A-LEVEL MATHEMATICS

7357

Specification

For teaching from September 2017 onwards

For A-level exams in 2018 onwards

Version 1.0 28 February 2017

Contents

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1 Introduction

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2 Specification at a glance

This qualification is linear. Linear means that students will sit all their exams at the end of the course.

2.1 Subject content

2.2 Assessments

Paper 1

What's assessed

Any content from:

- A: Proof
- B: Algebra and functions
- C: Coordinate geometry
- D: Sequences and series
- E: Trigonometry
- F: Exponentials and logarithms
- G: Differentiation
- H: Integration
- I: Numerical methods

How it's assessed

- Written exam: 2 hours
- 100 marks
- 33⅓ % of A-level

Questions

A mix of question styles, from short, single-mark questions to multi-step problems.

Paper 2

What's assessed

Any content from Paper 1 and content from:

- J: Vectors
- P: Quantities and units in mechanics
- Q: Kinematics
- R: Forces and Newton's laws
- S: Moments

How it's assessed

- Written exam: 2 hours
- 100 marks
- 33⅓ % of A-level

Questions

A mix of question styles, from short, single-mark questions to multi-step problems.

Paper 3

What's assessed

Any content from Paper 1 and content from:

- K: Statistical sampling
- L: Data presentation and Interpretation
- M: Probability
- N: Statistical distributions
- O: Statistical hypothesis testing

How it's assessed

- Written exam: 2 hours
- 100 marks
- 33⅓ % of A-level

Questions

A mix of question styles, from short, single-mark questions to multi-step problems.

3 Subject content

The subject content for A-level Mathematics is set out by the Department for Education (DfE) and is common across all exam boards. The content set out in this specification covers the complete A-level course of study.

3.1 Overarching themes

A-level specifications in mathematics must require students to demonstrate the overarching knowledge and skills contained in sections **OT1**, **OT2** and **OT3**. These must be applied, along with associated mathematical thinking and understanding, across the whole of the detailed content set out in sections **A** to **S**.

Students must use the mathematical notation and must be able to recall the mathematical formulae and identities set out in the DfE subject content.

3.1.1 OT1: Mathematical argument, language and proof

	Content
OT1.1	Construct and present mathematical arguments through appropriate use of diagrams; sketching graphs; logical deduction; precise statements involving correct use of symbols and connecting language, including: constant, coefficient, expression, equation, function, identity, index, term, variable.
OT1.2	Understand and use mathematical language and syntax as set out in the content.
OT1.3	Understand and use language and symbols associated with set theory, as set out in the content. Apply to solutions of inequalities and probability.
OT1.4	Understand and use the definition of a function; domain and range of functions.
OT1.5	Comprehend and critique mathematical arguments, proofs and justifications of methods and formulae, including those relating to applications of mathematics.

3.1.2 OT2: Mathematical problem solving

	Content
OT2.1	Recognise the underlying mathematical structure in a situation and simplify and abstract appropriately to enable problems to be solved.
OT2.2	Construct extended arguments to solve problems presented in an unstructured form, including problems in context.
OT2.3	Interpret and communicate solutions in the context of the original problem.

	Content
OT2.4	Understand that many mathematical problems cannot be solved analytically, but numerical methods permit solution to a required level of accuracy.
OT2.5	Evaluate, including by making reasoned estimates, the accuracy or limitations of solutions, including those obtained using numerical methods.
OT2.6	Understand the concept of a mathematical problem solving cycle, including specifying the problem, collecting information, processing and representing information and interpreting results, which may identify the need to repeat the cycle.
OT2.7	Understand, interpret and extract information from diagrams and construct mathematical diagrams to solve problems, including in mechanics.

3.1.3 OT3: Mathematical modelling

	Content
OT3.1	Translate a situation in context into a mathematical model, making simplifying assumptions.
OT3.2	Use a mathematical model with suitable inputs to engage with and explore situations (for a given model or a model constructed or selected by the student).
OT3.3	Interpret the outputs of a mathematical model in the context of the original situation (for a given model or a model constructed or selected by the student).
OT3.4	Understand that a mathematical model can be refined by considering its outputs and simplifying assumptions; evaluate whether the model is appropriate.
OT3.5	Understand and use modelling assumptions.

3.2 A: Proof

	Content
A1	• Understand and use the structure of mathematical proof, proceeding from given assumptions through a series of logical steps to a conclusion; use methods of proof, including proof by deduction, proof by exhaustion. • Disproof by counter example. • Proof by contradiction (including proof of the irrationality of $\sqrt{2}$ and the infinity of primes, and application to unfamiliar proofs).

3.3 B: Algebra and functions

	Content
B1	Understand and use the laws of indices for all rational exponents.

	Content
B2	Use and manipulate surds, including rationalising the denominator.

	Content
B3	Work with quadratic functions and their graphs; the discriminant of a quadratic function, including the conditions for real and repeated roots; completing the square; solution of quadratic equations including solving quadratic equations in a function of the unknown.

	Content
B4	Solve simultaneous equations in two variables by elimination and by substitution, including one linear and one quadratic equation.

	Content
B5	• Solve linear and quadratic inequalities in a single variable and interpret such inequalities graphically, including inequalities with brackets and fractions. • Express solutions through correct use of 'and' and 'or', or through set notation. • Represent linear and quadratic inequalities such as $y > x + 1$ and $y > ax^2 + bx + c$ graphically.

	Content
B6	• Manipulate polynomials algebraically, including expanding brackets and collecting like terms, factorisation and simple algebraic division; use of the factor theorem. • Simplify rational expressions including by factorising and cancelling, and algebraic division (by linear expressions only).

	Content
B7	• Understand and use graphs of functions; sketch curves defined by simple equations including polynomials, the modulus of a linear function, $y = \frac{a}{x}$ and $y = \frac{a}{x^2}$ (including their vertical and horizontal asymptotes); interpret algebraic solution of equations graphically; use intersection points of graphs to solve equations. • Understand and use proportional relationships and their graphs.

	Content
B8	Understand and use composite functions; inverse functions and their graphs.

	Content
B9	Understand the effect of simple transformations on the graph of $y = f(x)$ including sketching associated graphs: $y = af(x)$, $y = f(x) + a$, $y = f(x + a)$, $y = f(ax)$, and combinations of these transformations.

