

AS Mathematics



Specification

Pearson Edexcel Level 3 Advanced Subsidiary GCE in Mathematics (8MA0)

First teaching from September 2017

First certification from 2018

Issue 2

Summary of Pearson Edexcel Level 3 Advanced Subsidiary GCE in Mathematics Specification Issue 2 changes

Summary of changes made between previous issue and this current issue	Page number
The formatting of mathematical equations and notation has been corrected throughout the document.	Throughout the document

Earlier issues show previous changes.

If you need further information on these changes or what they mean, contact us via our website at:
qualifications.pearson.com/en/support/contact-us.html.

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1 Introduction

Why choose Edexcel AS Level Mathematics?

We have listened to feedback from all parts of the mathematics subject community, including higher education. We have used this opportunity of curriculum change to redesign a qualification that reflects the demands of a wide variety of end users as well as retaining many of the features that have contributed to the increasing popularity of GCE Mathematics in recent years.

We will provide:

- **Simple, intuitive specifications** that enable co-teaching and parallel delivery. Increased pressure on teaching time means that it's important you can cover the content of different specifications together. Our specifications are designed to help you co-teach A and AS Level, as well as deliver Maths and Further Maths in parallel.
- **Clear, familiar, accessible exams.** Our new exam papers will deliver everything you'd expect from us as the leading awarding body for maths. They'll take the most straightforward and logical approach to meet the government's requirements. They'll use the same clear design that you've told us makes them so accessible, while also ensuring a range of challenge for all abilities.
- **A wide range of exam practice** to fully prepare students and help you track progress. With the new linear exams, your students will want to feel fully prepared and know how they're progressing. We'll provide lots of exam practice to help you and your students understand and prepare for the assessments, including secure mock papers, practice papers and free topic tests with marking guidance.
- **Complete support and free materials** to help you understand and deliver the specification. Change is easier with the right support, so we'll be on-hand to listen and give advice on how to understand and implement the changes. Whether it's through our Launch, Getting Ready to Teach, and Collaborative Networks events or via the renowned Maths Emporium; we'll be available face to face, online or over the phone throughout the lifetime of the qualification. We'll also provide you with free materials such as schemes of work, topic tests and progression maps.
- **The published resources you know and trust**, fully updated for 2017. Our new A Level Maths and Further Maths textbooks retain all the features you know and love about the current series, while being fully updated to match the new specifications. Each textbook comes packed with additional online content that supports independent learning, and they all tie in with the free qualification support, giving you the most coherent approach to teaching and learning.

Supporting you in planning and implementing this qualification

Planning

- Our **Getting Started** guide gives you an overview of the new AS Level qualification to help you to get to grips with the changes to content and assessment, as well as helping you understand what these changes mean for you and your students.
- We will give you a **course planner** and **scheme of work** that you can adapt to suit your department.
- **Our mapping documents** highlight the content changes between the legacy modular specification and the new linear specification.

Teaching and learning

There will be lots of free teaching and learning support to help you deliver the new qualifications, including:

- topic guides covering new content areas
- teaching support for problem solving, modelling and the large data set
- student guide containing information about the course to inform your students and their parents.

Preparing for exams

We will also provide a range of resources to help you prepare your students for the assessments, including:

- specimen papers written by our senior examiner team
- practice papers made up from past exam questions that meet the new criteria
- secure mock papers
- marked exemplars of student work with examiner commentaries.

ResultsPlus and exam Wizard

ResultsPlus provides the most detailed analysis available of your students' exam performance. It can help you identify the topics and skills where further learning would benefit your students.

Exam Wizard is a data bank of past exam questions (and sample paper and specimen paper questions) allowing you to create bespoke test papers.

Get help and support

Mathematics Emporium - support whenever you need it

The renowned Mathematics Emporium helps you keep up to date with all areas of maths throughout the year, as well as offering a rich source of past questions and, of course, access to our in-house maths experts Graham Cumming and his team.

Sign up to get Emporium emails

Get updates on the latest news, support resources, training and alerts for entry deadlines and key dates direct to your inbox. Just email mathsemporium@pearson.com to sign up.

Emporium website

Over 12 000 documents relating to past and present Edexcel mathematics qualifications available free. Visit www.edexcelmaths.com to register for an account.

Qualification at a glance

Content and assessment overview

The Pearson Edexcel Level 3 Advanced Subsidiary GCE in Mathematics consists of two externally-examined papers.

Students must complete all assessment in May/June in any single year.

Paper 1: Pure Mathematics (*Paper code: 8MA0/01)
<i>Written examination: 2 hours</i> <i>62.5% of the qualification</i> <i>100 marks</i>
Content overview <ul style="list-style-type: none">• Topic 1 – Proof• Topic 2 – Algebra and functions• Topic 3 – Coordinate geometry in the (x, y) plane• Topic 4 – Sequences and series• Topic 5 – Trigonometry• Topic 6 – Exponentials and logarithms• Topic 7 – Differentiation• Topic 8 – Integration• Topic 9 – Vectors
Assessment overview <ul style="list-style-type: none">• Students must answer all questions.• Calculators can be used in the assessment.

Paper 2: Statistics and Mechanics (*Paper code: 8MA0/02)

Written examination: 1 hour 15 minutes

37.5% of the qualification

60 marks

Content overview

Section A: Statistics

- Topic 1 – Statistical sampling
- Topic 2 – Data presentation and interpretation
- Topic 3 – Probability
- Topic 4 – Statistical distributions
- Topic 5 – Statistical hypothesis testing

Section B: Mechanics

- Topic 6 – Quantities and units in mechanics
- Topic 7 – Kinematics
- Topic 8 – Forces and Newton's laws

Assessment overview

- The assessment comprises two sections: Section A – Statistics and Section B – Mechanics.
- Students must answer all questions.
- Calculators can be used in the assessment.

*See *Appendix 8: Codes* for a description of this code and all other codes relevant to this qualification.

2 Subject content and assessment information

Qualification aims and objectives

The aims and objectives of this qualification are to enable 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 that 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 it may be inappropriate to use them
- take increasing responsibility for their own learning and the evaluation of their own mathematical development.

Overarching themes

The overarching themes should be applied along with associated mathematical thinking and understanding, across the whole of the detailed content in this specification.

These overarching themes are inherent throughout the content and students are required to develop skills in working scientifically over the course of this qualification. The skills show teachers which skills need to be included as part of the learning and assessment of the students.

Overarching theme 1: Mathematical argument, language and proof

AS Mathematics students must use the mathematical notation set out in the booklet *Mathematical Formulae and Statistical Tables* and be able to recall the mathematical formulae and identities set out in *Appendix 1*.

	Knowledge/skill
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.
OT1.4	Not applicable to AS Mathematics.
OT1.5	Comprehend and critique mathematical arguments, proofs and justifications of methods and formulae, including those relating to applications of mathematics.

Overarching theme 2: Mathematical problem solving

	Knowledge/skill
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.
OT2.4	Not applicable to AS Mathematics.
OT2.5	Evaluate, including by making reasoned estimates, the accuracy or limitations of solutions.
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.

Overarching theme 3: Mathematical modelling

	Knowledge/skill
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.

Use of data in statistics

Pearson has provided a large data set, which will support the assessment of statistics in Paper 2: Statistics and Mechanics. Students are required to become familiar with the data set in advance of the final assessment.

