

Centripetal acceleration and gravity in orbit

AP Physics 1 (algebra-based) · Lab

Name: _____ Date: _____ Class: _____

A hanging weight supplies the tension that keeps a bung moving on a circle. By changing the weight and timing the revolutions, you test whether the centripetal force is proportional to $1/T^2$ and measure the gradient predicted by $4\pi^2 m r$.

Level: AP Physics 1 (algebra-based) · **Curriculum:** AP P1 Unit 2

Aim

Test how the centripetal force on a bung depends on its period of rotation, by balancing the tension with a hanging weight.

Equipment

- Rubber bung of mass 25 g tied to 1.5 m of string
- Smooth glass tube, length 15 cm, with taped ends
- Slotted masses (50 g to 250 g) and a hanger
- Stopwatch, metre rule, balance, adhesive tape marker

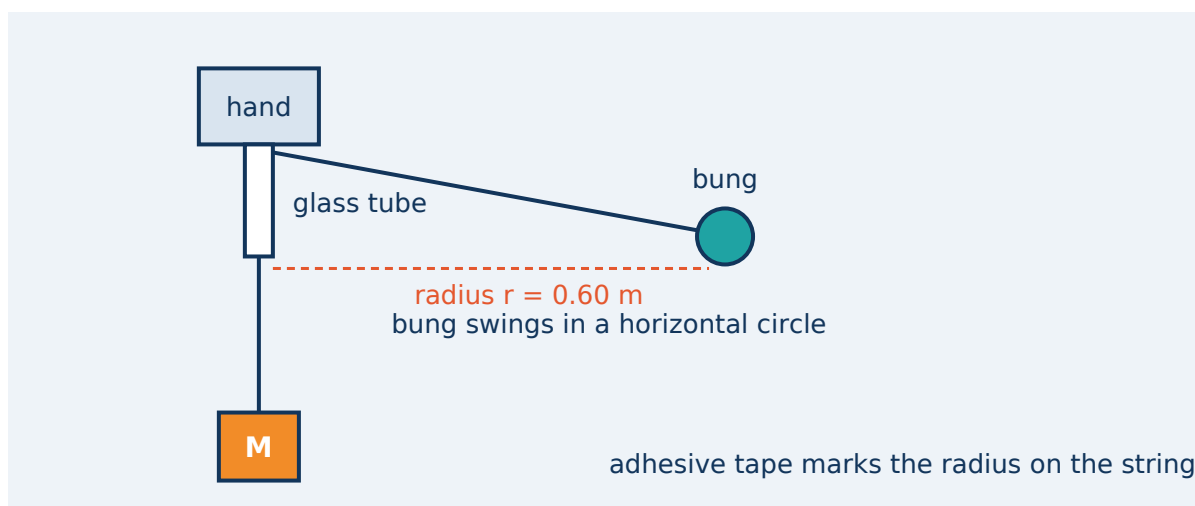
Safety

Safety

Wear goggles and swing the bung in a clear space away from other people. Keep the hanging masses over a soft surface and check the knots before every run. Tie the string to the bung with a secure knot.

Method

1. Weigh the bung. Pass the string through the tube, attach the hanger below, and mark a point 0.60 m from the bung with the tape.
2. Hang a mass $M = 0.050$ kg. Hold the tube vertically and whirl the bung in a horizontal circle so that the marker stays just below the tube.
3. Keep the radius constant. Time 20 revolutions with the stopwatch and record the time.
4. Repeat with $M = 0.100, 0.150, 0.200$ and 0.250 kg.
5. Calculate $F = Mg$, the period T and $1/T^2$ for each row.



Set-up: the weight Mg of the hanging masses supplies the centripetal force on the bung.

Results

Sample measurements (bung mass 0.025 kg , radius 0.60 m , $g = 9.81 \text{ N/kg}$):

Hanging mass M (kg)	Force $F = Mg$ (N)	Time for 20 revolutions (s)	Period T (s)	$1/T^2$ (s^{-2})
0.050	0.49	22.1	1.105	0.82
0.100	0.98	15.5	0.775	1.66
0.150	1.47	12.8	0.640	2.44
0.200	1.96	11.0	0.550	3.31
0.250	2.45	9.8	0.490	4.16

Analysis questions

Question 1 Completing a row

Show how the entries in the row for $M = 0.150 \text{ kg}$ were obtained.

Question 2 Drawing the graph

Plot F (vertical axis) against $1/T^2$ (horizontal axis) and draw the best-fit line. Describe the shape.

Question 3 Using the gradient

Calculate the gradient of the line and compare it with the theoretical value $4\pi^2 m r$.

Question 4 Timing uncertainty

The stopwatch reading for 20 revolutions is uncertain by $\pm 0.3 \text{ s}$. Find the percentage

uncertainty in $1/T^2$ for $M = 0.200$ kg.

Question 5 Effect of a sagging string

The string sags slightly instead of being level. Explain the effect on the gradient.

Question 6 Radius doubled

Predict the new gradient if the experiment is repeated with $r = 1.20$ m and the same bung.

Question 7 Improvements

Suggest two improvements that would reduce random errors.