

Physics

Overall grade boundaries

Grade:	E	D	C	B	A
Mark range:	0-6	7-13	14-20	21-26	27-34

The range and suitability of the work submitted

Overall most essays submitted were suitable and of good quality in terms of the subject and IB expectations. Wide variety of disciplines of physics, concepts and physics principles were covered and reflected on students' research and communication skills.

A large majority of submitted essays were investigations that required experimental setup and record of experimental data and observations. This type of investigation tends to achieve better results possibly due to the knowledge and experience acquired in the practical activities program. This approach often covers the full spectrum of the requirements of an extended essay in physics. There were lapses in terms of collecting and processing data as well as analysing them. In some cases, a large number of independent variables reduced the time available for a thorough and detailed analysis including evaluation and conclusion.

Theoretical essays were rarer. In a number of cases the topic and RQ were too broad or too complex or both, clearly above the grasp of the students. Statements in some essays were without data, lacked an argument supported by facts or did not consider alternative views.

Overall there was clear evidence of the interest and efforts students dedicated to their investigation.

Candidate performance against each criterion

Criterion A: focus and method

The new format for the title page is not always respected, often the title is missing while the RQ is generally stated. In a significant number of cases the relevant physics principles were not part of the introduction hence weakening the clarity and completeness of the communication of the topic. On the other hand, the RQ was generally clearly stated and focused. References and bibliography were appropriate. In some essays, too many references were concentrated on history or related to general knowledge e.g. Newton's

second law, wave interference, Ohm's law, but lacking references specific to the RQ itself hence showing limited research. The quality of the sources is more important than the quantity *per se*. The method (often experimental) was generally above satisfactory and often good. There was some difficulty in communicating an organized plan of the experiment, avoiding repetition.

Criterion B: knowledge and understanding

Generally, a physics theory or data/research from reliable sources must be part of the essay, hence avoiding a purely empirical essay. The link between theory and relevant variables was not always clearly described using appropriate concepts. The sources specifically related to RQ could have been used more effectively, in a number of cases the selection of these sources is quite limited. Such sources are expected in a physics EE. The terminology includes many aspects: scientific language, symbols, units, SI standards, annotated diagrams of all types as a tool of communication hence part of the language used by the student. Symbols, units, SI standards and diagrams need special attention, simple and efficient improvement can be made with regards to this. In data tables, units must be also associated to uncertainties not only to numerical values. It is good to use physics symbols instead of x and y in equations generated by software. Appropriate symbols need to be introduced for variables under study and used consistently throughout the essay.

Criterion C: critical thinking

A key criterion with many facets to satisfy. Wide range of performance with regards to the results for this criterion, reflecting the entire range of marks. The research was mainly good or adequate. Analysis was not as well done. Raw data was often collected but uncertainty not always considered, nor their propagation in processed data in the analysis. Uncertainty attached to the reading of an instrument and random uncertainty not always differentiated. Typically, the precision of a hand chronometer is confused with the uncertainty due to reaction time, hence the uncertainty of a given reading can be underestimated by a significant factor. Some analyses were just interpreting the graphs plotted with respect to the variables under study without discussing anomalous points, intersection of axes, the shape of graph, any other fit of graph, interpolation and extrapolation. Importantly, the analysis must refer to the theory, an empirical analysis using a polynomial of nth order is not satisfactory. Overall the analysis is often clearly relevant to the RQ and conclusion supported but not fully consistent with what has been presented in the body of the essay. The conclusions at times were ambivalent, not firmly stated. Evaluation was considered but usually lacked the discussion on the type of errors existing problem caused and how it affects the results. The research is usually partially critical.

Criterion D: presentation

Format and layout of essays were generally good. The organisation of the essay is logical and generally clear. One weakness is the presentation of equipment, often as a list including and the description of the procedure following a cookbook recipe style, which is not the style expected in an extended essay.

Figures, diagrams, data tables, graphs need to be labeled (which includes a number), *referred to in the text*, introduced and fully explained. This is the case also for figures extracted from a source. Key equations referred to in the text should be numbered.

There has been clear improvement in the use of appendices where only extra data tables and graphs are included (representative samples appear in the core of the essay). Students should use the appendices sparingly, as they are not part of the assessment. Any material that is not original must be carefully acknowledged, with specific attention paid to the acknowledgment and referencing of quotes and *ideas*.

Criterion E: engagement

On average the student's engagement was good. Many students were most engaged with their essays, honest about the challenges they faced and what they learned about research in physics. The ability to reflect varied significantly, at times lacking originality as well as quality work. Some students recorded part of the conversation between them and their supervisor which is not what is essentially expected. The expected content of the Reflections on planning and progress forms (RPPF) should be explained and discussed with students. Some forms were not filled properly and lacked necessary information. Criterion E is applied to the three student reflections only.

In the Extended essay guide (2016) under *Introducing students to the extended essay* information is given related to the Reflection sessions, first, interim and final reflection session (*viva voce*).

Recommendations for the supervision of future candidates

Explain the nature, role and importance of the three *reflection sessions*.

From the reading of the RPPF it seems that the choice of topic and RQ took a long time. Several students referred to their final choice in the interim reflection session. Selection of resources, online or hard copies both, sets the direction of the investigation. Both quality and relevance of the sources must be examined carefully.

Through the EE preparation, develop student's ability to analyse, discuss, evaluate and reflect.