	Content
B10	Decompose rational functions into partial fractions (denominators not more complicated than squared linear terms and with no more than 3 terms, numerators constant or linear).

	Content
B11	Use of functions in modelling, including consideration of limitations and refinements of the models.

3.4 C: Coordinate geometry in the (x,y) plane

	Content
C1	• Understand and use the equation of a straight line, including the forms: $y - y_1 = m(x - x_1)$ *and* $ax + by + c = 0$; gradient conditions for two straight lines to be parallel or perpendicular. • Be able to use straight line models in a variety of contexts.

	Content
C2	Understand and use the coordinate geometry of the circle including using the equation of a circle in the form $(x - a)^2 + (y - b)^2 = r^2$; completing the square to find the centre and radius of a circle; use of the following properties: • the angle in a semicircle is a right angle • the perpendicular from the centre to a chord bisects the chord • the radius of a circle at a given point on its circumference is perpendicular to the tangent to the circle at that point.

	Content
C3	Understand and use the parametric equations of curves and conversion between Cartesian and parametric forms.

	Content
C4	Use parametric equations in modelling in a variety of contexts.

3.5 D: Sequences and series

	Content
D1	• Understand and use the binomial expansion of $(a + bx)^n$ for positive integer n; the notations $n!$ and nCr; link to binomial probabilities. • Extend to any rational n, including its use for approximation; be aware that the expansion is valid for $\left\|\frac{bx}{a}\right\| < 1$. (proof not required).

	Content
D2	Work with sequences including those given by a formula for the nth term and those generated by a simple relation of the form $x_{n+1} = f(x_n)$; increasing sequences; decreasing sequences; periodic sequences.

	Content
D3	Understand and use sigma notation for sums of series.

	Content
D4	Understand and work with arithmetic sequences and series, including the formulae for nth term and the sum to n terms.

	Content
D5	Understand and work with geometric sequences and series including the formulae for the nth term and the sum of a finite geometric series; the sum to infinity of a convergent geometric series, including the use of $\|r\| < 1$; modulus notation.

	Content
D6	Use sequences and series in modelling.

3.6 E: Trigonometry

	Content
E1	• Understand and use the definitions of sine, cosine and tangent for all arguments; the sine and cosine rules; the area of a triangle in the form $\frac{1}{2}ab\sin C$ • Work with radian measure, including use for arc length and area of sector.

	Content
E2	Understand and use the standard small angle approximations of sine, cosine and tangent $\sin\theta \approx \theta,\ \cos\theta \approx 1 - \frac{\theta^2}{2},\ \tan\theta \approx \theta$ where θ is in radians.

	Content
E3	• Understand and use the sine, cosine and tangent functions; their graphs, symmetries and periodicity. • Know and use exact values of sin and cos for 0, $\frac{\pi}{6}, \frac{\pi}{4}, \frac{\pi}{3}, \frac{\pi}{2},\ \pi$ and multiples thereof, and exact values of tan for 0, $\frac{\pi}{6}, \frac{\pi}{4}, \frac{\pi}{3}, \pi$ and multiples thereof.

	Content
E4	Understand and use the definitions of secant, cosecant and cotangent and of arcsin, arccos and arctan; their relationships to sine, cosine and tangent; understanding of their graphs; their ranges and domains.

	Content
E5	• Understand and use $\tan\theta = \frac{\sin\theta}{\cos\theta}$ • Understand and use $sin^2\theta + cos^2\theta = 1$; $sec^2\theta = 1 + tan^2\theta$ and $cosec^2\theta = 1 + cot^2\theta$

	Content
E6	• Understand and use double angle formulae; use of formulae for $\sin(A \pm B),\ \cos(A \pm B)$and $\tan(A \pm B)$; understand geometrical proofs of these formulae. • Understand and use expressions for a $\cos\theta$ + b $\sin\theta$ in the equivalent forms of $r\cos(\theta \pm \alpha) or\ r\sin(\theta \pm \alpha)$

	Content
E7	Solve simple trigonometric equations in a given interval, including quadratic equations in sin, cos and tan and equations involving multiples of the unknown angle.

	Content
E8	Construct proofs involving trigonometric functions and identities.

	Content
E9	Use trigonometric functions to solve problems in context, including problems involving vectors, kinematics and forces.

3.7 F: Exponentials and logarithms

	Content
F1	• Know and use the function a^x and its graph, where a is positive. • Know and use the function e^x and its graph.

	Content
F2	Know that the gradient of e^{kx} is equal to ke^{kx} and hence understand why the exponential model is suitable in many applications.

	Content
F3	• Know and use the definition of $\log_a x$ as the inverse of a^x , where a is positive and $x \geq 0$ • Know and use the function $\ln x$ and its graph. • Know and use $\ln x$ as the inverse function of e^x

	Content
F4	Understand and use the laws of logarithms: $\log_a x + \log_a y = \log_a(xy)$; $\log_a x - \log_a y = \log_a\left(\frac{x}{y}\right)$; $k\log_a x = \log_a x^k$ (including, for example, $k = -1$ *and* $k = -\frac{1}{2}$).

	Content
F5	Solve equations of the form $a^x = b$

	Content
F6	Use logarithmic graphs to estimate parameters in relationships of the form $y = ax^n$ and $y = kb^x$, given data for x and y.

	Content
F7	Understand and use exponential growth and decay; use in modelling (examples may include the use of e in continuous compound interest, radioactive decay, drug concentration decay, exponential growth as a model for population growth); consideration of limitations and refinements of exponential models.

3.8 G: Differentiation

	Content
G1	• Understand and use the derivative of $f(x)$ as the gradient of the tangent to the graph of $y = f(x)$ at a general point (x, y); the gradient of the tangent as a limit; interpretation as a rate of change; sketching the gradient function for a given curve; second derivatives; differentiation from first principles for small positive integer powers of x and for $\sin x$ and $\cos x$ • Understand and use the second derivative as the rate of change of gradient; connection to convex and concave sections of curves and points of inflection.

