Internal Assessment: The Individual Investigation

The internal assessment (IA) for Physics consists of one individual scientific investigation on a topic of the student's own choosing. This internal assessment task will take about 10 hours and the write-up should be about 6 to 12 pages long. It is worth 20% of the final IB grade (where the three written exam papers at the end of this year count as the other 80%). It will also count for various components of the class grade as both the process and final product will be graded.

This individual investigation should cover a topic that comes from, or be related to, one of the topics of study in the course. Students should come up with their own ideas for their IA although some guidance and support will be provided. In a large class it is possible there is some overlap of topics provided there is an individual research question. Students may choose a topic which has been carried out in previous years but should use their own research question and hence their own approach in designing the experiment, collecting and analyzing data. It is unlikely that all projects chosen will be totally original, as long as the idea is new to the student and has not been plagiarized. The report produced should be complex and commensurate with the level of the course. It should include a purposeful research question and the scientific rationale for it.

As an international organization, IBO appreciates that there are many different ways to produce good reports and therefore they do not insist that any one style is used. Moderators will read the whole report when reviewing the teacher's mark. Nevertheless, the student should aim to write a well structured report where the information flows in a logical sequence in order to score highly on the communication criterion. The communication criterion is designed to assess skills in creating a logical, clear and well structured written report.

There are no formal guidelines with regard to font size or style, margins or paper size. Teachers and students are expected to use common sense and follow the style that they normally adopt in school. This would usually mean a font size of between 10 and 12 pt, and a style that can clearly be read by teachers and moderators. The write-up should be about 6 to 12 pages long. Investigations exceeding this length will be penalized in the communications criterion as lacking in conciseness. The student does not need to include a cover page. In addition, no abstract or table of contents is required. Appendices should not be included.

A paper copy and an electronic copy of the report must be submitted to the teacher for assessment. In addition, the student must submit an electronic copy to be checked for authenticity (such as to *turnitin.com*.) It is not permitted for a student to use this same IA for other sciences or for their Extended Essay.

Guidelines for the IA

All reports will be different but, generally speaking, the following sections should be included in some form:

a) **Introduction:** Give a brief overview of your experiment including why you chose this topic and what you did. Clearly state the research question. This section provides a good opportunity to establish your personal interest in the topic.

b) **Background Information:** Discuss the scientific context for your experiment by briefly describing the theory behind it. Clearly explain relevant concepts and issues. Brief but relevant social and/or historical comments may be included to establish the importance of the topic. Although not necessary, is there a math model? Note that a hypothesis is not required.

c) **Methodology:** Clearly explain how you carried out your experiment. What are the independent, dependent and control variables? How did you measure them? What did you do to process the data? Did any issues arise during your data collection and processing that required special handling? If a database investigation is conducted where data are taken from a database and not collected directly, students will need to justify the selection of the database they used in terms of reliability of data and may need to look at a few alternative sources to determine this. They will also be expected to justify any method of sampling data from the database.

d) **Data Collection:** Display your raw data clearly. Be sure there are enough data to establish a conclusion but if there is a very large amount of data, say from a database investigation, only display a representative sample, not all of it. Display the associated uncertainties and discuss how they were obtained. While there may be cases where an extra pair of hands is required during data collection, and students should be encouraged to help each other out, it would not be acceptable for both students to use the same data as part of their individual investigations. Thus collaboration is not permitted since this is an individual investigation and each student will be individually assessed.

e) **Data Processing:** Display how you processed the data and the uncertainties. Here is where graphs and sample calculations are most appropriate. Be sure to discuss each step so that your work can be easily followed.

f) **Conclusions:** Draw relevant valid and detailed conclusions from your processed data and give justifications for them. Be sure to draw relevant comparisons to the accepted scientific context that was described in the background information. For example, do your results agree with the literature value or the math model, if there is one?

g) **Evaluation:** Discuss strengths and weaknesses of the investigation, such as limitations of the data and sources of error or uncertainty, and how they impact any conclusions that were drawn. Also, discuss relevant and realistic suggestions for the improvement and extension of the investigation. Note that *improvement* and *extension* are two different things. Be sure to discuss each in sufficient detail. In some cases there will be sufficient discussion of how to improve the actual investigation to generate additional data which would make a conclusion more reliable, while in others questions may have been raised which can suggest further related investigations which could be carried out. An extension would not involve the creation of an entirely new research question.

