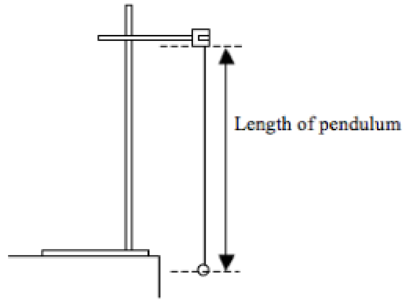
<u>Achievement Standard 91168 (Physics 2.1)</u>

<u>Guidelines</u>

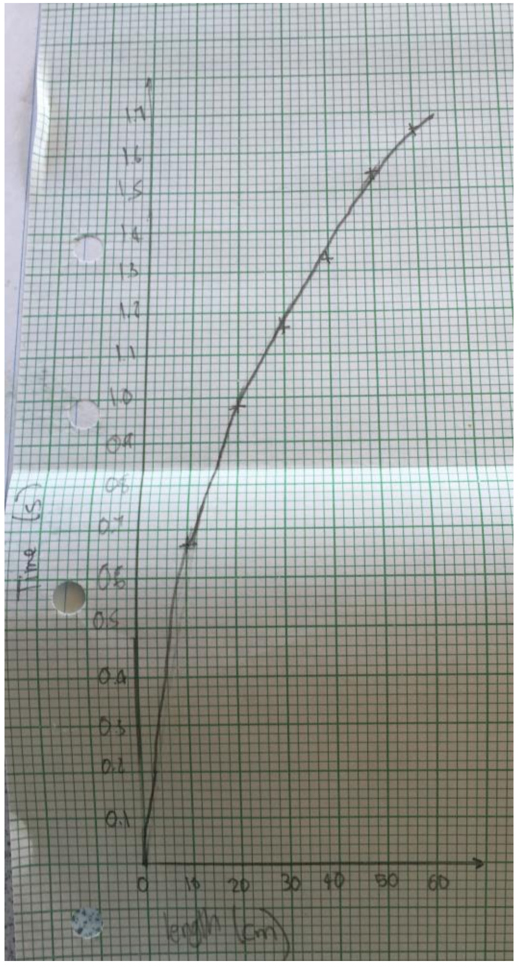
What follows is an interpretation of the standard. It has not been approved by the NZQA.

GUIDELINES	EXEMPLAR
<u>Aim</u> The aim of the experiment will be to find the relationship between two variables and to use the derived equation to calculate the value of a physics quantity.	**<u>Aim</u>** *To find the mathematical relationship between the **length of a pendulum, L,** and the **time period, T**.* *Theory states that* $$T = 2\pi\sqrt{\frac{L}{g}}$$  *Where **T** is the time period of the pendulum, **L** is the length of the pendulum, and **g** is the gravitational acceleration on the bob.*
<u>Identify the variables</u> • **Identify the dependent and independent variables.** • **Identify any variables that must be controlled.** You will need to identify: The independent variable - you choose these values)	**<u>Identify the variables</u>** *The independent variable: Length of pendulum,* ***L***

The dependent variable - you measure these values) The control variable – you keep this the same (and usually measure it)	*The dependent variable: Time period,* ***T*** *The control variable: Acceleration due to gravity,* ***g*** *(this is not ACTUALLY a Level 2 practical – you can't actually control gravity)*

GUIDELINES	EXEMPLAR
<u>Measurement and observation</u> • **Give all in an appropriately headed results table, using appropriate units and significant figures. (You must make sufficient measurements to allow you to draw a graph that will help you determine the required relationship.)** The number of observations to be made should be atleast five (and no more than seven). It is expected that you will use sensible intervals between each reading in this range. <u>Column headings.</u> It is expected that <u>all</u> column headings will consist of a quantity <u>and</u> a unit. The quantity may be represented by a symbol or written in words. The unit should be given correctly e.g. "seconds", "s" but NOT ""secs". <u>Results</u> Measurements must be correct, a unit must be stated and the measurement values must be stated to an appropriate number of significant figures. Record **all** raw measurements in an appropriately headed results table. <u>Repeated Readings</u> It is expected that you will repeat readings and calculate an average. It is only necessary to repeat readings so that two sets of values are obtained. Measurements are determined by the smallest scale division of each of the measuring instruments (e.g. a meter ruler can has scale divisions to the nearest millimetre).	***<u>Measurements</u>*** *For the pendulum experiment, you would measure multiple T e.g. 10T*

Length (cm)	Average Time for 10 Oscillations (s)	Time for 1 Oscillation (s)
10.0	6.77	0.677
20.0	9.84	0.984
30.0	11.64	1.164
40.0	13.30	1.330
50.0	15.44	1.544
60.0	16.55	1.655

