91521 Level 3 Physics Investigation

1 ***Carry out a practical investigation*** **involves:**

- collecting data relevant to the aim based on the manipulation of the independent variable over a reasonable range and number of values
- determining appropriate uncertainties in raw data
- using graphical analysis, including a consideration of uncertainties, from which the equation of the relationship/value of the physics quantity can be determined
- providing a conclusion that states the equation of the relationship/value of the physics quantity as determined from the graph and includes a comparison with the physics theory

Carry out an in-depth practical investigation **involves:**

- describing the control of other variable(s) that could significantly affect the results
- using techniques to improve the accuracy of measurements
- determining uncertainties in one of the variables expressed in the graphical analysis
- graphical analysis which expresses the uncertainty in the relationship consistent with the uncertainty in the data
- providing a conclusion that makes a quantitative comparison between the physics theory and the relationship/quantity obtained from the experimental data which includes consideration of uncertainties

Carry out a comprehensive practical investigation involves a discussion which addresses issues critical to the practical investigation, such as:

- the other variable(s) that could have changed and significantly affected the results, and how they could have changed the results
- the limitations to the theory's applicability both in the practical situation and/or at extreme values of the independent variable
- any unexpected outcomes of the processing of the results and a suggestion of how they could have been caused and the effect they had on the validity of the conclusion

2 A *practical investigation* is an activity that includes gathering, processing and interpreting data.

3 The variables under investigation should have a non-linear relationship according to a physics theory provided in the task.

In more detail:

At Achieved, there needs to be an appropriate equation or value for a physics quantity and a statement that indicates that there is recognition that the experimental relationship is consistent with theory.

This could be done by comparing:

- the type of relationship found experimentally with that expected
- a derived quantity with the theoretical value
- an experimental gradient with the theoretical gradient
- the experimental intercept with that expected.

The uncertainty analysis needs to be determined for at least one variable.

At Merit, this comparison between the theory and the experimental results must be quantitative and include reference to the uncertainties.

The uncertainty analysis in the gradient and/or intercept needs to be calculated in order to carry out the testing of the physics theory at this level.

At Excellence, at least two issues critical to the practical investigation need to be identified and a discussion included as to how the issues would affect the results/conclusion.

Issues could include:

- the other variable(s) that could have changed and significantly affected the results, and how they could have changed the results
- the limitations to the theory's applicability, both in the practical situation and/or at extreme values of the independent variable
- any unexpected outcomes of the processing of the results, and a suggestion of how they could have been caused and the effect they had on the validity of the conclusion.

Things likely to be in your internal assessment:

The Experiment

Aim - *This will be given to you.*
It is likely to be either a relationship you can investigate experimentally or a derived quantity that you can measure indirectly using an experiment.
Method
*You will need to identify the **i**ndependent variable (the one **I** measure) and the dependent variable (what changes). You will also need to state the control variables that that you can control but should not change during the experiment.*
Method Improvements
Any method that you used to improve accuracy by the way you do the experiment should be mentioned here.
Data Table (and uncertainties)
The uncertainty of a raw value is based upon the smallest scale division of the measuring device *When recording variables in a table the known uncertainty should be recorded.* *If the measurement of a variable is being improved by measuring events over a longer time and dividing by the number of events, or by repeating the measuring process (at least three times) and averaging the results, the raw data should be shown in the data table as well as the final improved data.* *The uncertainty in the final data should be shown. Use the half-range method for multiple results. Final uncertainties are always shown to ONE SIG FIG.*
Raw data transformation added to your data table
Because this investigation will be between two non-linear variables, you will be required to transform one of your variables. You will need to transform the values, the uncertainties and the units. Final uncertainties are always shown to ONE SIG FIG.

Processing the Results

Linear graph using transformed data

If the uncertainties in a variable are very small they may not show up as error bars. The assessment should have one variable that has big enough uncertainties to require error bars. "Error bars are too small to plot" is not evidence of capability.
The line of best fit should be drawn through the points.
The line of max or min slope should not miss more than two or three of the error bars.

Analysis of gradient

The uncertainty in the gradient is ± the difference between gradient of the line of best fit line and the error line of best fit.

The uncertainty in this value should always be corrected to ONE SIG FIG. The value of the slope should then be corrected to be consistent with this level of accuracy.

E.g. A slope of 125.6 ± 3.7 should become 126 ± 4

The value of the gradient and its uncertainty must come from the graph (written or produced by computer).

Analysis of y-intercept

The uncertainty in the y-intercept is ± the difference between y-intercept of the line of best fit line and the y-intercept error line of best fit.

The uncertainty in this value should always be corrected to ONE SIG FIG. The value of the slope should then be corrected to be consistent with this level of accuracy.

E.g. A y-intercept of 9.556 ± 0.0336 should become 9.56 ± 0.03

The value of the y-intercept and its uncertainty must come from the graph (written or produced by computer).

Conclusion

Your MATHEMATICAL conclusion must include the MATHEMATICAL relationship between the **variables** with actual values of the gradient and y-intercept shown including errors

e.g. $V = (2.9 \pm 0.3)/R^2 + 0.20 \pm 0.05$

Comparison

Your comparison should compare the Mathematical relationship (or value for the physical constant) with the theoretical relationship (or value for the physical constant). Your comparison should include errors.

Discussion:

There are **three areas** that you should **always discuss**:

Validity of results
• The **other variable(s)** that could have changed and significantly affected the results, and how they could have changed the results • Have you been given **gear or instruments that limit** the accuracy you can achieve? • What would you suggest that should be changed to improve results? • Did you have difficulty determining the gradient of the line of best fit or the y-intercept from your **graph** because of the way the points came out?
Relevant Physics theory
• You been given a **physics equation (or constant)** that relates to the experiment. Does your result match this equation? • Is your value high or low? Why? • The limitations to the theory's applicability in terms of the physics equation you were given in the aim, both in the practical situation and/or at extreme values of the independent variable
Critical thinking
• Are there any unexpected outcomes of the processing of the results? • How could they could have been caused and the effect they had on the validity of the conclusion. • Discuss the impact of any uncontrolled variable and what you might have done about it. • Discuss any **difficulties** you had to overcome, or **decisions** you had to make to carry out the experiment successfully.