

	Structural conventions relating to individuals and societies subjects include: clearly labelling diagrams, maps (that have all the required elements, such as scale and a key/legend), images and graphs, acknowledging if these are the work of others, and actively referring to them in the body of your essay; appropriate use of headings to organize your essay where appropriate.
B: Knowledge and understanding	<p>Each individuals and societies subject will have its own terminology, technical words and other special words or phrases that are used in that subject. Using this terminology identifies you as someone who understands the nature of the subject, e.g. “supply and demand” in economics or “digital systems” in digital society.</p> <p>Using important concepts in the subject in a meaningful and explanatory way in your writing demonstrates your knowledge and understanding. Application of key concepts in your writing is essential. For example, in a history extended essay you are likely to work the concepts “causation” and “consequence” into your essay. In social and cultural anthropology, you might apply a concept such as “marginalization” to show your understanding of a topic concerning the social exclusion of a group of people.</p>
C: Analysis and line of argument	Regardless of the individuals and societies subject you are using, when you “own” the theories, concepts and methods of that subject, and can weave your research findings towards conclusions that answer your research question, you will have produced a strong line of argument that links your analysis to the research question and the conclusion.
D: Discussion and evaluation	<p>Consider what a balanced discussion looks like in an essay written in your subject. Review good examples of extended essays and other academic essays in that subject, and ensure that the supporting evidence you have used is appropriate. Evaluate by weighing up the strengths and limitations of your essay.</p> <p>A balanced discussion considers different perspectives on your topic. For example, a social and cultural anthropology essay exploring elements of cultural control in the context of neocolonialism could include discussions stemming from analysing the perspectives of the different stakeholders involved.</p>
E: Reflection	Refer to the “ Generic guidance for the extended essay ” and the “ Reflection and the extended essay ” sections of this guide.

Sciences

Note: Before reading the following guidance, read the “[Generic guidance for the extended essay](#)” section in this guide.

What is distinctive about an extended essay in the sciences?

An extended essay in any of the science subjects—biology, chemistry, computer science, design technology, physics, and sports, exercise and health science—offers the opportunity to investigate and collect primary or secondary data, based on a focused research question. You collect evidence using scientific methodology. Your findings must lead to a valid, evidence-based conclusion.

Science essays can be characterized by the development of hypotheses, replicable data and the use of peer-reviewed publications. These three processes differentiate a scientific process from a pseudoscientific one.

A good extended essay is based on accepted, subject-specific methodology, requires a good understanding of the underlying concepts and uses appropriate terminology. Science extended essays based on primary data must use controlled, independent variables and a standardized methodology that makes the research applicable and allows valid conclusions to be drawn. For example, a good extended essay in biology could explore the anti-proliferative effect of anthocyanin. An extended essay in design technology could focus on new technologies and how they influence existing technologies.

Choosing a topic

When choosing a topic in any of the sciences, you must be realistic and mindful of the facilities at your disposal. The topic must have a strong focus on the subject for which the extended essay is submitted. Avoid topics that are beyond the scope and timeline of an extended essay or would involve lengthy research using sophisticated laboratory equipment not usually found in school laboratories (labs). Also be careful not to choose a topic where collecting sufficient data to answer the question is infeasible because it would be unethical or impractical.

Extended essays based on simple experimental data are just as valid as research conducted in university labs or hospitals. Obviously, the chosen topic must be of interest to you. Preferably, you already have some knowledge of the theory and understand the concepts. Conceptual understanding applies even more when writing an extended essay based on secondary data. Be aware that published (scientific) literature sometimes assumes knowledge and understanding that is higher than the level expected of a DP student; this can be challenging but also rewarding. You need to stay focused on valid analysis that leads to credible, evidenced conclusions. An additional aspect of basing an extended essay on secondary data is that the scientific articles or databases must use a similar standardized approach and controls, and preferably similar methodologies.

The basic premise when choosing a topic for an extended essay is not to overcomplicate it: keep it manageable within the time you have.

Example topics, research questions and approaches

Subject	Topic and research question	Outline of approach
Biology	<p>Topic: KNO_3 concentrations and growth rate</p> <p>Research question: What is the effect of increasing KNO_3 concentrations (0.1 mM, 0.2 mM, 0.3 mM, 0.4 mM, 0.5 mM) on the growth rate of onion roots (<i>Allium cepa</i>)?</p>	Independent variables, such as increasing nitrate concentrations, may have to be fine-tuned. Some concentrations may lead to the death of the plants. A pilot experiment is recommendable, as well as comparing with published (scientific) concentrations.
	<p>Topic: Parity as a measurable variable in the development of breast cancer</p> <p>Research question: To what extent is parity a measurable variable in the development of breast cancer?</p>	<p>Studies from different countries reporting rates of breast cancer and associated risk factors are accessed using PubMed, Directory of Open Access Journals (DOAJ), JSTOR, Google Scholar and Science Direct. Studies are selected using a set of predetermined criteria that are clearly explained.</p> <p>The data from the selected journal articles is analysed and evaluated in a way that allows valid comparisons to be</p>

