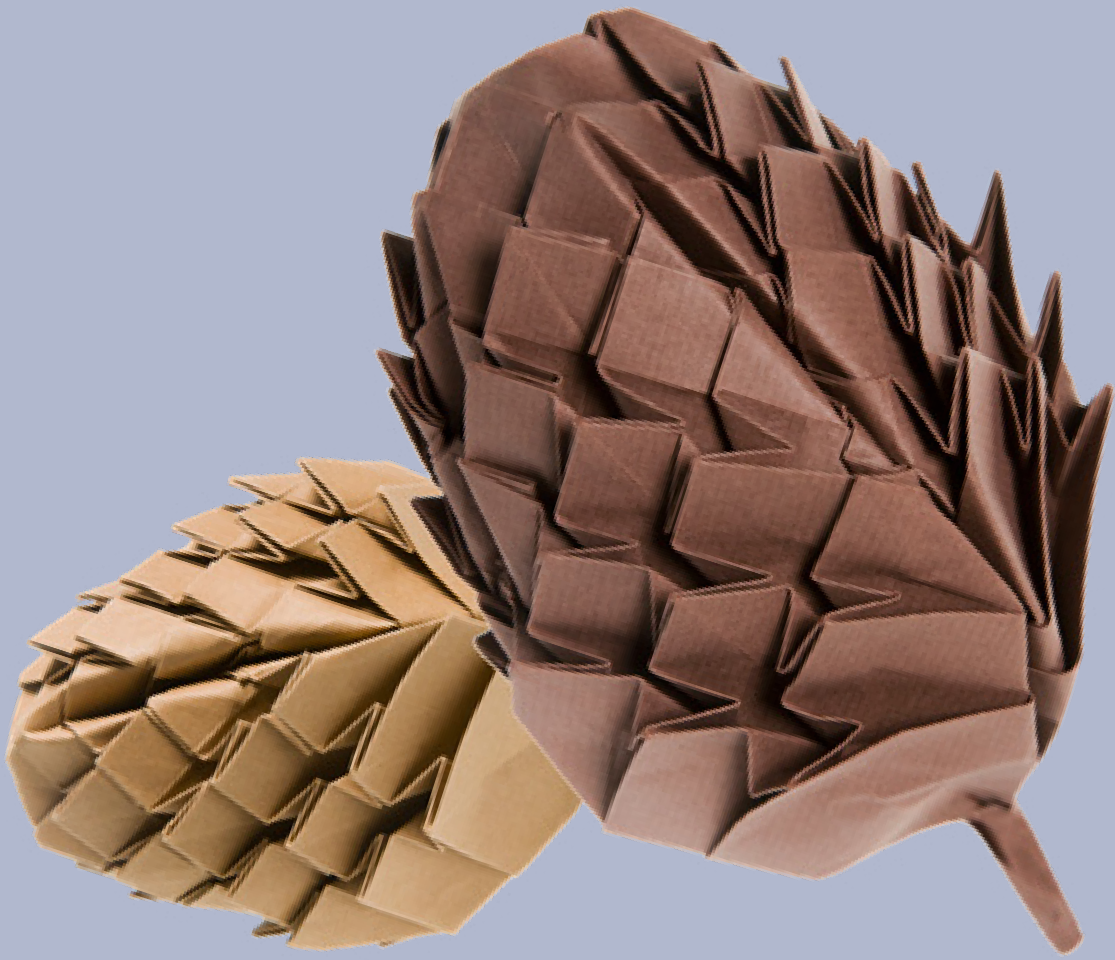
Pearson Edexcel

Pearson Edexcel
Level 3 Advanced GCE
Mathematics (9MA0)



Enhanced Content Guidance - 9MA0

First teaching from September 2017

First certification from 2018 | Issue 2

Edexcel, BTEC and LCCI qualifications

Edexcel, BTEC and LCCI qualifications are awarded by Pearson, the UK's largest awarding body offering academic and vocational qualifications that are globally recognised and benchmarked. For further information, please visit our qualifications website at qualifications.pearson.com. Alternatively, you can get in touch with us using the details on our contact us page at qualifications.pearson.com/en/contact-us.html

About Pearson

Pearson is the world's leading learning company, with 35,000 employees in more than 70 countries working to help people of all ages to make measurable progress in their lives through learning. We put the learner at the centre of everything we do, because wherever learning flourishes, so do people. Find out more about how we can help you and your learners at qualifications.pearson.com

Contents

Amendments

Summary of changes made between previous issue and this current issue	Page number
Typos corrected in the Content Exemplification column for 7.3	22

Introduction

The purpose of this document is to provide further exemplification of specific content areas within the Pearson/Edexcel A Level Mathematics specification. We have listened to feedback from teachers and, where appropriate, added further exemplification to assist you in your delivery.

The additional guidance can be found in the final column of the table – *'Content exemplification'*. Where appropriate, we have included examples of questions to add further clarity.

Please note that the exemplification provided here does not change or impact upon the specification.

Also included in this document is further guidance on the use of calculators.

Calculator guidance

Calculators may always be used to check answers.

Students should write down any equations that they are solving, so these can be checked and credit given.

We will always include instructions in questions to indicate that the use of a calculator is **not** permitted. Phrases used to signal that calculators should **not** be used include:

- Solutions relying entirely on calculator technology are not acceptable.
- Solutions based entirely on graphical or numerical methods are not acceptable.
- Numerical (calculator) integration/differentiation is not accepted in this question.
- Use algebraic integration/differentiation to …
- Use algebra to …
- Show that …
- Prove that …

Using a calculator in statistics

Students will need to be able to find probabilities for a binomial distribution using their calculators.