	Content
G2	• Differentiate x^n , for rational values of n, and related constant multiples, sums and differences. • Differentiate e^{kx} and a^{kx} , $\sin kx$, $\cos kx$, $\tan kx$ and related sums, differences and constant multiples. • Understand and use the derivative of $\ln x$

	Content
G3	• Apply differentiation to find gradients, tangents and normals, maxima and minima and stationary points, points of inflection. • Identify where functions are increasing or decreasing.

	Content
G4	Differentiate using the product rule, the quotient rule and the chain rule, including problems involving connected rates of change and inverse functions.

	Content
G5	Differentiate simple functions and relations defined implicitly or parametrically, for first derivative only.

	Content
G6	Construct simple differential equations in pure mathematics and in context, (contexts may include kinematics, population growth and modelling the relationship between price and demand).

3.9 H: Integration

	Content
H1	Know and use the Fundamental Theorem of Calculus.

	Content
H2	• Integrate x^n (excluding n = -1), and related sums, differences and constant multiples. • Integrate e^{kx}, $\frac{1}{x}$, $\sin kx$, $\cos kx$ and related sums, differences and constant multiples.

	Content
H3	Evaluate definite integrals; use a definite integral to find the area under a curve and the area between two curves.

	Content
H4	Understand and use integration as the limit of a sum.

	Content
H5	• Carry out simple cases of integration by substitution and integration by parts; understand these methods as the inverse processes of the chain and product rules respectively. • (Integration by substitution includes finding a suitable substitution and is limited to cases where one substitution will lead to a function which can be integrated; integration by parts includes more than one application of the method but excludes reduction formulae).

	Content
H6	Integrate using partial fractions that are linear in the denominator.

	Content
H7	Evaluate the analytical solution of simple first order differential equations with separable variables, including finding particular solutions (Separation of variables may require factorisation involving a common factor).

	Content
H8	Interpret the solution of a differential equation in the context of solving a problem, including identifying limitations of the solution; includes links to kinematics.

3.10 I: Numerical methods

	Content
I1	• Locate roots of $f(x) = 0$ by considering changes of sign of $f(x)$ in an interval of x on which $f(x)$ is sufficiently well-behaved. • Understand how change of sign methods can fail.

	Content
I2	• Solve equations approximately using simple iterative methods; be able to draw associated cobweb and staircase diagrams. • Solve equations using the Newton-Raphson method and other recurrence relations of the form $x_{n+1} = g(x_n)$ • Understand how such methods can fail.

	Content
I3	Understand and use numerical integration of functions, including the use of the trapezium rule and estimating the approximate area under a curve and limits that it must lie between.

	Content
I4	Use numerical methods to solve problems in context.

3.11 J: Vectors

	Content
J1	Use vectors in two dimensions and in three dimensions.

	Content
J2	Calculate the magnitude and direction of a vector and convert between component form and magnitude/direction form.

	Content
J3	Add vectors diagrammatically and perform the algebraic operations of vector addition and multiplication by scalars, and understand their geometrical interpretations.

	Content
J4	Understand and use position vectors; calculate the distance between two points represented by position vectors.

	Content
J5	Use vectors to solve problems in pure mathematics and in context, including forces and kinematics.

3.12 K: Statistical sampling

For sections K to O students must demonstrate the ability to use calculator technology to compute summary statistics and access probabilities from standard statistical distributions.

	Content
K1	• Understand and use the terms 'population' and 'sample'. • Use samples to make informal inferences about the population. • Understand and use sampling techniques, including simple random sampling and opportunity sampling. • Select or critique sampling techniques in the context of solving a statistical problem, including understanding that different samples can lead to different conclusions about the population.

3.13 L: Data presentation and interpretation

	Content
L1	• Interpret diagrams for single-variable data, including understanding that area in a histogram represents frequency. • Connect to probability distributions.

	Content
L2	• Interpret scatter diagrams and regression lines for bivariate data, including recognition of scatter diagrams which include distinct sections of the population (calculations involving regression lines are excluded). • Understand informal interpretation of correlation. • Understand that correlation does not imply causation.

	Content
L3	• Interpret measures of central tendency and variation, extending to standard deviation. • Be able to calculate standard deviation, including from summary statistics.

	Content
L4	• Recognise and interpret possible outliers in data sets and statistical diagrams. • Select or critique data presentation techniques in the context of a statistical problem. • Be able to clean data, including dealing with missing data, errors and outliers.

3.14 M: Probability

	Content
M1	• Understand and use mutually exclusive and independent events when calculating probabilities. • Link to discrete and continuous distributions.

	Content
M2	• Understand and use conditional probability, including the use of tree diagrams, Venn diagrams, two-way tables. • Understand and use the conditional probability formula. • $P(A \mid B) = \frac{P(A \cap B)}{P(B)}$

	Content
M3	Modelling with probability, including critiquing assumptions made and the likely effect of more realistic assumptions.

3.15 N: Statistical distributions

	Content
N1	Understand and use simple, discrete probability distributions (calculation of mean and variance of discrete random variables is excluded), including the binomial distribution, as a model; calculate probabilities using the binomial distribution.

	Content
N2	• Understand and use the Normal distribution as a model; find probabilities using the Normal distribution. • Link to histograms, mean, standard deviation, points of inflection and the binomial distribution.

	Content
N3	Select an appropriate probability distribution for a context, with appropriate reasoning, including recognising when the binomial or Normal model may not be appropriate.

3.16 O: Statistical hypothesis testing

	Content
O1	Understand and apply the language of statistical hypothesis testing, developed through a binomial model: null hypothesis, alternative hypothesis, significance level, test statistic, 1-tail test, 2-tail test, critical value, critical region, acceptance region, *p*-value]; extend to correlation coefficients as measures of how close data points lie to a straight line and be able to interpret a given correlation coefficient using a given *p*-value or critical value (calculation of correlation coefficients is excluded).

	Content
O2	• Conduct a statistical hypothesis test for the proportion in the binomial distribution and interpret the results in context. • Understand that a sample is being used to make an inference about the population and appreciate that the significance level is the probability of incorrectly rejecting the null hypothesis.

	Content
O3	Conduct a statistical hypothesis test for the mean of a Normal distribution with known, given or assumed variance and interpret the results in context.

