

## MATHEMATICS

### Overall grade boundaries

<b>Grade:</b>	E	D	C	B	A
<b>Mark range:</b>	0 - 7	8 - 15	16 - 22	23 - 28	29 - 36

### The range and suitability of the work submitted

There is still room for much improvement in this domain. The main types of inappropriate subjects are:

- 1) Subjects not lending themselves to mathematical treatment and therefore having only trivial and negligible mathematical content. (e.g. mathematics and sports, mathematics and music, mathematics and architecture, mathematics and beauty).
- 2) Subjects lending themselves (within the framework of an extended essay) to only minimal mathematical treatment, mostly enumeration and trivial arithmetical calculations (e.g. mathematics and blackjack, the Golden Proportion).
- 3) Statistical subjects which for the most part consist of an ill conceived survey followed by an elementary (and often inappropriate) statistical treatment, again with no real mathematical content.
- 4) Subjects too difficult for secondary school students (e.g. Fractals, Non Euclidean geometries, Game theory). Occasionally an exceptionally brilliant student may succeed with these subjects but it is quite rare.
- 5) Subjects in the history of mathematics, which could be quite adequate, are too often treated as a biography of mathematicians full of anecdotes and devoid of mathematical activity and understanding. It must be noted that this type of subject should be undertaken only by very competent candidates, to avoid sliding into pure biographies.

On the other hand it is always gratifying to read extended essays that have dealt clearly and efficiently with a well focused subject set within clear limits. Many (but not all) extended essays in number theory are well done as are many in classical geometry. Many successful extended essays are derived from problems presented in Mathematical Olympiads (for instance by seeking to generalize a result). This is not surprising since the Olympiads tend to deal with questions specially designed to test the creativity and ingenuity of the students.

In every session there are a few really outstanding extended essays; over the years, however, it appears that these brilliant extended essays seem to come from a limited and stable number of schools which again points to the necessity of training supervisors.

## **Candidate performance against each criterion**

### **Criterion A: research question**

This criterion was generally well met but in some cases it was not clear at all what the essay was about.

### **Criterion B: introduction**

This section was not very satisfactorily done on the whole: too many candidates thought that this was the place for an “autobiography” giving all sorts of anecdotal details about how they came to choose the subject instead of explaining why the subject is worth investigating.

### **Criterion C: investigation**

An important role for the supervisors is that of indicating an appropriate bibliography and in particular making sure that the online references are of good quality (this is by no means always the case). Many candidates produced a long list of “consulted sources” with the idea (perhaps) of impressing the examiner, but a short and well chosen bibliography is usually much better than a long list of works of questionable quality or relevance. Some subjects are completely self contained and do not require a bibliography at all.

### **Criteria D, E and F**

Candidates who had chosen a subject too difficult for them performed very poorly against these criteria: they tried to conceal their lack of understanding under masses of misunderstood quotations from sources. They copied – often inserting mistakes – texts from various sources without understanding or evaluating them, missing any reasoned argument.

### **Criterion G: use of language**

It must be stressed that in an extended essay in mathematics “use of language appropriate to the subject” includes the use when appropriate of headings such as “Theorem”, “Proof”, “Definition”, ... etc ..., the labelling of graphs, and generally using the rules of good mathematical writing. Very common faults in extended essays are the use of technical terms not previously “defined”, the faulty and casual statements of “theorems” (not clearly separated from the rest of the text), and the lack of indication as to where a “proof” starts and ends.

### **Criterion H: conclusion**

Too many candidates omitted a conclusion altogether or used this section to refer to results and arguments never mentioned in the corpus of the essay.

### **Criterion I: formal presentation**

The vast majority of extended essays were written using computers so that (with a few grievous exceptions) the presentation of the extended essays was good. A common error was to put in the appendix material that should be included in the corpus of the essay.

**Criterion J: abstract**

As in criterion B, many candidates thought that this was the place for autobiographical anecdotes to explain why the subject was chosen. Often the content was adequately described but the method or the approach in the essay used was frequently omitted.

**Criterion K: holistic judgment**

There are no general points on this criterion.

**Recommendations for the supervision of future candidates**

Normally only HL students should attempt to write an extended essay in mathematics though in some cases (for instance in schools where the HL is not offered) SL students may also write successful mathematics extended essays.

Many supervisors appear to have little idea of what is expected of them and when in doubt tend to adopt a “hands off” attitude with disastrous results. It is important to remember that the writing of an extended essay is above all a learning experience for the candidate and that it is the responsibility of the supervisor to help to make it successful. The assessment of an extended essay is essentially the assessment of how successful that learning experience turned out to be.

In particular the supervisor should play a key role in the selection of the topic: it is quite possible for the supervisor to suggest a topic but it is imperative that he/she makes sure that the topic area, if chosen by the candidate, is adequate. Supervisors should be firm in rejecting a research question when it seems inappropriate (too trivial or too difficult for the student or containing too little mathematics).

Finally, students who do not write in their mother tongue should make sure that the text is understandable and sufficiently readable: some supervisors, on that score, limit themselves to simply pointing out that “the language of the essay is not the mother tongue of the candidate” with the result that some essays are in parts utterly incomprehensible. Students writing in a second language are not marked down for poor English as long as it is intelligible. Supervisors are not permitted to change their text but they can indicate during the supervision process where the draft essay is hard to understand.