

Angular velocity, centripetal force and circular paths

Physics grades 11-12 (A Level · IB · Class 11-12) · Lab

Name: _____ Date: _____ Class: _____

How does the period of a whirled bung change as the centripetal force increases? In this lab you keep the radius fixed, vary the tension with hanging masses, time 20 revolutions and test the relationship $F = 4\pi^2 m r \div T^2$ against your data.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** A Level 3.6

Aim

To test how the period of a horizontal circular motion depends on the centripetal force, and to use the results to find the mass of the bung.

Equipment

- Rubber bung (mass 0.0205 kg) on 1.5 m of nylon thread
- Glass or plastic tube, smooth at both ends, about 12 cm long
- Hanger and slotted masses, 0.050 kg to 0.250 kg
- Paperclip or tape marker, metre rule, stopwatch, balance
- Safety glasses

Safety

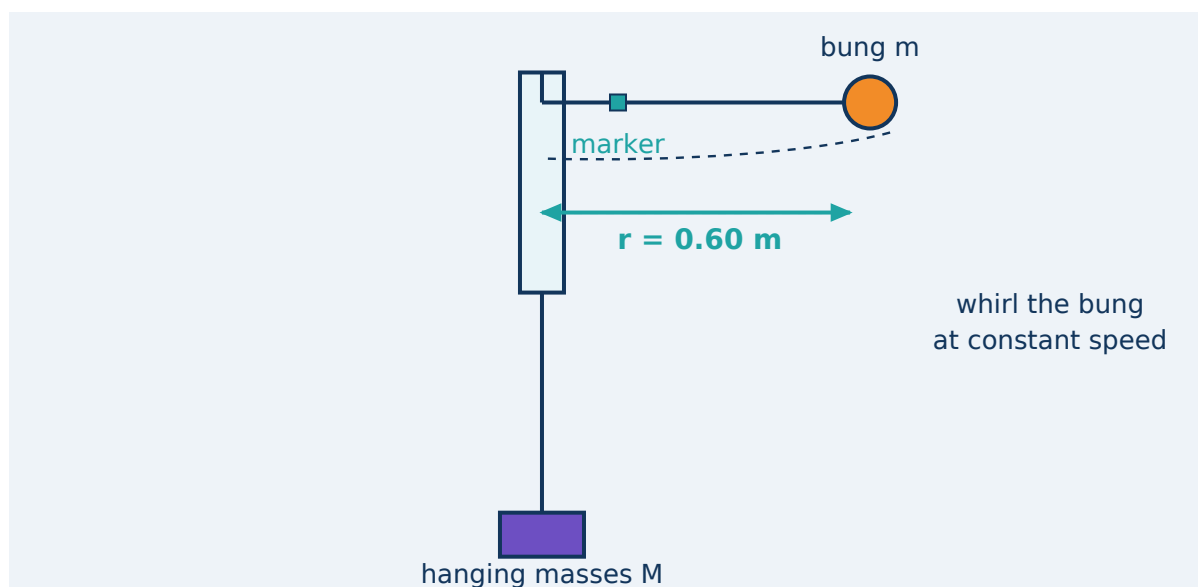
Safety

Wear safety glasses and swing the bung in a clear area, away from people. Tie the thread securely to the bung and the hanger. Do not let the bung hit anyone if the thread breaks, and keep the heavy masses over a soft box, not your feet.

Method

1. Thread the string through the tube. Tie the bung to the top end and the hanger to the bottom end. Place the marker on the string so that the distance from the bung to the top of the tube is 0.60 m.
2. Add 0.050 kg to the hanger. Hold the tube vertically and whirl the bung in a horizontal circle so that the marker stays just below the tube.
3. Time 20 revolutions with the stopwatch while the marker stays at the same place.

4. Calculate the period T from the time for 20 revolutions.
5. Repeat with 0.100, 0.150, 0.200 and 0.250 kg, keeping $r = 0.60$ m.



The weight of the hanging masses equals the tension that supplies the centripetal force on the bung.

Results

Sample results by Bilal in Lahore ($m = 0.0205$ kg, $r = 0.60$ m, $g = 9.81$ N/kg). The weight Mg of the hanging masses equals the tension.

M (kg)	time for 20 revolutions (s)	T (s)	T^2 (s ²)	1/M (kg ⁻¹)	tension Mg (N)	predicted tension $4\pi^2mr/T^2$ (N)
0.050	20.1	1.005	1.010	20.0	0.49	0.48
0.100	14.2	0.710	0.504	10.0	0.98	0.96
0.150	11.6	0.580	0.336	6.7	1.47	1.44
0.200	10.0	0.500	0.250	5.0	1.96	1.94
0.250	9.0	0.450	0.203	4.0	2.45	2.40

Analysis questions

Question 1 Why the weight equals the tension

Explain why the weight of the hanging masses equals the tension that supplies the centripetal force.

Question 2 Period

Calculate the period and the angular velocity for the 0.050 kg load.

Question 3 Predicted tension

Show how the last column was obtained for the 0.250 kg load and compare it with Mg .

Question 4 Straight-line graph

Show that a graph of T^2 against $1/M$ should be a straight line through the origin and state its gradient.

Question 5 Gradient from the data

Use the gradient of the best-fit line through the origin, about $0.050 \text{ s}^2 \text{ kg}$, to calculate the mass of the bung.

Question 6 Percentage uncertainty

The time for 20 revolutions is read to $\pm 0.3 \text{ s}$. Find the percentage uncertainty in T^2 for the 0.250 kg load.

Question 7 Sources of error

Give two reasons why the string is not exactly horizontal and say how this affects the results.

Question 8 Conclusion

State the relationship between centripetal force and period that your results support.