3.17 P: Quantities and units in mechanics

	Content
P1	• Understand and use fundamental quantities and units in the S.I. system: length, time, mass. • Understand and use derived quantities and units: velocity, acceleration, force, weight, moment.

3.18 Q: Kinematics

	Content
Q1	Understand and use the language of kinematics: position; displacement; distance travelled; velocity; speed; acceleration.

	Content
Q2	Understand, use and interpret graphs in kinematics for motion in a straight line: displacement against time and interpretation of gradient; velocity against time and interpretation of gradient and area under the graph.

	Content
Q3	Understand, use and derive the formulae for constant acceleration for motion in a straight line; extend to 2 dimensions using vectors.

	Content
Q4	Use calculus in kinematics for motion in a straight line: $v = \frac{dr}{dt}$, $a = \frac{dv}{dt} = \frac{d^2r}{dt^2}$, $r = \int v\,dt, v = \int a\,dt$; extend to 2 dimensions using vectors.

	Content
Q5	Model motion under gravity in a vertical plane using vectors; projectiles.

3.19 R: Forces and Newton's laws

	Content
R1	Understand the concept of a force; understand and use Newton's first law.

	Content
R2	Understand and use Newton's second law for motion in a straight line (restricted to forces in two perpendicular directions or simple cases of forces given as 2D vectors); extend to situations where forces need to be resolved (restricted to 2 dimensions).

	Content
R3	• Understand and use weight and motion in a straight line under gravity; gravitational acceleration, *g*, and its value in S.I. units to varying degrees of accuracy. • (The inverse square law for gravitation is not required and *g* may be assumed to be constant, but students should be aware that *g* is not a universal constant but depends on location).

	Content
R4	Understand and use Newton's third law; equilibrium of forces on a particle and motion in a straight line (restricted to forces in two perpendicular directions or simple cases of forces given as 2D vectors); application to problems involving smooth pulleys and connected particles; resolving forces in 2 dimensions; equilibrium of a particle under coplanar forces.

	Content
R5	Understand and use addition of forces; resultant forces; dynamics for motion in a plane.

	Content
R6	Understand and use the $F \leq \mu R$ model for friction; coefficient of friction; motion of a body on a rough surface; limiting friction and statics.

3.20 S: Moments

	Content
S1	Understand and use moments in simple static contexts.

3.21 Use of data in statistics

As set out in the Department for Education's *Mathematics: AS and A-level content* document, students studying A-level Mathematics must:

- become familiar with one or more specific large data set(s) in advance of the final assessment (these data must be real and sufficiently rich to enable the concepts and skills of data presentation and interpretation in the specification to be explored)
- use technology such as spreadsheets or specialist statistical packages to explore the data set(s)
- interpret real data presented in summary or graphical form
- use data to investigate questions arising in real contexts.

This requirement is common to all exam boards.

3.21.1 Data set

We have selected one data set that will feature in statistics questions throughout the lifetime of this specification.

The data set is an extract of a dataset that underpins DEFRA 'Family Food 2014 report' (published in 2015). The dataset contains information on purchased quantities of household food & drink by Government Office Region from 2001 until 2014. The specific extract that students need to be familiar with for the exam will only be available via the AQA website.

As part of our assessment monitoring procedure, we may decide to refresh or replace this data set during the lifetime of the specification. We will provide two years notice in advance of the first exam in which any change to the specified data set is assessed

The data set must be used in teaching to allow students to perform tasks that build familiarity with the contexts, the main features of the data and the ways in which technology can help explore the data. Students should also be able to demonstrate the ability to analyse a subset or features of the data using a calculator with standard statistical functions.

For the data set that students should be familiar with and supporting resources, visit aqa.org.uk/7357

4 Scheme of assessment

Find past papers and mark schemes, and specimen papers for new courses, on our website at aqa.org.uk/pastpapers

This specification is designed to be taken over two years.

This is a linear qualification. In order to achieve the award, students must complete all assessments at the end of the course and in the same series.

A-level exams and certification for this specification are available for the first time in May/June 2018 and then every May/June for the life of the specification.

All materials are available in English only.

Our A-level exams in Mathematics include questions that allow students to demonstrate their ability to:

- recall information
- draw together information from different areas of the specification
- apply their knowledge and understanding in practical and theoretical contexts.

4.1 Aims

Courses based on this specification must encourage students to:

- understand mathematics and mathematical processes in a way that promotes confidence, fosters enjoyment and provides a strong foundation for progress to further study
- extend their range of mathematical skills and techniques
- understand coherence and progression in mathematics and how different areas of mathematics are connected
- apply mathematics in other fields of study and be aware of the relevance of mathematics to the world of work and to situations in society in general
- use their mathematical knowledge to make logical and reasoned decisions in solving problems both within pure mathematics and in a variety of contexts, and communicate the mathematical rationale for these decisions clearly
- reason logically and recognise incorrect reasoning
- generalise mathematically
- construct mathematical proofs
- use their mathematical skills and techniques to solve challenging problems which require them to decide on the solution strategy
- recognise when mathematics can be used to analyse and solve a problem in context
- represent situations mathematically and understand the relationship between problems in context and mathematical models that may be applied to solve them
- draw diagrams and sketch graphs to help explore mathematical situations and interpret solutions
- make deductions and inferences and draw conclusions by using mathematical reasoning
- interpret solutions and communicate their interpretation effectively in the context of the problem
- read and comprehend mathematical arguments, including justifications of methods and formulae, and communicate their understanding

- read and comprehend articles concerning applications of mathematics and communicate their understanding
- use technology such as calculators and computers effectively and recognise when such use may be inappropriate
- take increasing responsibility for their own learning and the evaluation of their own mathematical development.

4.2 Assessment objectives

Assessment objectives (AOs) are set by Ofqual and are the same across all A-level Mathematics specifications and all exam boards.

The exams will measure how students have achieved the following assessment objectives.

- AO1: Use and apply standard techniques. Learners should be able to:
  - select and correctly carry out routine procedures;
  - accurately recall facts, terminology and definitions.
- AO2: Reason, interpret and communicate mathematically. Learners should be able to:
  - construct rigorous mathematical arguments (including proofs);
  - make deductions and inferences;
  - assess the validity of mathematical arguments;
  - explain their reasoning;
  - use mathematical language and notation correctly.