Subject	Topic and research question	Outline of approach
		made. It must then be made clear how the data has been interpreted and manipulated.
Chemistry	<p>Topic: The effect of manganese oxide versus copper (II) oxide in the catalysation of hydrogen peroxide</p> <p>Research question: What is the effect of manganese oxide versus copper (II) oxide in the catalysation of hydrogen peroxide at 21 °C?</p>	<p>Begin by gathering background information regarding decomposition of hydrogen peroxide and different catalytic pathways and mechanisms. Practical research is undertaken with careful selection of variables. Comparative graphs are produced showing the results and interpreting them using theory.</p>
	<p>Topic: The electronegativity of the distinctive atom in inorganic mono-oxoacids</p> <p>Research question: How does the electronegativity of the distinctive atom in inorganic mono-oxoacids affect its pKa values?</p>	<p>This can be typical data-based research. The background information initially gathered should consider appropriate acid-base theory, the definition of pKa and the inductive effect. Several sources must be used to determine values for dependent and independent variables. The results are shown in a graph that can be analysed using the main theoretical issues.</p>
Computer science	<p>Topic: The speed of execution of algorithms</p> <p>Research question: To what extent does the type of core (logical or physical) of a modern central processing unit (CPU) influence the speed at which algorithms are executed?</p>	<p>The essay investigates whether logical cores, using techniques such as hyperthreading, can be a viable alternative to the implementation of several more expensive physical cores. The technical details of both types of cores must be investigated prior to a benchmarking experiment that compares the running of different algorithms with large datasets.</p>
	<p>Topic: Classification of malignant cancer</p> <p>Research question: To what extent is a feed-forward neural network more accurate in classifying malignant cancer compared to k-nearest neighbour (KNN)?</p>	<p>The essay initially includes information on the theoretical background, including explanations on how the two algorithms are set up with respect to their parameters. The experiment then compares the two approaches. The two algorithms are constructed and evaluated using various Python libraries including Scikit, TensorFlow and Keras. An appropriate data set modified to better fit the experiment can be downloaded from the University of California (UCI).</p>

Subject	Topic and research question	Outline of approach
Design technology	<p>Topic: Sustainable design of egg packaging</p> <p>Research question: What is the most appropriate design for sustainable egg packaging suitable for food retailers in markets in Vietnam?</p>	<p>Establish primary evidence of the existing problem. You can include interviews with retailers and customer surveys. This is followed by a consideration of primary packaging, form, function and sustainability research.</p> <p>The essay then covers the selection of material and the construction of fidelity prototype models (physical or digital) made by the student to test the safety of packaging. Environmental impacts are also considered.</p> <p>Later steps are the selection of designs for field testing and feedback. Finally, develop a fidelity model solution and test it against the intended users' needs.</p>
	<p>Topic: The impact of circular economy practices on sustainability in the fashion industry</p> <p>Research question: What improvements can large fast fashion retailers make to minimize waste, maximize resource efficiency and promote sustainability?</p>	<p>Secondary research investigates circular economy practices within the fast fashion sector, highlighting that a more comprehensive approach can address environmental concerns and promote sustainable and circular practices throughout the product lifecycle.</p> <p>Primary research is also undertaken: a survey of customers or retailers to understand what changes would be desirable; similarly, research showing the steps that some large retailers have taken to mitigate their impacts.</p> <p>Potential supporting project areas could include: clothing rental and second-hand markets; recycling and upcycling initiatives; supply chain sustainability; consumer education and awareness policy; industry collaboration.</p>
Physics	<p>Topic: The relationship between exit velocity and the speed of the top surface of water</p> <p>Research question: Neglecting friction, how does the exit velocity, V, relate to the speed of the top surface of the water, v, at distance, h, above the opening?</p>	<p>This essay is based on primary data.</p> <p>It is an opportunity for you to look at this event holistically, applying fundamental principles of fluid dynamics.</p> <p>The set-up must allow constant measurement of two speeds during flow time.</p>
	<p>Topic: Estimating the mass of Saturn</p> <p>Research question: From data related to Saturn's satellites and rings, what is the best estimate of Saturn's mass?</p>	<p>This essay is based on secondary data.</p> <p>You would need to consider a number of satellites, near and far. Also, investigate the nature of the rings, what information is required and how it can be obtained.</p>

