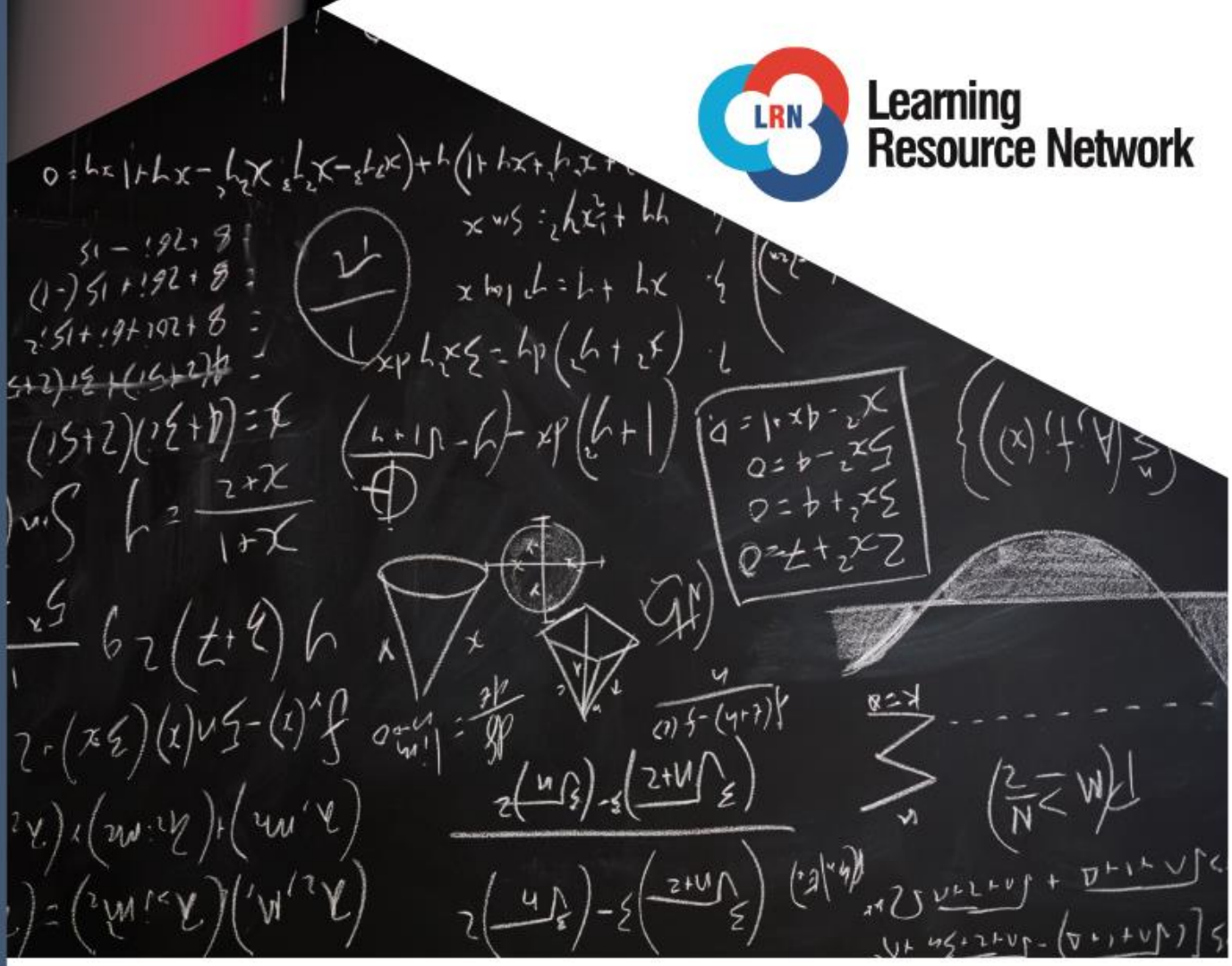
For exams January, May and November onwards
For teaching from September 2021 onwards

SPECIFICATION

Learning Resource Network



INTERNATIONAL GCSE MATHEMATICS (7131)

THE QUEEN'S AWARDS FOR ENTERPRISE: INTERNATIONAL TRADE 2020

Contents

BACKGROUND TO LRN

Learning Resource Network (LRN) is a recognised Awarding Organisation that offers a range of qualifications to candidates, educational institutes, training providers, schools and employers.

LRN is recognised for its high quality qualifications that enable candidates to progress to other areas of study and employment in their designated fields.

In producing its qualifications, LRN uses the experience and expertise of academics, professionals working in the pertinent industries and assessment practitioners with a wealth of best practice and knowledge of validation, verification, delivery and assessment.

ACCOLADES

Queen's Award

In April 2020, LRN received the Queen's Award for Enterprise for International Trade. LRN is one of 220 organisations in the UK to be recognised with this prestigious accolade. This was in recognition of the expansion LRN brought to the overseas qualification market.

MANAGEMENT SYSTEMS

LRN has been awarded international accreditation as part of its quality controls, policies, systems and overall approach to its management systems. These awards are externally validated by the British Assessment Bureau. LRN has achieved accreditation in the form of ISO 9001: Quality Management Systems, ISO 14001: Environment Management Systems and ISO 27001: Information Security Management Systems.

CUSTOMER SERVICE EXCELLENCE

LRN has achieved the prestigious award of Customer Service Excellence. This is in recognition of its customer service practices, approach to managing and dealing with UK and Overseas customer needs, including the diverse needs of its centres.

LRN was the first UK Awarding Organisation to achieve Customer Service Excellence. Following reaccreditation in 2019, LRN received an award for Customer Service Excellence: Compliance Plus, demonstrating that LRN went above and beyond the delivery of its customer service principles.

INTRODUCTION

This specification provides an overview to the LRN International GCSE Mathematics[1]. This document is suitable for various users, including candidates, centres, administrators, employers, parents/guardians, teachers (and other related staff) and examiners. The specification outlines the key features and administrative procedures required for this international qualification.

OBJECTIVE

The LRN International GCSE Mathematics is designed to enable international candidates to demonstrate their ability, in Language of Mathematics, Algebra, Graphs, Geometry, Mensuration and Vectors and Probability and Statistics.

MODE OF DELIVERY

This qualification has been constructed to be delivered within centres. Centres will need to demonstrate to LRN, through the centre recognition processes, that they have the resources, facilities and competence to deliver. However, centres must be able to demonstrate, in line with LRN's criteria, that they have the means, capability, capacity and resources (including suitably qualified centre staff) to deliver by the method chosen by the centre.

PROGRESSION

The LRN International GCSE Mathematics has been designed to reflect the wide variation in candidates' origins, levels of education and career aims. Progression opportunities may, therefore, take a variety of paths. Depending on the level of qualification achieved, it may be appropriate for the candidate to progress to:

1. Similar level 2 qualification in Mathematics;
2. LRN Level 2 Certificate or Diploma in Pre-A Foundation Studies;
3. LRN Level 3 Diploma in Pre-U Foundation Studies;
4. A higher level of any qualification – e.g. A-Level, Diploma
5. Vocationally Related Qualifications

[1] LRN International GCSEs are globally recognised qualifications designed specifically for international candidates and are available outside the United Kingdom. Candidates based in England refer to the Ofqual register.

QUALIFICATION OVERVIEW

Number	Subject Content	AO	Exam
1	Language of Mathematics	1, 2 and 3	Combination of written exam papers (externally set and marked) **Paper 1:** Short answer questions. Duration: 1 hour 30 minutes **Paper 2:** Structured questions. Duration: 2 hours 30 minutes
2	Algebra	1, 2 and 3	
3	Graphs	1, 2 and 3	
4	Geometry	1, 2 and 3	
5	Mensuration and Vectors	1, 2 and 3	
6	Probability and Statistics	1, 2 and 3	

BREAKDOWN OF ASSESSMENT OBJECTIVES

AO1 - Use and apply standard techniques:

- accurately recall facts, terminology and definitions
- use and interpret notation correctly
- accurately carry out routine procedures or set tasks requiring multi-step solutions

AO2 – Reason, interpret and communicate mathematically:

- make deductions, inferences and draw conclusions from mathematical information
- construct chains of reasoning to achieve a given result
- interpret and communicate information accurately
- present arguments and proofs
- assess the validity of an argument and critically evaluate a given way of presenting information

AO3 – Solve problems within mathematics and in other contexts:

- translate problems in mathematical or non-mathematical contexts into a process or a series of mathematical processes
- make and use connections between different parts of mathematics
- interpret results in the context of the given problem
- evaluate methods used and results obtained
- evaluate solutions to identify how they may have been affected by assumptions made

ASSESSMENT

The assessment for this qualification consists of written exam papers set and marked by the LRN.