Assessments will be designed in such a way that questions assume knowledge and understanding of the data set. The expectation is that these questions should be likely to give a material advantage to students who have studied and are familiar with the data set. They might include questions/tasks that:

- assume familiarity with the terminology and contexts of the data, and do not explain them in a way that gives students who have not studied the data set the same opportunities to access marks as students who have studied them
- use summary statistics or selected data from, or statistical diagrams based on, the data set – these might be given in the question/task, or as stimulus materials
- are based on samples related to the contexts in the data set, where students' work with the data set will help them understand the background context, and/or
- require students to interpret data in ways that would be too demanding in an unfamiliar context.

Students will not be required to have copies of the data set in the examination, nor will they be required to have detailed knowledge of the actual data within the data set.

The data set can be downloaded from our website, qualifications.pearson.com. This data set should be appropriate for the lifetime of the qualification. However we will review the data set on an annual basis to ensure it is appropriate. If we need to make changes to the data set, we will notify centres before the beginning of the one-year course before students complete their examination.

Paper 1: Pure Mathematics

Topics	What students need to learn:	
	Content	Guidance
1 Proof	<p>1.1 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:</p> <p>Proof by deduction</p> <p>Proof by exhaustion</p> <p>Disproof by counter example.</p>	<p>Examples of proofs:</p> <p>Proof by deduction, e.g. using completion of the square, prove that $n^2 - 6n + 10$ is positive for all values of n or, for example, differentiation from first principles for small positive integer powers of x. This is the most commonly used method of proof throughout this specification.</p> <p>Proof by exhaustion This involves trying all the options. Suppose x and y are odd integers less than 7. Prove that their sum is divisible by 2.</p> <p>Disproof by counter example – show that the statement “$n^2 - n + 1$ is a prime number for all values of n” is untrue</p>
2 Algebra and functions	2.1 Understand and use the laws of indices for all rational exponents.	$a^m \times a^n = a^{m+n}$, $a^m \div a^n = a^{m-n}$, $(a^m)^n = a^{mn}$ The equivalence of $a^{\frac{m}{n}}$ and $\sqrt[n]{a^m}$ should be known.
	2.2 Use and manipulate surds, including rationalising the denominator.	Students should be able to simplify algebraic surds using the results $(\sqrt{x})^2 = x$, $\sqrt{xy} = \sqrt{x}\sqrt{y}$ and $(\sqrt{x} + \sqrt{y})(\sqrt{x} - \sqrt{y}) = x - y$

Topics	What students need to learn:		
	Content	Guidance	
2 Algebra and functions <i>continued</i>	2.3	<p>Work with quadratic functions and their graphs.</p> <p>The discriminant of a quadratic function, including the conditions for real and repeated roots.</p> <p>Completing the square.</p> <p>Solution of quadratic equations,</p> <p>including solving quadratic equations in a function of the unknown.</p>	<p>The notation $f(x)$ may be used</p> <p>Need to know and to use</p> $b^2 - 4ac > 0, \quad b^2 - 4ac = 0 \text{ and } b^2 - 4ac < 0$ $ax^2 + bx + c = a \left(x + \frac{b}{2a} \right)^2 + \left(c - \frac{b^2}{4a} \right)$ <p>Solution of quadratic equations by factorisation, use of the formula, use of a calculator and completing the square.</p> <p>These functions could include powers of x, trigonometric functions of x, exponential and logarithmic functions of x.</p>
	2.4	<p>Solve simultaneous equations in two variables by elimination and by substitution, including one linear and one quadratic equation.</p>	<p>The quadratic may involve powers of 2 in one unknown or in both unknowns,</p> <p>e.g. solve $y = 2x + 3, y = x^2 - 4x + 8$</p> <p>or</p> $2x - 3y = 6, x^2 - y^2 + 3x = 50$
	2.5	<p>Solve linear and quadratic inequalities in a single variable and interpret such inequalities graphically,</p> <p>including inequalities with brackets and fractions.</p> <p>Express solutions through correct use of 'and' and 'or', or through set notation.</p> <p>Represent linear and quadratic inequalities such as $y > x + 1$ and $y > ax^2 + bx + c$ graphically.</p>	<p>For example, solving</p> $ax + b > cx + d,$ $px^2 + qx + r \geq 0,$ $px^2 + qx + r < ax + b$ <p>and interpreting the third inequality as the range of x for which the curve $y = px^2 + qx + r$ is below the line with equation $y = ax + b$</p> <p>These would be reducible to linear or quadratic inequalities,</p> <p>e.g. $\frac{a}{x} < b$ becomes $ax < bx^2$</p> <p>So, e.g. $x < a$ or $x > b$ is equivalent to $\{x : x < a\} \cup \{x : x > b\}$ and $\{x : c < x\} \cap \{x : x < d\}$ is equivalent to $x > c$ and $x < d$</p> <p>Shading and use of dotted and solid line convention is required.</p>

Topics	What students need to learn:		
	Content	Guidance	
2 Algebra and functions <i>continued</i>	2.6	<p>Manipulate polynomials algebraically, including expanding brackets and collecting like terms, factorisation and simple algebraic division; use of the factor theorem.</p>	<p>Only division by $(ax + b)$ or $(ax - b)$ will be required. Students should know that if $f(x) = 0$ when $x = a$, then $(x - a)$ is a factor of $f(x)$.</p> <p>Students may be required to factorise cubic expressions such as $x^3 + 3x^2 - 4$ and $6x^3 + 11x^2 - x - 6$.</p>
	2.7	<p>Understand and use graphs of functions; sketch curves defined by simple equations including polynomials</p> $y = \frac{a}{x} \quad \text{and} \quad y = \frac{a}{x^2}$ <p>(including their vertical and horizontal asymptotes)</p> <p>Interpret algebraic solution of equations graphically; use intersection points of graphs to solve equations.</p> <p>Understand and use proportional relationships and their graphs.</p>	<p>Graph to include simple cubic and quartic functions,</p> <p>e.g. sketch the graph with equation $y = x^2(2x - 1)^2$</p> <p>The asymptotes will be parallel to the axes e.g. the asymptotes of the curve with equation $y = \frac{2}{x + a} + b$ are the lines with equations $y = b$ and $x = -a$</p> <p>Direct proportion between two variables.</p> <p>Express relationship between two variables using proportion “\propto” symbol or using equation involving constant</p> <p>e.g. the circumference of a semicircle is directly proportional to its diameter so $C \propto d$ or $C = kd$ and the graph of C against d is a straight line through the origin with gradient k.</p>
	2.8	<p>Understand the effect of simple transformations on the graph of $y = f(x)$, including sketching associated graphs:</p> $y = af(x), \quad y = f(x) + a,$ $y = f(x + a), \quad y = f(ax)$	<p>Students should be able to apply one of these transformations to any of the functions listed: quadratics, cubics, quartics, reciprocal, $\frac{a}{x^2}$, $\sin x$, $\cos x$, $\tan x$, e^x and a^x) and sketch the resulting graph.</p> <p>Given the graph of any function $y = f(x)$, students should be able to sketch the graph resulting from one of these transformations.</p>

Topics	What students need to learn:	
	Content	Guidance
3 Coordinate geometry in the (x,y) plane	3.1 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.	To include the equation of a line through two given points, and the equation of a line parallel (or perpendicular) to a given line through a given point. $m' = m$ for parallel lines and $m' = -\frac{1}{m}$ for perpendicular lines For example, the line for converting degrees Celsius to degrees Fahrenheit, distance against time for constant speed, etc.
	3.2 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: <ul style="list-style-type: none"> • 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. 	Students should be able to find the radius and the coordinates of the centre of the circle given the equation of the circle, and vice versa. Students should also be familiar with the equation $x^2 + y^2 + 2fx + 2gy + c = 0$ Students should be able to find the equation of a circumcircle of a triangle with given vertices using these properties. Students should be able to find the equation of a tangent at a specified point, using the perpendicular property of tangent and radius.
4 Sequences and series	4.1 Understand and use the binomial expansion of $(a + bx)^n$ for positive integer n ; the notations $n!$ and ${}^n C_r$ link to binomial probabilities.	Use of Pascal's triangle. Relation between binomial coefficients. Considered further in Paper 2 Section 4.1.

