Year 12 Science: A physics investigation with a non-linear relationship

Name: _____ Date: _____

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

Practice

1. Theory says the height h a ball falls is proportional to t^2, where t is the time. What should you plot to get a straight line?

2. At a fixed voltage, current I is proportional to 1/R. What should you plot to get a straight line?

3. A pendulum's period is 1.40 s. Find T^2.

4. A graph of I against 1/R has a line of best fit through the origin and (0.10 Ω^{-1}, 0.60 A). Find the gradient and write the equation.

5. Explain why timing 10 swings gives a more accurate period than timing one.

Your turn: a marble on a ramp

Another Year 12 class let a marble roll from rest down a ramp and measured the time t to roll each distance d, three times each.

Distance d (m)	Mean time t (s)
0.20	0.89
0.40	1.26
0.60	1.55
0.80	1.79
1.00	2.00

6. Their graph of d against t curves upward, steeper and steeper. What should they plot to get a straight line?

7. Find t^2 for d = 0.40 m.

8. The straight-line graph has its line of best fit through the origin and (4.00 s^2, 1.00 m). Find the gradient and write the equation.

9. Name a controlled variable that would change the results if it changed, and say why.

Fix the mistake

10. Correct this statement: "The relationship is $T^2 = 4.02\,L$, so I wrote $y = 4.02x$."

11. Correct this statement: "I worked out the gradient from my first and last data points."

12. Correct this statement: "I kept the mass of the bob the same, so that is my controlled variable."

13. Correct this statement: "My graph of T against L is a curve, so there is no relationship."

Answer key (for parents and tutors)

1. Theory says the height h a ball falls is proportional to t^2, where t is the time. What should you plot to get a straight line?
   h against t^2.
2. At a fixed voltage, current I is proportional to 1/R. What should you plot to get a straight line?
   I against 1/R.
3. A pendulum's period is 1.40 s. Find T^2.
   $T^2 = 1.40^2 = 1.96\ s^2$.
4. A graph of I against 1/R has a line of best fit through the origin and (0.10 Ω^{-1}, 0.60 A). Find the gradient and write the equation.
   Gradient = 0.60 ÷ 0.10 = 6.0 A Ω (that is, 6.0 V), so I = 6.0 ÷ R.
5. Explain why timing 10 swings gives a more accurate period than timing one.
   The reaction-time error, about 0.2 s, is the same for any timing, so over 10 swings it is a ten times smaller share of the time, and dividing by 10 shrinks it in the period too.
6. Their graph of d against t curves upward, steeper and steeper. What should they plot to get a straight line?
   d against t^2.
7. Find t^2 for d = 0.40 m.
   $t^2 = 1.26^2 = 1.5876 \approx 1.59\ s^2$.
8. The straight-line graph has its line of best fit through the origin and (4.00 s^2, 1.00 m). Find the gradient and write the equation.
   Gradient = 1.00 m ÷ 4.00 s^2 = 0.25 m s^{-2}, so $d = 0.25t^2$.
9. Name a controlled variable that would change the results if it changed, and say why.
   The angle of the ramp: a steeper ramp gives the marble a bigger acceleration, so it would cover each distance faster.
10. Correct this statement: "The relationship is $T^2 = 4.02\ L$, so I wrote $y = 4.02x$."
    Write the equation in the real variables with units: $T^2 = 4.02\ L$, T in seconds and L in metres.
11. Correct this statement: "I worked out the gradient from my first and last data points."
    Use points that lie exactly on the line of best fit, far apart, because data points off the line give a different gradient.
12. Correct this statement: "I kept the mass of the bob the same, so that is my controlled variable."
    Mass has no effect on the period; for Merit, describe a control that would change the results, such as the starting angle.
13. Correct this statement: "My graph of T against L is a curve, so there is no relationship."
    A smooth curve is a relationship; plot a transformed variable, such as T^2 against L, to make it straight.