Student work is internally assessed by the teacher and externally moderated by the IB. The performance in internal assessment at both SL and HL is marked against common assessment criteria (see below), with a total mark out of 24. See the marked sample investigations (in class and on class website) for examples of what is expected and how it will be assessed.

The three main types of investigation are:

1) Hands-on: a hands-on laboratory investigation (may include video-analysis)
2) Database: extracting data from a database and analyzing it graphically
3) Simulation: using a simulation, provided it is interactive and open-ended

Anticipated Timeline for the Individual Investigation:

explore topics and process - early September
plan investigation - late September
carry out investigation - early October
begin analysis and write-up - late October
submit first draft - early November
submit final draft - late December

Internal assessment criteria

The assessment model uses five criteria to assess the final report of the individual investigation with the following raw marks and weightings assigned:

Personal engagement	Exploration	Analysis	Evaluation	Communication	Total
2 (8%)	6 (25%)	6 (25%)	6 (25%)	4 (17%)	24 (100%)

Personal engagement

This criterion assesses the extent to which the student engages with the exploration and makes it their own. Personal engagement may be recognized in different attributes and skills. These could include addressing personal interests or showing evidence of independent thinking, creativity or initiative in the designing, implementation or presentation of the investigation.

Mark	Descriptor
0	The student's report does not reach a standard described by the descriptors below.
1	**The evidence of personal engagement with the exploration is limited with little independent thinking, initiative or creativity.** The justification given for choosing the research question and/or the topic under investigation does not demonstrate **personal significance, interest or curiosity**. There is little evidence of **personal input and initiative** in the designing, implementation or presentation of the investigation.
2	**The evidence of personal engagement with the exploration is clear with significant independent thinking, initiative or creativity.** The justification given for choosing the research question and/or the topic under investigation demonstrates **personal significance, interest or curiosity**. There is evidence of **personal input and initiative** in the designing, implementation or presentation of the investigation.

Exploration

This criterion assesses the extent to which the student establishes the scientific context for the work, states a clear and focused research question and uses concepts and techniques appropriate to the Diploma Programme level. Where appropriate, this criterion also assesses awareness of safety, environmental, and ethical considerations.

Mark	Descriptor
0	The student's report does not reach a standard described by the descriptors below.
1–2	The topic of the investigation is identified and a research question of some relevance is **stated but it is not focused**.
	The background information provided for the investigation is **superficial** or of limited relevance and does not aid the understanding of the context of the investigation.
	The methodology of the investigation is only appropriate to address the research question to a very limited extent since it takes into consideration few of the significant factors that may influence the relevance, reliability and sufficiency of the collected data.
	The report shows evidence of limited awareness of the significant safety, ethical or environmental issues that are **relevant to the methodology of the investigation***.
3–4	The topic of the investigation is identified and a relevant but not fully focused research question is described.
	The background information provided for the investigation is mainly appropriate and relevant and aids the understanding of the context of the investigation.
	The methodology of the investigation is mainly appropriate to address the research question but has limitations since it takes into consideration only some of the significant factors that may influence the relevance, reliability and sufficiency of the collected data.
	The report shows evidence of some awareness of the significant safety, ethical or environmental issues that are **relevant to the methodology of the investigation***.
5–6	The topic of the investigation is identified and a relevant and fully focused research question is clearly described.
	The background information provided for the investigation is entirely appropriate and relevant and enhances the understanding of the context of the investigation.
	The methodology of the investigation is highly appropriate to address the research question because it takes into consideration all, or nearly all, of the significant factors that may influence the relevance, reliability and sufficiency of the collected data.
	The report shows evidence of full awareness of the significant safety, ethical or environmental issues that are **relevant to the methodology of the investigation**.*

* This indicator should only be applied when appropriate to the investigation.

Analysis

This criterion assesses the extent to which the student's report provides evidence that the student has selected, recorded, processed and **interpreted** the data in ways that are relevant to the research question and can support a conclusion.