Topics	What students need to learn:		
	Content	Guidance	
5 Trigonometry	5.1	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 $\frac{1}{2}ab \sin C$	Use of x and y coordinates of points on the unit circle to give cosine and sine respectively, including the ambiguous case of the sine rule.
	5.2	Understand and use the sine, cosine and tangent functions; their graphs, symmetries and periodicity.	Knowledge of graphs of curves with equations such as $y = \sin x$, $y = \cos(x + 30^\circ)$, $y = \tan 2x$ is expected.
	5.3	Understand and use $\tan \theta = \frac{\sin \theta}{\cos \theta}$ Understand and use $\sin^2 \theta + \cos^2 \theta = 1$	These identities may be used to solve trigonometric equations or to prove further identities.
	5.4	Solve simple trigonometric equations in a given interval, including quadratic equations in \sin , \cos and \tan and equations involving multiples of the unknown angle.	Students should be able to solve equations such as $\sin(x + 70^\circ) = 0.5$ for $0 < x < 360^\circ$, $3 + 5 \cos 2x = 1$ for $-180^\circ < x < 180^\circ$ $6 \cos^2 x^\circ + \sin x^\circ - 5 = 0$, $0 \leq x < 360^\circ$ giving their answers in degrees.
6 Exponentials and logarithms	6.1	Know and use the function a^x and its graph, where a is positive. Know and use the function e^x and its graph	Understand the difference in shape between $a < 1$ and $a > 1$
	6.2	Know that the gradient of e^{kx} is equal to ke^{kx} and hence understand why the exponential model is suitable in many applications.	Realise that when the rate of change is proportional to the y value, an exponential model should be used.

Topics	What students need to learn:	
	Content	Guidance
6 Exponentials and logarithms <i>continued</i>	6.3 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	$a \neq 1$ Solution of equations of the form $e^{ax+b} = p$ and $\ln(ax+b) = q$ is expected.
	6.4 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 $k = -\frac{1}{2}$)	Includes $\log_a a = 1$
	6.5 Solve equations of the form $a^x = b$	Students may use the change of base formula. Questions may be of the form, for example, $2^{3x-1} = 3$
	6.6 Use logarithmic graphs to estimate parameters in relationships of the form $y = ax^n$ and $y = kb^x$, given data for x and y	Plot $\log y$ against $\log x$ and obtain a straight line where the intercept is $\log a$ and the gradient is n Plot $\log y$ against x and obtain a straight line where the intercept is $\log k$ and the gradient is $\log b$
	6.7 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.	Students may be asked to find the constants used in a model. They need to be familiar with terms such as initial, meaning when $t = 0$. They may need to explore the behaviour for large values of t or to consider whether the range of values predicted is appropriate. Consideration of a second improved model may be required.

Topics	What students need to learn:		
	Content	Guidance	
7 Differentiation	7.1	<p>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</p> <p>sketching the gradient function for a given curve</p> <p>second derivatives</p> <p>differentiation from first principles for small positive integer powers of x</p> <p>Understand and use the second derivative as the rate of change of gradient.</p>	<p>Know that $\frac{dy}{dx}$ is the rate of change of y with respect to x.</p> <p>Knowledge of the chain rule is not required.</p> <p>The notation $f'(x)$ may be used for the first derivative and $f''(x)$ may be used for the second derivative.</p> <p>Given for example the graph of $y = f(x)$, sketch the graph of $y = f'(x)$ using given axes and scale. This could relate speed and acceleration for example.</p> <p>For example, students should be able to use, for $n = 2$ and $n = 3$, the gradient expression</p> $\lim_{h \rightarrow 0} \left(\frac{(x+h)^n - x^n}{h} \right)$ <p>Students may use δx or h</p> <p>Use the condition $f''(x) > 0$ implies a minimum and $f''(x) < 0$ implies a maximum for points where $f'(x) = 0$</p>
	7.2	<p>Differentiate x^n, for rational values of n, and related constant multiples, sums and differences.</p>	<p>For example, the ability to differentiate expressions such as</p> $(2x + 5)(x - 1) \text{ and } \frac{x^2 + 3x - 5}{4x^{\frac{1}{2}}}, x > 0,$ <p>is expected.</p>
	7.3	<p>Apply differentiation to find gradients, tangents and normals,</p> <p>maxima and minima and stationary points.</p> <p>Identify where functions are increasing or decreasing.</p>	<p>Use of differentiation to find equations of tangents and normals at specific points on a curve.</p> <p>To include applications to curve sketching. Maxima and minima problems may be set in the context of a practical problem.</p> <p>To include applications to curve sketching.</p>

Topics	What students need to learn:		
	Content	Guidance	
8 Integration	8.1	Know and use the Fundamental Theorem of Calculus.	Integration as the reverse process of differentiation. Students should know that for indefinite integrals a constant of integration is required.
	8.2	Integrate x^n (excluding $n = -1$) and related sums, differences and constant multiples.	For example, the ability to integrate expressions such as $\frac{1}{2}x^2 - 3x^{\frac{1}{2}}$ and $\frac{(x+2)^2}{x^2}$ is expected. Given $f'(x)$ and a point on the curve, Students should be able to find an equation of the curve in the form $y = f(x)$.
	8.3	Evaluate definite integrals; use a definite integral to find the area under a curve.	Students will be expected to understand the implication of a negative answer.
9 Vectors	9.1	Use vectors in two dimensions.	Students should be familiar with column vectors and with the use of i , and j unit vectors.
	9.2	Calculate the magnitude and direction of a vector and convert between component form and magnitude/direction form.	Students should be able to find a unit vector in the direction of a , and be familiar with the notation $ \mathbf{a} $
	9.3	Add vectors diagrammatically and perform the algebraic operations of vector addition and multiplication by scalars, and understand their geometrical interpretations.	The triangle and parallelogram laws of addition. Parallel vectors.
	9.4	Understand and use position vectors; calculate the distance between two points represented by position vectors.	$\vec{OB} - \vec{OA} = \vec{AB} = \mathbf{b} - \mathbf{a}$ The distance d between two points (x_1, y_1) and (x_2, y_2) is given by $d^2 = (x_1 - x_2)^2 + (y_1 - y_2)^2$

Topics	What students need to learn:	
	Content	Guidance
9 Vectors <i>continued</i>	9.5 Use vectors to solve problems in pure mathematics and in context, (including forces).	For example, finding position vector of the fourth corner of a shape (e.g. parallelogram) $ABCD$ with three given position vectors for the corners A , B and C finding position vector of a point C on a line through A and B dividing AB in a given ratio, where position vectors of A and B are given. Contexts such as velocity, displacement, kinematics and forces will be covered in Paper 3, Sections 6.1, 7.3 and 8.1–8.4

Assessment information

- First assessment: May/June 2018.
- The assessment is 2 hours.
- The assessment is out of 100 marks.
- Students must answer all questions.
- Calculators can be used in the assessment.
- The booklet '*Mathematical Formulae and Statistical Tables*' will be provided for use in the assessment.

Synoptic assessment

Synoptic assessment requires students to work across different parts of a qualification and to show their accumulated knowledge and understanding of a topic or subject area.

Synoptic assessment enables students to show their ability to combine their skills, knowledge and understanding with breadth and depth of the subject.

This paper assesses synopticity.

