6 Two of the assessment criteria – personal engagement and reflection – are about **what you think about the topic** you are exploring. Don't hesitate to pose your own relevant and insightful questions as part of your report, and then to address these questions using mathematics at a suitably sophisticated level along with sufficient written commentary.

7 Although your teacher will expect and require you to work independently, you are allowed to **consult with your teacher** – and your teacher is allowed to give you advice and feedback to a certain extent while you are working on your report. It is especially important to check with your teacher that any **mathematics in your report is correct**. Your teacher will not give mathematical answers or corrections, but can indicate where any errors have been made or where improvement is needed.

Mathematical Exploration HL – Student Checklist

Is your report written entirely by yourself – and trying to avoid simply replicating work and ideas from sources you found during your research?	☐	Yes	☐	No
Have you strived to: apply your personal interest; develop your own ideas; and use critical thinking skills during your exploration and demonstrate these in your report?	☐	Yes	☐	No
Have you referred to the five assessment criteria while writing your report?	☐	Yes	☐	No
Does your report focus on good mathematical communication – and does it read like an article for a mathematical journal?	☐	Yes	☐	No
Does your report have a clearly identified introduction and conclusion?	☐	Yes	☐	No
Have you documented all of your source material in a detailed bibliography in line with the IB academic honesty policy?	☐	Yes	☐	No
Not including the bibliography, is your report 6 to 12 pages?	☐	Yes	☐	No
Are graphs, tables and diagrams sufficiently described and labelled?	☐	Yes	☐	No
To the best of your knowledge, have you used and demonstrated mathematics that is at the same level, or above, of that studied in IB Mathematics HL?	☐	Yes	☐	No
Have you attempted to discuss mathematical ideas, and use mathematics, with a sufficient level of sophistication and rigour?	☐	Yes	☐	No
Are formulae, graphs, tables and diagrams in the main body of text? (preferably no full-page graphs; and no separate appendices)	☐	Yes	☐	No
Have you used technology – such as a GDC, spreadsheet, mathematics software, drawing and word-processing software – to enhance mathematical communication?	☐	Yes	☐	No
Have you used appropriate mathematical language (notation, symbols, terminology) and defined key terms?	☐	Yes	☐	No
Is the mathematics in your report performed precisely and accurately?	☐	Yes	☐	No
Has calculator/computer notation and terminology **not** been used? ($y = x^2$, not $y = x$^2; ≈, not = for approximate values; **π**, not pi; $\|x\|$, not abs(x); etc)	☐	Yes	☐	No
At suitable places in your report – especially in the conclusion – have you included reflective and explanatory comments about the mathematical topic being explored?	☐	Yes	☐	No

List of 200 ideas/topics for a Mathematical Exploration

The topics listed here range from fairly broad to quite narrow in scope. It is possible that some of these 200 could be the title or focus of a **Mathematical Exploration**, while others will require you to investigate further to identify a narrower focus to explore. Do not restrict yourself only to the topics listed below. This list is only the 'tip of the iceberg' with regard to potential topics for your Mathematical Exploration. Reading through this list may stimulate you to think of some other topic in which you would be interested in exploring. Many of the items listed below may be unfamiliar to you. A quick search on the internet should give you a better idea what each is about and help you determine if you're interested enough to investigate further – and see if it might be a suitable topic for your Mathematical Exploration.

Algebra and number theory		
Modular arithmetic	Goldbach's conjecture	Probabilistic number theory
Applications of complex numbers	Diophantine equations	Continued fractions
General solution of a cubic equation	Applications of logarithms	Polar equations
Patterns in Pascal's triangle	Finding prime numbers	Random numbers
Pythagorean triples	Mersenne primes	Magic squares and cubes
Loci and complex numbers	Matrices and Cramer's rule	Divisibility tests
Egyptian fractions	Complex numbers and transformations	Euler's identity: $e^{i\pi} + 1 = 0$
Chinese remainder theorem	Fermat's last theorem	Natural logarithms of complex numbers
Twin primes problem	Hypercomplex numbers	Diophantine application: Cole numbers
Odd perfect numbers	Euclidean algorithm for GCF	Palindrome numbers
Factorable sets of integers of the form $ak + b$	Algebraic congruences	Inequalities related to Fibonacci numbers
Combinatorics – art of counting	Boolean algebra	Graphical representation of roots of complex numbers
Roots of unity	Fermat's little theorem	Prime number sieves
Recurrence expressions for phi (golden ratio)		
Geometry		
Non-Euclidean geometries	Cavalieri's principle	Packing 2D and 3D shapes
Ptolemy's theorem	Hexaflexagons	Heron's formula
Geodesic domes	Proofs of Pythagorean theorem	Minimal surfaces and soap bubbles
Tesseract – a 4D cube	Map projections	Tiling the plane – tessellations
Penrose tiles	Morley's theorem	Cycloid curve