Mark	Descriptor
0	The student's report does not reach a standard described by the descriptors below.
1–2	The report includes **insufficient relevant** raw data to support a valid conclusion to the research question.
	Some **basic** data processing is carried out but is either too **inaccurate or too insufficient to lead to a valid** conclusion.
	The report shows evidence of little consideration of the impact of measurement uncertainty on the analysis.
	The processed data is incorrectly or insufficiently interpreted so that the conclusion is invalid or very incomplete.
3–4	The report includes relevant but incomplete quantitative and qualitative raw data that could support a simple or partially valid conclusion to the research question.
	Appropriate and sufficient data processing is carried out that could lead to a broadly valid conclusion but there are significant inaccuracies and inconsistencies in the processing.
	The report shows evidence of some consideration of the impact of measurement uncertainty on the analysis.
	The processed data is interpreted so that a broadly valid but incomplete or limited conclusion to the research question can be deduced.
5–6	The report includes sufficient relevant quantitative and qualitative raw data that could support a detailed and valid conclusion to the research question.
	Appropriate and sufficient data processing is carried out with **the accuracy** required to enable a conclusion to the research question to be drawn that is fully **consistent** with the experimental data.
	The report shows evidence of full and appropriate consideration of the impact of measurement uncertainty on the analysis.
	The processed data is correctly interpreted so that a completely valid and detailed conclusion to the research question can be deduced.

Evaluation

This criterion assesses the extent to which the student's report provides evidence of evaluation of the investigation and the results with regard to the research question and the accepted scientific context.

Mark	Descriptor
0	The student's report does not reach a standard described by the descriptors below.
1–2	A conclusion is **outlined** which is not relevant to the research question or is not supported by the data presented. The conclusion makes superficial comparison to the accepted scientific context. Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are **outlined** but are restricted to an **account** of the **practical** or **procedural issues** faced. The student has **outlined** very few realistic and relevant suggestions for the improvement and extension of the investigation.
3–4	A conclusion is **described** which is relevant to the research question and supported by the data presented. A conclusion is described which makes some relevant comparison to the accepted scientific context. Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are **described** and provide evidence of some awareness of the **methodological issues*** involved in establishing the conclusion. The student has **described** some realistic and relevant suggestions for the improvement and extension of the investigation.
5–6	A detailed conclusion is **described and justified** which is entirely relevant to the research question and fully supported by the data presented. A conclusion is correctly **described and justified** through relevant comparison to the accepted scientific context. Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are **discussed** and provide evidence of a clear understanding of the **methodological issues*** involved in establishing the conclusion. The student has **discussed** realistic and relevant suggestions for the improvement and extension of the investigation.

Communication

This criterion assesses whether the investigation is presented and reported in a way that supports effective communication of the focus, process and outcomes.

Mark	Descriptor
0	The student's report does not reach a standard described by the descriptors below.
1–2	**The presentation of the investigation is unclear, making it difficult to understand the focus, process and outcomes.** The report is 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. The understanding of the focus, process and outcomes of the investigation is obscured by the presence of inappropriate or irrelevant information. There are many errors in the use of subject specific terminology and conventions*.
3–4	**The presentation of the investigation is clear. Any errors do not hamper understanding of the focus, process and outcomes.** The report is well structured and clear: the necessary information on focus, process and outcomes is present and presented in a coherent way. The report is relevant and concise thereby facilitating a ready understanding of the focus, process and outcomes of the investigation. The use of subject-specific terminology and conventions is appropriate and correct. Any errors do not hamper understanding.

*For example, incorrect/missing labeling of graphs, tables, images; use of units, decimal places.

Simulation Sites: (Note that JAVA may need to be updated in Internet Explorer or Firefox - will not work in latest versions of Chrome)

1) PHET: https://phet.colorado.edu/
2) General Physics JAVA Applets: http://www.surendranath.org/Apps.html
3) My Physics Lab: http://www.myphysicslab.com/
4) Walter Fendt: http://www.walter-fendt.de/ph14e/
5) Physlets: http://vnatsci.ltu.edu/s_schneider/physlets/main/index.shtml
6) Collection of links: http://apphysicsb.homestead.com/vls.html

Video Analysis:

1) LoggerPro: *File/Open/Sample Movies*
2) Make your own!

