

# 16

## Exploration

### CHAPTER OBJECTIVES:

As part of your Mathematics SL course, you need to write an exploration, which will be assessed and counts as 20% of your final grade.

This chapter gives you advice on planning your exploration, hints and tips to help you get a good grade by making sure your exploration satisfies the assessment criteria, as well as suggestions on choosing a topic and getting started on your exploration.

### 16.1 About the exploration

The exploration is an opportunity for you to show that you can apply mathematics to an area that interests you.

You should aim to spend:

10 hours of class time	10 hours of your own time
<ul style="list-style-type: none"> <li>• Discussing the assessment criteria</li> <li>• Discussing suitable topics/titles</li> <li>• Discussing your progress with your teacher</li> </ul>	<ul style="list-style-type: none"> <li>• Planning your exploration, doing research to help select an appropriate topic</li> <li>• Researching, collecting and organising your data and/or information</li> <li>• Applying mathematical processes:               <ul style="list-style-type: none"> <li>■ Ensuring that all of your results are derived using logical deductive reasoning</li> <li>■ Ensuring that your proofs (when necessary) are coherent and correct</li> </ul> </li> <li>• Demonstrating mathematical communication and presentation:               <ul style="list-style-type: none"> <li>■ Checking that your notation and terminology are consistently correct</li> <li>■ Adding diagrams, graphs or charts where necessary</li> <li>■ Making sure your exploration is clearly structured and reads well</li> </ul> </li> </ul>

Your school will set you deadlines for submitting a draft and the final piece of work.

If you do not submit an exploration then you receive a grade of “N” for Mathematics SL, which means you will not receive your IB diploma.

### 16.2 Internal assessment criteria

Your exploration will be assessed by your teacher, against given criteria.

It will then be externally moderated by the IB using the same assessment criteria.

The final mark for each exploration is the sum of the scores for each criterion.

The maximum possible final mark is 20.

This is 20% of your final grade for Mathematics SL.

A good exploration should be clear and easily understood by one of your peers, and self-explanatory all the way through.

The criteria are split into five areas, A to E:

<b>Criterion A</b>	Communication
<b>Criterion B</b>	Mathematical presentation
<b>Criterion C</b>	Personal engagement
<b>Criterion D</b>	Reflection
<b>Criterion E</b>	Use of mathematics

#### Criterion A: Communication

This criterion assesses the organization, coherence, conciseness and completeness of the exploration.

Achievement level	Descriptor
0	The exploration does not reach the standard described by the descriptors below.
1	The exploration has some coherence.
2	The exploration has some coherence and shows some organization.
3	The exploration is coherent and well organized.
4	The exploration is coherent, well organized, concise and complete.

Every candidate taking Mathematics SL **must** submit an exploration. Ensure that you know your school's deadlines and keep to them.

These criteria are explained in more detail, with tips on how to ensure your exploration satisfies them. Make sure you understand these criteria and consult them frequently when writing your exploration.

## Your exploration

To get a good mark for **Criterion A:** Communication

- ✓ A well organized exploration should have
  - An **introduction** in which you should discuss the context of the exploration
  - A **rationale** which should include an explanation of why you chose this topic
  - A description of the **aim** of the exploration which should be clearly identifiable
  - A **conclusion**.
- ✓ A coherent exploration is logically developed and easy to follow.
- ✓ Your exploration should 'read well'.
- ✓ Any graphs, tables and diagrams that you use should accompany the work in the appropriate place and not be attached as appendices to the document.
- ✓ A concise exploration is one that focuses on the aim and avoids irrelevancies.
- ✓ A complete exploration is one in which all steps are clearly explained without detracting from its conciseness.
- ✓ It is essential that references are cited where appropriate, i.e.,
  - Your exploration should contain footnotes as appropriate. For example, if you are using a quote from a publication, a formula from a mathematics book, etc., put the source of the quote in a footnote.
  - Your exploration should contain a bibliography as appropriate. This can be in an appendix at the end. List any books you use, any websites you consult, etc.

## Criterion B: Mathematical presentation

This criterion assesses to what extent you are able to:

- use appropriate mathematical language (notation, symbols, terminology)
- define key terms, where required
- use multiple forms of mathematical representation such as formulae, diagrams, tables, charts, graphs and models, where appropriate.

