

Internal Assessment — Mathematical Exploration

IB SL Study Guide

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IB Math AI SL — Internal Assessment: Mathematical Exploration

Complete Guide to the Mathematical Exploration (20% of your IB grade)

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What Is the Mathematical Exploration?

The Mathematical Exploration is a 6–12 page written investigation on a mathematical topic of your own choosing. It is the only internally assessed component of IB Math AI SL, contributing **20% of your total IB grade** and counting toward your final diploma point score.

Your teacher marks your exploration against five criteria, and the IB moderates a sample of work from each school to ensure consistency. This means your teacher's marks are subject to change — the IB has final authority.

Key characteristics of the exploration:

- Written in your own voice — first person is expected and encouraged
- Assessed by your teacher, externally moderated by IB
- Must demonstrate personal engagement with the mathematics, not just textbook reproduction
- Should extend beyond recall and into genuine analysis, modelling, or investigation

Math AI SL vs Math AA SL — what this means for your IA:

Math Analysis and Approaches explorations tend toward abstract or pure mathematical investigation — proof, generalisation, algebraic structure. Math Applications and Interpretation explorations are expected to engage with **real-world data, mathematical modelling, and technology**. If you are sitting AI SL, your exploration will be strongest when it connects mathematics to a genuine context: sport, science, economics, environment, or social data.

EXAM ALERT

Your exploration should demonstrate DEPTH of understanding, not just BREADTH. One idea explored thoroughly — with layers of analysis, reflection on limitations, and mathematical precision — scores far higher than five ideas skimmed superficially. Choose a focussed research question and go deep.

The Five Assessment Criteria (A–E)

Your exploration is marked out of **20 marks** across five criteria. Your teacher applies each criterion independently.

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

Criterion A — Presentation (4 marks)

Presentation covers the overall organisation and coherence of your exploration. The IB asks whether a fellow IB student — not a teacher, not a mathematician — could read your work and follow the argument from start to finish.

What examiners look for:

- A clear structure: introduction, development, conclusion
- Consistent use of notation throughout (do not switch between r and R for the same value)
- Appropriate use of headings and subheadings that guide the reader
- Diagrams and tables that are titled, labelled, and referenced in your text
- Concise writing — padding penalises this criterion, not helps it

Common errors on Criterion A:

An exploration that opens with three pages of background context before any mathematics is structurally weak. The introduction should be brief: state your topic, your research question, and why it interests you — then move into the mathematics.

Criterion B — Mathematical Communication (4 marks)

This criterion assesses whether you communicate mathematics using correct notation and language throughout your exploration.

What examiners look for:

- All variables are defined when first introduced (“Let x represent the number of hours of sleep per night”)
- Units are stated for every measurement (e.g., x in hours, y in percentage score)
- Axes on every graph are labelled with variable names and units
- Mathematical terminology is used correctly (“correlation coefficient” rather than “how related they are”)
- Formulas are written properly — not as calculator output, not as screenshots

What to avoid:

Do not paste raw GDC output screenshots as your mathematical evidence. You may include a GDC output image to verify a calculation, but you must also write out the formula, define the variables, and explain what the output means. A screenshot with no written explanation earns minimal communication marks.

If you use formulas from external sources (textbooks, websites), cite them in a bibliography. The IB expects academic honesty in your exploration.

Criterion C — Personal Engagement (3 marks)

Personal engagement is the most distinctive criterion in the IB exploration. It asks whether there is genuine evidence that this is *your* exploration — not a template, not a copied structure.

What earns marks here:

- A clear explanation of why you chose this topic, grounded in your own life, curiosity, or experience
- Use of “I” naturally: “I chose to investigate this because I have played football since age eight and wanted to understand the geometry of free kicks”
- Original data you collected yourself (surveys, personal measurements, recorded observations)
- An unusual or creative angle on a familiar topic — unexpected data sources, novel comparisons, your own conjectures tested

What moderators flag:

Moderators review hundreds of explorations and recognise standard templates from popular IA websites. An exploration that uses the exact same dataset as hundreds of other students, follows the same structure step-for-step, and makes the same observations does not demonstrate personal engagement — regardless of how well it is written.

