

# Strand 1 Unifying strand

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## Building blocks elements

- U.1** Recall and understand concepts and procedures of each strand.
- U.2** Apply procedures accurately, effectively, and appropriately.
- U.3** Understand that equality means two expressions have the same value, either in specific cases (as in equations) or in all cases (as in identities).
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## Representation element

- U.4** Represent a mathematical situation in different ways—using numbers, algebra, graphs, physical models, or words—and be able to interpret, analyse, and compare these representations.
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## Connections elements

- U.5** Make connections within and between strands.
- U.6** Make connections between maths and real-world situations.
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## Problem solving elements

- U.7** Make sense of a given problem and, if needed, rewrite it in mathematical terms.
- U.8** Apply your knowledge and skills to solve the problem, including decomposing it (breaking it up) into manageable parts and/or simplifying it using reasonable assumptions.
- U.9** Interpret your solution in the **context** of the original problem.
- U.10** Consider all your solutions and decide which ones make sense. For example, is a negative distance allowed, or is it a logical error? Is your solution within the practical tolerances of the situation? Discuss any improvements or limitations in your model, if needed.
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## **Generalisation and proof elements**

**U.11** Use inductive reasoning to generate mathematical conjectures based on specific examples, and understand that a single counterexample disproves a conjecture.

**U.12** Use deductive reasoning to develop and evaluate mathematical arguments and proofs, based on the foundational building blocks of geometry: axioms—such as A1: **A unique line passes through any two points**—and primitive terms such as point, line, angle, set, etc.

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## **Communication element**

**U.13** Communicate mathematics effectively: justify your reasoning, interpret your results, explain your conclusions, and use mathematical language and notation to express ideas clearly and precisely.

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## Strand 2 Number Strand (5)

### N.1 Investigate the representation of numbers and arithmetic operations so that they can:

- a) Represent the operations of addition, subtraction, multiplication, and division in  $\mathbb{N}$ ,  $\mathbb{Z}$ , and  $\mathbb{Q}$  using models, including the number line, decomposition, and accumulating groups of equal size.
- b) Perform the operations of addition, subtraction, multiplication, and division and understand the relationship between these operations and the properties: commutative, associative, and distributive in  $\mathbb{N}$ ,  $\mathbb{Z}$ , and  $\mathbb{Q}$  (and in  $\mathbb{R} \setminus \mathbb{Q}$ , including operating on surds).
- c) Explore numbers written as  $a^b$  (index form) so that they can:
  - i. Flexibly translate between whole numbers and index representation of numbers.
  - ii. Use and apply generalizations such as  $a^p \times a^q = a^{p+q}$ ,  $\frac{a^p}{a^q} = a^{p-q}$ ,  $(a^p)^q = a^{pq}$ , and  $n^{\frac{1}{2}} = \sqrt{n}$ , for  $a \in \mathbb{Z}$ ,  $p, q, p - q, \sqrt{n} \in \mathbb{N}$ , **and for  $a, b, \sqrt{n} \in \mathbb{R}$ , and  $p, q \in \mathbb{Q}$ .**
  - iii. **Use and apply generalizations such as  $a^0 = 1$ ,  $a^{\frac{p}{q}} = \sqrt[q]{a^p} = (\sqrt{a})^p$ ,  $a^{-r} = \frac{1}{a^r}$ ,  $(ab)^r = a^r b^r$ , and  $(\frac{a}{b})^r = \frac{a^r}{b^r}$ , for  $a, b \in \mathbb{R}$ ;  $p, q \in \mathbb{Z}$ ; and  $r \in \mathbb{Q}$ .**
  - iv. Generalize numerical relationships involving operations involving numbers written in index form.
  - v. Correctly use the order of arithmetic and index operations, including the use of brackets.
- d) Calculate and interpret factors (including the highest common factor), multiples (including the lowest common multiple), and prime numbers.
- e) Present numerical answers to the degree of accuracy specified, e.g., correct to the nearest hundred, to two decimal places, or to three significant figures.
- f) Convert the number  $p$  in decimal form to the form  $a \times 10^n$ , where  $1 \leq a < 10$ ,  $n \in \mathbb{Z}$ ,  $p \in \mathbb{Q}$ , and  $p \geq 1$  and  **$0 < p < 1$**

## **N.2 Investigate equivalent representations of rational numbers so that they can:**

- a) Flexibly convert between fractions, decimals, and percentages.
- b) Use and understand ratio and proportion.
- c) Solve money-related problems, including:
  - i. Bills, VAT, profit or loss.
  - ii. % profit or loss (on the cost price).
  - iii. Cost price and selling price.
  - iv. Compound interest for not more than 3 years.
  - v. Income tax (standard rate only).
  - vi. Net pay (including other deductions of specified amounts).
  - vii. Value for money calculations and judgements.
- viii. **Mark up (profit as a % of cost price).**
- ix. **Margin (profit as a % of selling price).**
- x. **Compound interest.**
- xi. **Income tax and net pay (including other deductions).**

## **N.3 Investigate situations involving proportionality so that they can:**

- a) Use absolute and relative comparison where appropriate.
- b) Solve problems involving proportionality, including:
  - i. Currency conversion.
  - ii. Problems involving average speed, distance, and time.

