Year 13 Science: Testing a physics theory by experiment

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

Practice

1. Three timings of 10 oscillations are 8.42 s, 8.50 s and 8.46 s. Find T with its uncertainty.

2. Using $T = 0.846 \pm 0.004$ s, find T^2 with its absolute uncertainty.

3. Theory says $f = (1/2L)\sqrt{(F/\mu)}$, with tension F varied. What should you plot to get a straight line?

4. A graph of T^2 against m has gradient 2.47 $s^2\,kg^{-1}$. Find the spring constant k.

5. The steepest and shallowest lines on a graph have gradients 2.55 and 2.40 $s^2\,kg^{-1}$. What is the uncertainty in the gradient?

Fix the mistake

6. Correct this statement: "I timed one oscillation five times and averaged it, so my reaction time does not matter."

7. Correct this statement: "T has a 1.3% uncertainty, so T^2 has a 1.3% uncertainty too."

8. Correct this statement: "The theory has no constant term, so I forced my best-fit line through the origin."

9. Correct this statement: "My value of k is 20.0 and the other method gave 20.2, so they are different."

Answer key (for parents and tutors)

1. Three timings of 10 oscillations are 8.42 s, 8.50 s and 8.46 s. Find T with its uncertainty.
   Mean 10T = (8.42 + 8.50 + 8.46) ÷ 3 = 8.46 s, uncertainty (8.50 − 8.42) ÷ 2 = 0.04 s, so T = 0.846 ± 0.004 s.
2. Using T = 0.846 ± 0.004 s, find T^2 with its absolute uncertainty.
   $T^2 = 0.846^2 = 0.716\ s^2$; percentage uncertainty 2 × (0.004 ÷ 0.846) = 0.95%, so $T^2 = 0.716 \pm 0.007\ s^2$.
3. Theory says $f = (1/2L)\sqrt{(F/\mu)}$, with tension F varied. What should you plot to get a straight line?
   f against √F, a straight line through the origin with gradient $1/(2L\sqrt{\mu})$.
4. A graph of T^2 against m has gradient 2.47 $s^2\ kg^{-1}$. Find the spring constant k.
   gradient = $4\pi^2/k$, so $k = 4\pi^2 \div 2.47 = 39.48 \div 2.47 = 16.0\ N\ m^{-1}$.
5. The steepest and shallowest lines on a graph have gradients 2.55 and 2.40 $s^2\ kg^{-1}$. What is the uncertainty in the gradient?
   (2.55 − 2.40) ÷ 2 = ± 0.08 $s^2\ kg^{-1}$ (0.075 rounded).
6. Correct this statement: "I timed one oscillation five times and averaged it, so my reaction time does not matter."
   Time 10 or more oscillations each go, so the same reaction error is a tenth of the size per period.
7. Correct this statement: "T has a 1.3% uncertainty, so T^2 has a 1.3% uncertainty too."
   Squaring doubles the percentage uncertainty: 2 × 1.27% = 2.5% for T^2.
8. Correct this statement: "The theory has no constant term, so I forced my best-fit line through the origin."
   Draw the line the data give; an intercept is evidence you discuss, and forcing it changes the gradient.
9. Correct this statement: "My value of k is 20.0 and the other method gave 20.2, so they are different."
   Compare using uncertainties: 20.2 lies inside 20.0 ± 0.8 $N\ m^{-1}$, so the values agree.