Where questions/tasks targeting this assessment objective will also credit students for the ability to 'use and apply standard techniques' (AO1) and/or to 'solve problems within mathematics and in other contexts' (AO3) an appropriate proportion of the marks for the question/task must be attributed to the corresponding assessment objective(s).

- AO3: Solve problems within mathematics and in other contexts. Learners should be able to:
  - translate problems in mathematical and non-mathematical contexts into mathematical processes;
  - interpret solutions to problems in their original context, and, where appropriate, evaluate their accuracy and limitations;
  - translate situations in context into mathematical models;
  - use mathematical models;
  - evaluate the outcomes of modelling in context, recognise the limitations of models and, where appropriate, explain how to refine them.

Where questions/tasks targeting this assessment objective will also credit students for the ability to 'use and apply standard techniques' (AO1) and/or to 'reason, interpret and communicate mathematically' (AO2) an appropriate proportion of the marks for the question/task must be attributed to the corresponding assessment objective(s).

4.2.1 Assessment objective weightings for A-level Mathematics

Assessment objectives (AOs)	Component weightings (approx %)			Overall weighting (approx %)
	Paper 1	Paper 2	Paper 3	
AO1	50	50	50	50
AO2	25	25	25	25
AO3	25	25	25	25
Overall weighting of components	33⅓	33⅓	33⅓	100

4.3 Assessment weightings

The marks awarded on the papers will be scaled to meet the weighting of the components. Students' final marks will be calculated by adding together the scaled marks for each component. Grade boundaries will be set using this total scaled mark. The scaling and total scaled marks are shown in the table below.

Component	Maximum raw mark	Scaling factor	Maximum scaled mark
Paper 1	100	x1	100
Paper 2	100	x1	100
Paper 3	100	x1	100
		Total scaled mark:	300

5 General administration

You can find information about all aspects of administration, as well as all the forms you need, at aqa.org.uk/examsadmin

5.1 Entries and codes

You only need to make one entry for each qualification – this will cover all the question papers, non-exam assessment and certification.

Every specification is given a national discount (classification) code by the Department for Education (DfE), which indicates its subject area.

If a student takes two specifications with the same discount code, further and higher education providers are likely to take the view that they have only achieved one of the two qualifications. Please check this before your students start their course.

Qualification title	AQA entry code	DfE discount code
AQA Advanced Level GCE in Mathematics	7357	TBC

This specification complies with:

- Ofqual *General conditions of recognition* that apply to all regulated qualifications
- Ofqual GCE qualification level conditions that apply to all GCEs
- Ofqual GCE subject level conditions that apply to all GCEs in this subject
- all other relevant regulatory documents.

The Ofqual qualification accreditation number (QAN) is 603/1164/2.

5.2 Overlaps with other qualifications

There is overlapping content in the AS and A-level Mathematics specifications. This helps you teach the AS and A-level together.

5.3 Awarding grades and reporting results

The A-level qualification will be graded on a six-point scale: A*, A, B, C, D and E.

Students who fail to reach the minimum standard for grade E will be recorded as U (unclassified) and will not receive a qualification certificate.

5.4 Re-sits and shelf life

Students can resit the qualification as many times as they wish, within the shelf life of the qualification. NEA results can be carried forward for any students re-sitting the qualification.

5.5 Previous learning and prerequisites

There are no previous learning requirements. Any requirements for entry to a course based on this specification are at the discretion of schools and colleges.

However, we recommend that students should have the skills and knowledge associated with a GCSE Mathematics or equivalent.

5.6 Access to assessment: diversity and inclusion

General qualifications are designed to prepare students for a wide range of occupations and further study. Therefore our qualifications must assess a wide range of competences.

The subject criteria have been assessed to see if any of the skills or knowledge required present any possible difficulty to any students, whatever their ethnic background, religion, sex, age, disability or sexuality. Tests of specific competences were only included if they were important to the subject.

As members of the Joint Council for Qualifications (JCQ) we participate in the production of the JCQ document *Access Arrangements and Reasonable Adjustments: General and Vocational qualifications*. We follow these guidelines when assessing the needs of individual students who may require an access arrangement or reasonable adjustment. This document is published at jcq.org.uk

Students with disabilities and special needs

We're required by the Equality Act 2010 to make reasonable adjustments to remove or lessen any disadvantage that affects a disabled student.

We can make arrangements for disabled students and students with special needs to help them access the assessments, as long as the competences being tested aren't changed. Access arrangements must be agreed **before** the assessment. For example, a Braille paper would be a reasonable adjustment for a Braille reader.

To arrange access arrangements or reasonable adjustments, you can apply using the online service at aqa.org.uk/eaqa

Special consideration

We can give special consideration to students who have been disadvantaged at the time of the assessment through no fault of their own – for example a temporary illness, injury or serious problem such as family bereavement. We can only do this **after** the assessment.

Your exams officer should apply online for special consideration at aqa.org.uk/eaqa

For more information and advice visit aqa.org.uk/access or email accessarrangementsqueries@aqa.org.uk

5.7 Working with AQA for the first time

If your school or college hasn't previously offered our specifications, you need to register as an AQA centre. Find out how at aqa.org.uk/becomeacentre

5.8 Private candidates

This specification is available to private candidates.

A private candidate is someone who enters for exams through an AQA approved school or college but is not enrolled as a student there.

A private candidate may be self-taught, home schooled or have private tuition, either with a tutor or through a distance learning organisation. They must be based in the UK.

If you have any queries as a private candidate, you can:

- speak to the exams officer at the school or college where you intend to take your exams
- visit our website at aqa.org.uk/privatecandidates
- email privatecandidates@aqa.org.uk

5.9 Use of calculators

A calculator is required for use in all assessments in this specification. Details of the requirements for calculators can be found in the Joint Council for General Qualifications document *Instructions for conducting examinations*.

For A-level Mathematics exams, calculators should have the following as a required minimum:

- an iterative function
- the ability to compute summary statistics and access probabilities from standard statistical distributions
- an inverse normal function.

For the purposes of this specification, a 'calculator' is any electronic or mechanical device which may be used for the performance of mathematical computations. However, only those permissible in the guidance in the *Instructions for conducting examinations* are allowed in the A-level Mathematics exams.

