

Commentary on candidate evidence

Candidate 1

1 Abstract

The candidate was awarded **1 out of 1 mark** because the candidate has clearly stated the aim of the project and given findings for each procedure used.

The findings are consistent with stated conclusions. The abstract immediately follows the contents page.

2 Underlying physics

The candidate was awarded **1 out of 4 marks** because the candidate has included some short underlying physics paragraphs which contain some relevant background physics. There are however some mistakes:

- ◆ On page 4, there is an incorrect statement of $p = \text{velocity}$ and confusion with m and n .
- ◆ On page 5, $\sin\theta$ is not correctly defined and the rearrangement of relationship is incorrect.
- ◆ On page 8, the attempt at a derivation for λ includes an arithmetic error.
- ◆ No further underlying physics is included for procedures two or three.

3 Procedures

The candidate was awarded **5 out of 7 marks**. The marks were awarded as follows:

3(a) **1 out of 2 marks** was awarded because the candidate has included images for all three procedures.

Most of the images are labelled correctly however replication would be difficult given the information provided.

A circuit diagram for procedure one would be desirable.

3(b) **1 out of 2 marks** was awarded because the candidate has indicated repetition of measurements in all three procedures.

The description of two of the procedures did not include the range and interval of the independent variables, and so do not support straightforward replication. The descriptions of procedures were written in appropriate tense and voice.

3(c) **3 out of 3 marks** was awarded because the candidate has completed procedures which are all at an appropriate level and original to the candidate.

With a reasonable range of independent variables and a number of repeats, the procedures would have taken 10-15 hours of lab time.

The limitations in the analysis of the data in procedure one is considered in the analysis section.

4 Results (including uncertainties)

The candidate was awarded **3 out of 8 marks**. The marks were awarded as follows:

4(a) **1 out of 1 mark** was awarded because the candidate has included data that are both relevant and sufficient for each procedure.

4(b) **1 out of 4 marks** was awarded because the table headings, units and mean values are mostly correct.

The candidate has attempted graphical analysis for two of the three procedures. However, there are a number of mistakes, for example:

- ◆ On page 8, it is not clear what the values in the table are, an incorrect unit for $V^{-1/2}$ has been given, the average values for 3kV & 5kV are incorrect, it is not clear what values the candidate is using to calculate lambda, and the final calculation is incorrect for the values given.
- ◆ On page 13, an inappropriate graph is used to determine wavelength.
- ◆ On page 17, an inappropriate graph is used to determine wavelength.
- ◆ Both graphs are small and lack minor gridlines.

4(c) **1 out of 3 marks** was awarded because the candidate has shown an awareness of random, scale reading and calibration uncertainties.

The calculated random uncertainties are correct.

Error bars are included on the graphs, but it is not clear how they were established.

No attempt has been made at determining the uncertainty in the gradient.

No attempt has been made to combine uncertainties.

5 Discussion (conclusion(s) and evaluation)

The candidate was awarded **3 out of 8 marks**. The marks were awarded as follows:

5(a) **1 out of 1 mark** was awarded because all conclusions are stated correctly.

5(b) **1 out of 3 marks** was awarded because the candidate has attempted to address limitations of equipment, adequacy of repeated readings and control of variables.

However, there are many irrelevant statements leading to a lack of quality in their evaluation.

5(c) **1 out of 3 marks** was awarded because the candidate has attempted to compare results with expected values.

The candidate has made one suggestion for an improvement to procedure three.

5(d) **0 out of 1 mark** was awarded because this is not a quality project.

6 Presentation

The candidate was awarded **2 out of 2 marks**. The marks were awarded as follows:

6(a) **1 out of 1 mark** was awarded because a contents page and page numbers are included.

6(b) **1 out of 1 mark** was awarded because three references are given in Vancouver style and are correctly cited.

Overall

The candidate was awarded a total of **15 out of 30 marks**.

Candidate 2

1 Abstract

The candidate was awarded **1 out of 1 mark** because the candidate has clearly stated the aim and findings of the project.

2 Underlying physics

The candidate was awarded **3 out of 4 marks** because the candidate has included a short introductory underlying physics paragraph about the various pendula used.

The candidate has defined most of the variables used.