Assessment objectives (AOs)	Weighting	
	Paper 1	Paper 2
AO1	30%	30%
AO2	40%	40%
AO3	30%	30%

GUIDED LEARNING HOURS

The guided learning hours (GLH) for this qualification are 130. Please note the hours stated are indicative.

ENTRIES CODES

One entry per qualification is sufficient and will cover all the question papers including certification.

PRIVATE CANDIDATES

Centres are advised that private candidates are only to be enrolled with prior agreement and confirmation from LRN.

GRADING

Results are reported, as 9 to 1.

RESULTS

Exam series are in:

- January (results released in March)
- June (results released in August)
- November (results released in January)

RE-TAKES

Whereas candidates can re-take the whole qualification as often as they wish, individual components cannot be re-taken as it is a traditional linear specification.

Please remember, one entry per qualification is sufficient and will cover all the question papers including certification.

CUSTOMER SERVICE STATEMENT

Learning Resource Network (LRN) is committed to ensuring all customers are dealt with promptly and in a professional and helpful manner. In order to guarantee this, we commit to ensuring the following in our day to day interactions with candidates, assessment centres and our stakeholder network:

- All customers will be treated equally and with respect;
- All customer information will only be used in a way which has been agreed in advance, unless we are informed of something that places them or others at risk of harm;
- All customers will be treated by staff in a professional manner.

LRN has arrangements in place to provide a telephone and e-mail helpdesk which will be staffed from 09:00 to 17:00 from Monday to Friday. Furthermore, it will respond to each e-mail, letter or telephone message it receives regarding feedback on its qualifications, centre approvals process or other matters relating to its products and/or services. The timetable for responding is as follows:

- E-mail: 5 working days
- Letter: 5 working days
- Telephone message: 5 working days

DIVERSITY AND EQUALITY

Learning Resource Network (LRN) is committed to ensuring fair and equal access to its qualifications, examinations and support materials. Our Diversity and Equality policy seeks to eliminate unjustifiable discrimination, harassment and/or victimisation and to advance equality of opportunity, thereby ensuring all candidates are treated fairly, in accordance with the protected characteristics of the Equality Act 2010. Specifically, we comply fully with the requirements laid out in the Equality Act 2010. In addition, and within the constraints of this policy, LRN will have due regard for the General data Protection Regulations (GDPR) in the retention of information which is unnecessary.

1	Language of Mathematics		
Aim Mathematics is a language designed to allow us to easily express, and solve, complex problems. The aim of this subject content is to introduce much of the language that underpins most of mathematics.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand integers, decimals and fractions.	1.1	**Know and understand** what an 'Integer' is, that they can be positive, negative or zero, and that they can be 'Odd' or 'Even'.
		1.2	**Know and use** the place values for integers (e.g. units, tens, hundreds, etc).
		1.3	**Use** a number line (or otherwise) to place integers (positive, negative or zero) in order of increasing value.
		1.4	**Know and use** the simple relation symbols [and their names in written descriptions]: = [equal to], ≠ [not equal to], < [less than], and > [greater than].
		1.5	**Know and understand** what 'Fractions' and 'Mixed Numbers' are.
		1.6	**Know and use** standard notation to represent fractions and mixed numbers.
		1.7	**Know and understand** that the value on top of the fraction is called the 'Numerator' and the value on the bottom is called the 'Denominator'.
		1.8	**Know and understand** that 'Equivalent' fractions have the same value.
		1.9	**Use** equivalent fractions to place fractions in order of increasing value.
2	Understand how to add, subtract, multiply and divide.	2.1	**Know and understand** how to add, subtract, multiply and divide positive and negative integers.
		2.2	**Know and understand** that multiplying *A* and *B* is known as the 'Product' of *A* and *B*, and that one divided by *N* is the 'Reciprocal' of *N*.

		2.3	**Know and understand** that an ‘Operation’ is a mathematical process.
		2.4	**Know and use** simple methods for adding, subtracting, multiplying and dividing large numbers without the use of a calculator.
		2.5	**Know and understand** that the ‘Inverse’ of an operation is the operation that undoes the first operation.
		2.6	**Know and use** the fact that addition and subtraction are inverses of each other, and that multiplication and division are inverses of each other.
3	Understand prime numbers.	3.1	**Know and understand** that a ‘Prime Number’ is an integer greater than 1 that cannot be made by multiplying two integers greater than 1 together.
		3.2	**Know and use** the fact that the first six prime numbers are 2, 3, 5, 7, 11 and 13.
		3.3	**Know and understand** that a ‘Multiple’ of a number is that number multiplied by an integer greater than 1.
		3.4	**Know and understand** that ‘Factors’ of an integer *N* are integers that multiply together to get *N*, and that they are also called ‘Divisors’.
		3.5	**Know and use** the ‘Unique Prime Factorisation Theorem’: Every integer can be written in exactly one way as a product of prime numbers (ignoring the order).
		3.6	**Use** the unique prime factorisation theorem to write integers as a product of primes, including in the form $N = A^a B^b C^c \ldots$.
		3.7	**Know and use** the fact that for a set of numbers there will be ‘Common Multiples’, multiples that have the same value for all of them; and that the smallest common multiple is called the ‘Lowest Common Multiple’ or ‘LCM’.
		3.8	**Know and use** the fact that for a set of numbers there will be ‘Common Factors’, integers that are factors of all of them; and that the largest common factor is called the ‘Highest Common Factor’ or ‘HCF’.
		3.9	**Identify** common factors and multiples and use them to simplify fractions and solve problems.
4	Understand powers and roots.	4.1	**Know and understand** that a ‘Power’ of a number is repeated multiplication, that numbers to the power of 2 are called ‘Squared’ and those to the power of 3 are called ‘Cubed’.
		4.2	**Know and use** the indices notation to represent powers.

		4.3	**Calculate** the value of numbers to a power.
		4.4	**Know and understand** that 'Roots' are the inverse of powers, that second roots are called 'Square Roots' and third roots are called 'Cube Roots'.
		4.5	**Know and use** the fact that roots can be written as fractional powers or using root notation.
		4.6	**Calculate** the value of roots of numbers.
		4.7	**Know and use** the fact that powers and roots are inverses of each other, so that the square root of *N* squared is equal to *N*, $\sqrt{N^2} = \left(\sqrt{N}\right)^2 = N$.
		4.8	**Know and understand** that not all roots have an integer value (e.g. $\sqrt{2} = 1.414\ldots$) and that any number that contains a root and cannot be simplified is called a 'Surd'.
		4.9	**Simplify** expressions involving square roots.
		4.10	**Know and understand** that values should be left 'Exact' by using fractions, surds and powers of π, unless a (decimal) approximation is specified.
		4.11	**Know and use** the fact that the order of mathematical operations is clearly defined so that there is only one correct way of interpreting a sequence of written operations.
5	Understand fractions and ratios.	5.1	**Know and understand** that a 'Vulgar' or 'Common' fraction is a fraction where the numerator and denominator are both integers.
		5.2	**Know and understand** that 'Proper' fractions have a value between -1 and 1, otherwise the fraction is 'Improper'.
		5.3	**Know and understand** that a 'Complex' fraction is one where the numerator and/or the denominator is a fraction.
		5.4	**Simplify** complex fractions (division of fractions).
		5.5	**Know and understand** how to multiply fractions.
		5.6	**Know and use** the fact that a fraction can be used as the multiplicative inverse.

