

PHYSICS- Sample C leaking can

TOTAL MARKS (out of 24) FOR THIS INVESTIGATION = 11

PERSONAL ENGAGEMENT: Best-fit Mark = 0

Evidence of personal engagement: There is no evidence here other than what is covered in the third descriptor. The procedure and even the basic idea is a long time classic in high school physics. No ownership is seen here. (Markband 0)

Justification given for research question: There is no evidence of interest or curiosity other than doing the experiment (but that does not count as PE). (Markband 0)

Evidence of personal input and initiative in designing, implantation or presentation: Setting the water container at an angle and the basic method of timing may be interpreted here as a little personal input (Markband 1)

EXPLORATION: Best-fit Mark = 3

Topic of investigation identified, research question described: This is a basic but well-established high school experiment. It is focused and described. There is no reason not to reach the 6 level for this descriptor statement. (Markband 6)

Background information: There is no background information given, other than some rather unclear notions of gravity forcing water out of the hole. This investigation has been documented many times and the student should have done some research. Moreover, there should have been some common sense about the size of the hole as it relates to diameter. (Markband 0)

Appropriate methodology, consideration of reliability and sufficiency of data: Basic but acceptable. Attention is given to the whole size and its relation to the drill bit size, and attention is given to the timing method. Perhaps the same drill bit could have been used to make one hole, then two holes (twice the area), then three holes, etc. Following the drill bit sizes is not a linear progression. With the short times for the largest hole the student might have used more water. Major omission in equipment is a caliper or micrometer to check the diameter of the drill bits. It is just assumed they are what is stated on the bits. Repeated measurements were important here. (Markband 3)

Evidence of significant safety or environmental issues: No mentioned of significant safety issues other than those related to the reliability of timing. This descriptor could be an outlier here, but the use of an electric drill requires some thought about safety. (Markband 1)

ANALYSIS: Best-fit Mark = 2

General comment: The key to this investigation is the relationship of the hole size and the time to drain water, and because the graphing technique is inappropriate reducing the data to no real conclusion, the Analysis best-fit is someplace between 1 and 5. The moderator decided on 2.

Sufficient raw data for a valid conclusion: There is a minimal range of data but this is acceptable for the given exploration; there are repeated measurements so a relevant conclusion could be stated if an appropriate graph was used. (Markband 5)

Data processing, accuracy and consistent: The hyperbolic curve is inappropriate. If common sense about the area of a hole does not prevail then the student should have linearized the data with logarithms instead of an automatic mathematical fit (which is meaningless given the graph scale). The big fault here then is the scale on the graph; it is non-linear. The $\frac{1}{4}$ inch mark (according to the scale) is really $\frac{3}{16}$ inch, and so on, where $\frac{4}{16}$ is $\frac{1}{4}$, $\frac{6}{16}$ is $\frac{3}{8}$, and $\frac{8}{16}$ is $\frac{1}{2}$. The values are not linear on the graph. The curve fit is thereby meaningless. The second graph has no units on the x-axis and an incorrect title. The incorrect linear fit should have been obvious after this graph. There is some data processing but the moderator still thinks this indicator earns nothing. (Markband 0)

Impact of uncertainties on the analysis: The smallest drill size is quoted as having the same uncertainty, namely $\frac{1}{16}$ inch, which would be 100%. This does not seem likely. The difference between the drill bit size and the hole is recognized but more depth could have been shown here. Timing uncertainty has been addressed as well as controlled variables. The student provides full and appropriate awareness of the impact of uncertainties on the data but not on the graph, and the graph is the key here. (Markband 3)

Interpretation of processed data: The non-linear scale and the inappropriate curve fit suggest an incorrect interpretation. And yet the student reads the results here into a conclusion. (Markband 1)

EVALUATION: Best-fit Mark = 3

Conclusion statement, detailed, justified and supported by data: The conclusion is qualitative at best (confused in detailed explanation at worst) but the incorrectly processed data can be seen to support the conclusion. (Markband 3)

Conclusion and accepted theory, described and justified: There is no accepted theory, and the student's comments are confused at best. (Markband 0)

Strengths and weaknesses, limitations of data and method: The student shows some evidence of problems with the method and data, but this is fairly superficial. (Markband 3 at the most)

Realistic and relevant improvements and extensions: To a minor degree, the student comments on realistic and relevant improvements although some of the suggestions are not thought out in detail. There are no extension ideas. (Markband 3)

COMMUNICATION: Best-fit Mark = 3

Presentation of investigation and errors affecting understanding, focus and outcome: The presentation is mostly clear, and the errors do not hamper too much the understanding or focus (but were irritating to the reader, unscientific in many ways). The teacher should have guided the student in more appropriate ways. (Markband 2)

Report structure, focused and coherent: The student report is structured and flows in a clear, constructive way. (Markband 4)

Report relevance, concise, focus on outcome: The text is focused on the process and outcome. The errors commented upon under other Criteria descriptors do not affect this mark. (Markband 4)

Terminology, subject specific: This is a weak area of the report. Using inches instead of millimeters catches the reader's eye, but this alone does not affect the overall investigation. Assuming a linear progression of drill bit sizes is an incorrect use of technical language. A non-linear scale on a graph, no units on another graph, inappropriate curve fitting, and weak scientific language puts this Descriptor into the 1 and 2 markband. (Markband 1)