Achievement level	Descriptor
0	The exploration does not reach the standard described by the descriptors below.
1	There is some appropriate mathematical presentation.
2	The mathematical presentation is mostly appropriate.
3	The mathematical presentation is appropriate throughout.

## Your exploration

To get a good mark for **Criterion B:** Mathematical communication

- ✓ You are expected to use appropriate mathematical language when communicating mathematical ideas, reasoning and findings.
- ✓ You are encouraged to choose and use appropriate ICT tools such as graphic display calculators, mathematical software, spreadsheets, databases, drawing and word-processing software, as appropriate, to enhance mathematical communication.
- ✓ You should define key terms, where required.
- ✓ You should express your results to an appropriate degree of accuracy, when appropriate.
- ✓ You should always include scales and labels if you use a graph. Tables should have appropriate headings.
- ✓ Variables should be explicitly defined.
- ✓ Do not use calculator or computer notation. For example, use  $2^x$  and not  $2^{\wedge}x$ ; use  $x$  not  $*$ ; use  $0.028$  and not  $2.8e-2$ .

## Criterion C: Personal engagement

This criterion assesses the extent to which you engage with the exploration and make it your own.

Achievement level	Descriptor
0	The exploration does not reach the standard described by the descriptors below.
1	There is evidence of limited or superficial personal engagement.
2	There is evidence of some personal engagement.
3	There is evidence of significant personal engagement.
4	There is abundant evidence of outstanding personal engagement.

### Your exploration

**To get a good mark for Criterion C:** Personal engagement

- ✓ You should choose a topic for your exploration that you are interested in as it will be easier to display personal engagement.
- ✓ You can demonstrate personal engagement by using some of the following different attributes and skills. These include:
  - Thinking and working independently
  - Thinking creatively
  - Addressing your personal interests
  - Presenting mathematical ideas in your own way
  - Asking questions, making conjectures and investigating mathematical ideas
  - Looking for and creating mathematical models for real-world situations
  - Considering historical and global perspectives
  - Exploring unfamiliar mathematics.

### Criterion D: Reflection

This criterion assesses how you review, analyze and evaluate the exploration.

Achievement level	Descriptor
0	The exploration does not reach the standard described by the descriptors below.
1	There is evidence of limited or superficial reflection.
2	There is evidence of meaningful reflection.
3	There is substantial evidence of critical reflection.

### Your exploration

**To get a good mark for Criterion D:** Reflection

- ✓ Although reflection may be seen in the conclusion to the exploration, it may also be found throughout the exploration.
- ✓ You can show reflection in your exploration by
  - Discussing the implications of your results
  - Considering the significance of your findings and results
  - Stating possible limitations and/or extensions to your results
  - Making links to different fields and/or areas of mathematics.

### Criterion E: Use of mathematics

This criterion assesses to what extent you use mathematics in your exploration.

Achievement level	Descriptor
0	The exploration does not reach the standard described by the descriptors below.
1	Some relevant mathematics is used.
2	Some relevant mathematics is used. Limited understanding is demonstrated.
3	Relevant mathematics commensurate with the level of the course is used. Limited understanding is demonstrated.
4	Relevant mathematics commensurate with the level of the course is used. The mathematics explored is partially correct. Some knowledge and understanding are demonstrated.
5	Relevant mathematics commensurate with the level of the course is used. The mathematics explored is mostly correct. Good knowledge and understanding are demonstrated.
6	Relevant mathematics commensurate with the level of the course is used. The mathematics explored is correct. Thorough knowledge and understanding are demonstrated.

### Your exploration

**To get a good mark for Criterion E:** Use of mathematics

- ✓ You are expected to produce work that is commensurate with the level of the course you are studying. The mathematics you explore should either be part of the syllabus, or at a similar level (or beyond).
- ✓ You should ensure that the mathematics involved is not completely based on mathematics listed in the prior learning.
- ✓ **If the level of mathematics is not commensurate with the level of the course you can only get a maximum of two marks for this criterion.**
- ✓ You need to demonstrate that within your exploration that you fully understand the mathematics used.