		5.7	**Identify** common factors in the numerator and denominator; and cancel them out to simplify a fraction.
		5.8	**Identify** common multiples in the denominators of two fractions and use them to add the fractions.
		5.9	**Know and understand** that the common multiple used as the denominator for both fractions is called the 'Common Denominator'.
		5.10	**Simplify** fractions where surds or powers appear in the numerator and/or the denominator.
		5.11	**Know and understand** that a 'Ratio' is how many of one thing there is for a given number of another thing, stated "a to b" and written "$a:b$".
		5.12	**Calculate** the division of a quantity using a given set of ratios (given the set $a:b:c$ and quantity X, determine n such that $X = na + nb + nc$). {Ratios given in $a:b$ or $a:X$ form. Three part or less ratios only.}
		5.13	**Know and understand** that fractions can be used to represent ratios.
		5.14	**Use** equal ratios to find unknown quantities.
		5.15	**Use** ratios to solve problems involving real world contexts such as conversions, comparisons, scaling, mixing, and concentrations.
6	Understand decimals and percentages.	6.1	**Know and understand** that a 'Decimal' is a representation of a fractional (real) number.
		6.2	**Know and understand** that some decimals are exactly equal to a fraction (rational number) and some of them cannot be written as an exact fraction (irrational number).
		6.3	**Know and use** the place values for decimal numbers.
		6.4	**Know and understand** that a decimal can be 'Terminating' or 'Non-Terminating'.

		6.5	**Know and understand** that some non-terminating decimals are 'Recurring' and that the dot notation is used to represent them (e.g. $4.32\dot{6}4\dot{2}$). {Students should be aware of alternate recurring decimal notations, including ellipsis and overbars. Any correct notation will be accepted, but only dot notation will be used on exam papers and mark schemes.}
		6.6	**Know and understand** that all terminating or recurring decimals can be exactly expressed as a fraction, while other decimals can only be approximated.
		6.7	**Convert** between a fraction and its corresponding decimal, and vice versa.
		6.8	**Know and understand** that 'Percentage' means number of parts per hundred.
		6.9	**Calculate** a percentage of a given number.
		6.10	**Convert** a number into a percentage of another number (e.g., 2 is 40% of 5).
		6.11	**Convert** fractions or decimals to percentages, and vice versa.
		6.12	**Use** percentages to compare two quantities.
		6.13	**Know and understand** how to work with percentages over 100%.
		6.14	**Solve** problems involving percentage change. {Increase, decrease, and finding original values.}
		6.15	**Calculate** the result of repeated percentage change using repeated multiplication of decimals or fractions.
		6.16	**Calculate** compound interest by using $\text{Total money} = P\left(1+\frac{r}{100}\right)^n$, where *P* is the principal (initial) amount, *r* is the interest rate, and *n* is the number of times the interest is applied.
		6.17	**Know and understand** that large numbers can be represented by 'Standard Form', $A \times 10^n$, where $1 \leq A < 10$ and *n* is an integer.

		6.18	**Use** standard form and the laws of indices to simplify multiplication and division of large numbers.
7	Understand measurements and accuracy.	7.1	**Know and use** S.I. units for base and composite quantities, and common units for non-scientific quantities (e.g. £ or $ for money). {Base: s, m, kg, A, K. Special composite (special name and base equivalent)Hz, rad, N, Pa, J, W, C, V, Ω, ºC. composite: m/s, m^2, m^3, kg/m^3. Common prefixes (milli, centi and kilo) are included. }
		7.2	**Convert** between non-standard and standard units when given a conversion factor.
		7.3	**Know and understand** the difference between decimal places and significant figures and how to round values to a specified accuracy.
		7.4	**Know and understand** that a rounded number could have been a range of numbers before rounding, and that the lowest value it could have been is called the 'Lower Bound', and the highest value is the 'Upper Bound'.
		7.5	**Calculate** the upper and lower bounds of a rounded number and represent the interval using inequalities (e.g. $\text{if } x = 2.4 \text{ then } 2.35 \leq x < 2.45$).
		7.6	**Use** upper and lower bounds to solve problems where a degree of accuracy is given.
		7.7	**Estimate** the value of fractions, powers, surds, and compound calculations using truncated or rounded numbers.

2	Algebra		
Aim Algebra is the maths of representing unknown numbers with letters. The aim of this subject content is to turn mathematical problems in to equations with unknown values in them, and manipulate those equations to solve real-world problems.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the language of algebra.	1.1	**Know and understand** that a 'Variable' is a number that can change.
		1.2	**Know and understand** that symbols can be used to represent unknown numbers or variables in mathematics.
		1.3	**Know and understand** that an 'Expression' is a collection of mathematical symbols that represent a number or quantity, not a relationship.
		1.4	**Know and understand** that a 'Formula' is a relationship between two expressions.
		1.5	**Know and understand** that an 'Equation' is a formula where the relationship is 'equal to'.
		1.6	**Know and use** the relation symbols [and their names in written descriptions]: $\leq$ [less than or equal to] and $\geq$ [greater than or equal to]
		1.7	**Know and understand** that an 'Inequality' is a formula where the relationship is $<$, $>$, $\leq$, or $\geq$.
		1.8	**Know and understand** that an 'Identity' is an equation that is always true, and that the relationship symbol [name] is $\equiv$ [identically equal to]. {*Use of = instead of $\equiv$ will not be penalised at this level.}*
		1.9	**Know and understand** that a 'Term' is an expression that is added to another expression.

		1.10	**Know and understand** that a 'Factor' is an expression that multiplies another expression.
		1.11	**Know and understand** that algebraic expressions follow the rules of arithmetic.
2	Understand the notations used to make algebra easier to write.	2.1	**Use and interpret** standard algebraic notation for multiplication and division: ab instead of $a \times b$ $3a$ instead of $a + a + a$, or $3 \times a$ a^2b instead of $a \times a \times b$ $\frac{a}{b}$ instead of $a \div b$ $\frac{3}{2}a$ instead of $1.5\ a$
		2.2	**Use** brackets to group expressions.
		2.3	**Use and interpret** index notation for positive or negative, integer, fractional or zero powers: $a \times a \times a \equiv a^3$ $\frac{1}{a^3} \equiv a^{-3}$ $a^0 \equiv \frac{1}{a^0} \equiv 1$ $\sqrt[3]{a^2} \equiv a^{\frac{2}{3}}$ $\frac{1}{\sqrt{a}} \equiv a^{-\frac{1}{2}}$
		2.4	**Know and use** the index laws to simplify expressions: $x^m \times x^n \equiv x^{m+n}$

			$x^m \div x^n \equiv x^{m-n}$ $(x^m)^n \equiv x^{mn}$
		2.5	**Calculate** the numerical values of expressions.
		2.6	**Know and understand** that a 'Linear' expression is one that contains at least one variable, and all those variables have a power of 1.
		2.7	**Know and understand** that a 'Quadratic' expression is one that contains at least one variable, and the terms with the highest power are of the form x^2 and/or xy.
3	Understand how to simplify and manipulate algebraic expressions.	3.1	**Know and understand** that to 'Simplify' means to write an expression in the least complicated form by using fewer terms, smaller numbers, and/or simpler structures.
		3.2	**Simplify** algebraic expressions by collecting like terms.
		3.3	**Simplify** algebraic expressions by taking out a common factor.
		3.4	**Simplify** algebraic expressions by cancelling identical terms.
		3.5	**Simplify** algebraic expressions by cancelling factors.
		3.6	**Simplify** algebraic fractions where the numerator and/or the denominator are numeric, linear or quadratic:
		3.7	**Simplify** algebraic expressions by using the laws of indices.
		3.8	**Simplify** quadratic expressions by factorising it. {Of the form $ax^2 + bx + c$ only, including $(ax)^2 - (b)^2$.}
		3.9	**Simplify** quadratic expressions by completing the square. {Of the form $ax^2 + bx + c$ only.}
4	Understand how to manipulate algebraic expressions to solve problems.	4.1	**Manipulate** algebraic expressions by multiplying a single term by a bracket.
		4.2	**Manipulate** algebraic expressions by expanding the product of two or more brackets. {Binomial expressions in brackets only.}
		4.3	**Manipulate** algebraic fractions where the numerator and/or the denominator are numeric, linear or quadratic.