Subject	Topic and research question	Outline of approach
Sports, exercise and health science	<p>Topic: The effect of a high-intensity interval training (HIIT) programme on cardiovascular endurance</p> <p>Research question: Does a six-week HIIT programme provide significantly enhanced cardiovascular endurance?</p>	<p>This essay is based on primary research. It will involve experimental design, with participants randomized into intervention and control groups.</p>
	<p>Topic: The impact of exercise on symptoms of depression</p> <p>Research question: Does exercise meaningfully reduce depressive symptoms?</p>	<p>This essay is based on secondary research.</p> <p>A systematic review is undertaken to identify relevant research articles, from which findings are presented and a conclusion is reached.</p>

Researching and writing the essay

The first step is the carrying out of background research. This applies to essays based only on secondary data, and to those that use primary and secondary data. Before you delve into peer-reviewed scientific publications, ensure that you understand fully the theories and concepts associated with your topic. They must be linked to the topic and research question and support the argument. For secondary data, the selection criteria for the material to be included should be made explicit in the essay.

A focused research question will enable you to sustain an argument throughout the essay. The question will define the structure of your essay, the methodology based on scientific principles, and the terminology. It will support an analytical, data-based or data-driven discussion. The sources must support the introduction of the topic and be used to support and give context to the analysis and the discussion. Variables in the research question must be defined and justified, and allow measurements to be made in the investigation. The International System of Units (SI) must be used.

The methodology must be detailed so that the investigation can be replicated. The methodology must support measuring the dependent variables under standardized conditions.

The results must be presented in a standardized format. They must be clearly labelled with appropriate headings, units and numbering. Essays based on secondary data may copy graphs or tables from the selected sources, but the (statistical) analysis must be performed by you, the student.

The conclusions must be supported by the data. However, do not be concerned if the collected data does not support your hypothesis; “negative” results are just as valid as “positive” results in relation to the critical evaluation of the results and conclusions in the context of the research question.

The evaluation must be linked to the research question and the methodology. It must show the strengths and weaknesses of the essay, preferably in a scientific context, and must also include the sources.

Considering the assessment criteria

Make sure you use the extended essay assessment criteria to remind yourself of the expected elements of the extended essay. Each of the five criteria (A–E) is accompanied by a guiding question that should be applied to the context of the sciences. In this way, you can see how the assessment criteria relate to your own essay. It is important that you also refer to the “[Generic guidance for the extended essay](#)” section in this guide for a broader spectrum of advice on using the assessment criteria to inform your writing.

A: Framework for the essay	<p>The research question will decide the research methods, which then need to yield appropriately scientific data that supports a logical response to it. A focused question encourages strong data analysis and critical evaluation of findings.</p> <p>For sciences extended essays where the research is conducted in universities or other external organizations, ensure that the methods</p>
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	<p>used are your own and not just those established by the organization.</p> <p>Structural conventions: essays in the sciences often include more data than other subjects, so make sure that data tables, diagrams and graphs can be clearly understood and are appropriately labelled, and that all data is clearly processed. Examples of calculations should include mathematical uncertainties on the measurements collected.</p>
B: Knowledge and understanding	<p>Knowledge and understanding must be demonstrated by exploring and discussing the underlying processes and theories, using clear and well-explained terminology. This is especially critical in essays based on secondary data. For example, when investigating the turnover rate of an enzyme, it is essential to discuss enzyme kinetics.</p>
C: Analysis and line of argument	<p>Analysis must follow standard processes, including qualitative and quantitative approaches and statistical methods where appropriate, and may include mathematical transformation. The analysis should be done in such a way as to address the research question directly.</p> <p>Analysis of secondary data must be your own.</p> <p>A clear line of argument should be maintained throughout and all elements of your sciences extended essay should be linked; only then is it effective in communicating your message. For example, if the topic is about the kinetics of photosynthesis, then discussion of the morphology of plant leaves is not relevant.</p> <p>If the research question is not fully answered, you should state unresolved issues, account for these and suggest improvements.</p>
D: Discussion and evaluation	<p>The discussion should be critical, have a scientific context and must always be linked to the research question. Ensure that discussions use the sources to support conclusions.</p> <p>The conclusion should not be a repetition of results but a supported, well-explained synthesis of them.</p> <p>The evaluation of your essay should indicate any unresolved issues, accounting for these and suggesting improvements, and should be linked to the findings and the research question.</p>
E: Reflection	<p>Refer to the “Generic guidance for the extended essay” and the “Reflection and the extended essay” sections of this guide.</p>

Mathematics

Note: Before reading the following guidance, read the “[Generic guidance for the extended essay](#)” section in this guide.

What is distinctive about an extended essay in mathematics?

An extended essay in mathematics should generally take one of the following approaches.

- Explore an issue in mathematics of interest to you that is outside of the syllabus. Sometimes in the course of your studies or in your wider reading, your curiosity might be aroused by a problem in mathematics or a different approach to mathematics that you might be interested to explore: see examples 1, 2 and 3 under “Example topics, research questions and approaches” below. These could be called **theoretical** essays.