Personal Engagement

There are different ways to show personal engagement. One way is for the student to write how engaged they were in the activity but this is easy to fake and quite meaningless. If a student is genuinely engaged in the activity then it should shine through in their writing, if it doesn't then advise the student on how they might make it more obvious. What we are looking for is some personal input in the way they carried out the experiment. This does not necessarily mean that they have to invent the method, if they independently find out how to use a spectrometer to measure the wavelength of spectral lines, they have shown initiative. Using simulations to compare results with theoretical expectations gives another level of involvement.

It is often easier to see real personal engagement in the conclusion rather than the introduction so save your opinion until you get to the end. This is much more difficult to fake.

Personal engagement descriptors

Descriptor	0	1	2
Evidence of personal engagement with exploration	Standard not reached	limited with little independent thinking, initiative or insight	clear with significant independent thinking, initiative or creativity

Does the student follow a standard method or do they show some creativity?

Have they done any background research or are they just relying on what they learnt in class?

Quite a big difference between 1 and 2, limited and little vs clear and significant!

Descriptor	0	1	2
The justification given for choosing the research question and/or the topic under investigation	Standard not reached	does not demonstrate personal significance, interest or curiosity	demonstrates personal significance, interest or curiosity

This could be in the introduction or the conclusion/evaluation.

Make an holistic judgement on whether you think the student has demonstrated real interested.

Quite easy for a student to make it seem that they are interested but I think we are looking for more than this.

Descriptor	0	1	2
Evidence of personal input and initiative in the designing, implementation or presentation of the investigation.	Standard not reached	Little	A lot

We're not expecting every student to do some new piece of research but we are expecting them to do something that they haven't done before. It may be that the novel way that they have thought of measuring refractive index is just a standard method. Look for small variations, and clever use of standard equipment.

Exploration

Exploration is the act of searching for the purpose of discovery of information or resources (Wikepedia), it's what Roald Amundsen (and Captain Scott) did in Antarctica. We don't expect our students to be quite so adventurous but they should go a little bit into the unknown. It's important to put yourself into the students shoes, what is new and interesting to them might not be so ground breaking to their teacher. Most of the descriptors relate to the research question and method, if they don't have a good research question then it's difficult to score well.

Exploration descriptors

Descriptor	0	1-2	3-4	5-6
The topic of the investigation is identified and research question is	Standard not reached	relevant but not focused	relevant but not fully focused	relevant and fully focused

The difference between a standard lab and an investigation is that a standard lab would be focused on one method and one conclusion but an investigation could be more open, with several different ways of looking at different problems. For example a student could do an investigation based on the 3 gas laws which traditionally would be 3 separate lab reports. However the report could still be

focused as long as the student stuck to the gas laws. I would like to see students try a variety of techniques in their investigation however the report must be focused.

Descriptor	0	1-2	3-4	5-6
The background information provided for the investigation is	Standard not reached	superficial or of limited relevance and does not aid the understanding of the context of the investigation	mainly appropriate and relevant and aids the understanding of the context of the investigation	entirely appropriate and relevant and enhances the understanding of the context of the investigation

Background information could be the theoretical background, details of the apparatus, the context of the research, other people's findings and settings used in simulations. There is no point in simply adding information for the sake of it. As with most of the descriptors there are many places in a report where this could be applied.

Descriptor	0	1-2	3-4	5-6
Appropriateness of the methodology of the investigation	Standard not reached	Limited	Mainly	Highly

If the method leads to a conclusion then it must have been appropriate so the best way of assessing this is to read the conclusion.

Descriptor	0	1-2	3-4	5-6
Consideration of factors that may influence the relevance reliability and sufficiency of collected data	Standard not reached	few factors considered	some factors considered	nearly all factors considered

This is about developing a method that minimizes the uncertainties in the measured variables as well as controlling the controllable variables and being aware of factors that can't be controlled. Simple things like using a clamp stand to hold a pendulum rather than you hand makes a lot of difference.

