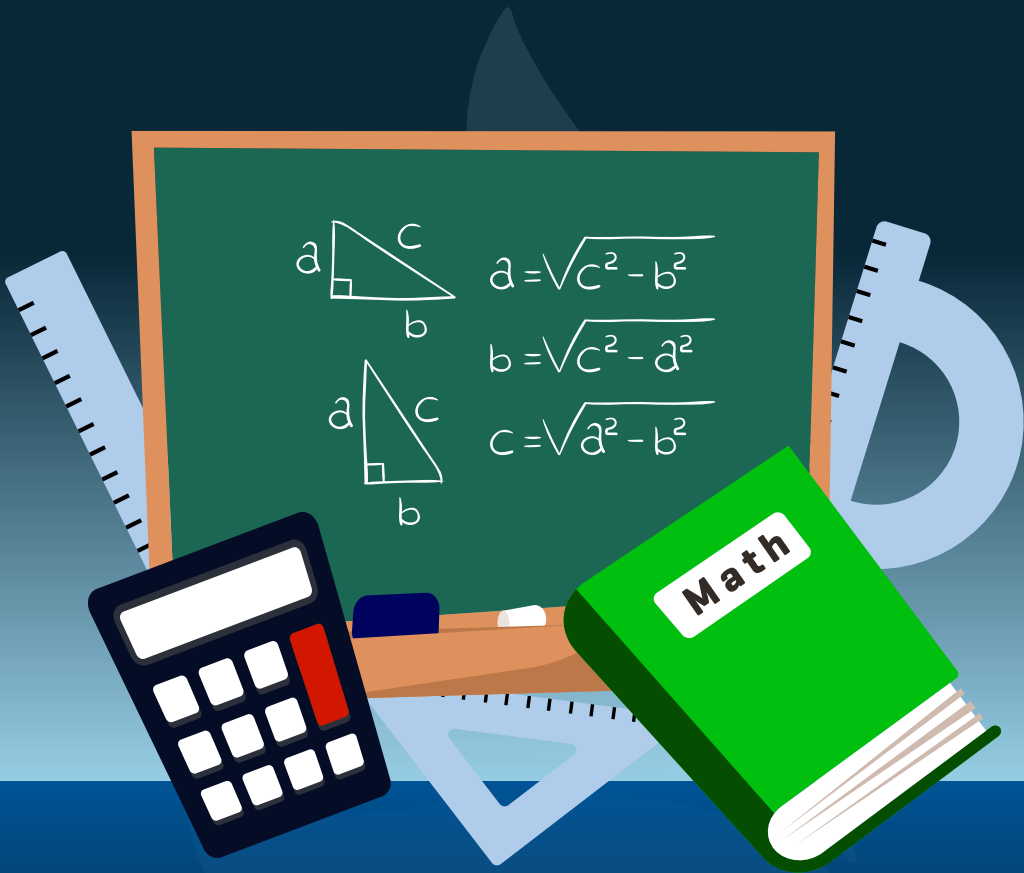
MATHS IA GUIDE



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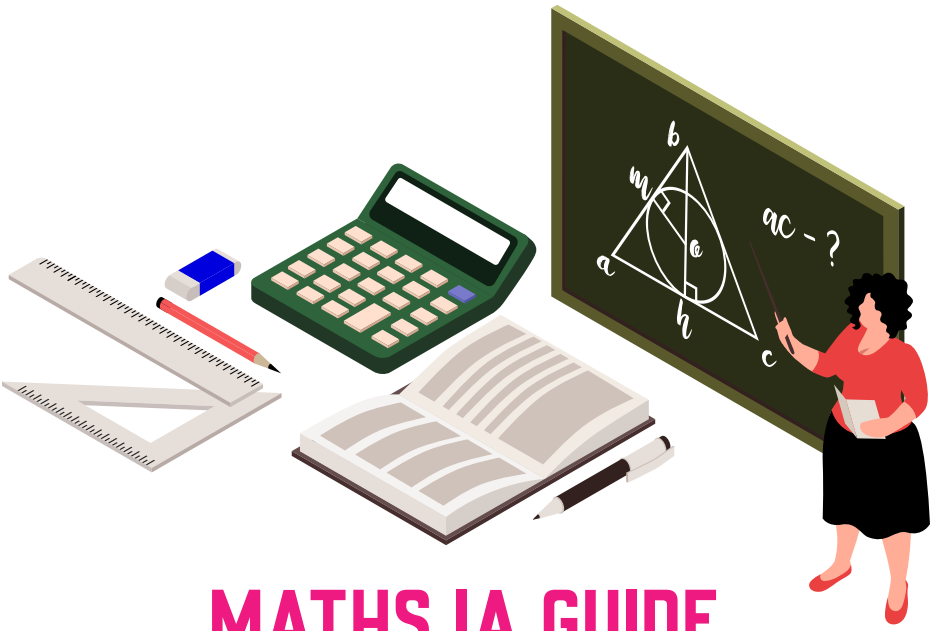

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IB Maths is a struggle for most people going through their diploma. To make matters worse, on top of just doing the dreaded maths exam, we're also expected to write a Maths IA exploration into a topic of our choice! Where do you even begin such a task? How do you even choose a topic? The maths IA, for many, is just as scary as the final exam. It's difficult to write an essay that not only has some level of personal engagement, but explores a topic at the adequate mathematical level. The following is a guide that will help you ace your Maths IA. Note that the IA requirements and structure is very similar in the new and old maths syllabus, so while **this guide is created for the new syllabus** it is relevant whether you're studying Maths AI SL/HL, Maths AA SL/HL, Maths HL, or Maths SL!

Let's take a look at the criteria. As with all IA's, the best thing you can do before starting your IA is to become familiar with the criteria. If you know how you're being graded it'll become so much easier to create an essay that checks off all the things you need to!

Criterion A	Presentation	4 marks
Criterion B	Mathematical Communication	4 marks
Criterion C	Personal Engagement	3 marks
Criterion D	Reflection	3 marks
Criterion E	Use of Mathematics	6 marks

Before breaking down these criteria one by one,

Criterion A: Presentation

The first criterion aims to look at the general organization and coherence of your IA. Although students tend to focus on the complexity of math that their exploration demonstrates, a full 4 points is rewarded for the clarity of your explanations and structure. In order to make sure that you score in the top range of this criteria, make sure your IA is clearly structured. We'd recommend you break your essay down into:

