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# Framework for piloting for applications of mathematics

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# 1 Introduction

GCSE subject criteria set out the knowledge, understanding, skills and assessment objectives common to all GCSE specifications in applications of mathematics. They provide the framework within which an awarding organisation creates the detail of the specification.

Specifications must also meet the regulators' general requirements, including the common and GCSE criteria as defined in *The statutory regulation of external qualifications* (QCA/04/1293).

Subject criteria are intended to:

- help ensure consistent and comparable standards in the same subject across the awarding bodies
- ensure that the rigour of GCSE is maintained
- ensure that specifications build on the knowledge, understanding and skills established by the national curricula for England, Northern Ireland and Wales, and facilitate progression to higher level qualifications in mathematics
- help higher education institutions, employers and other stakeholders, such as learners and parents/guardians, know what has been studied and assessed.

Any GCSE specification that contains significant elements of applications of mathematics must be consistent with the relevant parts of these subject criteria.

## 2 Aims and learning outcomes

GCSE specifications in applications of mathematics should encourage learners to be inspired, moved and changed by following a broad, coherent, satisfying and worthwhile course of study. They should help learners to develop confidence in, and a positive attitude towards, mathematics and to recognise the importance and relevance of mathematics, including statistics, in helping to solve problems in the real world. Specifications should prepare learners to make informed decisions about the use of technology, the management of money, further learning opportunities and career choices and to help them to function as informed citizens.

Specifications in applications of mathematics must enable learners to:

- develop knowledge, skills and understanding of mathematical and statistical methods, techniques and concepts

- select and apply appropriate mathematics and statistics in everyday situations and contexts from the real-world
- use mathematics to represent, analyse and interpret financial information
- understand and use the statistical problem solving cycle
- acquire and use strategies for problem solving and modelling in context, understanding that models may need refining and that there may be more than one way to solve a problem
- interpret mathematical results and draw and justify conclusions that are relevant to the context
- communicate mathematical information in a variety of forms.

### 3 Subject content

The content of GCSE specifications in applications of mathematics must reflect the learning outcomes.

GCSE specifications in applications of mathematics must be consistent with the national curriculum key stage 4 programmes of study requirements for mathematics in the orders for England and Wales, and the statutory requirements for key stage 4 in Northern Ireland.

In combination with GCSE in methods in mathematics, GCSE specifications in applications of mathematics must meet the requirements of the national curriculum key stage 4 programmes of study requirements for mathematics in the orders for England and Wales in full.

GCSE specifications in applications of mathematics must enable learners to develop the knowledge, skills and understanding specified below. **Higher tier content is in bold type.**

#### 3.1 Number

- Understand and use number operations and the relationships between them, including inverse operations and hierarchy of operations.
- Numbers and their representations including powers, roots, indices (integers, **fractional and negative**), and **standard index form**.
- Use the concepts and vocabulary of factor (divisor), multiple, common factor, common multiple and prime number.

- Approximate to specified or appropriate degrees of accuracy including a given power of ten, number of decimal places and significant figures.
- **Understand and use upper and lower bounds.**
- Understand that 'percentage' means 'number of parts per 100' and use this to compare proportions.
- Use multipliers for percentage change; **work with repeated percentage change; solve reverse percentage problems.**
- Interpret fractions, decimals and percentages as operators.
- Find proportional change and **repeated proportional change.**
- **Exponential growth/decay, its relationship with repeated proportional change including financial and scientific applications.**
- Understand and use direct and **inverse** proportion.
- Divide a quantity in a given ratio.
- Use calculators effectively and efficiently, including **trigonometrical** and statistical functions.

### 3.2 Financial and business applications

- Carry out calculations relating to enterprise, saving and borrowing, appreciation and depreciation and **understand AER.**
- Use mathematics in the context of personal and domestic finance including loan repayments, budgeting, *RPI and CPI*, exchange rates and commissions.
- Use spreadsheets to model financial, statistical and other numerical situations.
- Construct and use flow charts.

### 3.3 Measures

- Interpret scales on a range of measuring instruments and recognise the inaccuracy of measurements.
- Convert measurements from one unit to another.
- Make sensible estimates of a range of measures.
- Understand and use compound measures in familiar and **unfamiliar** contexts.
- Understand and use bearings.