Get help and support

Visit our website for information, guidance, support and resources at aqa.org.uk/7357

You can talk directly to the Mathematics subject team:

E: maths@aqa.org.uk

T: 0161 957 3852

Appendix A:

mathematical notation for AS and A level qualifications in mathematics and further mathematics

The tables below set out the notation that must be used by AS and A level mathematics and further mathematics specifications. Students will be expected to understand this notation without need for further explanation.

Mathematics students will not be expected to understand notation that relates only to further mathematics content. Further mathematics students will be expected to understand all notation in the list.

For further mathematics, the notation for the core content is listed under sub headings indicating 'further mathematics only'. In this subject, awarding organisations are required to include, in their specifications, content that is additional to the core content. They will therefore need to add to the notation list accordingly.

AS students will be expected to understand notation that relates to AS content, and will not be expected to understand notation that relates only to A level content.

1	Set Notation	
1.1	$\in$	is an element of
1.2	$\notin$	is not an element of
1.3	$\subseteq$	is a subset of
1.4	$\subset$	is a proper subset of
1.5	$\{x_1, x_2, \ldots\}$	the set with elements $x_1, x_2, \ldots$
1.6	$\{x: \ldots\}$	the set of all x such that …
1.7	$\mathrm{n}(A)$	the number of elements in set A
1.8	$\varnothing$	the empty set
1.9	$\mathcal{E}$	the universal set
1.10	A'	the complement of the set A
1.11	$\mathbb{N}$	the set of natural numbers, $\{1, 2, 3, \ldots\}$
1.12	$\mathbb{Z}$	the set of integers, $\{0, \pm 1, \pm 2, \pm 3, \ldots\}$
1.13	$\mathbb{Z}^+$	the set of positive integers, $\{1, 2, 3, \ldots\}$

1.14	$\mathbb{Z}_0^+$	the set of non-negative integers, $\{0, 1, 2, 3, \ldots\}$
1.15	$\mathbb{R}$	the set of real numbers
1.16	$\mathbb{Q}$	the set of rational numbers, $\left\{\frac{p}{q} : p \in \mathbb{Z},\ q \in \mathbb{Z}^+\right\}$
1.17	$\cup$	union
1.18	$\cap$	intersection
1.19	(x, y)	the ordered pair x, y
1.20	$[a, b]$	the closed interval $\{x \in \mathbb{R} : a \leq x \leq b\}$
1.21	$[a, b)$	the interval $\{x \in \mathbb{R} : a \leq x < b\}$
1.22	$(a, b]$	the interval $\{x \in \mathbb{R} : a < x \leq b\}$
1.23	(a, b)	the open interval $\{x \in \mathbb{R} : a < x < b\}$
1	**Set Notation (Further Mathematics only)**	
1.24	$\mathbb{C}$	the set of complex numbers
2	**Miscellaneous Symbols**	
2.1	$=$	is equal to
2.2	$\neq$	is not equal to
2.3	$\equiv$	is identical to or is congruent to
2.4	$\approx$	is approximately equal to
2.5	∞	infinity
2.6	$\propto$	is proportional to
2.7	$\therefore$	therefore
2.8	$\because$	because
2.9	$<$	is less than
2.10	$\leqslant, \leq$	is less than or equal to, is not greater than
2.11	$>$	is greater than
2.12	$\geqslant, \geq$	is greater than or equal to, is not less than
2.13	$p \Rightarrow q$	p implies q (if p then q)
2.14	$p \Leftarrow q$	p is implied by q (if q then p)
2.15	$p \Leftrightarrow q$	p implies and is implied by q (p is equivalent to q)
2.16	a	first term for an arithmetic or geometric sequence

2.17	l	last term for an arithmetic sequence
2.18	d	common difference for an arithmetic sequence
2.19	r	common ratio for a geometric sequence
2.20	S_n	sum to n terms of a sequence
2.21	S_∞	sum to infinity of a sequence

3	Operations	
3.1	$a+b$	a plus b
3.2	$a-b$	a minus b
3.3	$a\times b,\ ab,\ a.b$	a multiplied by b
3.4	$a\div b,\ \frac{a}{b}$	a divided by b
3.5	$\sum_{i=1}^{n} a_i$	$a_1+a_2+\ldots+a_n$
3.6	$\prod_{i=1}^{n} a_i$	$a_1\times a_2\times\ldots\times a_n$
3.7	$\sqrt{a}$	the non-negative square root of a
3.8	$\lvert a\rvert$	the modulus of a
3.9	$n!$	n factorial: $n!=n\times(n-1)\times\ldots\times 2\times 1,\ n\in\mathbb{N};\ 0!=1$
3.10	$\binom{n}{r},\ {}^{n}C_r,\ {}_{n}C_r$	the binomial coefficient $\frac{n!}{r!(n-r)!}$ for $n, r\in\mathbb{Z}_0^+, r\leqslant n$ or $\frac{n(n-1)\ldots(n-r+1)}{r!}$ for $n\in\mathbb{Q}, r\in\mathbb{Z}_0^+$
4	Functions	
4.1	$\mathrm{f}(x)$	the value of the function f at x
4.2	$\mathrm{f}: x\mapsto y$	the function f maps the element x to the element y
4.3	f^{-1}	the inverse function of the function f
4.4	gf	the composite function of f and g which is defined by $\mathrm{gf}(x)=\mathrm{g}(\mathrm{f}(x))$
4.5	$\lim_{x\to a}\ \mathrm{f}(x)$	the limit of $\mathrm{f}(x)$ as x tends to a
4.6	$\Delta x,\ \delta x$	an increment of x
4.7	$\frac{\mathrm{d}y}{\mathrm{d}x}$	the derivative of y with respect to x
4.8	$\frac{\mathrm{d}^n y}{\mathrm{d}x^n}$	the nth derivative of y with respect to x
4.9	$\mathrm{f}'(x),\ \mathrm{f}''(x),\ \ldots,\ \mathrm{f}^{(n)}(x)$	the first, second, ..., n^{th} derivatives of $\mathrm{f}(x)$ with respect to x
4.10	$\dot{x},\ \ddot{x},\ \ldots$	the first, second, ... derivatives of x with respect to t
4.11	$\int y\ \mathrm{d}x$	the indefinite integral of y with respect to x
4.12	$\int_a^b y\ \mathrm{d}x$	the definite integral of y with respect to x between the limits $x=a$ and $x=b$
5	Exponential and Logarithmic Functions	

