

## PHYSICS – Sample F Plancks constant

**TOAL MARKS (out of 24) FOR THIS INVESTIGATION = 15**

**PERSONAL ENGAGEMENT: Best-fit Mark = 0**

**Evidence of personal engagement:** There are no signs of personal interest other than a thorough approach to the study. The attention to details, establishing frequency uncertainties using data from the Internet, and other resources do suggest some initiative, if not predictable, as the student could have omitted much of the details. (Markband 1)

**Justification given for research question:** There is no attempt to justify this investigation other than to establish Planck' constant (which is the research question). (Markband 0)

**Evidence of personal input and initiative in designing, implantation or presentation:** Again, this is a well-established high school experiment and there is no evidence of personal input other than attention to detail as mentioned under the first Descriptor. The idea of using a black tube to view the LED is not original but comes from the same experiment as written up in a recent issue of *The Physics Teacher* journal and in an article published online by the Perimeter Institute of Theoretical Physics, where the student most likely found the method. No credit is given to the student. Indeed, the student's use of the term Photon energy array strongly indicates that this lab was copied. (Markband 0)

**EXPLORATION: Best-fit Mark = 3**

**Topic of investigation identified, research question described:** The RQ is clear and to the point. Mentioning the use of LEDs completes the description. A little more understanding would have helped the description. Although the student did little work here, the first descriptor is addressed well. (Markband 5)

**Background information:** The meaning of Planck's constant and how it relates to the investigation are not mentioned. There is no historical or scientific background. How does using LEDs work here? How does the *work function* and *threshold frequency* relate to the investigation's method? The student seems to be mirroring the many online versions of this very investigation. The theory used does not count as background. (Markband 0)

**Appropriate methodology, consideration of reliability and sufficiency of data:** The method is sound. It takes into consideration most of the factors but why use the charge of an electron to only two significant figures in this investigation? Using the black tube (as mentioned under PE above) is appropriate but not original here. Five values of LED is satisfactory but there could have been 10, according to commercial apparatus for doing this experiment or just a greater range of LED bought at a local electronics store. The full theory, as mentioned under the background descriptor, would have helped guide the student's analysis. There is no mention of independent or dependent

valuable and how measuring these will be used to determine Planck's constant. Does the student really know what they are doing? (Markband 3)

**Evidence of significant safety or environmental issues:** This is an outlier for this experiment. (Markband outlier)

### **ANALYSIS: Best-fit Mark = 5**

**Sufficient raw data for a valid conclusion:** Five is sufficient, as the range is limited but acceptable. Three repeats is acceptable too. (Markband 6)

**Data processing, accuracy and consistent:** There is considerable attention to process here, although the presentation (which under Communications) could have been clearer. Only 2 significant figures for the charge of an electron and only one SF for the speed of light will affect the conclusion, but in a systematic way. (Markband 5)

**Impact of uncertainties on the analysis:** Uncertainties are at the forefront of this investigation. The student does a consistent and comprehensive study. (Markband 6)

**Interpretation of processed data:** The student thinks they do comprehensive job here, including identifying an outlier on the graph, but the meaning of the results are lost to the student. As long as it is the gradient that is useful, the results are acceptable. (Markband 5)

### **EVALUATION: Best-fit Mark = 4**

**Conclusion statement, detailed, justified and supported by data:** The student consistently says the units for Planck's constant is joules. The student never understood the theory, including work function and threshold frequency. The graph reveals this ignorance. Nonetheless, the student does make use of the graph's gradient in a way that approximates the magnitude of Planck's constant. (Markband 3)

**Conclusion and accepted theory, described and justified:** Using incorrect units, the results are compared with the accepted theory. There is enough detail to say the student is justified, if not mistaken in some important areas. This high school experiment is usually 15 to 20% off the accepted value. (Markband 4)

**Strengths and weaknesses, limitations of data and method:** Without revisiting the theory, the student does make a thorough job of considering the strengths and weakness of their work, although some comments are too vague to be relevant. The moderator does not think, however, that the student has a clear understanding of the methodological issues. Markband 3 or 4 would be appropriate but here we give it a 4. (Markband 4)

**Realistic and relevant improvements and extensions:** The student has demonstrated attention to many details but under realistic and relevant suggestions for improvement and extensions, there is little of interest. As moderators we must read

“improvements and extensions” as either one or the other or both, as a student may well have the best suggestions for improvements but no extensions, and we would otherwise be forced to award a zero. That is, the conjunction “and” can be read or and “or”. (Markband 4)

### COMMUNICATION: Best-fit Mark = 3

**Presentation of investigation and errors affecting understanding, focus and outcome:** The presentation was easy to follow. More theory in the research question would have suggested notions of the work function and threshold frequency, and so a proportional graph would not have been the desired result. Nonetheless, the report flowed in the way the student wanted it. (Markband 4)

**Report structure, focused and coherent:** The structure is focused, concise and logical. Occasional awkward language confuses the reader. The presentation of the equations also confuses the reader. The sections are indicated clearly. (Markband 3)

**Report relevance, concise, focus on outcome:** The research question is always in the forefront, and the method follows in a focused and direct way. The purpose of each section is clear. (Markband 4)

**Terminology, subject specific:** Here the student makes some scientific mistakes, like the units for Planck’s constant, the confusion between  $F$  and  $f$ , and a few other things. Nonetheless, we can follow the reasoning. The student should have used MathType (as found in MS Word) or similar equation tools to write the various mathematical expressions, as this would have made reading easier. (Markband 3)

**GENERAL COMMENT ABOUT ACADEMIC HONESTY.** This report (Planck’s constant) should have never been submitted by the teacher, as there are no references other than [www.gizmology.net](http://www.gizmology.net) (for the LED frequency ranges). It is clear that the student followed an established method, and with all the references online and methods provided by commercial equipment suppliers, some reference is needed. Indeed, some reference in the theory would have helped the student focus. Could this be a case of academic dishonesty? Perhaps it was the teacher that informed the student here. The issues of academic honesty, concerns over plagiarism, are not covered in the assessment criteria but come under DP candidacy requirements. Students and teachers must sign the 4/ICCS form