## **N.4 Numerical Patterns**

Analyse numerical patterns in different ways, including making out tables and graphs, and continue such patterns.

## **N.5 Sets**

Explore the concept of a set so that they can:

- a) Understand the concept of a set as a well-defined collection of elements, and that set equality is a relationship where two sets have the same elements.

- b) Define sets by listing their elements, if finite (including in a 2-set or **3-set** Venn diagram), or by generating rules that define them.
- c) Use and understand suitable set notation and terminology, including null set,  $\emptyset$ , subset, complement, element,  $\in$ , universal set, cardinal number,  $\#$ , intersection,  $\cap$ , union,  $\cup$ , set difference,  $\setminus$ ,  $\mathbb{N}$ ,  $\mathbb{Z}$ ,  $\mathbb{Q}$ ,  $\mathbb{R}$ , and  $\mathbb{R} \setminus \mathbb{Q}$ .
- d) Perform the operations of intersection and union on 2 sets **and on 3 sets**, set difference, and complement, including the use of brackets to define the order of operations.
- e) **Investigate whether the set operations of intersection, union, and difference are commutative and/or associative.**

## **Strand 3   Geometry and Trigonometry Strand**

**GT.1** - Calculate, interpret, and apply units of measure and time.

**GT.2** - Investigate 2D shapes and 3D solids so that they can:

- a) Draw and interpret scaled diagrams.
- b) Draw and interpret nets of rectangular solids, prisms (polygonal bases), cylinders.
- c) Find the perimeter and area of plane figures made from combinations of discs, triangles, and rectangles, including relevant operations involving pi.
- d) Find the volume of rectangular solids, cylinders, triangular-based prisms, spheres, and combinations of these, including relevant operations involving pi.
- e) Find the surface area and curved surface area (as appropriate) of rectangular solids, cylinders, triangular-based prisms, spheres, and combinations of these.

**GT.3** - Investigate the concept of proof through their engagement with geometry so that they can:

- a) Perform constructions 1 to 15 in Geometry for Post-Primary School Mathematics (constructions 3 and 7 at HL only).
- b) Recall and use the concepts, axioms, theorems, corollaries and converses, specified in Geometry for Post-Primary School Mathematics (section 9 for OL and section 10 for HL)
  - i) Axioms 1, 2, 3, 4 and 5.

- ii) Theorems 1, 2, 3, 4, 5, 6, 9, 10, 13, 14, 15 **and 11, 12, 19**, and appropriate converses, including relevant operations involving square roots.
- iii) Corollaries 3, 4 and 1, 2, 5 and appropriate converses.
- c) Use and explain the terms: theorem, proof, axiom, corollary, converse, and implies.
- d) Create and evaluate proofs of geometrical propositions.
- e) Display understanding of the proofs of theorems 1, 2, 3, 4, 5, 6, 9, 10, 14, 15, and 13, 19; and of corollaries 3, 4, and 1, 2, 5 (full formal proofs are not examinable).

**GT.4** - Evaluate and use trigonometric ratios (sin, cos, and tan, defined in terms of right-angled triangles) and their inverses, involving angles between  $0^\circ$  and  $90^\circ$  at integer values and in decimal form.

**GT.5** - Investigate properties of points, lines and line segments in the co-ordinate plane so that they can:

- a) Find and interpret: distance, midpoint, slope, point of intersection, and slopes of parallel and perpendicular lines.
- b) Draw graphs of line segments and interpret such graphs in context, including discussing the rate of change (slope) and the y intercept.
- c) Find and interpret the equation of a line in the form  $y = mx + c$ ;  $y - y_1 = m(x - x_1)$ ; and  $ax + by + c = 0$  (for  $a, b, c, m, x_1, y_1 \in \mathbb{Q}$ ); including finding the slope, the y intercept, and other points on the line.

**GT.6** - Investigate transformations of simple objects so that they can:

- a) Recognise and draw the image of points and objects under translation, central symmetry, axial symmetry, and rotation.
- b) Draw the axes of symmetry in shapes.

## Strand 4 Algebra and Functions

### Patterns and relationships

**AF.1** Investigate patterns and relationships (linear, quadratic, doubling and tripling) in number, spatial patterns and real-world phenomena involving change so that they can:

- a) Represent these patterns and relationships in tables and graphs.
- b) Generate a generalised expression for linear (and quadratic) patterns in words and algebraic expressions and fluently convert between each representation.
- c) Categorise patterns as linear, non-linear, quadratic, and exponential (doubling and tripling) using their defining characteristics as they appear in the different representations.

## Algebraic expressions

**AF.2** Investigate situations in which letters stand for quantities that are variable so that they can:

- a) Generate and interpret expressions in which letters stand for numbers.
- b) Find the value of expressions given the value of the variables.
- c) Use the concept of equality to generate and interpret equations.