The safest approach: collect your own data. Survey your classmates, download local weather records, pull historical sports statistics from a team you follow. Any exploration built on data you gathered or chose specifically for personal reasons is inherently more authentic than one built on a generic downloaded dataset.

Criterion D — Reflection (3 marks)

Reflection must appear **throughout your exploration**, not only in the conclusion. The IB penalises explorations where reflection is confined to a single paragraph at the end.

Effective reflection includes:

- Acknowledging assumptions your model makes and why those assumptions may not hold in reality
- Identifying specific limitations of your data (sample size, data source reliability, measurement error)
- Suggesting concrete extensions: “A further investigation could include a control variable for study hours, which my current model does not account for”
- Interpreting unexpected results rather than ignoring them: “The negative correlation I observed may be explained by...”

Ineffective reflection to avoid:

Generic statements such as “This was an interesting topic and I learned a lot” earn no marks. The IB expects specific mathematical reflection: what did you learn about the mathematics, what surprised you, and what would a more sophisticated version of this investigation include?

IB TIP

Treat reflection as an ongoing conversation with the reader. A brief reflective sentence after each major section — “This $R^2 = 0.54$ indicates the linear model captures only moderate variation, suggesting a non-linear fit may be more appropriate” — is more convincing than two pages of reflection wedged into the conclusion.

Criterion E — Use of Mathematics (6 marks)

Use of Mathematics is the **highest-weighted criterion at 6 marks** and is the area where most students lose the most marks. The IB distinguishes between three levels:

Band Description

- 5–6 Sophisticated mathematics, demonstrated with understanding, essentially error-free
- 3–4 Mostly correct mathematics, some errors, or mathematics not fully explained
- 1–2 Elementary mathematics, significant errors present

What “sophisticated” means for AI SL:

In the context of Math Applications and Interpretation SL, sophisticated mathematics does not require abstract proof or advanced pure maths. It means using the tools of your course **correctly and with full understanding**:

- Regression analysis (linear, quadratic, exponential, logistic) with correct interpretation of r , R^2 , and residuals

- Chi-squared test (χ^2) with correct null hypothesis, expected frequencies, degrees of freedom, and p -value interpretation
- Spearman's rank correlation for non-linear or ordinal data
- Normal distribution probability calculations with stated parameters μ and σ
- Logistic function modelling with interpretation of carrying capacity and growth rate

Using only mean, median, mode, and a bar chart earns band 1–2 marks regardless of how well everything else is written. The investigation must include inferential statistics, hypothesis testing, or modelling to reach band 5–6.

IB TIP

Criterion E — Use of Mathematics is the most heavily weighted criterion. Your teacher looks for correct, well-explained mathematics at each step. A focused, 8-page exploration with flawless regression analysis, a properly conducted chi-squared test, and careful interpretation of r and R^2 will score higher on Criterion E than a 14-page exploration with careless arithmetic errors and undefined variables.

Topic Ideas by Syllabus Area

The best IA topic sits at the intersection of genuine personal interest and mathematics from your AI SL course. The ideas below are starting points — you should adapt them with your own data, your own context, and your own research question.

MEMORISE THIS

Statistics and Probability (Topic 4 — most popular for AI SL IA)

Topic 4 is the natural home for AI SL explorations because it directly supports real-world data analysis.

- **Does the frequency of natural disasters correlate with GDP?** Use World Bank data. Apply Spearman's rank correlation and a chi-squared test of independence to categorise countries by disaster frequency and income band.
- **Modelling the spread of a social media trend using logistic regression.** Collect weekly view/follower count data for a viral post or account. Fit a logistic model $P(t) = \frac{L}{1+e^{-k(t-t_0)}}$ and interpret L (carrying capacity) and k (growth rate).
- **Is there a relationship between a country's internet access rate and literacy rate?** Download UNESCO and ITU data. Compute Pearson's r and fit a linear regression. Test whether the correlation is statistically significant.
- **Predicting exam scores from study hours: comparing linear and quadratic regression.** Conduct a survey of classmates. Compare R^2 for both models. Reflect on why one model may be more appropriate.

MEMORISE THIS

Functions and Modelling (Topic 2)

Topic 2 functions appear most naturally when your data follows a recognisable growth, decay, or periodic pattern.