GUIDELINES	EXEMPLAR
<u>Data analysis</u> • **Plot an appropriate graph to find the type of relationship between length of the pendulum, L, and the time period, T. Draw a curve of best fit (the raw data will not give a straight-line graph).** <u>Plotting your non-linear graph</u> All your observations will be plotted on the graph grid. The raw data should be used to plot a non-linear graph. If no instructions are given plot dependent variable against independent variable. • Axes should be labelled with quantity and unit. • The scales on each axis must be easily read and give a graph that is large enough to allow reasonable accuracy. • Points should be plotted accurately. • A graph line (in this case a curve) that best fits the plotted data should be drawn. • The line must be thin and clear. • State what relationship the graph shows.	*Example of non-linear graph* 

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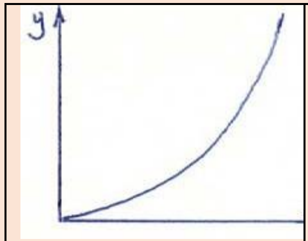
<u>State the relationship the graph shows</u>

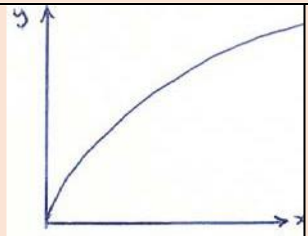
You should be able to identify the relationship as non-linear and be able to convert one of the two variables by squaring, reciprocating, or inverse squaring.

The graph should not indicate a linear relationship.

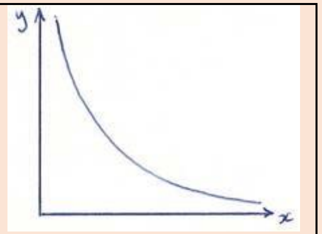
Using your knowledge of graph shapes OR the equation:



y α x^2



y α √x



y α 1/x

Describe the type of relationship that the **first** graph suggests. You must describe the relationship based on the variables you investigated AND write this down using the ACTUAL variables from your experiment.

You will typically be supplied with the relationship and, if this is the case, you should be able to use the equation to determine what graph they would need to plot.

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In this case, based on the shape OR the equation given:

T α √ L

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GUIDELINES	EXEMPLAR

GUIDELINES

Determine the type of relationship that this graph suggests.

- **Process the data so that you can draw a straight-line graph. Plot and draw the straight-line graph.**

Processing Data

Record all processed data, including the transformed unit, in your results table.

The processed data should be used to plot a linear graph.

Plotting your linear graph

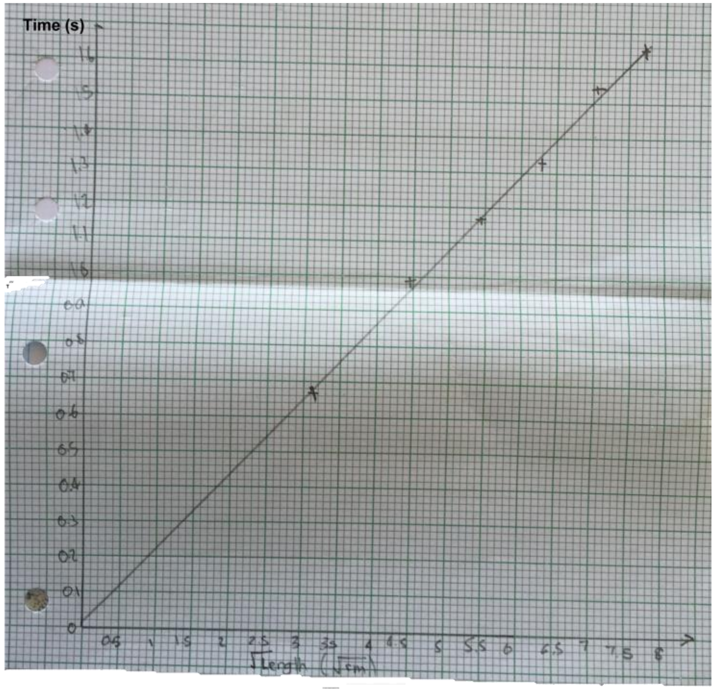
- Axes should be labelled with quantity and unit. (including transformed data and units)
- The scales on each axis must be easily read and give a graph that is large enough to allow reasonable accuracy.
- Points should be plotted accurately.
- A straight graph line (in this case a curve) that best fits the plotted data should be drawn.
- The line must be thin and clear.

EXEMPLAR

Now you know the relationship, use your calculator to calculate values for √L

(Note: the units will also changed too).

