

## Subject-specific guidance

### Overview

This section covers individual subjects' requirements for the extended essay (EE) in terms of:

- Choice of topic
- Treatment of topic
- Assessment:
  - Criterion A: focus and method
  - Criterion B: knowledge and understanding
  - Criterion C: critical thinking
  - Criterion D: presentation
  - Criterion E: engagement.

It assumes that teachers are already familiar with the EE generic guide and the EE teacher support material, in particular the process whereby students choose a subject area and topic, write their research question and select the research method(s) they will use to explore and answer it.

For a full summary, see the process diagram and the generic assessment criteria.

Or for a quick refresher, read [Extended essay: general requirements](#) .

## General requirements

The EE is an in-depth study of a focused topic. It gives students the opportunity to:

- engage in independent research with intellectual initiative, creativity and rigour
- develop research, thinking, self-management and communication skills
- reflect on what they have learned throughout the research and writing process.

All students must:

- provide a logical and coherent rationale for their choice of topic
- review what has already been written about the topic
- formulate a clear research question
- offer a concrete description of the methods they use to investigate the question
- generate reasoned interpretations and conclusions based on their reading and independent research in order to answer the question.

## Choice of topic

See also *Initial guidance on research and writing*

Students first need to identify the broad area of inquiry they are interested in.

Sources of ideas may include:

- work already undertaken as part of the course
- preliminary reading of academic journals and reputable scholarly e-resources, eg conference papers, essays, book chapters or journal articles. A school librarian can advise on this
- conversations with teachers, fellow students and librarians.

## Literature review

Students should try to read as much as they can of what has already been written about their topic. Time spent on a literature review early on in the research process will guide and improve their work. It will help them to:

- contextualize their research question and subsequent findings
- meet criterion B: demonstrating knowledge and understanding .

While conducting their literature review, students may find it useful to compile an annotated bibliography and to record their responses to what they read in their researcher's reflection space (RRS).

If using the internet, students are encouraged to use specialized academic search engines that will find resources appropriate for citation in the EE.

Students must be aware of their responsibilities to cite properly the resources they use and to check their work for plagiarism. Their citations should adhere to [the requirements of the IB](#) and be consistently applied.

## Research question

Students should identify a **working** research question early on but be prepared to change, eg if too little information is available to permit the intended investigation.

Students should be guided by the idea that what they are writing is important because:

- it seeks to fill a gap in understanding their chosen topic, or
- it offers a resolution to some controversial argument.

The research question should therefore be non-trivial and follow from the existing body of literature on the topic. It must be:

- specific, sharply focused and capable of being answered within a 4,000-word essay
- stated clearly in the introduction of the essay and on the title page
- related to the chosen topic.

Students need to avoid researching questions that are too narrow or too obvious as this will limit their ability to formulate reasoned arguments.

Their answer to the question must be analytical rather than descriptive.

## Title

The title is a formal requirement on the title page of the essay. If the title is missing, it will be considered on balance with the other formal requirements against criterion D. While there is no explicit penalty in criterion A, the title will help address the requirements as it expands on the student's intended focus. Without a title, students lose an opportunity to clarify their focus.

## Treatment of the topic

Once students have identified their topic and written their research question, they can decide how to research their answer. They may find it helpful to write a statement outlining their broad approach.

The definition of "research" and terms such as "primary data" and "secondary data" varies from subject to subject.

In some subjects, students must use both primary and secondary data. In others, students may, or even must, rely exclusively on secondary data.

However, all students must carry out secondary research in terms of a literature review for their topic.

## Two important reminders

1. Undertaking an extended essay is a challenge. Planning is crucial. Students need to start writing their papers early and discuss any emerging difficulties with their supervisor. As well as their supervisors, librarians are a great source of information, advice and support for students.
2. Students risk their diploma if found guilty of academic misconduct:

## The sciences

An overview of writing an extended essay in the sciences, see [The sciences: An introduction](#).

Environmental systems and societies guidance is in the interdisciplinary essays section.

# Physics: Subject-specific guidance

See also: EE generic guide and EE teacher support material

## Overview

An extended essay (EE) in physics should answer a research question in physics through focused, evidence-based argumentation. The evidence may be drawn from the student's personal experimentation and/or book- and internet-based research. Whichever method of research is adopted, the student must use the principles of physics.