## Operating on algebraic equations

**AF.3** Investigate situations in which letters stand for quantities that are variable so that they can:

- a) Add, subtract and simplify:
  - i) Linear expressions in one or more variables with coefficients in  $\mathbb{Q}$ .
  - ii) Quadratic expressions in one variable with coefficients in  $\mathbb{Z}$ .
  - iii) Expressions of the form  $a/(bx + c)$ , where  $a, b, c \in \mathbb{Z}$ .
- b) Multiply expressions of the form:
  - i)  $a(bx + cy + d)$ ;  $a(bx^2 + cx + d)$ ; and  $ax(bx^2 + cx + d)$ , where  $a, b, c, d \in \mathbb{Z}$ .
  - ii)  $(ax + b)(cx + d)$  and  $(ax + b)(cx^2 + dx + e)$ , where  $a, b, c, d, e \in \mathbb{Z}$ .
- c) Divide quadratic and cubic expressions by linear expressions, where all coefficients are integers and there is no remainder.
- d) Flexibly convert between the factorised and expanded forms of algebraic expressions of the form:
  - i)  $axy$ , where  $a \in \mathbb{Z}$ .
  - ii)  $axy + byz$ , where  $a, b \in \mathbb{Z}$ .

- iii)  $sx - ty + tx - sy$ , where  $s, t \in \mathbb{Z}$ .
- iv)  $dx^2 + bx; x^2 + bx + c$ ; (and  $ax^2 + bx + c$ ), where  $b, c, d \in \mathbb{Z}$  and  $a \in \mathbb{N}$ .
- v)  $x^2 - a^2$  (and  $a^2x^2 - b^2y^2$ ), where  $a, b \in \mathbb{N}$ .

## Solving algebraic equations

**AF.4** Select and use suitable strategies (graphic, numeric, algebraic, trial and improvement, working backwards) for finding solutions to:

- a) Linear equations in one variable with coefficients in  $\mathbb{Q}$  and solutions in  $\mathbb{Z}$  or in  $\mathbb{Q}$ .
- b) Quadratic equations in one variable with coefficients and solutions in  $\mathbb{Z}$  or coefficients in  $\mathbb{Q}$  and solutions in  $\mathbb{R}$ .
- c) Simultaneous linear equations in two variables with coefficients and solutions in  $\mathbb{Z}$  or in  $\mathbb{Q}$ .
- d) Linear inequalities in one variable of the form  $g(x) < k$ , and graph the solution sets on the number line for  $x \in \mathbb{N}, \mathbb{Z}$ , and  $\mathbb{R}$ .

## Generating quadratic equations

### AF.5

- a) Generate quadratic equations given integer roots.

## Changing the subject of a formula

**AF.6** Apply the relationship between operations and an understanding of the order of operations including brackets and exponents to change the subject of a formula.

## Functions

**AF.7** Investigate functions so that they can:

- a) Demonstrate understanding of the concept of a function.
- b) Represent and interpret functions in different ways—graphically (for  $x \in \mathbb{N}, \mathbb{Z}$ , and  $\mathbb{R}$ , [continuous functions only], as appropriate), diagrammatically, in words, and algebraically—using the language and notation of functions (domain, range, co-domain,  $f(x) =$ ,  $f : x \mapsto$ , and  $y =$ ) (drawing the graph of a function given its algebraic expression is limited to linear and quadratic functions at OL).

- c) Use graphical methods to find and interpret approximate solutions of equations such as  $f(x) = g(x)$  and approximate solution sets of inequalities such as  $f(x) < g(x)$ .
- d) Make connections between the shape of a graph and the story of a phenomenon, including identifying and interpreting maximum and minimum points.

## **Strand 5 Statistics and Probability Strand**

### **SP.1 investigate the outcomes of experiments so that they can**

- a) Generate a sample space for an experiment in a systematic way, including tree diagrams for successive events and two-way tables for independent events
- b) Use the fundamental principle of counting to solve authentic problems

### **SP.2 investigate random events so that they can:**

- a) Demonstrate understanding that probability is a measure on a scale of 0-1 of how likely an event (including an everyday event) is to occur
- b) Use the principle that, in the case of equally likely outcomes, the probability of an event is given by the number of outcomes of interest divided by the total number of outcomes
- c) Use relative frequency as an estimate of the probability of an event, given experimental data, and recognise that increasing the number of times an experiment is repeated generally leads to progressively better estimates of its theoretical probability

### **SP.3 carry out a statistical investigation which includes the ability to:**

- a) Generate a statistical question
- b) Plan and implement a method to generate and/or source unbiased, representative data, and present this data in a frequency table
- c) Classify data (categorical, numerical)
- d) Select, draw and interpret appropriate graphical displays of univariate data, including pie charts, bar charts, line plots, histograms (equal intervals), ordered stem and leaf plots, and ordered back-to-back stem and leaf plots

- e) Select, calculate and interpret appropriate summary statistics to describe aspects of univariate data. Central tendency: mean (including of a grouped frequency distribution), median, mode. Variability: range
- f) Evaluate the effectiveness of different graphical displays in representing data
- g) Discuss misconceptions and misuses of statistics
- h) Discuss the assumptions and limitations of conclusions drawn from sample data or graphical/numerical summaries of data