		4.4	**Use** algebraic manipulation and simplification to prove that two expressions are the same.
		4.5	**Know and understand** that a 'Function' is a relationship between two variables and that it can be described by an equation.
		4.6	**Know and understand** that the reverse of a function is called the 'Inverse Function'.
		4.7	**Know and understand** that the relationship between two quantities is 'Directly Proportional' if they are related by a function of the form $y = kx$.
		4.8	**Manipulate** simple equations to find their inverse function.
		4.9	**Know and understand** that a 'Composite Function' is applying a function to the result of another function. {Notation is not required}
		4.10	**Use** algebraic techniques to support and construct arguments and proofs.
5	Understand how to solve equations and inequalities.	5.1	**Know and understand** that 'Solving' an equation means finding all the possible values of the variable for which the equation would be true; and that these variables are called 'Unknowns'.
		5.2	**Calculate** values by substituting numerical values into expressions and formulae.
		5.3	**Solve** linear equations where the unknown is on one or both sides of the equation.
		5.4	**Know and understand** that a quadratic equation can have zero, one or two real solutions.
		5.5	**Use** the 'Quadratic Formula', $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$, to obtain the solutions to a quadratic equation of the form $ax^2 + bx + c = 0$ (equation given).
		5.6	**Solve** quadratic equations by rearranging, factoring, completing the square or using the quadratic formula.

		5.7	**Know and understand** that 'Simultaneous Equations' are a set of equations that share variables and are solved for values of the variables such that all the equations are true.
		5.8	**Solve** two simultaneous equations (both linear or one linear and one quadratic) in two variables.
		5.9	**Manipulate** equations into iterative forms.
		5.10	**Calculate** approximate numerical solutions to equations using iteration.
		5.11	**Use** descriptions to set-up linear, quadratic, or simultaneous equations, solve them, and interpret the result in relation to the description.
		5.12	**Express** growth and decay problems in terms of iterative processes. {Including compound interest.}
		5.13	**Solve and interpret** the solutions to growth and decay problems.
6	Understand sequences.	6.1	**Know and understand** that a 'Sequence' is an ordered set of numbers with a rule (function) to get the next number in the sequence.
		6.2	**Know and understand** that the next number rule can either use the previous numbers in the sequence, term-to-term rule, or the position of the number in the sequence, position-to-term rule.
		6.3	**Use** a sequence's rule to find specified terms.
		6.4	**Know and understand** that 'Arithmetic Sequences' have a constant difference between terms, and that this is called the 'Common Difference'.
		6.5	**Know and use** the fact that the nth term of an arithmetic sequence is given by $x_n = a + d(n-1)$ where *a* is the first term and *d* is the common difference, and be able to derive it.
		6.6	**Prove** the equation for the nth term of an arithmetic sequence.

		6.7	**Know and understand** that 'Geometric Sequences' terms are found by multiplying the previous term by a common constant, which is called the 'Common Ratio'.
		6.8	**Know and use** the fact that the nth term of a geometric sequence is given by $x_n = ar^n$ where *a* is the first term, and *r* is the common ratio ($r \neq 0$). {*r* will be limited to rational numbers, or surds, greater than zero.}
		6.9	**Know and understand** that the 'Triangular Number Sequence' is the set of number of objects that can be arranged into an equilateral triangle.
		6.10	**Know and use** the fact that the nth term of the triangular number sequence is $x_n = \frac{n(n+1)}{2}$.
		6.11	**Know and understand** that the 'Square number Sequence' is the sequence where the nth term is $x_n = n^2$.
		6.12	**Know and understand** that the 'Cubic number Sequence' is the sequence where the nth term is $x_n = n^3$.
		6.13	**Know and understand** that the 'Fibonacci Sequence' is the sequence where the nth term is the sum of the previous two terms $x_n = x_{n-1} + x_{n-2}$, and that the sequence is defined as starting [0, 1, 1,…].
		6.14	**Know and understand** that a 'Quadratic Sequence' is a sequence where the 'Second Difference', the difference between consecutive differences between terms, is constant.
		6.15	**Know and use** the fact that the nth term of a quadratic sequence is of the form $x_n = ax^2 + bx + c$ where *a* is half the second difference, and *c* is the first term.

3	Graphs		
Aim Graphs are good method for displaying and analysing data. The aim of this subject content is to draw/plot accurate graphs from data sets or functions, and use them to extract additional data.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand how to draw graphs	1.1	**Draw** axes using a ruler.
		1.2	**Label** axes with descriptions, and units if applicable.
		1.3	**Label** axes with correct scales. {Only increments of powers of ten of 1, 2 or 5 are acceptable. Scales do not need to start at zero, but the start value must be clearly labelled. Contracted axes will not be accepted}
		1.4	**Plot** data points using a cross. {The centre of the cross must be within half a grid square of the correct point.}
		1.5	**Draw** a line of best fit using a ruler.
		1.6	**Label** different data sets clearly when they are plotted on the same axes.
		1.7	**Draw** a triangle at least half the size of one of the graph dimensions when finding a gradient.
		1.8	**Draw** a shaded region when finding the area under a graph.
		1.9	**Draw** sketch graph axes with a ruler.
		1.10	**Label** sketch graph axes with descriptions but not units.
		1.11	**Sketch** the general shape of the curve for sketch graphs.
2	Understand how to plot linear graphs in cartesian coordinates.	2.1	**Know and use** the 'Cartesian Coordinate System' for determining points in two dimensions.
		2.2	**Use** cartesian coordinates to plot graphs using all four quadrants.

		2.3	**Identify** points on a graph when given their cartesian coordinates.
		2.4	**Use** cartesian coordinates to find the midpoint of a straight line between two known points.
		2.5	**Know and understand** that the general equation of a straight line is $y = mx + c$.
		2.6	**Know and understand** that a graph shows direct proportionality if it is a straight line through the origin, $y = mx$.
		2.7	**Determine** the equations for horizontal lines, vertical lines, and diagonal lines that pass through the origin.
		2.8	**Show** that two lines are parallel or perpendicular by comparing their equations.
		2.9	**Construct** the equations for specific lines given two points that they pass through, or one point and the gradient of the line.
		2.10	**Plot** graphs of straight lines from their equations.
		2.11	**Determine** the gradient, m, and y-axis intercept, c, from a straight-line graph.
3	Understand graphs of functions	3.1	**Plot and sketch** graphs of quadratic and simple cubic functions (upto 3 terms).
		3.2	**Plot and sketch** graphs of the reciprocal function $y = \frac{1}{x}$ when $x \neq 0$, and exponential functions of the form $y = k^x$ where k is positive.
		3.3	**Plot and sketch** graphs of the trigonometric functions, $\sin\theta, \cos\theta, \text{ and } \tan\theta$, where θ is any angle in degrees.
		3.4	**Sketch** translations, 1-D enlargements (stretches) and/or reflections (in x-axis, y-axis, or y=x line) of graphical or algebraic functions.
		3.5	**Use** graphs to find the value(s) of x that correspond to a value of y, or vise-versa.
		3.6	**Identify** roots, intercepts and turning points from graphs of functions.

		3.7	**Determine** the points of intersection of two graphs. {one linear, one non-linear}
		3.8	**Know and use** the fact that the points of intersection of two graphs are the solutions to the equation $f_1(x) - f_2(x) = 0$.
		3.9	**Know and use** the equation of a circle of radius r with its centre at the origin: $x^2 + y^2 = r^2$
		3.10	**Draw** the circle given its equation.
		3.11	**Determine** the equation of an origin centred circle from its graph.
		3.12	**Determine** the equation of the tangent to a circle at a given point.
		3.13	**Use** graphs to approximate the solutions for single equations (axis intercepts), and for simultaneous equations (line intercepts).
		3.14	**Draw** linear inequalities in one or two variables, and quadratic inequalities in one variable, on a graph using solid lines for ≥ and ≤, and dashed lines for < and >.
4	Understand gradients.	4.1	**Calculate** the gradient and area under (box counting or polygon methods) linear graphs.
		4.2	**Estimate** the gradient at a point and area under (box counting or polygon methods) non-linear graphs.
		4.3	**Use** the information represented by gradients or areas to solve problems.
		4.4	**Know and understand** that the gradient of a straight-line can be interpreted as the 'Rate of Change' of the function.
		4.5	**Know and understand** that the gradient at a point on a curve can be interpreted as the 'Instantaneous' rate of change of the function.