Sample assessment materials

A sample paper and mark scheme for this paper can be found in the *Pearson Edexcel Level 3 Advanced Subsidiary GCE in Mathematics Sample Assessment Materials (SAMs)* document.

Paper 2: Statistics and Mechanics

All the content of the specification for Paper 1 is assumed knowledge for Paper 2 and may be tested within parts of questions.

Topics	What students need to learn:	
	Content	Guidance
1 Statistical sampling	1.1 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.	Students will be expected to comment on the advantages and disadvantages associated with a census and a sample. Students will be expected to be familiar with: simple random sampling, stratified sampling, systematic sampling, quota sampling and opportunity (or convenience) sampling.
2 Data presentation and interpretation	2.1 Interpret diagrams for single-variable data, including understanding that area in a histogram represents frequency. Connect to probability distributions.	Students should be familiar with histograms, frequency polygons, box and whisker plots (including outliers) and cumulative frequency diagrams.

Topics	What students need to learn:	
	Content	Guidance
2 Data presentation and interpretation <i>continued</i>	2.2 Interpret scatter diagrams and regression lines for bivariate data, including recognition of scatter diagrams that include distinct sections of the population (calculations involving regression lines are excluded). Understand informal interpretation of correlation. Understand that correlation does not imply causation.	Students should be familiar with the terms 'explanatory (independent)' and 'response (dependent)' variables. Use of interpolation and the dangers of extrapolation. Variables other than x and y may be used. Use of terms such as 'positive', 'negative', 'zero', 'strong' and 'weak' are expected. No calculations or appreciation of values of correlation are required.
	2.3 Interpret measures of central tendency and variation, extending to standard deviation. Be able to calculate standard deviation, including from summary statistics.	Data may be discrete, continuous, grouped or ungrouped. Understanding and use of coding. Measures of central tendency: mean, median, mode. Measures of variation: variance, standard deviation, range and interpercentile ranges. Use of linear interpolation to calculate percentiles from grouped data is expected. Students should be able to use the statistic $S_{xx} = \sum (x - \bar{x})^2 = \sum x^2 - \frac{(\sum x)^2}{n}$ Use of standard deviation = $\sqrt{\frac{S_{xx}}{n}}$ (or equivalent) is expected but the use of $S = \sqrt{\frac{S_{xx}}{n-1}}$ (as used on spreadsheets) will be accepted.

Topics	What students need to learn:		
	Content		Guidance
2 Data presentation and interpretation <i>continued</i>	2.4	<p>Recognise and interpret possible outliers in data sets and statistical diagrams.</p> <p>Select or critique data presentation techniques in the context of a statistical problem.</p> <p>Be able to clean data, including dealing with missing data, errors and outliers.</p>	<p>Any rule needed to identify outliers will be specified in the question. For example, use of $Q_1 - 1.5 \times \text{IQR}$ and $Q_3 + 1.5 \times \text{IQR}$ or $\text{mean} \pm 3 \times \text{standard deviation}$</p> <p>Students will be expected to draw simple inferences and give interpretations to measures of central tendency and variation. Significance tests, other than that mentioned in section 5.2, will not be expected.</p> <p>For example, students may be asked to identify possible outliers on a box plot or scatter diagram.</p>
3 Probability	3.1	<p>Understand and use mutually exclusive and independent events when calculating probabilities.</p> <p>Link to discrete and continuous distributions.</p>	<p>Venn diagrams or tree diagrams may be used but use of set notation to describe events is not required.</p> <p>A formal understand of conditional probability is not expected.</p> <p>No formal knowledge of probability density functions is required but students should understand that area under the curve represents probability in the case of a continuous distribution.</p>
4 Statistical distributions	4.1	<p>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.</p>	<p>Students will be expected to use distributions to model a real-world situation and to comment critically on the appropriateness.</p> <p>Students should know and be able to identify the discrete uniform distribution.</p> <p>The notation $X \sim B(n, p)$ may be used.</p> <p>Use of a calculator to find individual or cumulative binomial probabilities.</p>
5 Statistical hypothesis testing	5.1	<p>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.</p>	<p>An informal appreciation that the expected value of a binomial distribution is given by np may be required for a 2-tail test.</p>

Topics	What students need to learn:		
	Content		Guidance
5 Statistical hypothesis testing <i>continued</i>	5.2	<p>Conduct a statistical hypothesis test for the proportion in the binomial distribution and interpret the results in context.</p> <p>Understand that a sample is being used to make an inference about the population</p> <p>and</p> <p>appreciate that the significance level is the probability of incorrectly rejecting the null hypothesis.</p>	<p>Hypotheses should be expressed in terms of the population parameter p</p> <p>A formal understanding of Type I errors is not expected.</p>
6 Quantities and units in mechanics	6.1	<p>Understand and use fundamental quantities and units in the S.I. system: length, time, mass.</p> <p>Understand and use derived quantities and units: velocity, acceleration, force, weight.</p>	
7 Kinematics	7.1	Understand and use the language of kinematics: position; displacement; distance travelled; velocity; speed; acceleration.	
	7.2	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.	<p>Derivation may use knowledge of Sections 7.2 and/or 7.4</p> <p>Understand and use <i>suvat</i> formulae for constant acceleration in 2D.</p>

Topics	What students need to learn:		
	Content		Guidance
7 Kinematics <i>continued</i>	7.3	Understand, use and derive the formulae for constant acceleration for motion in a straight line.	Derivation may use knowledge of sections 7.2 and/or 7.4 Understand and use <i>suvat</i> formulae for constant acceleration in 2D.
	7.4	Use calculus in kinematics for motion in a straight line: $v = \frac{dr}{dt}, \quad a = \frac{dv}{dt} = \frac{d^2r}{dt^2}$ $r = \int v \, dt, \quad v = \int a \, dt$	The level of calculus required will be consistent with that in Sections 7 and 8 in Paper 1.
8 Forces and Newton's laws	8.1	Understand the concept of a force; understand and use Newton's first law.	Normal reaction, tension, thrust or compression, resistance.
	8.2	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 2-D vectors).	Problems will involve motion in a straight line with constant acceleration in scalar form, where the forces act either parallel or perpendicular to the motion. Resolving forces is not required. Problems will involve motion in a straight line with constant acceleration in vector form, where the forces are given in $\mathbf{i} - \mathbf{j}$ form or as column vectors.
	8.3	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 default value of g will be 9.8 m s^{-2} but some questions may specify another value, e.g. $g = 10 \text{ m s}^{-2}$ 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.
	8.4	Understand and use Newton's third law; equilibrium of forces on a particle and motion in a straight line; application to problems involving smooth pulleys and connected particles.	Equilibrium problems will not require forces to be resolved (restricted to forces in two perpendicular directions or simple cases of forces given as 2-D vectors). For pulley problems, the strings will either be horizontal or vertical. Connected particle problems could include problems with particles in contact, e.g. lift problems.

Assessment information

- First assessment: May/June 2018.
- The assessment is 1 hour 15 minutes.
- The assessment is out of 60 marks.
- Students must answer all questions.
- Calculators can be used in the assessment.
- The booklet *Mathematical Formulae and Statistical Tables* will be provided for use in the assessment.

Synoptic assessment

Synoptic assessment requires students to work across different parts of a qualification and to show their accumulated knowledge and understanding of a topic or subject area.

Synoptic assessment enables students to show their ability to combine their skills, knowledge and understanding with breadth and depth of the subject.

This paper assesses synopticity.

Sample assessment materials

A sample paper and mark scheme for this paper can be found in *the Pearson Edexcel Level 3 Advanced Subsidiary GCE in Mathematics Sample Assessment Materials (SAMs)* document.