Geometry (continued)		
Symmetries of spider webs	Fractal tilings	Euler line of a triangle
Fermat point for polygons and polyhedra	Pick's theorem and lattices	Properties of a regular pentagon
Conic sections	Nine-point circle	Geometry of the catenary curve
Regular polyhedra	Euler's formula for polyhedra	Eratosthenes – measuring earth's circumference
Stacking cannon balls	Ceva's theorem for triangles	Constructing a cone from a circle
Conic sections as loci of points	Consecutive integral triangles	Area of an ellipse
Mandelbrot set and fractal shapes	Curves of constant width	Sierpinksi triangle
Squaring the circle	Polyominoes	Reuleaux triangle
Architecture and trigonometry	Spherical geometry	Gyroid – a minimal surface
Geometric structure of the universe	Rigid and non-rigid geometric structures	Tangrams
Calculus/analysis and functions		
Mean value theorem	Torricelli's trumpet (Gabriel's horn)	Integrating to infinity
Applications of power series	Newton's law of cooling	Fundamental theorem of calculus
Brachistochrone (minimum time) problem	Second order differential equations	L'Hôpital's rule and evaluating limits
Hyperbolic functions	The harmonic series	Torus – solid of revolution
Projectile motion	Why e is base of natural logarithm function	
Statistics and modelling		
Traffic flow	Logistic function and constrained growth	Modelling growth of tumours
Modelling epidemics/spread of a virus	Modelling the shape of a bird's egg	Correlation coefficients
Central limit theorem	Modelling change in record performances for a sport	Hypothesis testing
Modelling radioactive decay	Least squares regression	Modelling the carrying capacity of the earth
Regression to the mean	Modelling growth of computer power past few decades	
Probability and probability distributions		
The Monty Hall problem	Monte Carlo simulations	Random walks
Insurance and calculating risks	Poisson distribution and queues	Determination of π by probability
Lotteries	Bayes' theorem	Birthday paradox
Normal distribution and natural phenomena	Medical tests and probability	Probability and expectation

Games and game theory		
The prisoner's dilemma	Sudoku	Gambler's fallacy
Poker and other card games	Knight's tour in chess	Billiards and snooker
Zero sum games		
Topology and networks		
Knots	Steiner problem	Chinese postman problem
Travelling salesman problem	Königsberg bridge problem	Handshake problem
Möbius strip	Klein bottle	
Logic and sets		
Codes and ciphers	Set theory and different 'size' infinities	Mathematical induction (strong)
Proof by contradiction	Zeno's paradox of Achilles and the tortoise	Four colour map theorem
Numerical analysis		
Linear programming	Fixed-point iteration	Methods of approximating π
Applications of iteration	Newton's method	Estimating size of large crowds
Generating the number e	Descartes' rule of signs	Methods for solving differential equations
Physical, biological and social sciences		
Radiocarbon dating	Gravity, orbits and escape velocity	Mathematical methods in economics
Biostatistics	Genetics	Crystallography
Computing centres of mass	Elliptical orbits	Logarithmic scales – decibel, Richter, etc.
Fibonacci sequence and spirals in nature	Predicting an eclipse	Change in a person's BMI over time
Concepts of equilibrium in economics	Mathematics of the 'credit crunch'	Branching patterns of plants
Column buckling – Euler theory		
Miscellaneous		
Paper folding	Designing bridges	Mathematics of rotating gears
Mathematical card tricks	Curry's paradox – 'missing' square	Bar codes
Applications of parabolas	Music – notes, pitches, scales…	Voting systems
Flatland by Edwin Abbott	Terminal velocity	Towers of Hanoi puzzle
Photography	Art of M.C. Escher	Harmonic mean
Sundials	Navigational systems	The abacus
Construction of calendars	Slide rules	Different number systems
Mathematics of juggling	Global positioning system (GPS)	Optical illusions
Origami	Napier's bones	Celtic designs/knotwork
Design of product packaging	Mathematics of weaving	