Database Sites:

1) Sinbad Astronomical Databases: http://simbak.cfa.harvard.edu/simbad/
2) European Space Agency Planetary Database: http://pdb.estec.esa.int/

Ideas for Experiments:

1) Vernier website: http://www.vernier.com/
2) Institute of Physics - Teaching Advanced Physics: http://tap.iop.org/
3) Nuffield Foundation: http://www.nuffieldfoundation.org/practical-physics#1
4) 300 Stimulating Ideas: https://obelkobusnel.files.wordpress.com/2012/03/300-lab-ideas.pdf
5) School Physics: http://www.schoolphysics.co.uk/age16-19/General/text/Experimental_work/index.html
6) National STEM Centre: http://www.nationalstemcentre.org.uk/elibrary/
7) Interesting and Inexpensive Experiments: http://newt.phys.unsw.edu.au/~jw/I&Iexperiments.pdf
8) Zooniverse: https://www.zooniverse.org
9) LoggerPro: *File/Open/* then any one of several folders with experiments and sample data

Physics Exploration criteria requirements:

Personal Engagement:

Dos:

1. Be an independent thinker by taking up self – initiative and applying creativity.
2. Give justification for choosing the research question.
3. The topic under investigation must demonstrate personal significance, interest and curiosity.
4. There must be evidence of personal input and initiative throughout the exploration.
5. Combine syllabus content with personal interest.
6. Be focussed on the research question.
7. Be enthusiastic and passionate about the topic.
8. If it revolves around a simulation, show some initiative in choosing the right simulation among various simulations which would help confirm the known equation.
9. A lot of thought must be implemented into the project.
10. It's good to see a mathematical model being associated with a hands – on physics experiment; not necessarily though.
11. There must be more than one or many references to personal interest.

Don'ts:

1. There is little evidence of personal input or initiative.
2. There is no genuine interest or curiosity for the research involved.
3. There is only a slight personal connection to the topic.
4. There is hardly one, two or any reference to personal engagement in the exploration.
5. The design and method of the experimentation are straightforward and demonstrates no personal input/s.
6. There is no insight, creativity and independent thinking.
7. The justification for choosing the topic is minimal.

Exploration:

Dos:

1. The topic of the investigation is identified and a relevant and fully focused research question is clearly described.
2. The background information provided for the investigation is entirely appropriate and relevant and enhances the understanding of the context of the investigation.
3. The methodology of the investigation is highly appropriate to address the research question because it takes into consideration all, or nearly all, of the significant factors that may influence the relevance, reliability and sufficiency of the collected data.
4. The report shows evidence of full awareness of the significant safety, ethical or environmental issues that are relevant to the methodology of the investigation.
5. Sufficient social and historical, as well as scientific, background is covered.
6. The method of analysis and presentation are relevant.
7. The student has identified and focused on an appropriate investigation, and one that is interesting.

8. Various sections clearly and concisely state the relevant scientific context, and this dovetails nicely with the physics syllabus.
9. If the exploration is based on a simulation, the student appreciates the limitations of using a simulation.
10. The methodology, given the limited nature of modelling, is most appropriate and indeed proves interesting (in the case of explorations based on modelling).
11. The methods used are totally appropriate to the physics Diploma Programme.

Don’ts:

1. There is much more scientific context that needs to be explained.
2. The background information provided for the investigation is superficial or of limited relevance and does not aid the understanding of the context of the investigation.
3. The methodology of the investigation is only appropriate to address the research question to a very limited extent since it takes into consideration few of the significant factors that may influence the relevance, reliability and sufficiency of the collected data.
4. There is no thought given to the method; the student assumes essential aspects.
5. The methodology is mostly mere calculations, much like a homework assignment.
6. The student is not aware of assumptions, accuracy and precision in the data, errors and uncertainties.
7. The variety of experiments makes any single research question unfocused.
8. There is some weak use of language and the student often needs to get to the point more directly.
9. The student shows no or some awareness of the key safety issues.

Analysis:

Dos:

1. The report includes sufficient relevant quantitative and qualitative raw data that could support a detailed and valid conclusion to the research question.
2. Appropriate and sufficient data processing is carried out with the accuracy required to enable a conclusion to the research question to be drawn that is fully consistent with the experimental data.
3. The report shows evidence of full and appropriate consideration of the impact of measurement uncertainty on the analysis.
4. The processed data is correctly interpreted so that a completely valid and detailed conclusion to the research question can be deduced.
5. The student did make a reasonable attempt at evaluative analysis.
6. The student has selected, recorded and processed appropriate data. He or she also appreciated the scope and limitations of the data.
7. There is no doubt that the student has selected, recorded, processed and then interpreted the data in a way that directly addresses the question.
8. The range of data is adequate (indeed, with a simulation the range may or may not be a significant issue).
9. The accuracy of the data has been represented with error bars where appropriate.
10. The research question has been addressed, answered, explained and understood.