		4.6	**Determine** the average rate of change by approximating a curve to a straight line and finding that line's gradient.
		4.7	**Determine** average and instantaneous rates of change from the gradients of chords and tangents in numerical, algebraic and graphical forms.
		4.8	**Know and use** the fact that if *A* is inversely proportional to *B* then $A = \frac{k}{B}$.
		4.9	**Know and use** the fact that if *A* is inversely proportional to *B* then a plot of *A* against $\frac{1}{B}$ will have a gradient that is equal to the constant of proportionality.
		4.10	**Interpret** data from distance-time, velocity-time, and financial graphs.

4	Geometry

Aim

Geometry is the study of shapes. The aim of this subject content is to analyse and draw shapes in two and three dimensions.

Learning Outcomes - The learner will:		Assessment Criteria - The learner can:	
1	Understand the language of geometry.	1.1	**Know and understand** that a 'Dimension' is a measure of length in one direction, and that the notation 1-D, 2-D, etc is used to indicate the number of dimensions.
		1.2	**Know and understand** that a 'Point' is an exact location without any size, and that it has zero dimensions.
		1.3	**Know and understand** that a '(Straight) Line' is a set of points that is straight and extends infinitely in both directions, and that they have one dimension, length (along the line from an origin point).
		1.4	**Know and understand** that a 'Line Segment' is finite part of a line, it has two end points and a measurable distance between them.
		1.5	**Know and understand** that an 'Edge' is a line segment that forms part of the outside of a 2-D shape.
		1.6	**Know and understand** that a 'Vertex' is a point where edges meet.
		1.7	**Know and understand** that a 'Plane' is a flat, 2-D surface that infinitely in all four directions.
		1.8	**Know and understand** that a 'Polygon' is flat, 2-D shape of finite size, with at least three edges (sides).
		1.9	**Know and understand** that polygons can be 'Regular' – all side lengths are the same, and all (internal) angles are the same; or 'Irregular' if they are not all the same.

		1.10	**Know and use** the names for the first eight polygons: Triangle (3 sides), Quadrilateral (4), Pentagon (5), Hexagon (6), Heptagon (7), Octagon (8), Nonagon (9), and Decagon (10).
		1.11	**Know and understand** that 'Parallel Lines' are a constant distance apart, and never meet.
		1.12	**Know and understand** that a 'Right Angle' is a 90 degree angle and is represented on a diagram by a box instead of a curve.
		1.13	**Know and understand** that 'Perpendicular Lines' meet exactly once and that the angle between them is a right angle.
		1.14	**Know and understand** that a 'Perpendicular Bisector' is the line that crosses the mid-point of a line segment, and is perpendicular to the line segment.
		1.15	**Know and use** the vertex naming convention (vertex A, side AB, and angle at B $\angle ABC$).
		1.16	**Know and understand** that the 'Perimeter' of a shape is the distance around the outside of the shape, and that the perimeter of a polygon is the sum of the lengths of each side.
2	Understand angles between lines.	2.1	**Know and use** the fact that the sum of the angles on a straight line is 180º.
		2.2	**Know and use** the fact that the sum of the angles around a point is 360º.
		2.3	**Know and understand** that there are three types of angles when a line crosses two parallel lines, and that they are called 'Alternate', 'Allied' or 'Corresponding' angles.
		2.4	**Know and understand** that alternate angles are the same and that they are found in a Z-shape.
		2.5	**Know and understand** that allied angles add up to 180º and that they are found in C or U-shape.

		2.6	**Know and understand** that corresponding angles are the same and that they are found in an F-shape.
		2.7	**Determine** unknown angles in geometry by identifying alternate, allied and corresponding angles.
		2.8	**Know and understand** that an 'Interior Angle' is an angle inside a polygon, and that an 'Exterior Angle' is the angle between a side and the adjacent side extended outward.
		2.9	**Know and understand** that the sum of an interior angle and the adjacent exterior angle is 180^o.
		2.10	**Know and understand** that the sum of the interior angles of a triangle is 180^o.
		2.11	**Determine** the sum of the interior angles of a polygon by splitting the polygon into triangles.
		2.12	**Prove** that the exterior angle of a triangle is equal to the sum of the opposite interior angles.
		2.13	**Prove** that the sum of the interior angles of a polygon is $(n-2) \times 180^o$, and the sum of the exterior angles is 360^o.
		2.14	**Determine** the interior and exterior angles of a regular polygon.
		2.15	**Determine** unknown angles in a diagram.
3	Understand triangles.	3.1	**Know and understand** that an 'Equilateral Triangle' is a regular triangle.
		3.2	**Know and understand** that an 'Isosceles Triangle' has two sides the same length and two equal angles.
		3.3	**Know and understand** that a 'Right Triangle' or 'Right Angled Triangle' has a right angle as one of its angles.

		3.4	**Know and understand** that the longest side of a right angled triangle is called the 'The Hypotenues', and that the side opposite a given (non-right) angle is called 'The Opposite' and the other side is called 'The Adjacent'.
		3.5	**Know and understand** 'Pythagoras' Theorem' for right-angled triangle: $a^2 + b^2 = c^2$
		3.6	**Know and understand** that a 'Scalene Triangle' has no angles or sides that are the same.
		3.7	**Know and use** the naming convention for triangles where a side and the angle and vertex opposite that side are labelled with the same letter.
4	Understand quadrilaterals.	4.1	**Know and understand** that a 'Square' has four sides of equal length and four right angles.
		4.2	**Prove** that opposite sides of a square must be parallel, and that the diagonals bisect each other at right angles.
		4.3	**Know and understand** that a 'Rectangle' has four right angles and that opposite sides are the same length.
		4.4	**Prove** that opposite sides of a rectangle are parallel, that the diagonals bisect, and that all squares are rectangles.
		4.5	**Know and understand** that a 'Parallelogram' has opposite sides of equal length and opposite angles of equal length.
		4.6	**Prove** that opposite sides of a parallelogram are parallel, that the diagonals bisect, and that all rectangles are parallelograms.
		4.7	**Know and understand** that a 'Rhombus' has four equal sides and that opposite angles are equal.

		4.8	**Prove** that opposite sides of a rhombus are parallel, that the diagonals bisect each other at right angles, and that all squares are rhombuses and all rhombuses are parallelograms.
		4.9	**Know and understand** that a ‘Trapezium’ has two parallel sides.
		4.10	**Prove** that all parallelograms are trapeziums.
		4.11	**Know and understand** that a ‘Kite’ has two pairs of equal sides, and that the sides in a pair are adjacent to each other.
		4.12	**Prove** that the diagonals of a kite bisect at right angles, and that all rhombuses are kites.
5	Understand circles.	5.1	**Know and understand** that a ‘Circle’ is all the points a fixed distance from a point, and that that point is the ‘Centre’ of the circle.
		5.2	**Know and understand** that the ‘Radius’ of a circle is the distance between the centre and any point on the circle.
		5.3	**Know and understand** that the ‘Diameter’ of a circle is the length of the line segment that starts and ends on the circle and passes through the centre.
		5.4	**Know and understand** that the Circumference is the perimeter of a circle.
		5.5	**Know and understand** that a ‘Chord’ is any line segment that starts and ends on a circle.
		5.6	**Know and understand** that a ‘Tangent’ is any line that just touches the circle.
		5.7	**Know and understand** that an ‘Arc’ is a section of the circle.
		5.8	**Know and understand** that a ‘Sector’ is the area enclosed by two radii and an arc, and that for two specific radii the larger area is the ‘Major Sector’ and the smaller area is the ‘Minor Sector’.