- **Modelling population growth of a city using logistic functions.** Source census data from two or three decades. Fit a logistic model, identify the inflection point, and interpret the carrying capacity in context.
- **Modelling temperature variation across the year using sinusoidal functions.** Download monthly mean temperature data from a weather station. Fit $T(m) = A \sin(Bm + C) + D$ and interpret amplitude and period in meteorological terms.
- **Comparing linear and exponential models for smartphone adoption rates.** Use ITU or Statista data for a developing country. Discuss which model better captures the data for different time periods and why.

MEMORISE THIS

Geometry and Trigonometry (Topic 3)

Topic 3 is less commonly chosen for AI SL IAs but can produce distinctive, well-differentiated explorations.

- **Using Voronoi diagrams to optimise the placement of emergency services in a city.** This topic is explicitly included in the AI SL syllabus. Map real ambulance stations or fire stations in a city. Construct Voronoi cells, identify coverage gaps, and propose an optimised additional station location.
- **Modelling the trajectory of a projectile using quadratic functions and trigonometry.** Analyse real throw data (a javelin, a basketball free throw) using video analysis software. Compare your theoretical model with observed data and reflect on air resistance as a limitation.
- **Analysing optimal stadium seating design using angles of elevation.** Choose a real stadium. Calculate angles of elevation to the pitch from various seating rows. Determine the minimum rake angle required for an unobstructed sightline.

MEMORISE THIS

Number and Algebra (Topic 1)

Topic 1 alone is unlikely to support a sophisticated AI SL exploration, but it works well when combined with statistics or modelling.

- **The mathematics of compound interest: comparing mortgage plans.** Model two or three real mortgage products using $FV = PV \times (1 + r)^n$ where r is the per-period interest rate (as a decimal) and n is the total number of compounding periods — aligned with the IB formula booklet's $FV = PV(1 + r/100k)^{kn}$ notation. Build amortisation schedules, calculate total interest paid, and compare the effect of interest rate and term length.

- **Currency exchange rate fluctuations modelled as a financial time series.** Download daily exchange rate data for two currencies over 12 months. Compute the mean, standard deviation, and analyse seasonal patterns. Fit an appropriate model and reflect on its predictive limitations.

MEMORISE THIS

Calculus (Topic 5)

Topic 5 calculus exploration topics tend to appeal to students who are comfortable with differentiation and integration beyond basic applications.

- **Maximising revenue for a business using differential calculus.** Research a real product with known demand data. Model the demand function $D(p)$, construct the revenue function $R(p) = p \cdot D(p)$, and find the price p that maximises revenue by solving $R'(p) = 0$.
- **Modelling the rate of change of drug concentration in the body.** Use published pharmacokinetic data. Model the concentration as $C(t) = C_0 e^{-kt}$, compute the half-life, and integrate to find total drug exposure (AUC — area under the curve). Reflect on assumptions of the one-compartment model.

Common Pitfalls and How to Avoid Them

WORKED EXAMPLE

Pitfall 1 — Too simple mathematics

A student investigates whether taller students perform better in basketball. They collect height and points-scored data for 20 classmates and compute the mean height for players who scored above and below average. They present a bar chart and conclude “taller players scored more points on average.”

This exploration uses only mean and basic comparison — elementary mathematics that earns Criterion E band 1–2 marks.

How to fix it: Use a scatter plot. Calculate Pearson’s correlation coefficient r using your GDC. Fit a linear regression line and state its equation. Interpret R^2 . Conduct a chi-squared test of independence by categorising height into “tall” and “not tall” and points into “high scorer” and “low scorer” — then test whether the categories are independent. Now you have inferential statistics and criterion E marks are achievable at band 4 or above.

 WORKED EXAMPLE

Pitfall 2 — No personal engagement

A student downloads a dataset from ibmathsresources.com titled “IA example — GDP and happiness scores” and produces an exploration that mirrors the example structure almost exactly, using the same dataset, the same analysis steps, and near-identical conclusions.

IB moderators review large numbers of explorations and are familiar with publicly available template explorations. An exploration that closely resembles a published template earns low Criterion C marks regardless of mathematical quality.

How to fix it: Use the template as structural inspiration only. Collect your own data. If you want to investigate wellbeing and economics, choose a different wellbeing index (the Legatum Prosperity Index, for example), select your own set of countries based on personal relevance, and add a variable the template did not include. A small genuine adaptation is far more convincing than a large copied dataset.