5.1	e	base of natural logarithms
5.2	e^x, $\exp x$	exponential function of x
5.3	$\log_a x$	logarithm to the base a of x
5.4	$\ln x$, $\log_{\mathrm{e}} x$	natural logarithm of x
6	**Trigonometric Functions**	
6.1	$\sin$, $\cos$, $\tan$, cosec, $\sec$, $\cot$	the trigonometric functions
6.2	$\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$ $\arcsin, \arccos, \arctan$	the inverse trigonometric functions
6.3	$^\circ$	degrees
6.4	rad	radians
6	**Trigonometric and Hyperbolic Functions (Further Mathematics only)**	
6.5	cosec^{-1}, $\sec^{-1}$, $\cot^{-1}$ $\mathrm{arccosec}$, arcsec, arccot	the inverse trigonometric functions
6.6	$\sinh$, $\cosh$, $\tanh$, cosech, sech, $\coth$	the hyperbolic functions
6.7	$\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$ cosech^{-1}, sech^{-1}, $\coth^{-1}$ arsinh, arcosh, artanh, $\mathrm{arcosech}$, $\mathrm{arcsech}$, arcoth	the inverse hyperbolic functions
7	**Complex Numbers (Further Mathematics only)**	
7.1	i, j	square root of -1
7.2	$x+\mathrm{i}y$	complex number with real part x and imaginary part y
7.3	$r\,(\cos\theta+\mathrm{i}\sin\theta)$	modulus argument form of a complex number with modulus r and argument θ
7.4	z	a complex number, $z=x+\mathrm{i}y=r(\cos\theta+\mathrm{i}\sin\theta)$
7.5	$\mathrm{Re}(z)$	the real part of z, $\mathrm{Re}(z)=x$
7.6	$\mathrm{Im}(z)$	the imaginary part of z, $\mathrm{Im}(z)=y$
7.7	$\lvert z\rvert$	the modulus of z, $\lvert z\rvert=\sqrt{x^2+y^2}$
7.8	$\arg(z)$	the argument of z, $\arg(z)=\theta$, $-\pi<\theta\leq\pi$
7.9	z^*	the complex conjugate of z, $x-\mathrm{i}y$
8	**Matrices (Further Mathematics only)**	

8.1	$\mathbf{M}$	a matrix $\mathbf{M}$
8.2	$\mathbf{0}$	zero matrix
8.3	$\mathbf{I}$	identity matrix
8.4	$\mathbf{M}^{-1}$	the inverse of the matrix $\mathbf{M}$
8.5	$\mathbf{M}^{\mathrm{T}}$	the transpose of the matrix $\mathbf{M}$
8.6	Δ, det $\mathbf{M}$ or $\lvert\mathbf{M}\rvert$	the determinant of the square matrix $\mathbf{M}$
8.7	$\mathbf{Mr}$	Image of column vector $\mathbf{r}$ under the transformation associated with the matrix $\mathbf{M}$
9	**Vectors**	
9.1	$\mathbf{a}$, $\underline{a}$, $\underset{\sim}{a}$	the vector $\mathbf{a}$, $\underline{a}$, $\underset{\sim}{a}$; these alternatives apply throughout section 9
9.2	$\overrightarrow{\mathrm{AB}}$	the vector represented in magnitude and direction by the directed line segment AB
9.3	$\hat{\mathbf{a}}$	a unit vector in the direction of $\mathbf{a}$
9.4	$\mathbf{i}$, $\mathbf{j}$, $\mathbf{k}$	unit vectors in the directions of the cartesian coordinate axes
9.5	$\lvert\mathbf{a}\rvert$, a	the magnitude of $\mathbf{a}$
9.6	$\lvert\overrightarrow{\mathrm{AB}}\rvert$, AB	the magnitude of $\overrightarrow{\mathrm{AB}}$
9.7	$\begin{pmatrix} a \\ b \end{pmatrix}$, $a\mathbf{i}+b\mathbf{j}$	column vector and corresponding unit vector notation
9.8	$\mathbf{r}$	position vector
9.9	$\mathbf{s}$	displacement vector
9.10	$\mathbf{v}$	velocity vector
9.11	$\mathbf{a}$	acceleration vector

9	Vectors (Further Mathematics only)	
9.12	**a.b**	the scalar product of **a** and **b**
10	**Differential Equations (Further Mathematics only)**	
10.1	ω	angular speed
11	**Probability and Statistics**	
11.1	A, B, C, etc.	events
11.2	$A \cup B$	union of the events A and B
11.3	$A \cap B$	intersection of the events A and B
11.4	$\mathrm{P}(A)$	probability of the event A
11.5	A'	complement of the event A
11.6	$\mathrm{P}(A \mid B)$	probability of the event A conditional on the event B
11.7	X, Y, R, etc.	random variables
11.8	x, y, r, etc.	values of the random variables X, Y, R etc.
11.9	x_1, x_2, …	observations
11.10	f_1, f_2, …	frequencies with which the observations x_1, x_2, … occur
11.11	$\mathrm{p}(x)$, $\mathrm{P}(X = x)$	probability function of the discrete random variable X
11.12	p_1, p_2, …	probabilities of the values x_1, x_2, … of the discrete random variable X
11.13	$\mathrm{E}(X)$	expectation of the random variable X
11.14	$\mathrm{Var}(X)$	variance of the random variable X
11.15	~	has the distribution
11.16	$\mathrm{B}(n, p)$	binomial distribution with parameters n and p, where n is the number of trials and p is the probability of success in a trial
11.17	q	$q = 1 - p$ for binomial distribution
11.18	$\mathrm{N}(\mu, \sigma^2)$	Normal distribution with mean μ and variance σ^2
11.19	$Z \sim \mathrm{N}(0,1)$	standard Normal distribution
11.20	ϕ	probability density function of the standardised Normal variable with distribution $\mathrm{N}(0, 1)$
11.21	Φ	corresponding cumulative distribution function
11.22	μ	population mean
11.23	σ^2	population variance
11.24	σ	population standard deviation
11.25	$\bar{x}$	sample mean