		5.9	**Know and understand** that a 'Segment' is the area enclosed by a chord and an arc, and that for a specific chord the larger area is the 'Major Segment' and the smaller area is the 'Minor Segment'.
6	Understand the circle theorems.	6.1	**Prove** that the tangent to a point on a circle is at 90^{o} to the radius that finishes on the circle at that point (Circle theorem – Radius to a Tangent).
		6.2	**Prove** that two radii, and the chord that joins their end points, form an isosceles triangle (Circle theorem – Isosceles Triangle).
		6.3	**Prove** that the perpendicular bisector of a chord passes through the centre of the circle (Circle theorem – Perpendicular Bisector).
		6.4	**Prove** that the angle between two radii is twice the angle between the two chords that start at a point on the circle and finish at the points the radii touch the circle (Circle theorem – Angle at the Centre).
		6.5	**Prove** that the triangle whose vertices are the ends of a diameter and any other point on the circumference has a right angle at that third point (Circle theorem – Angles in a Semi-Circle).
		6.6	**Prove** that triangles whose vertices are the ends of a chord and a point on the circumference have the same angle at that point if the triangles are drawn in the same segment of the circle, and that the sum of the angle in the major segment and the angle in the minor segment is 180^{o} (Circle theorem – Angles in the Same Segment).
		6.7	**Prove** that for a quadrilateral whose vertices are all on the circumference of the circle, both pairs of opposite angles add up to 180^{o} (Circle theorem – Cyclic Quadrilateral).
		6.8	**Prove** that if two tangents of a circle cross at a point outside the circle, then the distances from the intersection point to the points where the tangents meet the circle are the same (Circle theorem – Tangents from a Point).

		6.9	**Prove** that the angle between a tangent and a chord that starts at the intersection of the tangent and the circle is the same as the angle between the lines drawn from the ends of the chord to a point on the circle (Circle theorem – Alternate Segment Theorem).
		6.10	**Use** the circle theorems by name to prove other results (e.g. "Using the circle theorem – tangents from a point OA = OB").
7	Understand congruent and similar shapes.	7.1	**Know and use** the fact that if two shapes are 'Congruent' then they are exactly the same size and shape, but they may be rotated or reflected.
		7.2	**Know and use** the fact that two triangles are congruent if any one of the following is true: SSS: Three sides match. AAS: Two angles and a side opposite one of them match. SAS: Two sides and the angle between them match. RHS: A right angle, the hypotenuse and another side match. {The three letter abbreviations can be used in proofs}.
		7.3	**Know and use** the fact that if two shapes are 'Similar' then they are exactly the same shape, but may be enlarged, rotated or reflected.
		7.4	**Know and use** the fact that two triangles are similar if any one of the following is true: Two of the angles match (the third will too). All three sides are proportional. Two sides are proportional and the angle between them is the same.
		7.5	**Use** ratios to find unknown side lengths for similar shapes.
		7.6	**Identify** congruent and similar shapes.
		7.7	**Use** the properties of congruent and similar shapes in simple proofs
		7.8	**Know and understand** that shapes can have 'Line' and/or 'Rotational Symmetry'.

		7.9	**State** the number of lines of symmetry of a polygon.
		7.10	**Draw** the lines of symmetry of a polygon.
		7.11	**State** the 'Order' of rotational symmetry of a polygon.
		7.12	**Know and understand** that a shape without rotational symmetry is said to be of order 1.
8	Understand construction methods.	8.1	**Know and understand** how to use a ruler, compass and protractor to construct shapes accurately. {Construction lines must be clearly shown.}
		8.2	**Know and understand** that 'Loci' are sets of points that all share a property (e.g. 2m away from a point).
		8.3	**Use** a ruler, compass and protractor to construct loci accurately. {Construction lines must be clearly shown.}
		8.4	**Construct** a triangle using a ruler and compass, or a ruler and protractor.
		8.5	**Construct** the locus of points equidistant from a point.
		8.6	**Construct** the locus of points equidistant from two non-parallel lines, and know that this is the angle bisector of the angle between the lines.
		8.7	**Construct** the locus of points equidistant from two points on a line, and know that this is the perpendicular bisector of the line.
		8.8	**Construct** a line that is perpendicular to another line at a given point.
		8.9	**Construct** accurate angles at 60^{o} and 90^{o}.
		8.10	**Construct** the locus of points equidistant from a line (parallel lines).
		8.11	**Construct** the locus of points equidistant from a line segment.

		8.12	**Use** construction methods to draw a region the fits the set of criteria given in a description.
		8.13	**Know and understand** that the shortest distance between a point and a line is the perpendicular distance.
		8.14	**Use** construction methods to prove that the shortest distance between a point and a line is the perpendicular distance.
		8.15	**Draw** diagrams from written information.
9	Understand transformations.	9.1	**Know and understand** that a 'Translation' is a movement in a given direction, that it can be represented by a vector, and that a shape can be translated by applying the translation to each of its vertices.
		9.2	**Draw** translations of simple geometric shapes.
		9.3	**Know and understand** that a 'Rotation' is a circular translation around a central point, and that it is described by an angle, a direction (clockwise or anti-clockwise), and a centre of rotation.
		9.4	**Draw** rotations of 90^o, 180^o or 270^o for simple geometric shapes.
		9.5	**Know and understand** that a reflection is a flip in a given reflection line, and that it is described by the equation of the reflection line.
		9.6	**Draw** reflections in the x-axis, y-axis, of y=x line.
		9.7	**Identify** combinations of transformations (rotations, reflections and translations) which leave a shape unchanged and unmoved.
		9.8	**Describe** the changes to shapes under combinations of transformations.
		9.9	**Know and understand** that an 'Enlargement' is a change in size about a given point, and that it is described by a 'Scale Factor' and an enlargement centre.

		9.10	**Know and understand** that the magnitude of the scale factor determines the change in size (scale factor >1 enlarges, <1 reduces), and the sign determines the side of the enlargement centre the resultant shape is on (a -ve scale factor rotates by 180^{o} about the enlargement centre).
		9.11	**Draw** enlargements of simple geometric shapes with scale factors (positive or negative) of 4, 3, 2, $\frac{1}{2}$, $\frac{1}{3}$, or $\frac{1}{4}$.
		9.12	**Know and understand** how the scale factor changes lengths, areas and volumes.
		9.13	**Use** scale factors to obtain data from scale diagrams and maps.
10	Understand 3D shapes.	10.1	**Know and understand** that 'Cubes' are 3D shapes where all sides are the same length and all angles are 90^{o}, and
		10.2	**Know and understand** that 'Cuboids' have six rectangular faces and all angles are 90^{o}.
		10.3	**Know and understand** that a 'Tetrahedron' is a 3D shape with four triangular sides.
		10.4	**Know and understand** that a 'Square-based Pyramid' is a 3D shape with one square side and four isosceles triangle sides.
		10.5	**Know and understand** that a 'Right Prism' is a 3D shape with constant cross-section (e.g. a 'Cylinder' – cross-section is always the same circle).
		10.6	**Know and understand** that a 'Sphere' is a 3D shape with a surface that is a constant distance (radius) from a point (centre).
		10.7	**Know and understand** that a 'Cone' is a 3D shape that narrows smoothly (and in a constant way) from a circular base to a point. (Other types of cone are ignored at this level)
		10.8	**Draw** 3D shapes (straight edges at 90^{o}) on isometric grids.

		10.9	**Know and understand** that ‘Projections’ are the 2D views of a 3D object from the front (‘Front Elevation’), side (‘Side Elevation’) and above (‘Plan’).
		10.10	**Draw and sketch** the three 2D projections of a 3D shape given a diagram with measurements or an isometric drawing.
		10.11	**Interpret** projection (plan and elevation) drawings of 3D objects.
		10.12	**Know and understand** that a ‘Net’ is the flattened surface of a 3D shape.
		10.13	**Sketch** the nets of simple 3D shapes and
		10.14	**Use** the net of a 3D shape to find the surface areas of the shape.

5	**Mensuration and Vectors**		
Aim Mensuration is the maths of finding the lengths, areas and volumes of geometric shapes, and vectors are a way of representing the directions. The aim of this subject content is to break complicated systems down into simpler systems where sizes can be easily found.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand how to find lengths, angles, perimeters and areas in 2D.	1.1	**Measure** the length of line segments and the size of angles on scale drawings.
		1.2	**Interpret** maps and scale drawings using measured lengths and angles.
		1.3	**Draw** lines and angles accurately on a grid.
		1.4	**Calculate** the area of a triangle using $\text{Area} = \frac{1}{2}bh$.
		1.5	**Calculate** the areas of quadrilaterals: $A_{\text{parallelogram}} = \text{base} \times \text{vertical height}$ $A_{\text{kite}} = \text{width} \times \text{height}$ $A_{\text{trapezium}} = \text{average of parallel sides} \times \text{vertical height}$ (equation given).
		1.6	**Calculate** properties of a circle using $\text{circumference} = 2\pi r = \pi d$, and $\text{area} = \pi r^2$.
		1.7	**Calculate** the perimeter, arc length and/or area of a sector of a circle given the angle at the centre.
		1.8	**Calculate** the angle of a sector of a circle for a given perimeter, arc length or area.
		1.9	**Calculate** the area and perimeter of composite 2D shapes by breaking them down into triangles, quadrilaterals, and/or sectors of circles.
2	Understand how to find the surface areas and volumes of 3D shapes.	2.1	**Calculate** the surface area of cuboids, right prisms, regular tetrahedrons and square-based pyramids.
		2.2	**Calculate** the surface area of a sphere using $A = 4\pi r^2$, where *r* is the radius of the sphere (equation given).

