# Maths SL & HL

# 200 Exploration Ideas/Topics

# Algebra & 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 & cubes

Loci and complex numbers

Matrices and Cramer’s rule

Divisibility tests

Egyptian fractions

Complex numbers & transformations

Euler’s identity: 

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

# Statistics & 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

Regression to the mean

Modelling growth of computer power

# 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 & soap bubbles

Tesseract – a 4D cube

Map projections

Tiling the plane – tessellations

Penrose tiles

Morley’s theorem

Cycloid curve

Symmetries of spider webs

Fractal tilings

Euler line of a triangle

Fermat point for polygons & polyhedra

Pick’s theorem & 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

# Calculus/Analysis & 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 (min.time) problem

Second order differential equations

l’Hopital’s rule and evaluating limits

Hyperbolic functions

The harmonic series

Torus – solid of revolution

# Probability & Probability Distributions

The Monty Hall problem

Monte Carlo simulations

Random walks

Insurance and calculating risks

Poisson distribution and queues

Determination of  by probability

Lotteries

Bayes’ theorem

Birthday paradox

Normal distribution and natural phenomena

# Games & Game Theory

The prisoner’s dilemma

Sudoku

Gambler’s fallacy

Poker and other card games

Knight’s tour in chess

# Topology & Networks

Knots

Steiner problem

Chinese postman problem

Travelling Salesman Problem

Königsberg bridge problem

Handshake problem

Möbius strip

Klein bottle

# Logic & Sets

Codes and ciphers

Set theory and different ‘size’ infinities

Mathematical induction (strong)

Proof by contradiction

Proving that a number is irrational

# Numerical Analysis

Linear programming

Fixed point iteration

Methods of approximating 

Applications of iteration

Newton’s method

Estimating size of large crowds

Generating the number *e*

Descartes’ rule of signs

Methods for solving differential equations

Compiled by: Tim Garry

# Physical, Biological & Social Sciences

Radiocarbon dating

Gravity, orbits & 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 BMI for a person over time

Concepts of equilibrium in economics

# Miscellaneous

Paper folding

Designing bridges

Methods of approximating 

Mathematical card tricks

Curry’s paradox – ‘missing’ square

Barcodes

Applications of parabolas

Music – notes, pitches, scales, etc

Voting systems

*Flatland* by Edwin Abbott (book)

Terminal velocity

Towers of Hanoi puzzle

Photography

Art of M.C. Escher

Harmonic mean

Sundials

Navigational systems

*A Beautiful Mind* (film)

The abacus

Construction of calendars

Slide rules

Different number systems

Mathematics of juggling

Global positioning system (GPS)

Airline routes