Assessment Objectives

Students must:		% in GCE AS Level
AO1	<p>Use and apply standard techniques</p> <p>Students should be able to:</p> <ul style="list-style-type: none"> • select and correctly carry out routine procedures; and • accurately recall facts, terminology and definitions 	58–62
AO2	<p>Reason, interpret and communicate mathematically</p> <p>Students should be able to:</p> <ul style="list-style-type: none"> • construct rigorous mathematical arguments (including proofs) • make deductions and inferences • assess the validity of mathematical arguments • explain their reasoning; and • use mathematical language and notation correctly. <p>Where questions/tasks targeting this Assessment Objective will also credit candidates 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).</p>	18–22
AO3	<p>Solve problems within mathematics and in other contexts</p> <p>Students should be able to:</p> <ul style="list-style-type: none"> • 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; and • evaluate the outcomes of modelling in context, recognise the limitations of models and, where appropriate, explain how to refine them. <p>Where questions/tasks targeting this Assessment Objective will also credit candidates 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).</p>	18–22
Total		100%

Further guidance on the interpretation of these assessment objectives is given in *Appendix 4*.

Breakdown of Assessment Objectives

Paper	Assessment Objectives			Total for all Assessment Objectives
	AO1 %	AO2 %	AO3 %	
Paper 1: Pure Mathematics	37.50–40.00	11.25–13.75	10.00–12.50	62.5%
Paper 2: Statistics and Mechanics	18.13–20.63	7.50–10.00	8.13–10.63	37.5%
Total for GCE AS Level	58–62	18–22	18–22	100%

NB Totals have been rounded either up or down.

3 Administration and general information

Entries

Details of how to enter students for the examinations for this qualification can be found in our *UK Information Manual*. A copy is made available to all examinations officers and is available on our website: qualifications.pearson.com

Discount code and performance tables

Centres should be aware that students who enter for more than one GCE qualification with the same discount code will have only one of the grades they achieve counted for the purpose of the school and college performance tables. This will be the grade for the larger qualification (i.e. the A Level grade rather than the AS grade). If the qualifications are the same size, then the better grade will be counted (please see *Appendix 8: Codes*).

Please note that there are two codes for AS GCE qualifications; one for Key Stage 4 (KS4) performance tables and one for 16–19 performance tables. If a KS4 student achieves both a GCSE and an AS with the same discount code, the AS result will be counted over the GCSE result.

Students should be advised that if they take two GCE qualifications with the same discount code, the colleges, universities and employers to which they wish to progress are likely to take the view that this achievement is equivalent to only one GCE. The same view may be taken if students take two GCE qualifications that have different discount codes but which have significant overlap of content. Before embarking on their programmes, students or their advisers who have any doubts about their subject combinations should check with the institution to which they wish to progress.

Access arrangements, reasonable adjustments, special consideration and malpractice

Equality and fairness are central to our work. Our equality policy requires all students to have equal opportunity to access our qualifications and assessments, and our qualifications to be awarded in a way that is fair to every student.

We are committed to making sure that:

- students with a protected characteristic (as defined by the Equality Act 2010) are not, when they are undertaking one of our qualifications, disadvantaged in comparison to students who do not share that characteristic
- all students achieve the recognition they deserve for undertaking a qualification and that this achievement can be compared fairly to the achievement of their peers.

Language of assessment

Assessment of this qualification will be available in English. All student work must be in English.

Access arrangements

Access arrangements are agreed before an assessment. They allow students with special educational needs, disabilities or temporary injuries to:

- access the assessment
- show what they know and can do without changing the demands of the assessment.

The intention behind an access arrangement is to meet the particular needs of an individual student with a disability, without affecting the integrity of the assessment. Access arrangements are the principal way in which awarding bodies comply with the duty under the Equality Act 2010 to make 'reasonable adjustments'.

Access arrangements should always be processed at the start of the course. Students will then know what is available and have the access arrangement(s) in place for assessment.

Reasonable adjustments

The Equality Act 2010 requires an awarding organisation to make reasonable adjustments where a person with a disability would be at a substantial disadvantage in undertaking an assessment. The awarding organisation is required to take reasonable steps to overcome that disadvantage.

A reasonable adjustment for a particular person may be unique to that individual and therefore might not be in the list of available access arrangements.

Whether an adjustment will be considered reasonable will depend on a number of factors, including:

- the needs of the student with the disability
- the effectiveness of the adjustment
- the cost of the adjustment; and
- the likely impact of the adjustment on the student with the disability and other students.

An adjustment will not be approved if it involves unreasonable costs to the awarding organisation, or affects timeframes or the security or integrity of the assessment. This is because the adjustment is not 'reasonable'.

Special consideration

Special consideration is a post-examination adjustment to a student's mark or grade to reflect temporary injury, illness or other indisposition at the time of the examination/assessment, which has had, or is reasonably likely to have had, a material effect on a candidate's ability to take an assessment or demonstrate their level of attainment in an assessment.

Further information

Please see our website for further information about how to apply for access arrangements and special consideration.

For further information about access arrangements, reasonable adjustments and special consideration, please refer to the JCQ website: www.jcq.org.uk.

Malpractice

Candidate malpractice

Candidate malpractice refers to any act by a candidate that compromises or seeks to compromise the process of assessment or which undermines the integrity of the qualifications or the validity of results/certificates.

Candidate malpractice in examinations **must** be reported to Pearson using a *JCQ Form M1* (available at www.jcq.org.uk/exams-office/malpractice). The form can be emailed to pqsmalpractice@pearson.com or posted to Investigations Team, Pearson, 190 High Holborn, London, WC1V 7BH. Please provide as much information and supporting documentation as possible. Note that the final decision regarding appropriate sanctions lies with Pearson.

Failure to report malpractice constitutes staff or centre malpractice.

Staff/centre malpractice

Staff and centre malpractice includes both deliberate malpractice and maladministration of our qualifications. As with candidate malpractice, staff and centre malpractice is any act that compromises or seeks to compromise the process of assessment or which undermines the integrity of the qualifications or the validity of results/certificates.

All cases of suspected staff malpractice and maladministration **must** be reported immediately, before any investigation is undertaken by the centre, to Pearson on a *JCQ Form M2(a)* (available at www.jcq.org.uk/exams-office/malpractice). The form, supporting documentation and as much information as possible can be emailed to pqsmalpractice@pearson.com or posted to Investigations Team, Pearson, 190 High Holborn, London, WC1V 7BH. Note that the final decision regarding appropriate sanctions lies with Pearson.

Failure to report malpractice itself constitutes malpractice.

More detailed guidance on malpractice can be found in the latest version of the document *General and Vocational Qualifications Suspected Malpractice in Examinations and Assessments Policies and Procedures*, available at www.jcq.org.uk/exams-office/malpractice.

Awarding and reporting

This qualification will be graded, awarded and certificated to comply with the requirements of Ofqual's General Conditions of Recognition.

This AS Level qualification will be graded and certificated on a five-grade scale from A to E using the total combined marks (out of 160) for the two compulsory papers. Individual papers are not graded.

Students whose level of achievement is below the minimum judged by Pearson to be of sufficient standard to be recorded on a certificate will receive an unclassified U result.

The first certification opportunity for this qualification will be 2018.

Student recruitment and progression

Pearson follows the JCQ policy concerning recruitment to our qualifications in that:

- they must be available to anyone who is capable of reaching the required standard
- they must be free from barriers that restrict access and progression
- equal opportunities exist for all students.

Prior learning and other requirements

There are no prior learning or other requirements for this qualification.