L (cm)	10 T (s)	T (s)	√L (√cm)
10.0	6.77	0.677	3.16
20.0	9.84	0.984	4.47
30.0	11.64	1.164	5.47
40.0	13.30	1.330	6.32
50.0	15.44	1.544	7.07
60.0	16.55	1.655	7.74



GUIDELINES	EXEMPLAR
<u>Calculating the gradient</u> Calculate the gradient of the straight graph line. **Show your working** including the unit for the gradient. All the working must be shown. if the triangle used to find the gradient were to be drawn on the graph grid and the co-ordinates of the vertices clearly labelled. If plots are used which have been taken from the table of results then they must lie on the line of best fit.	$\text{Gradient} = \frac{y^2 - y^1}{x^2 - x} \quad \frac{1.5 - 0.1}{7 - 0.4} = 0.212121 \quad \frac{s}{\sqrt{cm}}$
<u>Conclusion</u> ***Conclusion:*** Using information from the straight-line graph, state the mathematical relationship between length of the pendulum, L, and the time period, T State the gradient of your straight graph line (this must include a **unit** that has been derived from the graph). Use the gradient of your graph to write the mathematical equation relating the variables.	*By substituting the two variables, the gradient and the y-intercept into the Equation y = mx + c producing:* *T = 0.21√L + 0.*

GUIDELINES	EXEMPLAR
<u>Method</u> • **Identify how you maximized the accuracy of the data you gathered.** For each measurement you make, decide what accuracy-improving technique(s) would be appropriate and write a description of each of the technique(s) you used. Your written method should include a description of the accuracy improving techniques you chose to use. <u>Different sources of errors</u> **Repeating and Averaging** – where results have random errors. For example, almost all stopwatches will give times to one hundredth of a second, but You clearly cannot operate the watch to this accuracy. Human reaction time will give errors of (typically) 0.1 s to 0.4 s. **Multiple Measurements** – where results have systematic errors. Stopwatches will give times to one hundredth of a second, but You clearly cannot operate the watch to this accuracy. Human reaction time will give errors of (typically) 0.1 s to 0.4 s so multiple measurements for e.g. a pendulum will reduce the effect of the reaction time error. **Parallax** - the observer and/or the instrument placement apply to measurements such as length and temperature, where parallax errors may make it difficult for You to measure a length to the accuracy of the rule used. **Zero End correction** – the instrument used to make a measurement may have a systematic error e.g. a meter ruler placed vertically on a bench will not measure from 0.00 m due to its manufacture. **Choice of scale** – the measuring instrument may have more than one scale to select from. Where possible, the most accurate scale should always be used.	*In this case:* • *Multiple measurements i.e. measured 10 oscillations (since 1 oscillation was too quick) and then divide by 10* • *Parallax i.e. lined up eye with end of swing to reduce error OR when measuring the length if the pendulum string* • *Choice of scale i.e. using mm scale on a metre rule rather than cm scale to improve accuracy*

GUIDELINES	EXEMPLAR
Discussion: **Discussion statements should attempt to validate your conclusion. They could include:**	***Critical Thinking*** *In your write up you may need to discuss critical issues such as:*
• **How the findings of your investigation relate to stated physics theory. If an unexpected result is obtained you should suggest how it could have been caused or explain the effect it had on the validity of the conclusion.**	*From* $T = 2\pi\sqrt{\frac{L}{g}}$ *2π/√g = 2.00 which doesn't really match the experimental value of 0.21 (because this exemplar uses cm – non SI unit). If this exemplar used L in metres then theoretical = 0.20 and experimental = 0.21 so this is a very good match.*
• **For the variables you controlled, a description of how each was controlled and an explanation of why it needed to be controlled.**	*For example, in a pendulum experiment, a change in the starting amplitude of swing (e.g. a mixture of little and big swings) introduces a second variable to the experiment.*
• **For the accuracy improving techniques you used, a description of what you did and an explanation of why it needed to be done**	*Multiple measurements i.e. measured 10 oscillations (since 1 oscillation was too quick) and then divide by 10 OR Parallax i.e. lined up eye with end of swing to reduce error OR when measuring the length if the pendulum string OR Choice of scale i.e. using mm scale on a metre rule rather than cm scale to improve accuracy*
• **A description of any difficulties you encountered when making measurements and an explanation of how these difficulties were overcome.**	*The time taken for one oscillation (particularly for small values of L) is short so multiple measurements e.g. 10T make it easier to measure one oscillation by reducing systematic errors associated with using a stopwatch.*
• **A reason why there was a limit to the range of values you chose for the independent variable.**	*In this experiment there is a lower limit to length of pendulum string that could be used since the time interval would be too short to measure without reaction time becoming a large factor compared to the time measured.*