Descriptor	0	1-2	3-4	5-6
Evidence of awareness of the significant safety, ethical or environmental issues that are relevant to the methodology of the investigation*.	Standard not reached	limited	some	full

This isn't so applicable in physics investigations since our subject is so environmentally friendly already however there maybe ethical considerations on a small scale related to selecting data to make it fit a hypothesis, leaving out outliers etc. Safety might be an issue but if a student is doing anything unsafe then it probably should be stopped before getting to the report writing stage.

Analysis

Analysis of data is basically what we used to call data collection processing and presentation plus a bit of the evaluation. As with the other criteria this is a holistic assessment based on the whole report so you can't pin it down as easily as you could with DCP. There are many ways of analyzing data, linearizing and drawing straight lines, curve plotting and statistical analysis, all count provided they are appropriate and have been done correctly. To fulfill this criteria your students will need to have practiced a variety of methods so it is important that the build up to the investigation is well planned. Old style linearizing to get a best fit lines where the gradient has some meaning is perfectly acceptable but not the only way.

Descriptor	0	1-2	3-4	5-6
Raw data is	Standard not reached	insufficient to support a valid conclusion	relevant but incomplete. Could support a simple or partially valid conclusion	sufficient. Could support a detailed and valid conclusion

Need to look at the data together with the conclusion, was there sufficient data to support the conclusion? Is the raw data presented properly?

Descriptor	0	1-2	3-4	5-6
Data processing	Standard not reached	basic, inaccurate or too insufficient to lead to a valid conclusion	appropriate and sufficient. Could lead to a broadly valid conclusion but there are significant inaccuracies and inconsistencies in the processing	appropriate and sufficient with sufficient accuracy so as to enable a conclusion to the research question to be drawn that is fully consistent with the experimental data

Data processing will often involve the drawing of a graph, if possible it is best to linearise the equation since a straight line graph is much easier to interpret. This aspect also takes into account the conclusion, if the conclusion is weak then the processing might be at fault.

Descriptor	0	1-2	3-4	5-6
Impact of uncertainties	Standard not reached	little consideration	some consideration	full and appropriate consideration

This is where you decide if the uncertainties have been considered sufficiently. We are not expecting a full and rigorous treatment but that they have been considered and the conclusion does not make claims that can not be supported. Tables of raw data should include justified uncertainties in headers, uncertainties should be propagated throughout any calculation and error bars should be drawn on graphs. Where gradients are used to calculate values either steepest and least steep lines or computer generated uncertainties should be used to find the uncertainty in the final value. Quite a lot to do to get a high score but we shouldn't let the uncertainties dominate the investigation.

Evaluation

One of the important differences between the new investigation and the old design labs is that students are expected to demonstrate an understanding of the physics involved, the evaluation is the place to show it. Another difference is that, in my class at least, students always did their evaluation at home, in the new system I intend to give class time for writing the evaluations so I will be on hand to help point my students in the right direction. Choice of topic is very important here since if they don't understand the physics they won't be able to evaluate the results. As with an EE, a good research question will lead to a good evaluation. Investigating the size of "splat" made when a piece of plasticine is dropped on the ground from different heights may be an interesting investigation but the physical explanation is to difficult to derive a simple model that can be tested. Using computer simulations to compare a model to experimental result could be a good way to get around the difficulty of deriving an equation. More often than not the reason why a students experimental results don't match theory is because the theory used is making some assumptions that aren't valid; no air resistance, no energy loss, isolated bodies, no change in temp, ideal gas, perfectly elastic etc. The task is to explain how the ignored factors would have changed the results (hopefully in the way observed). This is where a computer simulation can be useful to repeat the experiment in simulation without air resistance to see what would happen.

Descriptor	0	1-2	3-4	5-6
Conclusion	Standard not reached	outlined but may not be relevant to the research question or may not be supported by the data presented	described, relevant to the research question and supported by the data presented	described in detail and justified, entirely relevant to the research question and fully supported by the data presented

Although this criteria is called evaluation the descriptors refer to conclusion, there always was an overlap between conclusion and evaluation so this new more holistic approach should be better. The sort of justification that can be made are that the points are close to the line, the curve passes through all the points, the error bars are small and reflect the spread of data. "Supported by the data" implies that the student refers to their graphs and tables of results. This is often badly done, students

will often go through the process of making the right sort of statement but without connecting it to their actual results.