## 16.3 How the exploration is marked

Once you have submitted the final version of your exploration, your teacher will mark it. The teacher looks at each criterion in turn, starting from the lowest grade. As soon as your exploration fails to meet one of the grade descriptors, then the mark for that criterion is set.

The teacher submits these marks to the International Baccalaureate, via a special website. A sample of your school's explorations is selected automatically from the marks that are entered and this sample is sent to an external moderator to be checked. This person moderates the explorations according to the assessment criteria and checks that your teacher has marked the explorations accurately.

If your teacher has applied the criteria to the exploration too severely then your school's exploration marks may be increased.

If your teacher has applied the exploration criteria too leniently then your school's exploration marks may be decreased.

## 16.4 Academic Honesty

This is extremely important in all your work. Make sure that you have read and are familiar with the IB Academic Honesty document.

**Academic Honesty** means:

- that your work is authentic
- that your work is your own intellectual property
- that you conduct yourself properly in written examinations
- that any work taken from another source is properly cited.

**Authentic work:**

- is work based on your own original ideas
- can draw on the work and ideas of others, but this must be fully acknowledged (e.g. in footnotes and a bibliography)
- must use your own language and expression – for both written and oral assignments
- must acknowledge all sources fully and appropriately (e.g. in a bibliography).

Your teacher or IB Diploma Programme coordinator will be able to give you this document.

## Malpractice

The IB defines **malpractice** as 'behavior that results in, or may result in, the candidate or any other candidate gaining an unfair advantage in one or more assessment components'.

**Malpractice** includes:

- plagiarism – copying from others' work, published or otherwise
- collusion – working secretly with at least one other person in order to gain an undue advantage. This includes having someone else write your exploration, and passing it off as your own
- duplication of work
- any other behavior that gains an unfair advantage.

'Plagiarism' is a word derived from Latin, meaning 'to kidnap'.

### Advice to schools:

- A school-wide policy must be in place to promote Academic Honesty
- All candidates must clearly understand this policy
- All subject areas must promote the policy
- Candidates must be clearly aware of the penalties for academic dishonesty
- Schools must enforce penalties, if incurred.

## Acknowledging sources

Remember to acknowledge all your sources. Both teachers and moderators can usually tell when a project has been plagiarised. Many schools use computer software to check for plagiarism. If you are found guilty of plagiarism then you will not receive your diploma. It is not worth taking the risk.

You will find a definition of plagiarism in the Academic Honesty document.

## 16.5 Record keeping

Throughout the course, it would be a good idea to keep an exploration journal, either manually or online. Keeping a journal will help you to focus your search for a topic, and also remind you of deadlines.

Keeping a journal while you write your exploration will also help you to demonstrate its academic honesty.

If you use a journal for Theory of knowledge you will probably appreciate how much help it is when writing your essays. In the same way, keeping a journal for your exploration will be a great assistance in focusing your efforts.

- Make notes of any books or websites you use, as you go along, so you can include them in your bibliography.
- There are different ways of referencing books, websites, etc. Make sure that you use the style advised by your school and **be consistent**.
- Keep a record of your actions so that you can show your teacher how much time you are spending on your exploration. Include any meetings you may have with your teacher about your exploration.
- Remember to follow your teacher's advice and meet the school's deadlines.
- The teacher is there to help you – so do not be afraid to ask for guidance. The more focused your questions are, the better guidance your teacher can give you.

## 16.6 Choosing a topic

You need to choose a topic that interests you, because then you will enjoy working on your exploration, you will put more effort into the exploration, and you will be able to demonstrate authentic personal engagement more effectively. You should discuss the topic with your teacher before you put too much time and effort into writing your exploration.

Your teacher might give your class a set of stimuli – general areas from which you could choose a topic. Alternatively they might encourage you to find your own topic based on your interests and level of mathematical competence.

Each chapter of this book suggests some ideas for explorations, which could be starting points for you to choose a topic.

