Unit A – Practical 3

Relationship between centripetal force and period in circular motion

Safety

Wear safety glasses. Leave plenty of space between you and others or surrounding objects.

Apparatus and materials

- rubber stopper, 2 cm diameter, with a hole in the centre
- nylon string, 1.5 m long, with a small loop at each end
- glass or plastic tube, 20 cm long, polished rims
- mass hanger, 20g
- slot masses, 20g
- stopwatch
- crocodile clip
- top-pan balance
- ruler

Introduction

In this practical, you will investigate the relationship between centripetal force and speed.

When an object of mass *m* moves in a circle of radius *r*, with constant speed *v* the resultant force on it acts as centripetal force, with its direction pointing towards the centre of the circle and its magnitude *F* given by:

$$F = \frac{mv^2}{r}$$

Combining the above equation with $v = \omega r = \frac{2\pi}{T} r$, we get:

$$F_c = \frac{4\pi^2 mr}{T^2}$$

or:

$$T^2 = \frac{4\pi^2 mr}{F_c}$$

Where ω is the angular speed, *r* is the radius of the circular motion and *T* its period.

Procedure

1 Measure the mass of the rubber stopper.

2 Thread the string through the hole in the stopper and pass the other end of the string through the small loop and tighten.

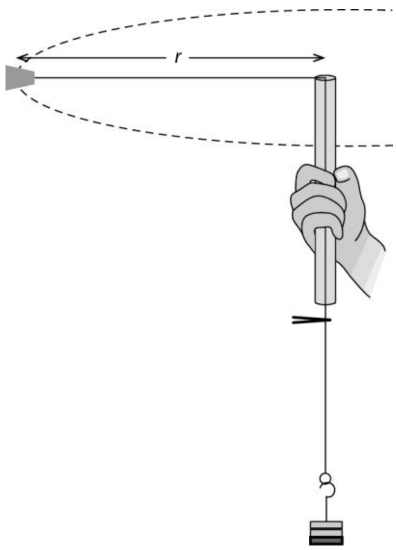
3 Put the other end of the string through the tube and attach the mass hanger to the loop. Add a 20g slot mass to the hanger.

4 Adjust the radius *r* to 40 cm (distance from centre of stopper to rim of tube with the string stretched so it is straight).

5 Without moving the string and keeping it straight along the tube, place the crocodile grip about 1 cm below the bottom rim of the tube. This will act as a marker to help you keep the radius constant.

6 Making sure there is no one very close to you, whirl the stopper in a horizontal circle above your head. Adjust the speed of rotation so that the marker is about 1 cm below the rim of the tube.

7 Another member of the group will measure the time while you count 20 full revolutions at this speed.



8 Calculate one period, T = time measured/20. Calculate the square of the period T^2.

9 The centripetal force is provided by the tension of the string, which is equal to the weight attached to its lower end. Record the total mass of the mass hanger and slot mass and calculate the weight. Record all measurements and calculations in a suitable table.

10 Repeat four more times for the same weight.

11 Repeat the process (steps **4**–**10**) four more times, increasing the mass at the end of the string by 20 g each time.

12 Plot a graph of period T^2 against $\frac{1}{weight} = \frac{1}{F_c}$.

13 Calculate the gradient of the graph and its uncertainty.

14 Use this value, together with the value for the radius, to determine the mass of the stopper. Compare this value with the one measured at the beginning of this experiment.

Questions

1 Is centripetal force attractive or repulsive?

2 What type of motion would the stopper do if the string broke during the rotation?