The essay must go beyond simply informing the reader and involve the elements of personal and original thinking.

## Assumptions about the essay's readers

It should be written for an international peer audience, familiar with the Diploma Programme physics course. The essay can therefore refer to any physics from the course without proof or explanation, eg Newton's laws.

However, material from outside the physics course should be fully explained and referenced where necessary. Students should explain it freshly as it applies to their research question, thereby convincing the reader that they have a genuine grasp of the physics involved.

Students should also explain any culture-specific matters they refer to in the essay in relation to physics, eg cricket or baseball.

## Choice of topic

The topic should be a challenge for the student without being over-specialized. It should use the knowledge gained in the physics course to answer a research question that goes beyond the course content. The question must not be trivial in nature.

## Inappropriate topics

Topics that require theory that is beyond the grasp of the student should be discouraged. Students should avoid broad or complex topics beyond the scope of the EE, such as investigations into quantum computers or black holes.

## Research question

Having decided upon the area of investigation, the student should define a narrow and well-focused question. At this stage it is important to imagine the possible outcomes and conclusions. Doing so will help in the process of defining the question and choosing the methodology.

The selection of the topic and research question is a crucial step of the student's investigation. The guidance of the supervisor is vital in making sure that the student's choice is proper, relevant, realistic and promising.

## Examples of topics

These examples are just for guidance. Students must ensure their choice of topic is focused (left-hand column) rather than broad (right-hand column).

✓ Focused topics	✗ Broad topics
The time taken for a single domino to fall depending upon its height and width	Falling dominoes
The frequency of sound produced by a violin depending on room temperature	Musical instruments
The rate of diffusion of different gases from an inflated balloon	Deflating balloons

## Treatment of the topic

Physics essays usually have a title, which sums up the essence of the investigation. It is based on the student's identified topic area.

The research question further refines and defines the topic. It must be expressed as a question, not a statement. It must be expressed clearly and precisely, and appear early in the introduction of the essay and on the title page of the essay.

For example, a student may have noticed how it is difficult to spin an uncooked egg. After discussion with the supervisor, the student decides to fill a tin with liquids of different viscosities and roll them down an inclined plane. The title of the essay may be: "The effect of the viscosity of a body on its angular acceleration."

The research question, though, should be much more specific: "What is the relationship between the angular acceleration of a cylindrical can rolling down an inclined plane and the viscosity of its contents?"

## Methods of approach

Students can choose to answer their research question with an essay based solely on theory or one based on data and theory.

If their essay is data based, students can choose to collect their own primary data or use secondary data that has already been collected elsewhere.

Students should consider the reliability of both primary and secondary sources at the start of the planning stage. Students must critically evaluate secondary data and the design of the experiment(s) by which they were collected with the same care that they would their own.

## Importance of theory

Every EE in physics will involve applying relevant theory to the topic selected. Students must ground any experimental work in good background research from existing sources of information.

Before embarking on experimental work, students must first ensure that there is scope to explore and model the physics that underpins it. A purely empirical investigation that relates a number of variables in the absence of any theoretical foundation is never satisfactory.

For example, in an investigation relating the index of refraction of a salt solution to its concentration, the student must model the physics relating the index to the concentration.

## Using secondary data

Students using data collected elsewhere can access all the assessment criteria and achieve the highest marks. For example, they can obtain astronomical data from databases and manipulate it in order to contribute to a research question that looks for the evidence of extrasolar planets.

Ideally, students will manipulate or analyse this secondary data in an original way. Essays that simply restate facts or data taken directly from the sources are of little value. The element of personal analysis and evaluation is extremely important.

## Collecting primary data

Students should choose experiments that do not require extensive lengths of time for the construction of apparatus. Highly sophisticated instruments are rarely required and can hinder the understanding of a phenomenon. Some of the best EEs have been written by students investigating relatively simple phenomena using standard school apparatus, and this approach is to be encouraged.

Students must give a clear and concise description of their experimental procedure so that it can be repeated by others. This will normally involve clearly annotated scientific diagrams. Exhaustive lists of equipment and detailed descriptions of procedures should be avoided.