Don’ts:

1. Some basic data processing is carried out but is either too inaccurate or too insufficient to lead to a valid conclusion.
2. The report shows evidence of little consideration of the impact of measurement uncertainty on the analysis.
3. The processed data is incorrectly or insufficiently interpreted so that the conclusion is invalid or very incomplete.
4. The report includes relevant but incomplete quantitative and qualitative raw data that could support a simple or partially valid conclusion to the research question.
5. The study includes relevant but insufficient data, the processing is basic but confused, there is the expression of errors and uncertainties but they are not related to the measurements themselves, and the overall interpretation is confused.
6. The impact of uncertainties has not been addressed under analysis (it could be a part of conclusion, though).
7. The lack of any awareness of assumptions, errors, uncertainties, precision, accuracy or even significant figures is a fault under the analysis criterion.
8. The student’s research project is so simplistic that there is no question that the simulation will provide a valid conclusion.

Evaluation:

Dos:

1. A detailed conclusion is described and justified which is entirely relevant to the research question and fully supported by the data presented.
2. A conclusion is correctly described and justified through relevant comparison to the accepted scientific context.
3. Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are discussed and provide evidence of a clear understanding of the methodological issues involved in establishing the conclusion.
4. The student has discussed realistic and relevant suggestions for the improvement and extension of the investigation.
5. The conclusion is visually presented and summarized in the text.
6. The data supports the conclusion and the research question has been answered.
7. The student’s conclusion of the investigation clearly addresses the research question and it appreciates in a qualitative sense the degree of accuracy.
8. The results illustrate any given equation, and the data range and graphs were all appropriate.
9. Although the student addresses all the descriptors under evaluation for any modelling investigation, more attention to the conclusions would be needed for the top mark.
10. The student is aware of assumptions and uncertainties and systematic errors throughout the investigation, and these are all addressed in the concluding comments.

Don’ts:

1. A conclusion is outlined which is not relevant to the research question or is not supported by the data presented.

2. Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are outlined but are restricted to an account of the practical or procedural issues faced.
3. A conclusion is described which makes some relevant comparison to the accepted scientific context.
4. No or some attempt was made to evaluate the quality of the data in terms of uncertainties or assumptions.
5. The conclusions as such are properly described but only partially justified.
6. There is no attempt at addressing the methodology or technique of this investigation and improvements or extensions have not been addressed; this is an influencing factor in deciding the final mark.
7. He or she did not do an "interesting" scientific investigation with the data.
8. No thought is given to the scope or limit of the method, data analysis or any other aspect of the methodology.
9. There are no suggestions for improvements.
10. Strengths and weakness are not given the depth that one would like.

Communication:

Dos:

1. The presentation of the investigation is clear. Any errors do not hamper understanding of the focus, process and outcomes.
2. The report is well structured and clear: the necessary information on focus, process and outcomes is present and presented in a coherent way.
3. The report is relevant and concise thereby facilitating a ready understanding of the focus, process and outcomes of the investigation.
4. The use of subject specific terminology and conventions is appropriate and correct. Any errors do not hamper understanding.
5. The student's report is clearly written and presented, and there are many illustrations and mathematical calculations to remove any doubt of what the student is talking about.
6. The report flows nicely and is within the page limit. There are a number of personal touches too that help make the work interesting.
7. The structure is clear and divided into manageable sections.
8. The experimental process was clear and the comments were relevant.
9. Moreover, the calculation techniques are explained, and the graphs illustrate beautifully what the reader is to understand.

Don'ts:

1. The presentation of the investigation is unclear, making it difficult to understand the focus, process and outcomes.
2. The report is 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.
3. The understanding of the focus, process and outcomes of the investigation is obscured by the presence of inappropriate or irrelevant information.
4. There are many errors in the use of subject specific terminology and conventions.
5. The research issues are not as focused as they should have been.

6. A number of sentences are vague, some scientific context and terminology is wrong, and the graphs do not always help the understanding of the data.
7. Sometimes, the student was not as direct as he or she could have been.