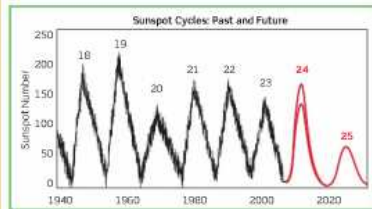
These questions may help you to find a topic for your exploration:

- What areas of the syllabus am I enjoying the most?
- What areas of the syllabus am I performing best in?
- Which mathematical skills are my strengths?
- Do I prefer pure mathematics, or applied problems and modeling?
- Have I discovered, either through reading or the media, mathematical areas outside of the syllabus that I find interesting?
- What career do I eventually want to enter, and what mathematics is important in this field?
- What are my own special interests or hobbies? Where is the mathematics in these areas?

# Mind map

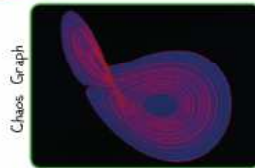
One way of choosing a topic is to start with a general area of interest and create a mind map. This can lead to some interesting ideas on applications of mathematics to explore.

The mind map below shows how the broad topic 'Geography' can lead to suggestions for explorations into such diverse topics as the spread of disease, earthquakes or global warming.



Predictions  
 Spread of disease  
 Dynamic Systems  
 Chaos Theory

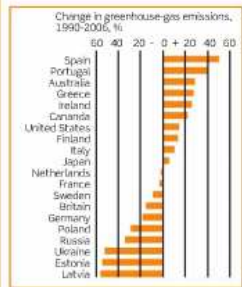
Population



Comparative study of emission of gases

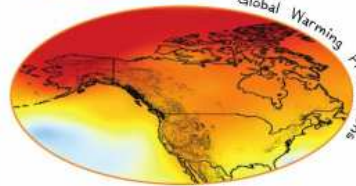
Temperature differences

Global Warming



Differences in ozone concentrations

Global Warming Predictions



Maps

Four color problem  
 Lengths of borders

How it was proven  
 Fractal dimensions of coastlines and borders



Time zones

Origin and development  
 Calendars  
 International time zones and GMT

Non Euclidian Geometries

Gradient grids



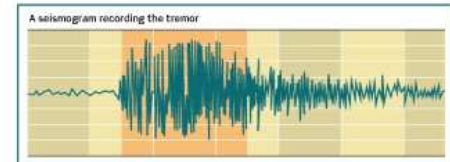
GEOGRAPHY

Environment

Bridges

Skyscrapers

Dams and artificial lakes



Continental Drift

Earthquakes and the Richter Scale



Volcanoes

Volcano



## 16.7 Getting started

Once you have chosen your topic, the next step is to do some research. The purpose of the research is to determine the suitability of your topic.

Do not limit your research to the internet. Your school library will have books on mathematics that are interesting and related to a variety of different fields.

These questions will help you to decide if your chosen topic is suitable.

- What areas of mathematics are contained in my topic?
- Which of these areas are accessible to me or are part of the syllabus?
- Is there mathematics outside the syllabus that I would have to learn in order to complete the exploration successfully? Am I capable of doing this?
- Can I show personal engagement in my topic, and how?
- Can I limit my work to the recommended length of 6 to 12 pages if I choose this topic?

If your original choice of topic is not suitable, has your research suggested another, better topic? Otherwise, could you either widen out or narrow down your topic to make it more suitable for the exploration?

Once you think you have a workable topic, write a brief outline covering:

- why you chose this topic
- how your topic relates to mathematics
- the mathematical areas in your topic, e.g. algebra, geometry, trigonometry, calculus, probability and statistics, etc.
- the key mathematical concepts in your topic, e.g. areas of irregular shapes, curve fitting, modeling data, etc.
- the mathematical skills you will need, e.g. writing formal proofs, integration, operations with complex numbers, graphing piecewise functions, etc.

- any mathematics outside the syllabus that you will need
- possible technology and software that can help in the design of your exploration and in doing the mathematics
- key mathematical terminology and notation required in your topic.

Now you are ready to start writing the topic in detail.

Remember that your fellow students (your peers) should be able to read and understand your exploration. You could ask one of your classmates to read your work and comment on any parts which are unclear, so you can improve them.

Make sure you keep every internal deadline that your teacher assigns. In this way, you will receive feedback in time for you to be able to complete your exploration successfully.