

Oscillations, springs, pendulums and resonance

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

Model answers use the sample table. Your own results will differ slightly, but the gradient, the intercept and the conclusions should follow the same pattern if your timing is careful.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB C.1

Question 1 Calculate the period

Timing 20 oscillations reduces the effect of reaction time on each period. For $m = 0.300 \text{ kg}$, $T = 15.6 \div 20 = 0.780 \text{ s}$ and $T^2 = \mathbf{0.608 \text{ s}^2}$.

Question 2 Uncertainty in the timing

Percentage uncertainty in $t = 0.2 \div 12.9 \times 100 = 1.6 \%$, the same for T . T^2 doubles this: **3.1 %**.

Question 3 Plot and gradient

Gradient = $(1.010 - 0.216) \div (0.500 - 0.100) = 0.7938 \div 0.400 = \mathbf{1.98 \text{ s}^2/\text{kg}}$. The points lie close to a straight line.

Question 4 Spring stiffness

gradient = $4\pi^2/k$, so $k = 4\pi^2 \div 1.98 = 39.48 \div 1.98 = \mathbf{19.9 \text{ N/m}}$.

Question 5 The intercept

Using the first point, intercept = $0.216 - 1.98 \times 0.100 = \mathbf{0.018 \text{ s}^2}$. The spring itself oscillates, so the effective mass is $m + m_s/3$, which shifts the line. Intercept $\div$ gradient = $m_s/3 = 0.009 \text{ kg}$, so the spring mass is about 27 g.

Question 6 Testing proportionality

If $T \propto m$, then T/m would be constant: for 0.100 kg it is 4.65 s/kg and for 0.500 kg it is 2.01 s/kg, so it is not constant. The graph of T^2 against m is straight, so **T^2 is proportional to $(m + m_s/3)$** , that is $T \propto \sqrt{m}$.

Question 7 Amplitude check

Use one mass, time 20 oscillations for starting displacements of 1 cm, 2 cm and 4 cm (all small), and repeat each. The times should agree within the timing uncertainty, so **the period is independent of amplitude.**

Question 8 Improvements

Use a motion sensor or video with a frame counter to find the period more precisely, and repeat each measurement three times to find a mean. Start timing at the equilibrium marker, where the speed is greatest, so the start and stop moments are sharper. **Always use small amplitudes without swaying.**