- Introduction - explains the aim of the exploration. Why are you looking into this mathematical question and what results are you expecting? Give a general description of how you are going about your explanation. Make sure to include evidence of personal engagement, explaining why this topic is of personal interest to you.
- Main Body Paragraphs - the bulk of your marks. This is your mathematical exploration, finding an answer to the question you posed in your introduction. Graphs, tables, and diagrams should be included in this section and not attached as appendices. Appendices should only be used to include large data sets or any additional figures that may not be strictly relevant to your research question.

- Conclusion - summarize your findings. Link back to your introduction, explaining whether your original hypothesis was supported by the mathematics and data that you explored.

Criterion B: Mathematical Communication

The second criterion looks largely at the mathematical language you have used throughout your exploration. What do we mean by mathematical language?

- Notation
- Symbols
- Terminology

Checking that these three components are accurate and consistent throughout your IA makes up the main portion of your points in this second criteria. Terms like "plug in" or "put in" should be avoided and more mathematically sophisticated words like "substitute" should be used in their absence.

Calculator and computer notation is acceptable only if it is software generated. Otherwise it is expected that you use appropriate mathematical notation in their work.

As with all other IA's, you should define all your key terms and variables when you first introduce them. Do not have a list of definitions at the top of your IA. Instead, when you first bring up a topic, include a short definition to clarify and demonstrate your understanding of the math that you're presenting.