- Measure and draw lines and angles.

### 3.4 Algebra

- Manipulate algebraic expressions by collecting like terms, by multiplying a single term over a bracket, and by taking out common factors.
- Set up, and solve simple equations and inequalities.
- Derive a formula, substitute numbers into a formula.
- Use the conventions for coordinates in the plane and plot points in all four quadrants.
- Recognise and plot equations that correspond to straight-line graphs in the coordinate plane.
- Solve linear inequalities in one **or two** variables, and represent the solution set on a number line **or suitable diagram**.
- **Set up and solve problems in linear programming, finding optimal solutions.**
- **Set up and solve linear simultaneous equations in two unknowns.**
- Find approximate solutions of equations using graphical methods and systematic trial and improvement.
- Find and interpret gradients and intercepts of straight line graphs in practical contexts.
- Construct linear, **quadratic and other** functions from real-life problems and plot their corresponding graphs.
- **Interpret the gradient at a point on a curve as the rate of change.**
- Recognise and use graphs that illustrate direct and **inverse** proportion.
- Discuss, plot and interpret graphs (which may be non-linear **and/or periodic**) modelling real situations, including journeys / travel graphs.
- Estimate areas of irregular shapes and **areas under curves**.

### 3.5 Geometry

- Recall and use properties of angles at a point, angles at a point on a straight line (including right angles), perpendicular lines, and vertically opposite angles.

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- Understand and use the angle properties of parallel and intersecting lines, triangles and quadrilaterals.
- Recall the properties and definitions of special types of quadrilateral, including square, rectangle, parallelogram, trapezium, kite and rhombus.
- Recognise reflection and rotation symmetry of 2D shapes.
- Understand congruence and similarity, including the relationship between lengths, **areas and volumes** in similar figures.
- Use Pythagoras' theorem in 2D **and 3D**.
- **Use the trigonometrical ratios to solve 2D and 3D problems.**
- Distinguish between centre, radius, chord, diameter, circumference, tangent, arc, sector and segment.
- Use 2D representations of 3D shapes.
- Use and interpret maps and scale drawings.
- Draw triangles and other 2D shapes using a ruler, pair of compasses and protractor.
- Use straight edge and a pair of compasses to do constructions.
- Construct loci.
- Find circumferences of circles and areas enclosed by circles.
- Calculate perimeters and areas of shapes made from triangles and rectangles **and other shapes**.
- Calculate volumes of right prisms and of shapes made from cubes and cuboids.
- **Solve mensuration problems involving more complex shapes and solids.**

### 3.6 Statistics and probability

- Understand and use the vocabulary of probability and the probability scale.
- Understand and use theoretical models for probabilities including the model of equally likely outcomes.
- Understand and use estimates of probability from relative frequency.
- Understand and use the statistical problem solving process/handling data cycle.

- Design an experiment or survey, identifying possible sources of bias.
- Design data-collection sheets distinguishing between different types of data.
- Extract data from publications, charts, tables and lists.
- Design, use and interpret two-way tables for discrete and grouped data.
- Look at data to find patterns and exceptions.
- Compare distributions and make inferences.
- Produce and interpret charts and diagrams for categorical data including bar charts, pie charts and pictograms.
- Produce and interpret diagrams for ungrouped discrete numerical data, including vertical line charts and stem-and-leaf diagrams.
- **Produce and interpret diagrams for grouped discrete data and continuous data, including histograms with unequal class intervals.**
- **Produce and use cumulative frequency graphs and box-and-whisker plots.**
- Work with time series and **moving averages**, including their graphical representation.
- Calculate, and **for grouped data estimate**, median, mean, range, **quartiles and inter-quartile range**, mode and modal class.
- Recognise correlation and draw and/or use lines of best fit by eye, understanding and interpreting what these represent, and appreciating that correlation does not imply causality.
- Understand that when a statistical experiment or survey is repeated there will usually be different outcomes, and that increasing sample size generally leads to better estimates of probability and population characteristics.
- Discuss and start to estimate risk.