 WORKED EXAMPLE

Pitfall 3 — Ignoring limitations

A student models the growth of a city’s population using an exponential function. The model fits the data from 1980 to 2020 reasonably well. The conclusion states: “My model accurately predicts population growth and shows the city will reach 2 million by 2045.”

This exploration makes no acknowledgement of model limitations and treats a mathematical model as ground truth.

How to fix it: Address limitations explicitly. An exponential growth model assumes a constant growth rate, ignores resource constraints and migration policy changes, and cannot account for economic shocks. State these limitations and suggest that a logistic model would impose a carrying capacity that better reflects real-world constraints. The IB rewards students who understand what their model *cannot* do, not only what it can.

WORKED EXAMPLE

Pitfall 4 — Padded length

A student includes twelve full-page screenshots of GDC calculation screens, three pages of raw data tables, and a four-page literature review on the history of statistics before any original analysis begins. The exploration is 19 pages long.

Every page should add mathematical understanding. Screenshots, raw data dumps, and background context without mathematical purpose pad length without adding substance.

How to fix it: Move raw data to an appendix (or state clearly that data is available on request). Replace GDC screenshots with written mathematical statements: state the formula, define the variables, give the result, and interpret it. The IB explicitly states that length is not assessed — quality is.

WORKED EXAMPLE

Pitfall 5 — Weak conclusion

A student's conclusion reads: "In conclusion, I found that there is a positive correlation between hours of sleep and exam scores. This was an interesting topic and I learned a lot about statistics."

This conclusion restates a result without interpreting it and offers no reflection on methodology or extensions.

How to fix it: A strong conclusion directly answers your research question, contextualises the mathematical result, acknowledges what your analysis cannot prove, and suggests a meaningful extension:

"This investigation found a moderate positive linear correlation ($r = 0.73$) between self-reported nightly sleep hours and exam percentage scores among 30 Year 12 students. While the regression model ($y = 5.8x + 42.1$) accounts for 53% of the variation in scores ($R^2 = 0.53$), the remaining 47% suggests that additional variables — study hours, subject difficulty, test anxiety — play a significant role. The chi-squared test found no statistically significant association between sleep category and grade band ($\chi^2 = 8.3 < \chi_{\text{crit}}^2 = 9.49, df = 4, p > 0.05$), suggesting the relationship is not strong enough to reject the null hypothesis in this sample. A key limitation is the reliance on self-reported data; future research could use actigraphy devices for objective sleep measurement and expand the sample to multiple schools."

Sample Exploration Structure (Model Outline)

The following is a model structure for an AI SL exploration. It is not a template to copy — it is an illustration of how to proportion your sections and what to include at each stage.

Topic: “Does Hours of Sleep Affect Exam Performance Among IB Students?”

WORKED EXAMPLE

Introduction (1–2 pages)

- Personal motivation: “As an IB student sleeping an average of 6 hours per night during exam season, I want to investigate whether the commonly cited 8-hour recommendation has measurable impact on academic performance.”
- Research question: “Is there a statistically significant positive correlation between average nightly sleep duration and exam percentage score among Year 12 IB students?”
- Hypotheses: H_0 : sleep duration and exam score are independent; H_1 : students who sleep more score higher on average
- Brief outline of methods to be used

Data Collection (1 page)

- Survey of 30 Year 12 classmates: sleep hours recorded as self-reported average during exam fortnight; exam score as most recent mock paper percentage
- Variables defined: x = average nightly sleep (hours), y = exam score (%)
- Limitation acknowledged upfront: self-reported data may be unreliable; sample is from a single school

Mathematical Analysis (4–5 pages)

- Scatter plot of (x, y) with labelled axes, scale, and title
- Linear regression using GDC: equation $\hat{y} = 5.8x + 42.1$, correlation coefficient $r = 0.73$, coefficient of determination $R^2 = 0.53$
- Interpretation: “A moderate positive linear relationship is indicated. The model predicts that each additional hour of sleep is associated with a 5.8 percentage point increase in exam score, though this is a correlation and does not imply causation.”
- Chi-squared test of independence: students categorised as low sleep (< 6 h), moderate sleep (6–8 h), high sleep (> 8 h) and grades as A ($\geq 70\%$), B (50–69%), C ($< 50\%$)