Overall, the candidate has worked through the theory methodically, arriving at the relationships required to obtain g graphically, although procedure two is a little difficult to follow and there are some large algebraic jumps in procedure three.

3 Procedures

The candidate was awarded **5 out of 7 marks**. The marks were awarded as follows:

3(a) **2 out of 2 marks** was awarded because the candidate has included labelled images for each procedure.

3(b) **0 out of 2 marks** was awarded because for procedure one the candidate has not used the past, impersonal voice in their description. The candidate has not given information about the number of repetitions and the range and interval of the independent variable.

For procedure two, the candidate has given information about range, interval, and repetitions. The candidate has used a mixture of past, impersonal and present voice.

For procedure three, the candidate has not given information about number of repetitions and the range and interval of the independent variable.

3(c) **3 out of 3 marks** was awarded because the candidate has chosen three procedures all at an appropriate level for Advanced Higher Physics. The experimental procedures would have taken at least 10-15 hours.

4 Results (including uncertainties)

The candidate was awarded **6 out of 8 marks**. The marks were awarded as follows:

4(a) **1 out of 1 mark** was awarded because the candidate has included sufficient and relevant data.

4(b) **3 out of 4 marks** was awarded because the candidate has analysed their data using appropriate graphical methods for all three procedures, generating a line of best fit and determining the gradient.

The candidate's graph for procedure one is a little small. They have used the graph gradient appropriately to determine a value for g .

The procedure two graph is an appropriate size. The candidate has used the graph gradient appropriately to determine a value for g .

For procedure three, the candidate has generated the curves by joining the dots. Also, four points is insufficient to lead to a valid value of the pendulum effective length l required to determine g . It is also unclear how the value of l was derived from these graphs. This value is then used appropriately to generate a line of best fit from which a value of g was determined. The candidate has also included an inappropriate 'dot-to-dot' line.

4(c) **2 out of 3 marks** was awarded because for procedure one the candidate has used the LINEST function to correctly determine the gradient uncertainty and apply this to their value for g . The candidate has not included individual reading, random or calibration uncertainties for their data.

For procedure two, they have correctly combined their LINEST gradient uncertainty with $2x_l$ and the height uncertainty. Both reading uncertainties are quoted as 1%. The candidate has correctly used the uncertainty power rule. They have applied this correctly to determine an absolute uncertainty for g .

For procedure three, the candidate has correctly determined the gradient uncertainty using the LINEST function. They have however, incorrectly combined reading uncertainties with the gradient uncertainty which is inappropriate for this procedure.

5 Discussion (conclusion(s) and evaluation)

The candidate was awarded **5 out of 8 marks**. The marks were awarded as follows:

5(a) **1 out of 1 mark** was awarded because the candidate has stated individual conclusions for each procedure.

5(b) **2 out of 3 marks** was awarded because the candidate has made a reasonable effort to discuss the accuracy and precision of their experimental

measurements. They did mention repetition although not range. They discussed limitation of equipment. The candidate mentioned systematic uncertainties for all procedures.

5(c) **1 out of 3 marks** was awarded because the candidate has discussed the interpretation of their results compared to the accepted value of g , although they misinterpreted their results for procedure two. The candidate discussed some problems that they had to overcome. They did not discuss the selection of their procedures. They did discuss further improvements but did not suggest any further work.

5(d) **1 out of 1 mark** was awarded because this is a good, competent project, well-worked through.

6 Presentation

The candidate was awarded **1 out of 2 marks**. The marks were awarded as follows:

6(a) **1 out of 1 mark** was awarded because the candidate has included an informative title page, contents page and page numbers.

6(b) **0 out of 1 mark** was awarded because although the candidate has cited at least three references, the reference style used is neither Harvard or Vancouver.

Overall

The candidate was awarded a total of **21 out of 30 marks**.

Candidate 3

1 Abstract

The candidate was awarded **0 out of 1 mark** because the candidate has stated aims but has not identified all methods or reported all findings (drop weight is missing). In addition, the finding of direct proportion for Jaeger's method is not supported by the candidate's graph.

2 Underlying physics

The candidate was awarded **2 out of 4 marks** because there is a reasonable attempt at a referenced derivation of the relationship used in the drop weight method. However, the candidate does not define all the symbols used and Figure 2.1 does not assist.