Students who would benefit most from studying this qualification are likely to have a Level 2 qualification such as a GCSE in Mathematics.

Progression

Students can progress from this qualification to:

- a range of different, relevant academics or vocational higher education qualifications
- employment in a relevant sector
- further training.

Appendices

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Appendix 1: Formulae

Formulae that students are expected to know for AS Level Mathematics are given below and will not appear in the booklet 'Mathematical Formulae and Statistical Tables' which will be provided for use with the paper.

Pure Mathematics

Quadratic Equations

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

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

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

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

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

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

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 $m_1 m_2 = -1$

Trigonometry

In the triangle ABC

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

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

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

$$\cos^2 A + \sin^2 A \equiv 1$$

Mensuration

Circumference and area of circle, radius r and diameter d :

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

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 \times length

Calculus and Differential Equations

Differentiation

Function	Derivative
----------	------------

x^n	nx^{n-1}
-------	------------

e^{kx}	ke^{kx}
----------	-----------

$f(x) + g(x)$	$f'(x) + g'(x)$
---------------	-----------------

Integration

Function	Integral
----------	----------

x^n	$\frac{1}{n+1}x^{n+1} + c, n \neq -1$
-------	---------------------------------------

$f'(x) + g'(x)$	$f(x) + g(x) + c$
-----------------	-------------------

Area under a curve = $\int_a^b y \, dx$ ($y \geq 0$)

Vectors

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

Statistics

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

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:

$$v = \frac{dr}{dt} \quad a = \frac{dv}{dt} = \frac{d^2r}{dt^2}$$

$$r = \int v \, dt \quad v = \int a \, dt$$

Appendix 2: Notation

The tables below set out the notation that must be used in AS Level Mathematics examinations. Students will be expected to understand this notation without need for further explanation.

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	$\{x_1, x_2, \dots\}$	the set with elements x_1, x_2, \dots
1.6	$\{x : \dots\}$	the set of all x such that ...
1.7	$n(A)$	the number of elements in set A
1.8	\emptyset	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, $\{1, 2, 3, \dots\}$
1.12	\mathbb{Z}	the set of integers, $\{0, \pm 1, \pm 2, \pm 3, \dots\}$
1.13	\mathbb{Z}^+	the set of positive integers, $\{1, 2, 3, \dots\}$
1.14	\mathbb{Z}_0^+	the set of non-negative integers, $\{0, 1, 2, 3, \dots\}$
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 $\{x \in \mathbb{R} : a < x < b\}$

2	Miscellaneous symbols	
2.1	=	is equal to
2.2	≠	is not equal to
2.3	≡	is identical to or is congruent to
2.4	≈	is approximately equal to
2.5	∞	infinity
2.6	∝	is proportional to
2.7	∴	therefore
2.8	∵	because
2.9	<	is less than
2.10	≤, ≤	is less than or equal to, is not greater than
2.11	>	is greater than
2.12	≥, ≥	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	$a \times b, ab, a \cdot b$	a multiplied by b
3.4	$a \div b, \frac{a}{b}$	a divided by b
3.5	$\sum_{i=1}^n a_i$	$a_1 + a_2 + \dots + a_n$
3.6	$\prod_{i=1}^n a_i$	$a_1 \times a_2 \times \dots \times a_n$
3.7	\sqrt{a}	the non-negative square root of a
3.8	$ a $	the modulus of a
3.9	$n!$	n factorial: $n! = n \times (n-1) \times \dots \times 2 \times 1, n \in \mathbb{N}; 0! = 1$
3.10	$\binom{n}{r}, {}^n C_r, {}_n C_r$	the binomial coefficient $\frac{n!}{r!(n-r)!}$ for $n, r \in \mathbb{Z}_0^+, r \leq n$ or $\frac{n(n-1)\dots(n-r+1)}{r!}$ for $n \in \mathbb{Q}, r \in \mathbb{Z}_0^+$

4	Functions	
4.1	$f(x)$	the value of the function f at x
4.2	$f : x \mapsto y$	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 $gf(x) = g(f(x))$
4.5	$\lim_{x \rightarrow a} f(x)$	the limit of $f(x)$ as x tends to a
4.6	$\Delta x, \delta x$	an increment of x
4.7	$\frac{dy}{dx}$	the derivative of y with respect to x
4.8	$\frac{d^n y}{dx^n}$	the n th derivative of y with respect to x
4.9	$f'(x), f''(x), \dots, f^{(n)}(x)$	the first, second, ..., n th derivatives of $f(x)$ with respect to x

4	Functions (continued)	
4.10	\dot{x}, \ddot{x}, \dots	the first, second, ... derivatives of x with respect to t
4.11	$\int y \, dx$	the indefinite integral of y with respect to x
4.12	$\int_a^b y \, dx$	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	$\ln x, \log_e x$	natural logarithm of x

6	Trigonometric Functions	
6.1	$\sin, \cos, \tan,$ $\operatorname{cosec}, \sec, \cot$	the trigonometric functions
6.2	$\sin^{-1}, \cos^{-1}, \tan^{-1}$ $\operatorname{arcsin}, \operatorname{arccos}, \operatorname{arctan}$ }	the inverse trigonometric functions
6.3	$^\circ$	Degrees
6.4	rad	radians

7	Vectors	
7.1	$\mathbf{a}, \underline{a}, \hat{a}$	the vector $\mathbf{a}, \underline{a}, \hat{a}$; these alternatives apply throughout section 9
7.2	\overline{AB}	the vector represented in magnitude and direction by the directed line segment \mathbf{AB}
7.3	$\hat{\mathbf{a}}$	a unit vector in the direction of \mathbf{a}
7.4	$\mathbf{i}, \mathbf{j}, \mathbf{k}$	unit vectors in the directions of the cartesian coordinate axes
7.5	$ \mathbf{a} , a$	the magnitude of \mathbf{a}
7.6	$ \overline{AB} , AB$	the magnitude of \overline{AB}
7.7	$\begin{pmatrix} a \\ b \end{pmatrix}, a\mathbf{i} + b\mathbf{j}$	column vector and corresponding unit vector notation

7	Vectors (continued)	
7.8	\mathbf{r}	position vector
7.9	\mathbf{s}	displacement vector
7.10	\mathbf{v}	velocity vector
7.11	\mathbf{a}	acceleration vector

8	Probability and Statistics	
8.1	$A, B, C, \text{ etc.}$	events
8.2	$A \cup B$	union of the events A and B
8.3	$A \cap B$	intersection of the events A and B
8.4	$P(A)$	probability of the event A
8.5	A'	complement of the event A
8.6	$P(A B)$	probability of the event A conditional on the event B
8.7	$X, Y, R, \text{ etc.}$	random variables
8.8	$x, y, r, \text{ etc.}$	values of the random variables X, Y, R etc.
8.9	x_1, x_2, \dots	observations
8.10	f_1, f_2, \dots	frequencies with which the observations x_1, x_2, \dots occur
8.11	$p(x), P(X = x)$	probability function of the discrete random variable X
8.12	p_1, p_2, \dots	probabilities of the values x_1, x_2, \dots of the discrete random variable X
8.13	$E(X)$	expectation of the random variable X
8.14	$\text{Var}(X)$	variance of the random variable X
8.15	\sim	has the distribution
8.16	$B(n, p)$	binomial distribution with parameters n and p , where n is the number of trials and p is the probability of success in a trial
8.17	q	$q = 1 - p$ for binomial distribution
8.18	$N(\mu, \sigma^2)$	Normal distribution with mean μ and variance σ^2
8.19	$Z \sim N(0,1)$	standard Normal distribution