Use various forms of mathematical representation to make the data you're conveying as clear as possible. If you can show the same data in various ways (formulae, diagrams, tables, charts, graphs, models, or other) that is just a bonus as you are showing the examiner that you understand the data and are capable of displaying it in various formats, making it more accessible for the reader.

One common mistake that loses students points is silly mistakes like incomplete or incorrect axes labels on your diagrams, or not fully explaining your diagram. Don't leave your diagram hanging! If you display the data through a particular visual format, explain to the reader what you aim to show through the figure.

Criterion C: Personal Engagement

This criterion mainly looks at how you make the mathematics 'your own'. Perhaps the most difficult part of the IA is not to do the calculations, as you have tons of time to make sure there are no mistakes, but making sure that your IA stands out from the rest! That's what the personal engagement criterion is all about.

Many students mistake this criterion, thinking that they need to have a personal vested interest in the topic that they're choosing. This leads to students writing blatant lies like 'I've been fascinated by Pascal's problem since I was a kid' or 'I find myself thinking about the Fibonacci sequence on a daily basis as I see flowers in my garden'. Examiners know that this is all just garbage.

Instead, to score top marks in the personal engagement criterion you should make sure that your exploration is independent and unique. It should display some degree of creativity in that you present mathematical ideas in your own way and explore the topic from various different perspectives. It includes making predictions about things you may be interested in, and then finding ways to manipulate your problem/formula/question to encompass those areas!

The IB clearly highlights that 'textbook style explorations or reproduction of readily available mathematics without the candidate's own perspective are unlikely to achieve the higher levels'. What this tells us is that if you can find the exact same question or exploration explored elsewhere you aren't on the right track! If you've done the exact same math you're planning to do in your IA during your maths classes, you are on an equally misguided way.

In order to achieve the top marks for personal engagement, your engagement must be truly authentic, and drive the exploration forward. A great example of this would be the following.

You are an avid football player, and your passion for the game is a large part of your life. You choose to write a math IA attempting to graph the flight of a football after it leaves your foot.

Already you have shown some personal engagement as you are choosing a topic based on a hobby of yours. However, in order to get into the higher marks of personal engagement, remember that your engagement must 'drive the exploration forward'. So, let's add the following twist.

You are known for being able to bend the ball, or curl it by adding spin on it by how you strike the ball. After having done the initial exploration of the movement of a 'normally' struck ball, you add a secondary component that goes into the Magnus effect and how it leads to the ball swerving!

In this IA, not only would the topic be one that has some personal importance to you, but your personal interest in the question leads to an added layer of complexity that not many students may have written about before! That's what personal engagement is all about.

Keep this information in mind as you continue to read this guide. At the end of this guide you'll see 50 possible IA topic ideas. All of these topics must be adapted to fit you in order to score highly in this criterion. A 'standard' topic from a list that we're publishing you is unlikely to let you reach the top marks in criterion C.

Criterion D: Reflection

The fourth criterion of reflection is not tied to a specific part of the exploration, although it is likely to be most heavily featured in the conclusion. The way to make sure you pick up 'reflection' marks is to avoid describing your results. The IB needs us to do more than just show what we've done. For instance, connecting our results to our initial aims, looking at what we might have learnt throughout the process and evaluating our research are all evidence that we have done more than some mathematical tests. The IB is all about learning, so show the marker your growth throughout the IA.

To access all three marks in the D criterion, the IB needs us to have aspects of these reflective elements present throughout the exploration. Your introduction is always a good place to start. For instance, noting the reasoning for the choice of not only the topic, but the manner you are approaching it. Why did you choose such a mathematical technique? Why is that a better alternative to another approach?

As you communicate your study and display the maths you have used, there is ample opportunity to show reflective skills. You can examine a particular secondary source - is the data credible? - or look at your methodology. Is there something you cannot account for? Don't ignore this - embrace it! Examining the things that you could do better is a sign of competence. It's not enough however, to draw attention to an issue. Make sure you explain how you have accounted for it or altered your exploration in the face of it.