		2.3	**Calculate** the surface area of a cone using $A = \pi rl + \pi r^2$, where *r* is the radius of the base and *l* is the length of the slanted side (equation given)..
		2.4	**Calculate** the surface area of a cylinder using $A = 2\pi rh + 2\pi r^2$, where *r* is the radius of the base and *h* is the height of the cylinder.
		2.5	**Calculate** the surface area of other related shapes (e.g. a hemisphere or a cone with the top removed).
		2.6	**Calculate** the volume of cuboids and right prisms using $V =$ $\text{Area of the front face} \times \text{Depth of prism}$ (equation given).
		2.7	**Calculate** the volume of a sphere using $V = \frac{4}{3}\pi r^3$, where *r* is the radius of the sphere (equation given).
		2.8	**Calculate** the volume of a cone using $V = \frac{1}{3}\pi r^2 h$, where *r* is the radius of the base and *h* is the height of the cone (equation given).
		2.9	**Calculate** the surface area and volume of composite 3D shapes by breaking them down into simpler shapes.
		2.10	**Use** the properties of congruent and similar shapes (2D and 3D) to find lengths, area or volume of a similar/congruent shape.
3	Understand trigonometry.	3.1	**Know and use** the definitions of the trigonometric function: $\sin\theta = \frac{\text{Opposite}}{\text{Hypotenuse}}$, $\cos\theta = \frac{\text{Adjacent}}{\text{Hypotenuse}}$, and $\tan\theta = \frac{\text{Opposite}}{\text{Adjacent}}$.
		3.2	**Prove** that $\tan\theta = \sin\theta/\cos\theta$.
		3.3	**Know and use** the exact values of $\sin\theta, \cos\theta$ and $\tan\theta$ for the angles 0º, 30º, 45º, 60º and 90º, and explain why $\tan 90$ is undefined.

		3.4	**Use** the trigonometric functions to find unknown sides lengths and angles of a right-angled triangle.
		3.5	**Plot and sketch** graphs of the trigonometric functions, $\sin\theta, \cos\theta,$ and $\tan\theta$, where θ is any angle in degrees.
		3.6	**Sketch** the graphs of sin, cos and tan after the transformations 'Enlarge' ($Af(\theta)$), 'Stretch' ($f(B\theta)$), and/or '(Phase) Shift' ($f(\theta + C)$).
		3.7	**Use** the 'Sine Rule' for finding unknown angles or side lengths of a general triangle, $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$ (equation given).
		3.8	**Use** the 'Cosine Rule' for finding unknown angles or side lengths of a general triangle, $a^2 = b^2 + c^2 - 2bc\cos\theta$ (equation given).
		3.9	**Use** the area of a triangle sine rule, $\text{Area} = \frac{1}{2}ab\sin C$, to find the area, side lengths or angles of a general triangle (equation given).
		3.10	**Prove** the area of a triangle sine rule.
4	Understand vectors.	4.1	**Identify** 'Scalar' quantities.
		4.2	**Identify** 'Vector' quantities.
		4.3	**Know and use** vector notation, including row and column vectors, and the representations $\overrightarrow{OA}$ and **v**. {Students should also be aware that in written rather than typed text there are other notations: $\vec{a}, \bar{b},$ or $\underline{c}$. Any clear and consistent notation in written answers will be accepted.}
		4.4	**Know and understand** how to multiply vectors by scalars.
		4.5	**Know and understand** how to add and subtract vectors numerically and algebraically.
		4.6	**Express** vectors in terms of other available vectors.

		4.7	**Know and understand** that the 'Modulus' of a vector is its magnitude and is denoted $\|\boldsymbol{v}\|$.
		4.8	**Calculate** the modulus of vectors.
		4.9	**Draw** vector diagrams, labelling vector lines with an arrow in the direction of the vector.
		4.10	**Draw** vectors accurately on a grid, including vectors described using bearing notation (a distance and an angle clockwise from north).
		4.11	**Interpret** maps and scale drawings using bearings.
		4.12	**Know and understand** that translations can be represented by a vector.
		4.13	**Use** vector properties to determine the location of translated points. {2D only}
		4.14	**Use** vectors to construct geometric proofs and simplify calculations.

6	**Probability and Statistics**		
Aim Probability and statistics are the study of complex systems through averaging over large numbers of similar events. The aim of this subject content is to calculate and interpret probabilities based on models of random events or data from experiments.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand how probability applies to single events.	1.1	**Know and understand** that an 'Event' is where something describable happens.
		1.2	**Know and understand** that an 'Outcome' is a possible result of an event, and that 'The Outcome' is what actually happens.
		1.3	**Know and understand** that a 'Random Event' is one where the outcome cannot be known before it happens.
		1.4	**Know and understand** that the 'Probability' of an outcome is how likely that outcome is to happen, and that it can be used to predict the outcome of a random event.
		1.5	**Know and understand** that a probability is expressed as a value between 0 and 1, in either fractional or decimal form, and that a higher number means the outcome is more likely.
		1.6	**Know and understand** that a probability of 1 means the outcome is certain (will definitely happen), and a probability of 0 means the outcome is impossible (definitely won't happen).
		1.7	**Prove** that the probability can't be greater than 1 or less than zero.
		1.8	**Know and use** the notation for probabilities P(outcome): P(Coin lands head side up) = P(Heads) = 0.5
		1.9	**Describe** the likelihood of an event: "Definitely will happen" [P=1], "Very likely" [P>0.75], "Likely" [P>0.5], "As likely as not" [P=0.5], "Unlikely" [P<0.5], "Very unlikely" [P<0.25], "Definitely won't happen" [P=0].

		1.10	**Know and prove** that the probability of an event happening plus the probability of the event not happening is equal to 1: P(event happens) + P(event doesn't happen) = 1
		1.11	**Know and prove** that the sum of probabilities for all possible outcomes must equal 1.
		1.12	**Know and understand** that 'Equally Likely' means that each outcome of an event has the same probability, and that the event would be described as 'Fair'.
		1.13	**Know and understand** that an event where the outcomes are not equally likely is described as "Biased" or "Unfair".
		1.14	**Know and use** the fact that the probability of a range of equally likely outcomes is given by: $\text{Probability} = \frac{\text{Number of wanted outcomes}}{\text{Total number of outcomes}}$
		1.15	**Use** probability analysis on scenarios involving single events like picking a card or rolling a die, or similar random events.
2	Understand how probability applies to multiple events.	2.1	**Know and understand** that "Mutually Exclusive Outcomes" means that only one of the outcomes can happen.
		2.2	**Know and prove** that the sum of probabilities for an exhaustive set of mutually exclusive events must equal 1.
		2.3	**Use** the facts that the probabilities for an exhaustive set of mutually exclusive events, and for an exhaustive set of outcomes, must sum to 1 to find unknown probabilities.
		2.4	**Know and understand** that, for a repeated event, the relative frequency of an outcome is an estimate of its probability.
		2.5	**Explain** why estimates are not valid for a small number of repetitions, and why the estimate improves as the number of repetitions increases.
		2.6	**Estimate** the probability of a future outcome from past data.
		2.7	**Know and use** the fact that, for a repeated event, the expected number of times an outcome will happen is equal to the probability of the outcome occurring times the number of times the event repeats. {Students should be aware that this is an estimate and not a guarantee.}