11.26	s^2	sample variance
11.27	s	sample standard deviation
11.28	H_0	Null hypothesis
11.29	H_1	Alternative hypothesis
11.30	r	product moment correlation coefficient for a sample
11.31	ρ	product moment correlation coefficient for a population
12	**Mechanics**	
12.1	kg	kilograms
12.2	m	metres
12.3	km	kilometres
12.4	m/s, m s^{-1}	metres per second (velocity)
12.5	m/s^2, m s^{-2}	metres per second per second (acceleration)
12.6	F	Force or resultant force
12.7	N	Newton
12.8	N m	Newton metre (moment of a force)
12.9	t	time
12.10	s	displacement
12.11	u	initial velocity
12.12	v	velocity or final velocity
12.13	a	acceleration
12.14	g	acceleration due to gravity
12.15	μ	coefficient of friction

Appendix B:

mathematical formulae and identities

Students must be able to use the following formulae and identities for AS and A level mathematics, without these formulae and identities being provided, either in these forms or in equivalent forms. These formulae and identities may only be provided where they are the starting point for a proof or as a result to be proved.

Pure Mathematics

Quadratic Equations

$ax^2 + bx + c = 0$ has roots $\dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Laws of Indices

$a^x a^y \equiv a^{x+y}$

$a^x \div a^y \equiv a^{x-y}$

$(a^x)^y \equiv a^{xy}$

Laws of Logarithms

$x = a^n \Leftrightarrow n = \log_a x$ for $a > 0$ and $x > 0$

$\log_a x + \log_a y \equiv \log_a (xy)$

$\log_a x - \log_a y \equiv \log_a \left(\dfrac{x}{y}\right)$

$k \log_a x \equiv \log_a \left(x^k\right)$

Coordinate Geometry

A straight line graph, gradient *m* passing through (x_1, y_1) has equation

$y - y_1 = m(x - x_1)$

Straight lines with gradients m_1 and m_2 are perpendicular when $m_1 m_2 = -1$

Sequences

General term of an arithmetic progression:

$u_n = a + (n-1)d$

General term of a geometric progression:

$u_n = ar^{n-1}$

Trigonometry

In the triangle ABC

Sine rule: $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$

Cosine rule: $a^2 = b^2 + c^2 - 2bc\cos A$

Area $= \frac{1}{2}ab\sin C$

$\cos^2 A + \sin^2 A \equiv 1$
$\sec^2 A \equiv 1 + \tan^2 A$
$\operatorname{cosec}^2 A \equiv 1 + \cot^2 A$

$\sin 2A \equiv 2\sin A \cos A$
$\cos 2A \equiv \cos^2 A - \sin^2 A$

$\tan 2A \equiv \frac{2\tan A}{1 - \tan^2 A}$

Mensuration

Circumference and Area of circle, radius *r* and diameter *d*:

$C = 2\pi r = \pi d \qquad A = \pi r^2$

Pythagoras' Theorem: In any right-angled triangle where *a*, *b* and *c* are the lengths of the sides and *c* is the hypotenuse:

$c^2 = a^2 + b^2$

Area of a trapezium = $\frac{1}{2}(a+b)h$, where *a* and *b* are the lengths of the parallel sides and *h* is their perpendicular separation.

Volume of a prism = area of cross section × length

For a circle of radius *r*, where an angle at the centre of θ radians subtends an arc of length *s* and encloses an associated sector of area *a*:

$s = r\theta \qquad a = \frac{1}{2}r^2\theta$

Calculus and Differential Equations

Differentiation

Function	Derivative
x^n	nx^{n-1}
$\sin kx$	$k\cos kx$
$\cos kx$	$-k\sin kx$
e^{kx}	$k\mathrm{e}^{kx}$
$\ln x$	$\frac{1}{x}$
$\mathrm{f}(x)+\mathrm{g}(x)$	$\mathrm{f}'(x)+\mathrm{g}'(x)$
$\mathrm{f}(x)\mathrm{g}(x)$	$\mathrm{f}'(x)\mathrm{g}(x)+\mathrm{f}(x)\mathrm{g}'(x)$
$\mathrm{f}(\mathrm{g}(x))$	$\mathrm{f}'(\mathrm{g}(x))\mathrm{g}'(x)$

Integration

Function	Integral
x^n	$\frac{1}{n+1}x^{n+1}+c,\ n\neq -1$
$\cos kx$	$\frac{1}{k}\sin kx+c$
$\sin kx$	$-\frac{1}{k}\cos kx+c$
e^{kx}	$\frac{1}{k}\mathrm{e}^{kx}+c$
$\frac{1}{x}$	$\ln\lvert x\rvert+c,\ x\neq 0$
$\mathrm{f}'(x)+\mathrm{g}'(x)$	$\mathrm{f}(x)+\mathrm{g}(x)+c$
$\mathrm{f}'(\mathrm{g}(x))\mathrm{g}'(x)$	$\mathrm{f}(\mathrm{g}(x))+c$

Area under a curve $=\int_a^b y\,\mathrm{d}x\ (y\geq 0)$

Vectors

$|x\mathbf{i} + y\mathbf{j} + z\mathbf{k}| = \sqrt{(x^2 + y^2 + z^2)}$

Mechanics

Forces and Equilibrium

Weight = mass $\times g$

Friction: $F \leq \mu R$

Newton's second law in the form: $F = ma$

Kinematics

For motion in a straight line with variable acceleration:

$$v = \frac{\mathrm{d}r}{\mathrm{d}t} \qquad a = \frac{\mathrm{d}v}{\mathrm{d}t} = \frac{\mathrm{d}^2 r}{\mathrm{d}t^2}$$

$$r = \int v \,\mathrm{d}t \qquad v = \int a \,\mathrm{d}t$$

Statistics

The mean of a set of data: $\bar{x} = \frac{\sum x}{n} = \frac{\sum fx}{\sum f}$

The standard Normal variable: $Z = \frac{X - \mu}{\sigma}$ where $X \sim \mathrm{N}\left(\mu, \sigma^2\right)$