You can almost think of the criterion D as how well you have evaluated throughout your essay. But this doesn't mean critique all parts - if you feel like you have done something particularly well, by all means draw attention to it! The markers want to see how self-aware you are, and using a balance of positive and negative points is a surefire way of doing this!

Purely thinking in this way, however, can lead you into a narrative trap. To make sure you show 'critical' reflection, consider further explorations or the implications of your results. Tying your exploration with a paragraph on one of these is a great way to end it!

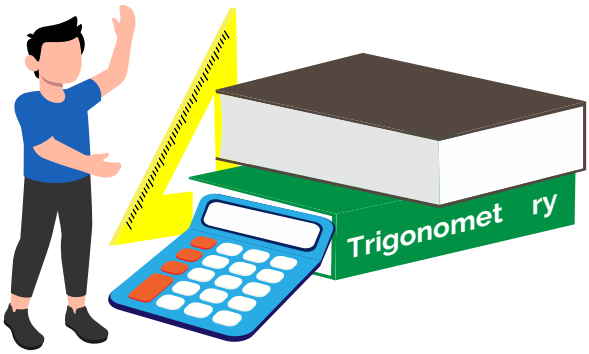
Criterion E: Use of Mathematics

This criterion makes up the largest portion of your overall IA marks. 6 out of your 20 marks are dictated by the quality of your mathematical usage. 'Use of Mathematics' essentially looks at the quality of your maths and how relevant it is to the exploration. By 'relevant', the IB means that you only include maths that is directly intended to answer the question you asked in your introduction. We've seen students time and time again get sidetracked during the course of their exploration as, through collecting data or exploring the question, they find another topic that seems more interesting. Although your maths may be 'correct', if you spend time and words diving into a different question than the one you asked you're at risk of losing tremendous amounts of points.

Moreover, do not overcomplicate your exploration! If you can explain a concept through a simple mathematical tool, you will not be rewarded extra (and actually may be penalized!)

The maths that you produce should be at a similar level to the math you cover in your syllabus. This doesn't mean that you're confined to only looking into topics that are covered on your syllabus, but it should be of the same rigor!

We at Lanterna find that the most important thing to make sure you're doing well within Criterion E is to understand that 'demonstrating understanding' and 'getting the right answer' are two vastly different concepts. Just because you ask a question, do the calculations to it, and leave the readers with an answer, you aren't demonstrating any understanding! Make sure that you give explanations throughout your IA, at each step of the way, explaining why you're going about answering the problem in the way that you are!



50 IA Topic Ideas

We want to give you some ideas of potential topics that could get some ideas brewing. This list is one that we've compiled, which includes 50 starting points. These topics aren't once that you should copy word for word, as they will not get you the results you're looking for. As this guide discussed with regards to personal engagement, each one of these topics will need evidence of being personal to you. Additionally, depending on your level of math, each topic may need an added layer of complexity.

1. **Pascal's triangle:** Discovering patterns within this famous array of numbers
2. **Pythagorean triples:** Can you find patterns in what numbers form a pythagorean triple?
3. **Monty Hall problem:** How does Bayesian probability work in this real-life example, and can you add a layer of complexity to it?
4. **The Chinese Remainder Theorem:** An insight into the mathematics of number theory
5. **Sum of all positive integers is -1/12?** Explore this fascinating physics phenomenon through the world of sequences and series
6. **Birthday paradox:** Why is it that in a room of people probability dictates that people are very likely to share a birthday?
7. **Harmonic series:** Explore why certain notes/chords in music sound dissonant, and others consonant, by looking at the ratios of frequencies between the notes.
8. **Optimizing areas:** Optimizing the area of a rectangle is easy, but can you find a way to do it for any polygon?
9. **Optimizing volumes:** Explore the mathematics of finding a maximum volume of a cuboid subject to some constraint
10. **Flow of traffic:** How does mathematics feed into our traffic jams that we endure every morning?
11. **Football statistics:** Does spending a lot of cash during the transfer window translate to more points the following year? Or is there a

better predictor of a team's success like wages, historic performance, or player valuation?