8	Probability and Statistics	
8.20	ϕ	probability density function of the standardised Normal variable with distribution $N(0, 1)$
8.21	Φ	corresponding cumulative distribution function
8.22	μ	population mean
8.23	σ^2	population variance
8.24	σ	population standard deviation
8.25	\bar{x}	sample mean
8.26	s^2	sample variance
8.27	s	sample standard deviation
8.28	H_0	Null hypothesis
8.29	H_1	Alternative hypothesis
8.30	r	product moment correlation coefficient for a sample
8.31	ρ	product moment correlation coefficient for a population

9	Mechanics	
9.1	kg	kilograms
9.2	m	metres
9.3	km	kilometres
9.4	m/s, $m s^{-1}$	metres per second (velocity)
9.5	m/s^2 , $m s^{-2}$	metres per second per second (acceleration)
9.6	F	Force or resultant force
9.7	N	Newton
9.8	N m	Newton metre (moment of a force)
9.9	t	time
9.10	s	displacement
9.11	u	initial velocity
9.12	v	velocity or final velocity
9.13	a	acceleration
9.14	g	acceleration due to gravity
9.15	μ	coefficient of friction

Appendix 3: Use of calculators

Students may use a calculator in all AS Level Mathematics examinations. Students are responsible for making sure that their calculators meet the guidelines set out in this appendix.

The use of technology permeates the study of AS Level Mathematics. Calculators used **must** include the following features:

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

In addition, students **must** be told these regulations before sitting an examination:

<p>Calculators must be:</p> <ul style="list-style-type: none">• of a size suitable for use on the desk• either battery or solar powered• free of lids, cases and covers that have printed instructions or formulas.	<p>Calculators must not:</p> <ul style="list-style-type: none">• be designed or adapted to offer any of these facilities:<ul style="list-style-type: none">◦ language translators◦ symbolic algebra manipulation◦ symbolic differentiation or integration◦ communication with other machines or the internet• be borrowed from another student during an examination for any reason*• have retrievable information stored in them – this includes<ul style="list-style-type: none">◦ databanks◦ dictionaries◦ mathematical formulas◦ text.
<p>The student is responsible for the following:</p> <ul style="list-style-type: none">• the calculator's power supply• the calculator's working condition• clearing anything stored in the calculator.	

Advice: *An invigilator may give a student a replacement calculator.

Appendix 4: Assessment Objectives

The following tables outline in detail the strands and elements of each Assessment Objective for AS Level Mathematics, as provided by Ofqual in the document *GCE Subject Level Guidance for Mathematics*.

- A 'strand' is a discrete bullet point that is formally part of an Assessment Objective
- An 'element' is an ability that the Assessment Objective does not formally separate, but that could be discretely targeted or credited.

AO1: Use and apply standard techniques.		50% (A Level) 60% (AS)
Learners should be able to: <ul style="list-style-type: none"> ▪ select and correctly carry out routine procedures ▪ accurately recall facts, terminology and definitions 		
Strands	Elements	
1. select and correctly carry out routine procedures	1a – select routine procedures	
	1b – correctly carry out routine procedures	
2. accurately recall facts, terminology and definitions	This strand is a single element	

AO2: Reason, interpret and communicate mathematically		25% (A Level) 20% (AS)
Learners should be able to: <ul style="list-style-type: none"> ▪ 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 		
Strands	Elements	
1. construct rigorous mathematical arguments (including proofs)	This strand is a single element	
2. make deductions and inferences	2a – make deductions	
1.	2b – make inferences	
3. assess the validity of mathematical arguments	This strand is a single element	
4. explain their reasoning	This strand is a single element	
5. use mathematical language and notation correctly	This strand is a single element	

AO3: Solve problems within mathematics and in other contexts

**25% (A Level)
20% (AS)**

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**

Strands	Elements
1. translate problems in mathematical and non-mathematical contexts into mathematical processes	1a – translate problems in mathematical contexts into mathematical processes
	1b – translate problems in non-mathematical contexts into mathematical processes
2. interpret solutions to problems in their original context, and, where appropriate evaluate their accuracy and limitations	2a – interpret solutions to problems in their original context
	2b – where appropriate, evaluation the accuracy and limitations of solutions to problems
3. translate situations in context into mathematical models	This strand is a single element
4. use mathematical models	This strand is a single element
5. evaluate the outcomes of modelling in context, recognise the limitations of models and, where appropriate, explain how to refine them	5a – evaluate the outcomes of modelling in context
	5b – recognise the limitations of models
	5c – where appropriate, explain how to refine models

Assessment Objectives coverage

There will be full coverage of all elements of the Assessment Objectives, with the exceptions of AO3.2b and AO3.5c, in each set of AS Mathematics assessments offered by Pearson. Elements AO3.2b and AO3.5c will be covered in each route through the qualification within three years.

Appendix 5: The context for the development of this qualification

All our qualifications are designed to meet our World Class Qualification Principles^[1] and our ambition to put the student at the heart of everything we do.

We have developed and designed this qualification by:

- reviewing other curricula and qualifications to ensure that it is comparable with those taken in high-performing jurisdictions overseas
- consulting with key stakeholders on content and assessment, including learned bodies, subject associations, higher-education academics, teachers and employers to ensure this qualification is suitable for a UK context
- reviewing the legacy qualification and building on its positive attributes.

This qualification has also been developed to meet criteria stipulated by Ofqual in their documents *GCE Qualification Level Conditions and Requirements* and *GCE Subject Level Conditions and Requirements for Mathematics*, published in April 2016.

^[1] Pearson's World Class Qualification Principles ensure that our qualifications are:

- **demanding**, through internationally benchmarked standards, encouraging deep learning and measuring higher-order skills
- **rigorous**, through setting and maintaining standards over time, developing reliable and valid assessment tasks and processes, and generating confidence in end users of the knowledge, skills and competencies of certified students
- **inclusive**, through conceptualising learning as continuous, recognising that students develop at different rates and have different learning needs, and focusing on progression
- **empowering**, through promoting the development of transferable skills, see *Appendix 6*.

From Pearson's Expert Panel for World Class Qualifications

May 2014

"The reform of the qualifications system in England is a profoundly important change to the education system. Teachers need to know that the new qualifications will assist them in helping their learners make progress in their lives.

When these changes were first proposed we were approached by Pearson to join an 'Expert Panel' that would advise them on the development of the new qualifications.

We were chosen, either because of our expertise in the UK education system, or because of our experience in reforming qualifications in other systems around the world as diverse as Singapore, Hong Kong, Australia and a number of countries across Europe.

We have guided Pearson through what we judge to be a rigorous qualification development process that has included:

- extensive international comparability of subject content against the highest-performing jurisdictions in the world
- benchmarking assessments against UK and overseas providers to ensure that they are at the right level of demand
- establishing External Subject Advisory Groups, drawing on independent subject-specific expertise to challenge and validate our qualifications
- subjecting the final qualifications to scrutiny against the DfE content and Ofqual accreditation criteria in advance of submission.

Importantly, we have worked to ensure that the content and learning is future oriented. The design has been guided by what is called an 'Efficacy Framework', meaning learner outcomes have been at the heart of this development throughout.

We understand that ultimately it is excellent teaching that is the key factor to a learner's success in education. As a result of our work as a panel we are confident that we have supported the development of qualifications that are outstanding for their coherence, thoroughness and attention to detail and can be regarded as representing world-class best practice."

