

Angular velocity, centripetal force and circular paths

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

The answers use the sample results in the table, so your own values will differ slightly. Check that you timed 20 revolutions, divided by 20 for the period, and squared the period before plotting T^2 against $1/M$.

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

Question 1 Why the weight equals the tension

The hanging mass is in equilibrium, so the tension in the string equals Mg . The same string tension acts on the bung, and it is the only horizontal force on it, so it is the centripetal force.

$$T = M g.$$

Question 2 Period

$$T = 20.1 \div 20 = 1.005 \text{ s (to 3 d.p. 1.005 s). } \omega = 2\pi \div T = 6.283 \div 1.005 = 6.25 \text{ rad/s.}$$

$$T = 1.005 \text{ s; } \omega = 6.25 \text{ rad/s.}$$

Question 3 Predicted tension

$$F = m \omega^2 r = 4\pi^2 m r \div T^2 = 39.48 \times 0.0205 \times 0.60 \div 0.203 = 2.40 \text{ N. } Mg = 0.250 \times 9.81 = 2.45 \text{ N. They agree to within 2 \%.$$

predicted 2.40 N against 2.45 N.

Question 4 Straight-line graph

From $M g = 4\pi^2 m r \div T^2$, $T^2 = (4\pi^2 m r \div g) \times (1 \div M)$. So T^2 is proportional to $1/M$ and the gradient is $4\pi^2 m r \div g = 39.48 \times 0.0205 \times 0.60 \div 9.81 = 0.0495 \text{ s}^2 \text{ kg.}$

$$\text{gradient} = 4\pi^2 m r \div g.$$

Question 5 Gradient from the data

$m = \text{gradient} \times g \div (4\pi^2 r) = 0.050 \times 9.81 \div (39.48 \times 0.60) = 0.0207 \text{ kg, in agreement (within about 1 \%) with the measured 0.0205 kg.}$

$$m = 20.7 \text{ g.}$$

Question 6 Percentage uncertainty

Uncertainty in time = $0.3 \div 9.0 \times 100 \% = 3.3 \%$. T^2 doubles this, so the percentage uncertainty in T^2 is about 6.7 %. Timing 20 revolutions already reduces the effect of reaction time.

$\pm 6.7 \%$.

Question 7 Sources of error

The bung also has weight, so the string makes a small angle below the horizontal, which makes the real tension a little larger than the horizontal component. Friction between the string and the tube also reduces the tension at the bung. Both effects make the measured period slightly longer than expected.

measured T is a little larger than predicted.

Question 8 Conclusion

At constant radius, the centripetal force is inversely proportional to T^2 : doubling the tension reduces T^2 by a factor of about two. The results agree with $F = 4\pi^2 m r \div T^2$.

$F \propto 1/T^2$.