Descriptor	0	1-2	3-4	5-6
Conclusion	Standard not reached	erroneous or superficially compared to the accepted scientific context	some relevant comparison to accepted scientific context	Justified through relevant comparison to the accepted scientific context

The conclusion of an experiment can be quite short and often includes an experimental quantity that is compared with some accepted value, this is not going to be the case in many investigations but they should be able to compare their results a prediction that was based on some physics they learnt during the course. Note that the descriptor says relevant comparison to scientific context not accepted value.

Descriptor	0	1-2	3-4	5-6
Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are	Standard not reached	outlined but are restricted to an account of the practical or procedural issues faced	described and provide evidence of some awareness of the methodological issues* involved in establishing the conclusion	discussed and provide evidence of a clear understanding of the methodological issues* involved in establishing the conclusion

Again this must be based on the data collected. There is no point in saying the air resistance was a problem if there is no evidence that it was. I always tell my students that they should act like detectives, look for evidence before making conclusions. Sometimes it is good to go right back to the original raw data, if for example there is an outlier the raw data might show why.

Descriptor	0	1-2	3-4	5-6
Realistic and relevant suggestions for the improvement and extension of the investigation.	Standard not reached	very few outlined	some described	are discussed

The difference between discussed and described is important here. A list of possible improvements will gain 1 or 2. Some description of how those improvements could be achieved gets 3 or 4, but for the full mark they need to compare different possible improvements, or discuss why they think a given improvement might make a difference.

Descriptor	0	1-2	3-4	5-6
Interpretation of processed data	Standard not reached	incorrect or insufficient leading to an invalid or very incomplete conclusion	broadly valid leading to limited conclusion.	correct leading to a valid and detailed conclusion.

Interpretation is usually carried out in the conclusion and evaluation, this is simplest if a straight line graph has been plotted since there is only the gradient and intercept to explain. If the result is a curve there should be some attempt to make sense of it.

Communication

This is a real essay marking criteria rather than the sort of thing we normally assess in lab work, definitely aimed at the whole essay not just one section. I suppose the best way of assessing whether a student has communicated well is if, as a reader, you can understand what they are trying to say without having to read passages many times. Is there a lot of repetition or is everything relevant? Are diagrams used to enhance explanations or are they simply there to fill space? Using some sort of "lab report" structure with titles such as introduction, method, results etc will make it more coherent. Physical terms should be used correctly but the odd mistake doesn't necessarily mean a point is lost. if the essay is tool long the it can be penalised as it is not concise, if too short then maybe it is lacking in sufficient depth.

Descriptor	0	1-2	3-4
Presentation of the investigation	Standard not reached	unclear, making it difficult to understand the focus, process and outcomes.	clear, any errors do not hamper understanding of the focus, process and outcomes

Not many people get there names mentioned in the IA criteria although I'm not sure that I like the context. The statement implies that there can be some errors but that any errors made shouldn't detract from the focus of the investigation.

Sticking to some sort of formal structure will help here. I'm certainly going to get my students to use subtitles. In Extended essays students can often wander off the point, hopefully this won't be such a problem with this shorter investigation.

Descriptor	0	1-2	3-4
Relevance	Standard not reached	the understanding of the focus, process and outcomes of the investigation is obscured by the presence of inappropriate or irrelevant information	relevant and concise thereby facilitating a ready understanding of the focus, process and outcomes of the investigation

This could easily be quantified in terms of how much of the essay is related to the research question and how much is off topic padding.

Descriptor	0	1-2	3-4
Terminology	Standard not reached	There are many errors in the use of subject specific terminology and conventions*	The use of subject specific terminology and conventions is appropriate and correct. Any errors do not hamper understanding

Descriptor	0	1-2	3-4
Structure	Standard not reached	not well structured and is unclear: the necessary information on focus, process and outcomes is missing or is presented in an incoherent or disorganized way	well-structured and clear: the necessary information on focus, process and outcomes is present and presented in a coherent way