A more complete diagram would have been helpful for procedure 2, as the explanation refers to apparatus not shown in Figure 3.1. Most variables are defined but there are inconsistencies between the variables in the text and those in the accompanying diagram, and the use of $(2t+2t)$ rather than $(2l+2t)$. There is a reference to, but no attempt to demonstrate understanding of, the underlying physics for procedure three. The candidate's use of non-standard symbols is confusing.

3 Procedures

The candidate was awarded **4 out of 7 marks**. The marks were awarded as follows:

3(a) **1 out of 2 marks** was awarded because the candidate has included a diagram for each procedure. Most labels are present, but some apparatus is missing from each of the diagrams.

3(b) **1 out of 2 marks** was awarded because there are a number of instances where the candidate has used an incorrect tense, therefore the maximum that can be awarded is 1 mark.

Despite some omissions of range/repetition, the descriptions are sufficient for replication.

3(c) **2 out of 3 marks** was awarded because the candidate has selected a range of procedures commensurate with Advanced Higher level.

The execution of procedure one lacks sophistication and could have been adapted to allow for graphical analysis by utilising a range of internal diameters, rather than a single glass tube.

Procedure three has been adapted from a direct measurement of γ to investigate the effect of temperature on surface tension, however no attempt was made to determine density of water by experiment.

4 Results (including uncertainties)

The candidate was awarded **1 out of 8 marks**. The marks were awarded as follows:

4(a) **0 out of 1 mark** was awarded because the candidate has not included raw data for procedure three.

4(b) **1 out of 4 marks** was awarded because the analysis for procedure one is based on the substitution of mean values into a relationship. There was an opportunity to perform graphical analysis by using tubing of different internal radii. The final value obtained for procedure one is correct, despite a missing $\times 10^{-3}$ in the penultimate line of the calculation.

Procedure two also relies on substitution of averaged values into a relationship. There is inappropriate averaging of the slide dimensions, which affects the individual values of surface tension obtained by the candidate.

In procedure three, the sample calculation of γ is incorrect, but the correct value appears in the table on page 19. Surface tension values (column four, rows two and three) of the table are incorrect. The graph is small, lacks minor gridlines and the data points are too large.

4(c) **0 out of 3 marks** was awarded because the candidate has shown an awareness of scale reading and random uncertainty but not mentioned calibration uncertainty.

In procedure one, the candidate has attempted combinations but has made too many mistakes, for example the candidate has correctly handled the uncertainty in the mass of one droplet but goes on to apply the same factor of ten to the uncertainty in radius.

The approach adopted in procedure two is inappropriate as measurements of different slides were used to calculate random uncertainty.

For procedure three, there is no raw data, so uncertainties cannot be checked.

5 Discussion (conclusion(s) and evaluation)

The candidate was awarded **2 out of 8 marks**. The marks were awarded as follows:

5(a) **0 out of 1 mark** was awarded because the candidate has only provided a conclusion for procedure one.

5(b) **1 out of 3 marks** was awarded because the candidate has included a suggestion to improve the reliability of procedure one and repeated comments on cleanliness of equipment, despite the procedures including cleaning of glassware.

The candidate identifies issues with 'zeroing' of the torsion balance in procedure two.

The candidate has attributed the result of procedure three to problems with an airtight seal and bubbles in the manometer. They have identified that a metre stick was not an appropriate tool for measurement in this procedure.

5(c) **1 out of 3 marks** was awarded because the candidate raised problems with vibrations due to people walking by.

The candidate compares the results of procedures one and two to the accepted value to determine the 'best' method. The candidate identified procedure two to be the most accurate and the easiest to set up.

The candidate suggested the use of a travelling microscope to improve the procedure.

5(d) **0 out of 1 mark** was awarded because this is not a quality project.

6 Presentation

The candidate was awarded **2 out of 2 marks**. The marks were awarded as follows:

6(a) **1 out of 1 mark** was awarded because the project has a structure that is easy to follow.

6(b) **1 out of 1 mark** was awarded because the candidate has included references in Vancouver style and has cited them in the text. There are sufficient citations in the text to be awarded the mark despite the lack of edition numbers for the books in the list.

Overall

The candidate was awarded a total of **11 out of 30 marks**.