		2.8	**Know and understand** that a 'Sample Space' is a list of all the possible outcomes for an event: The sample space for two coin flips is {HH, HT, TH, TT}.
		2.9	**Know and understand** that two events are 'Independent' if the outcome of an event do not affect the other event.
		2.10	**Know and understand** that an event is 'Dependent' on another event if it is affected by its outcome.
		2.11	**Know and use** the fact that, for independent events, the 'AND' rule gives the probability of both events happening: $P(A \text{ and } B) = P(A) \times P(B)$
		2.12	**Know and use** the fact that, for mutually exclusive events, the 'OR' rule gives the probability that at least one event happens: $P(A \text{ or } B) = P(A) + P(B)$
		2.13	**Use** listing techniques, including the 'Product Rule for Counting' to identify all possible outcomes of a set of multiple events.
		2.14	**Use** probability analysis on scenarios involving multiple events like picking several cards or multiple die rolls, or similar random events.
3	Understand how to use tables and diagrams to calculate probabilities of multiple events.	3.1	**Construct** 'Sample Space Diagrams' (tables) for the combined outcome of two independent events.
		3.2	**Use** a sample space diagram to find the probability of a particular set of outcomes for two mutually exclusive events.
		3.3	**Draw and interpret** 'Venn Diagrams' for two or more combined events.
		3.4	**Use** Venn diagrams to distinguish between events that are mutually exclusive and those that are not.
		3.5	**Calculate** the probability of an outcome or set of outcomes.
		3.6	**Use** a Venn diagram to prove the 'OR' rule for mutually exclusive events.
		3.7	**Use** a Venn diagram to find the probability that at least one event happens if the events are not mutually exclusive.
		3.8	**Draw and interpret** 'Tree Diagrams' for two or more events.
		3.9	**Know and use** the fact that, on a tree diagram, the probabilities of any set of branches that meet at a point must sum to 1, and that the sum of all the probabilities at the ends of the branches is 1.

		3.10	**Use** tables, grids, Venn diagrams and tree diagrams to systematically enumerate sets and combinations of sets.
		3.11	**Calculate and interpret** probabilities for combined events, where the events are independent, dependent, or a mixture.
		3.12	**State** any assumption made when calculating a probability.
		3.13	**Explain** why any assumptions used when calculating probabilities are valid.
		3.14	**Construct and interpret** 'Two-Way Tables' for sets of frequency data.
		3.15	**Calculate and interpret** conditional probabilities by using expected frequencies from data sets, and probability representations (e.g., tree diagrams).
4	Understand how to collect data.	4.1	**Know and understand** that the 'Population' is the whole group you want to find out about (e.g., every person who went to the 2007 Leeds Festival).
		4.2	**Know and understand** that a 'Member' is an individual from the population (e.g. rock 372 from a set of rocks).
		4.3	**Know and understand** that a 'Sample' is set of members from a population that represents that population.
		4.4	**Know and understand** that a 'Representative Sample' is a sample that fairly represents a population such that any conclusion based on the sample is also true for the population.
		4.5	**Know and understand** that a 'Random Sample' is one where every member of the population has an equal chance of being in the sample.
		4.6	**Know and understand** that a representative sample needs to be random and large enough.
		4.7	**Know and understand** that a sample is 'Biased' if it does not represent the population, and that this can be because the sample is not random or is too small, so that significant groups are missing (e.g. population is car drivers, but the sample contains only men).

		4.8	**Know and understand** that the results from empirical unbiased samples tend towards those from theoretical probability distributions as the sample size increases.
		4.9	**Identify** problems with methods for choosing a sample.
		4.10	**Describe** a simple method for selecting a random sample.
		4.11	**Describe** how to use 'Stratified Sampling' to reduce bias when taking a sample from a diverse population (e.g. population is 1000 men and 500 women, take random samples containing 100 men and 50 women).
		4.12	**Use** sampling to infer properties of populations and distributions.
		4.13	**Describe** the limitations of sampling.
		4.14	**Know and understand** that, when collecting survey data, the questions used must be clear, with no ambiguity; and the answers must be easily and accurately recorded.
		4.15	**Know and understand** that data can be qualitative (words) or quantitative (numbers).
		4.16	**Know and understand** that quantitative data can be discrete (exact values) or continuous (range of values) and that the range of the data can be broken down into groups called "Classes".
		4.17	**Describe** classes using "equals"/"is" for discrete variables, and inequalities for continuous variables.
		4.18	**Know and understand** that classes used for data collection must cover all possible responses to the question (e.g. "over 6ft" and "under 6ft" misses anyone who is 6ft exactly).
		4.19	**Explain** what is wrong with a questionnaire, or the way the data is collected from it.

5	Understand how to process data.	5.1	**Know and understand** that there are three different averages (Mode, Median and Mean) and make use of the correct terminology.
		5.2	**Know and understand** that the 'Mode' is the most common value in a data set, that if all the values are unique there is no mode, and if multiple values are tied for most common the data is described as bimodal (2), trimodal (3) or multimodal (>1).
		5.3	**Know and understand** that the 'Median' is the middle value in an ordered numerical data set, and that if there is an even number of values in the set the median is halfway between the two middle values.
		5.4	**Know and understand** that the 'Mean' is the sum of all the values in a numerical data set divided by the number of values in the set.
		5.5	**Calculate and interpret** the mean, median and mode for a data set.
		5.6	**Describe** advantages and disadvantages of each average, and use the most appropriate one(s) when writing an analysis of the data.
		5.7	**Know and understand** that the 'Range' and 'Interquartile Range' are measures of how spread out the data is.
		5.8	**Know and understand** that the 'Range' of a numerical data set is the highest value minus the lowest value.
		5.9	**Know and understand** that a set arranged in ascending order can be divided into four equal groups at the 'Quartiles', and that they occur at 25% (lower quartile, Q_1), 50% (median, Q_2), 75% (upper quartile, Q_3), and 100% (whole set, Q_4) of the way through the set.
		5.10	**Know and understand** that the 'Interquartile Range' is the upper quartile minus the lower quartile
		5.11	**Draw and use** a 'Stem and Leaf' diagram to find the quartiles and ranges for a set of unordered data.

		5.12	**Draw** 'Box Plots' to show the quartiles and ranges in graphical form.
		5.13	**Draw and use** a 'Frequency Table' to find the averages and the range for discrete data.
		5.14	**Draw and use** a 'Grouped Frequency Table' to find the modal and median classes, and to estimate the mean and the range, for continuous data.
		5.15	**Compare** two data sets using their averages and spreads. {Including commenting on outliers/anomalies.}
6	Understand statistical data graphs.	6.1	**Draw and interpret** simple means of displaying data, including tables, charts and diagrams.
		6.2	**Draw and use** a 'Cumulative Frequency Graph' to estimate the quartiles and the interquartile range.
		6.3	**Use** a cumulative frequency graph to estimate the number of values less than, or greater than, a given value.
		6.4	**Draw** a 'Histogram' using data from a grouped frequency table.
		6.5	**Use** data from a histogram to complete a grouped frequency table.
		6.6	**Draw** a 'Frequency Polygon' using data from a grouped frequency table.
		6.7	**Draw or complete** a 'Two-Way Table' to display two types of related information.
		6.8	**Plot** a 'Scatter Graph' from a data set, and draw an appropriate line of best fit.
		6.9	**Know and use** 'Interpolation' and 'Extrapolation' to approximate trends and make predictions.
		6.10	**Describe** the dangers and limitations of using interpolation and extrapolation.
		6.11	**Know and understand** that 'Correlation' is a measure of how two variables change in relation to each other, and that it does not imply 'Causation'.

		6.12	**Know and understand** that data can be described as having ‘Strong’, Weak’, or ‘No Correlation’, and that correlation can be ‘Positive’ or ‘Negative.
		6.13	**Use** a scatter graph to justify a description of the data set’s correlation.
		6.14	**Describe and interpret** statistical data sets.

APPENDIX

FORMULA

Kinematics

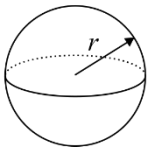
$$s = ut + \frac{1}{2}at^2$$

$$v = u + at$$

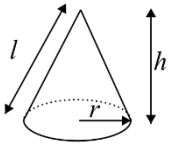
$$v^2 = u^2 + 2as$$

Geometry

Sphere

	$A = 4\pi r^2$ $V = \frac{4}{3}\pi r^3$

Cone

	$A = \pi rl + \pi r^2$ $V = \frac{1}{3}\pi r^2 h$