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

- Degrees of freedom: $df = (r - 1)(c - 1) = (3 - 1)(3 - 1) = 4$, critical value $\chi_{\text{crit}}^2 = 9.49$ at $\alpha = 0.05$
- Computed $\chi^2 = 8.3$ — fail to reject H_0 at 5% significance; note the result is close to the boundary
- Comparison of linear vs. quadratic regression R^2 to assess whether a non-linear model improves fit

Reflection (1–2 pages)

- Self-reported sleep data introduces measurement error — an objective method would improve reliability

- Sample of 30 from one school limits generalisability; a multi-school study would reduce sampling bias
- Study hours, subject selection, and test anxiety are potential confounding variables not controlled for
- The near-significant chi-squared result ($\chi^2 = 8.3$ vs. $\chi_{\text{crit}}^2 = 9.49$) suggests a larger sample might yield significance — this is a meaningful mathematical observation, not a failure
- Extension: controlling for study hours via multiple regression would allow isolation of the sleep effect

Conclusion (0.5 pages)

- Direct answer to the research question: moderate positive correlation found, chi-squared test inconclusive at $n = 30$
- Honest assessment of model reliability
- What the exploration process taught you about the relationship between data quality and statistical conclusions

EXAM ALERT

Page count is not assessed directly, but IB guidance specifies 6–12 pages. Moderators flag work that is clearly padded beyond 12 pages or so thin it cannot demonstrate sufficient mathematical depth. Aim for 8–10 pages of substantive content: every page should contain mathematics, interpretation, or meaningful reflection — not background context, excessive screenshots, or decorative formatting.

Useful Tools and Resources

Technology for your exploration:

- **GDC (TI-Nspire CX or Casio fx-CG50):** Your primary statistical tool. Use it for regression analysis (linear, quadratic, exponential, logistic), chi-squared tests, normal distribution calculations, and graphing. Show GDC work by writing out what you inputted and what the output means — do not submit screenshots alone.
- **Desmos ([desmos.com/calculator](https://www.desmos.com/calculator)):** Free, browser-based graphing tool. Produces clean, exportable graphs with labelled axes — far more readable in a written exploration than GDC screen photographs. Use Desmos for your scatter plots and fitted curves, then verify calculations with your GDC.
- **Google Sheets or Microsoft Excel:** Efficient for organising raw data, computing summary statistics, and creating preliminary visualisations before moving to your GDC or Desmos for final analysis.
- **IB Mathematics AI SL Formula Booklet:** Available through your IB coordinator. Every formula you use in your exploration should appear in the formula booklet or be derived from it — demonstrating that you know *when* to apply each formula is part of Criterion E.

Data sources:

- **Our World in Data (ourworldindata.org):** Free, citable datasets on health, economics, environment, education, and demography. Excellent for AI SL explorations requiring cross-country comparison.
- **World Bank Open Data (data.worldbank.org):** GDP, development indicators, and historical economic data by country.
- **National meteorological services:** Local weather agencies publish historical temperature, rainfall, and climate data — useful for modelling explorations.
- Your own collected data (surveys, measurements, observations) is always the most authentic and protects against plagiarism concerns.

Reference materials:

- IB Maths Resources — IA topic ideas — A curated list of exploration topics including AI-specific ideas. Use for inspiration; do not copy structures or datasets directly.
- Nrich Mathematics (nrich.maths.org) — Problem-based mathematical ideas that can spark exploration topics, particularly for geometry and number investigations.
- **IBO Mathematics: Applications and Interpretation SL Subject Guide, Section 4 (Internal Assessment)** — The definitive source for criterion descriptors and mark boundaries. Download from your IB coordinator or the IB Programme Resource Centre. Read the criterion descriptors for Criterion E carefully — the distinction between “elementary” and “sophisticated” mathematics is spelled out there.

IB TIP

Read the criterion descriptors in the IB Subject Guide before you start writing, and again after your first draft. For each page of your exploration, ask: which criterion does this page provide evidence for? If a page does not clearly support at least one criterion, consider whether it belongs in the main body or could be moved to an appendix.