12. **Football statistics #2:** How does a manager sacking affect results?
13. **Gini coefficient:** Can you use integration to derive the gini coefficient for a few countries, allowing you to accurately compare their levels of economic inequality?
14. **Linear regressions:** Run linear regressions using OLS to predict and estimate the effect of one variable on another.
15. **The Prisoner's Dilemma:** Use game theory in order to deduce the optimal strategy in this famous situation
16. **Tic Tac Toe:** What is the optimal strategy in this legendary game? Will my probability of winning drastically increase by some move that I can make?
17. **Monopoly:** Is there a strategy that dominates all others? Which properties should I be most excited to land on?
18. **Rock Paper Scissors:** If I played and won with rock already, should I make sure to change what I play this time? Or is it better to switch?
19. **The Toast problem:** If there is a room of some number of people, how many toasts are necessary for everyone to have toasted with everyone?
20. **Cracking a Password:** How long would it take to be able to correctly guess a password? How much safer does a password get by adding symbols or numbers?
21. **Stacking Balls:** Suppose you want to place balls in a cardboard box, what is the optimal way to do this to use your space most effectively?
22. **The Wobbly Table**: Many tables are wobbly because of uneven ground, but is there a way to orient the tables to make sure they are always stable?
23. **The Stable Marriage Problem:** Is there a matching algorithm that ensures each person in society ends up with their one true love? What is the next best alternative if this is not viable?

24. **Mathematical Card Tricks:** Look at the probabilities at play in the famous 3 card monte scam.
25. **Modelling the Spread of a Virus:** How long would it take for us all to be wiped out if a deadly influenza spreads throughout the population?
26. **The Tragedy of the Commons:** Our population of fish is dwindling, but how much do we need to reduce our production by in order to ensure the fish can replenish faster than we kill?
27. **The Risk of Insurance:** An investigation into asymmetric information and how being unsure about the future state of the world may lead us to be risk-averse
28. **Gabriel's Horn:** This figure has an infinite surface area but a finite volume, can you p rove this?
29. **Modelling the Shape of an Egg:** Although it may sound easy, finding the surface area or volume of this common shape requires some in-depth mathematical investigation
30. **Voting Systems:** What voting system ensures that the largest number of people get the official that they would prefer? With 2 candidates this is logical, but what if they have more than 2?
31. **Probability:** Are Oxford and Cambridge biased against state-school applicants?
32. **Statistics:** With Tokyo 2020 around the corner, how about modelling change in record performances for a particular discipline?
33. **Analysing Data:** In the 200 meter dash, is there an advantage to a particular lane in track?
34. **Coverage:** Calculation of rate of deforestation, and afforestation. How long will our forests last?
35. **Friendly numbers, Solitary numbers, perfect numbers:** Investigate what changes the condition of numbers
36. **Force:** Calculating the intensity of a climber's fall based upon their distance above where they last clamped in
37. **Königsberg bridge problem:** Using networks to solve problems.

38. **Handshake problem:** How many handshakes are required so that everyone shakes hands with all the other people in the room?
39. **The mathematics of deceit:** How con artists use pyramid schemes to get rich quick!
40. **Modelling radioactive decay:** The maths of Chernobyl – when will it be safe to live there?
41. **Mathematics and photography:** Exploring the relationship between the aperture of a camera and a geometric sequence
42. **Normal Distribution:** Using distributions to examine the 2008 financial crisis
43. **Mechanics:** Body Proportions for Track and Field events
44. **Modelling:** How does a cup of Tea cool?
45. **Relationships:** Do BMI ratings and country wealth share a significant relationship?
46. **Modelling:** Can we mathematically model musical chords and concepts like dissonance?
47. **Evaluating limits:** Exploring L'Hôpital's rule
48. **Chinese postman problem:** How do we calculate shortest possible routes?
49. **Maths and Time:** Exploring ideas regarding time dilation
50. **Plotting Planets:** Using log functions to track planets!

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