## 4 Assessment objectives

All specifications in applications of mathematics must require learners to demonstrate their ability to:

Assessment objectives		Weighting (%)
<b>AO1</b>	Recall and use their knowledge of the prescribed content	<b>40–50</b>
<b>AO2</b>	Select and apply mathematical methods in a range of contexts	<b>30–40</b>
<b>AO3</b>	Interpret and analyse problems and generate strategies to solve them	<b>15–25</b>

## 5 Scheme of assessment

GCSE specifications in applications of mathematics must allocate a weighting of 100 per cent to external assessment.

Question papers in applications of mathematics must be targeted at either foundation or higher tier.

GCSE assessments in applications of mathematics must allocate a weighting of 20-30 per cent on higher tier and 30-40 per cent on foundation tier for the functional elements of mathematics.

## 6 Grade descriptions

Grade descriptions are provided to give a general indication of the standards of achievement likely to have been shown by candidates awarded particular grades. The descriptions must be interpreted in relation to the content in the specification; they are not designed to define that content.

The grade awarded will depend in practice upon the extent to which the candidate has met the assessment objectives overall. Shortcomings in some aspects of candidates' performance in the assessment may be balanced by better performances in others.

Grade	Description
<p><b>A</b></p>	<p>Candidates use a wide range of mathematical techniques, terminology, diagrams and symbols consistently, appropriately and accurately. Candidates are able to use different representations effectively and they recognise equivalent representations for example numerical, graphical and algebraic representations. Their numerical skills are sound, they use a calculator effectively and they demonstrate algebraic fluency. They use trigonometry and geometrical properties to solve problems.</p> <p>Candidates identify and use mathematics accurately in a range of contexts. They evaluate the appropriateness, effectiveness and efficiency of different approaches. Candidates choose methods of mathematical communication appropriate to the context. They are able to state the limitations of an approach or the accuracy of results. They use this information to inform conclusions within a mathematical or statistical problem.</p> <p>Candidates make and test hypotheses and conjectures. They adopt appropriate strategies to tackle problems (including those that are novel or unfamiliar), adjusting their approach when necessary. They tackle problems that bring together different aspects of mathematics and may involve multiple variables. They can identify some variables and investigate them systematically; the outcomes of which are used in solving the problem.</p> <p>Candidates communicate their chosen strategy. They can construct a rigorous argument, making inferences and drawing conclusions. They produce simple proofs and can identify errors in reasoning.</p>
<p><b>C</b></p>	<p>Candidates use a range of mathematical techniques, terminology, diagrams and symbols consistently, appropriately and accurately. Candidates are able to use different representations effectively and they recognise some equivalent representations eg numerical, graphical and algebraic representations of linear functions; percentages, fractions and decimals. Their numerical skills are sound and they use a calculator accurately. They apply ideas of proportionality to numerical problems and use geometric properties of angles, lines and shapes.</p> <p>Candidates identify relevant information, select appropriate</p>

	<p>representations and apply appropriate methods and knowledge. They are able to move from one representation to another, in order to make sense of a situation. Candidates use different methods of mathematical communication.</p> <p>Candidates tackle problems that bring aspects of mathematics together. They identify evidence that supports or refutes conjectures and hypotheses. They understand the limitations of evidence and sampling, and the difference between a mathematical argument and conclusions based on experimental evidence.</p> <p>They identify strategies to solve problems involving a limited number of variables. They communicate their chosen strategy, making changes as necessary. They construct a mathematical argument and identify inconsistencies in a given argument or exceptions to a generalisation.</p>
<p><b>F</b></p>	<p>Candidates use some mathematical techniques, terminology, diagrams and symbols from the foundation tier consistently, appropriately and accurately. Candidates use some different representations effectively and can select information from them. They complete straightforward calculations competently with and without a calculator. They use simple fractions and percentages, simple formulae and some geometric properties, including symmetry.</p> <p>Candidates work mathematically in everyday and meaningful contexts. They make use of diagrams and symbols to communicate mathematical ideas. Sometimes, they check the accuracy and reasonableness of their results.</p> <p>Candidates test simple hypotheses and conjectures based on evidence. Candidates are able to use data to look for patterns and relationships. They state a generalisation arising from a set of results and identify counter-examples. They solve simple problems, some of which are non-routine.</p>

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