## Theoretical essays

Theoretical essays offer students the challenge of exploring existing material in a new way. This may mean applying the theories and techniques of physics to an unconventional area.

Students may be tempted to incorporate mathematics or computer science, but they must ensure that the focus of the analysis and evaluation is on the discipline of physics.

Where computer programs are used and analysed from a physics perspective, they should be placed in the appendix. Each line of code of a program fragment included in the body of the essay will count as two words towards the word limit.

## Examples of topics, research questions and suggested approaches

Once students have identified their topic and written their research question, they can decide how to research their answer. They may find it helpful to write a statement outlining their broad approach. These examples are for guidance only.

Topic	<b>The relationship between the dimensions of an exhaust pipe and the sound it emits</b>
Research question	What is the relationship between the length of an exhaust pipe and the frequency of the sound it emits?
Approach	A clear opportunity for theory here and this can be supported by a student-designed simulation. Conducting the experiments may be difficult but can be achieved by analysing the recorded sound.

Topic	<b>The time taken to reach terminal velocity</b>
Research question	How does the time taken to reach terminal velocity depend upon the viscosity of the fluid it is falling through?
Approach	This is a good opportunity for experimentation using a viscous liquid. Quantitatively measuring viscosity and changing the viscosity without changing other variables will provide additional challenges. Mathematically modelling using a spreadsheet simulation will help to determine the expected answer.

Topic	<b>The temperature dependence of the sound of flowing water</b>
Research question	How does the frequency spectrum of the sound of running water depend upon its temperature?
Approach	This would be a very doable challenge. The student would be expected to do the experiment and also to find some way of accounting for and modelling the change of frequency observed.

## An important note on “double-dipping”

Students must ensure that their EE does not duplicate other work they are submitting for the Diploma Programme. For example, the same experiments cannot be used for the EE and the internal assessment or other practical work carried out during the course.

## The physics EE and internal assessment

In particular, an EE in physics is not an extension of the internal assessment (IA) task. Students must ensure that they understand the differences between the two.

- The IA is more likely to focus on the syllabus content, whereas the EE can explore aspects of physics not covered in the syllabus.
- The IA must include data collection and analysis (from hands-on experiments, databases, simulations or modelling) and cannot purely be a literature review.
- The EE must construct a theoretical framework for the underlying physics of the chosen topic, whereas the IA focuses on the application of the scientific method to a problem of interest and will only include some background information.
- The EE explicitly assesses the students’ ability to analyse and evaluate scientific arguments.

**Supervisors play an important role in guiding students on these distinctions. Students risk their diploma if academic misconduct is detected.**



# Interpreting the EE assessment criteria

## Criterion A: Focus and method

(Strands: Topic, Research question, Methodology)

The title of the essay should:

- reflect the essence of the investigation
- by itself clearly describe the topic or aim of the essay
- not be too long
- be clarified, if necessary, early in the essay
- be different from the research question
- usually be presented as a statement.

Early in the essay the student should also outline the area of the research and the purpose and focus of the essay to clearly establish the context of the research question. It is usually appropriate to identify the physics principles relevant to the research question.

For example, a brief description of the motion of a cylindrical magnet falling inside a copper pipe will include the application of the laws of electromagnetic induction as well as Newton's laws of motion.

For this, the student should write a qualitative description of the forces acting on the falling magnet, and their possible variations along its path. Their description could usefully include diagram(s) and perhaps a sketch graph.

A formal development of the theory relevant to the research question follows later on in the essay.

The research question must be centred on physics as a science. It must not focus on peripheral issues, such as the history of physics or social implications of discoveries in physics.

The way in which students plan their investigation will depend on the approach they choose. They must demonstrate that their chosen methods and materials do address the research question.

If the essay is data-based, students' planning should include:

- the relevant physics theory based on reliable and appropriate literature research
- an appreciation of the uncertainties and limitations of techniques and apparatus for data collection.

Students must explain clearly the rationale for choosing their particular experimental methods. However, preliminary work should not be part of the core of the essay.

If their study is based on the research of secondary data, students need to ensure that the selection of sources is sufficiently wide and reliable.

## Criterion B: Knowledge and understanding

(Strands: Context, Subject-specific terminology and concepts)

The essay must show clear evidence of understanding of the physics focused on in the essay.