.