Sir Michael Barber (Chair)

Chief Education Advisor, Pearson plc

Professor Lee Sing Kong

Director, National Institute of Education, Singapore

Bahram Bekhradnia

President, Higher Education Policy Institute

Professor Jonathan Osborne

Stanford University

Dame Sally Coates

Principal, Burlington Danes Academy

Professor Dr Ursula Renold

Federal Institute of Technology, Switzerland

Professor Robin Coningham

Pro-Vice Chancellor, University of Durham

Professor Bob Schwartz

Harvard Graduate School of Education

Dr Peter Hill

Former Chief Executive ACARA

All titles correct as at May 2014

Appendix 6: Transferable skills

The need for transferable skills

In recent years, higher education institutions and employers have consistently flagged the need for students to develop a range of transferable skills to enable them to respond with confidence to the demands of undergraduate study and the world of work.

The Organisation for Economic Co-operation and Development (OECD) defines skills, or competencies, as 'the bundle of knowledge, attributes and capacities that can be learned and that enable individuals to successfully and consistently perform an activity or task and can be built upon and extended through learning.'^[1]

To support the design of our qualifications, the Pearson Research Team selected and evaluated seven global 21st-century skills frameworks. Following on from this process, we identified the National Research Council's (NRC) framework as the most evidence-based and robust skills framework. We adapted the framework slightly to include the Program for International Student Assessment (PISA) ICT Literacy and Collaborative Problem Solving (CPS) Skills.

The adapted National Research Council's framework of skills involves:^[2]

Cognitive skills

- **Non-routine problem solving** – expert thinking, metacognition, creativity.
- **Systems thinking** – decision making and reasoning.
- **Critical thinking** – definitions of critical thinking are broad and usually involve general cognitive skills such as analysing, synthesising and reasoning skills.
- **ICT literacy** – access, manage, integrate, evaluate, construct and communicate.^[3]

Interpersonal skills

- **Communication** – active listening, oral communication, written communication, assertive communication and non-verbal communication.
- **Relationship-building skills** – teamwork, trust, intercultural sensitivity, service orientation, self-presentation, social influence, conflict resolution and negotiation.
- **Collaborative problem solving** – establishing and maintaining shared understanding, taking appropriate action, establishing and maintaining team organisation.

Intrapersonal skills

- **Adaptability** – ability and willingness to cope with the uncertain, handling work stress, adapting to different personalities, communication styles and cultures, and physical adaptability to various indoor and outdoor work environments.
- **Self-management and self-development** – ability to work remotely in virtual teams, work autonomously, be self-motivating and self-monitoring, willing and able to acquire new information and skills related to work.

Transferable skills enable young people to face the demands of further and higher education, as well as the demands of the workplace, and are important in the teaching and learning of this qualification. We will provide teaching and learning materials, developed with stakeholders, to support our qualifications.

^[1] OECD – *Better Skills, Better Jobs, Better Lives* (OECD Publishing, 2012)

^[2] Koenig J A, National Research Council – *Assessing 21st Century Skills: Summary of a Workshop* (National Academies Press, 2011)

^[3] PISA – *The PISA Framework for Assessment of ICT Literacy* (2011)

Appendix 7: Level 3 Extended Project qualification

What is the Extended Project?

The Extended Project is a standalone qualification that can be taken alongside GCEs. It supports the development of independent learning skills and helps to prepare students for their next step – whether that be higher education or employment. The qualification:

- is recognised by higher education for the skills it develops
- is worth half of an Advanced GCE qualification at grades A*–E
- carries UCAS points for university entry.

The Extended Project encourages students to develop skills in the following areas: research, critical thinking, extended writing and project management. Students identify and agree a topic area of their choice for in-depth study (which may or may not be related to a GCE subject they are already studying), guided by their teacher.

Students can choose from one of four approaches to produce:

- a dissertation (for example an investigation based on predominately secondary research)
- an investigation/field study (for example a practical experiment)
- a performance (for example in music, drama or sport)
- an artefact (for example creating a sculpture in response to a client brief or solving an engineering problem).

The qualification is coursework based and students are assessed on the skills of managing, planning and evaluating their project. Students will research their topic, develop skills to review and evaluate the information, and then present the final outcome of their project.

The Extended Project has 120 guided learning hours (GLH) consisting of a 40-GLH taught element that includes teaching the technical skills (for example research skills) and an 80-GLH guided element that includes mentoring students through the project work. The qualification is 100% internally assessed and externally moderated.

How to link the Extended Project with mathematics

The Extended Project creates the opportunity to develop transferable skills for progression to higher education and to the workplace, through the exploration of either an area of personal interest or a topic of interest from within the mathematics qualification content.

Through the Extended Project, students can develop skills that support their study of mathematics, including:

- conducting, organising and using research
- independent reading in the subject area
- planning, project management and time management
- defining a hypothesis to be tested in investigations or developing a design brief
- collecting, handling and interpreting data and evidence
- evaluating arguments and processes, including arguments in favour of alternative interpretations of data and evaluation of experimental methodology
- critical thinking.

In the context of the Extended Project, critical thinking refers to the ability to identify and develop arguments for a point of view or hypothesis and to consider and respond to alternative arguments.

Types of Extended Project related to mathematics

Students may produce a dissertation on any topic that can be researched and argued. In mathematics this might involve working on a substantial statistical project or a project that requires the use of mathematical modelling.

Projects can give students the opportunity to develop mathematical skills that cannot be adequately assessed in exam questions.

- **Statistics** – students can have the opportunity to plan a statistical enquiry project, use different methods of sampling and data collection, use statistical software packages to process and investigate large quantities of data and review results to decide if more data is needed.
- **Mathematical modelling** – students can have the opportunity to choose modelling assumptions, compare with experimental data to assess the appropriateness of their assumptions and refine their modelling assumptions until they get the required accuracy of results.

Using the Extended Project to support breadth and depth

In the Extended Project, students are assessed on the quality of the work they produce and the skills they develop and demonstrate through completing this work. Students should demonstrate that they have extended themselves in some significant way beyond what they have been studying in mathematics. Students can demonstrate extension in one or more dimensions:

- **deepening understanding** – where a student explores a topic in greater depth than in the specification content. This could be an in-depth exploration of one of the topics in the specification
- **broadening skills** – where a student learns a new skill. This might involve learning the skills in statistics or mathematical modelling mentioned above or learning a new mathematical process and its practical uses
- **widening perspectives** – where the student's project spans different subjects. Projects in a variety of subjects need to be supported by data and statistical analysis. Students studying mathematics with design and technology can do design projects involving the need to model a situation mathematically in planning their design.

A wide range of information to support the delivery and assessment of the Extended Project, including the specification, teacher guidance for all aspects, an editable scheme of work and exemplars for all four approaches, can be found on our website.

Appendix 8: Codes

Type of code	Use of code	Code
Discount codes	<p>Every qualification eligible for performance tables is assigned a discount code that indicates the subject area to which it belongs.</p> <p>Discount codes are published by the DfE.</p>	Please see the GOV.UK website*
Regulated Qualifications Framework (RQF) codes	<p>Each qualification title is allocated an Ofqual Regulated Qualifications Framework (RQF) code.</p> <p>The RQF code is known as a Qualification Number (QN). This is the code that features in the DfE Section 96 and on the LARA as being eligible for 16–18 and 19+ funding, and is to be used for all qualification funding purposes. The QN will appear on students' final certification documentation.</p>	<p>The QN for this qualification is:</p> <p>603/1307/9</p>
Subject codes	The subject code is used by centres to enter students for a qualification. Centres will need to use the entry codes only when claiming students' qualifications.	AS – 8MA0
Paper codes	These codes are provided for reference purposes. Students do not need to be entered for individual papers.	<p>Paper 1: 8MA0/01</p> <p>Paper 2: 8MA0/02</p>

*www.gov.uk/government/publications/2018-performance-tables-discount-code

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