Students are expected to use a calculator to find probabilities for a Normal distribution.

When finding a critical region or using an inverse Normal, we cannot assume that all students will be able to do this using a calculator and so tables of values are provided. However, if students do have the facility to do this on their calculator then that is an acceptable method.

Paper 1 and Paper 2: Pure Mathematics

To support the co-teaching of this qualification with the AS Mathematics qualification, common content has been highlighted in bold.

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
1 **Proof**	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:** **Proof by deduction** **Proof by exhaustion**	**Examples of proofs:** **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** or proving results for arithmetic and geometric series. **This is the most commonly used method of proof throughout this specification** **Proof by exhaustion** **This involves trying all the options. Given that p is a prime number such that $3 < p < 25$, prove by exhaustion, that $(p - 1)(p + 1)$ is a multiple of 12.**	**Candidates may have to choose the most appropriate method of tackling the proof.**

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
1 **Proof** *continued*	1.1 *cont.*	**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).	**Disproof by counter example** **e.g. show that the statement "$n^2 - n + 1$ is a prime number for all values of n" is untrue**	
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** $\left(\sqrt{x}\right)^2 = x$, $\sqrt{xy} = \sqrt{x}\sqrt{y}$ **and** $\left(\sqrt{x}+\sqrt{y}\right)\left(\sqrt{x}-\sqrt{y}\right) = x - y$	

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
2 **Algebra and functions** *continued*	2.3	**Work with quadratic functions and their graphs.**	**The notation $\mathrm{f}(x)$ may be used**	
		The discriminant of a quadratic function, including the conditions for real and repeated roots.	**Need to know and to use** $b^2 - 4ac > 0,\ b^2 - 4ac = 0$ **and** $b^2 - 4ac < 0$	
		Completing the square.	$ax^2 + bx + c = a\left(x + \frac{b}{2a}\right)^2 + \left(c - \frac{b^2}{4a}\right)$	
		Solution of quadratic equations	**Solution of quadratic equations by factorisation, use of the formula, use of a calculator or completing the square.**	**Candidates should use the most appropriate method of solving the given quadratic.** **Questions will be phrased in such a way as to make clear if calculators should not be used.** **For example:** **Solve, using algebra and showing each stage of your working, the equation** $x - 6\sqrt{x} + 4 = 0$.
		including solving quadratic equations in a function of the unknown.	**These functions could include powers of x, trigonometric functions of x, exponential and logarithmic functions of x.**	**Exponential functions could include examples of the form** $4^x - 7(2^x) + 12 = 0$.
	2.4	**Solve simultaneous equations in two variables by elimination and by substitution, including one linear and one quadratic equation.**	**This may involve powers of 2 in one unknown or in both unknowns,** **e.g. solve** $y = 2x + 3,\ y = x^2 - 4x + 8$ **or** $2x - 3y = 6,\ x^2 - y^2 + 3x = 50$	**Students may be required to set up and solve equations within a modelling context.**

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
2 **Algebra and functions** *continued*	2.5	**Solve linear and quadratic inequalities in a single variable and interpret such inequalities graphically,**	**e.g. solving** $ax + b > cx + d$, $px^2 + qx + r \geq 0$, $px^2 + qx + r < ax + b$ **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 $y = ax + b$**	
		including inequalities with brackets and fractions.	**These would be reducible to linear or quadratic inequalities** **e.g.** $\frac{a}{x} < b$ **becomes** $ax < bx^2$	
		Express solutions through correct use of 'and' and 'or', or through set notation.	**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** $x < d$	
		Represent linear and quadratic inequalities such as $y > x + 1$ **and** $y > ax^2 + bx + c$ **graphically.**	**Shading and use of dotted and solid line convention is required.**	

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
2 **Algebra and functions** *continued*	2.6	**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).	**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 $f(x)$.** **Students may be required to factorise cubic expressions such as x^3+3x^2-4 and $6x^3+11x^2-x-6$.** Denominators of rational expressions will be linear or quadratic, e.g. $\dfrac{1}{ax+b}$, $\dfrac{ax+b}{px^2+qx+r}$, $\dfrac{x^3+a^3}{x^2-a^2}$	**When factorising cubic expressions, students will be given one factor or enough information to work out one factor.**
	2.7	**Understand and use graphs of functions; sketch curves defined by simple equations including polynomials** The modulus of a linear function.	**Graph to include simple cubic and quartic functions,** **e.g. sketch the graph with equation $y=x^2(2x-1)^2$** Students should be able to sketch the graph of $y=\lvert ax+b\rvert$ They should be able to use their graph. For example, sketch the graph with equation $y=\lvert 2x-1\rvert$ and use the graph to solve the equation $\lvert 2x-1\rvert=x$ or the inequality $\lvert 2x-1\rvert>x$	**Students may be required to sketch the graph of any function defined by the specification, including polynomial, exponential, logarithmic and trigonometric functions.**

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
2 **Algebra and functions** *continued*	2.7 *cont.*	$y=\dfrac{a}{x}$ and $y=\dfrac{a}{x^2}$ **(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.**	**The asymptotes will be parallel to the axes e.g. the asymptotes of the curve with equation** $y=\dfrac{2}{x+a}+b$ **are the lines with equations** $y=b$ **and** $x=-a$ **Express relationship between two variables using proportion "$\propto$" symbol or using equation involving constant** **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**.**	**Where students are required to find the asymptotes of a curve defined by a function that is more complicated than those they are expected to sketch, the graph will be provided.**

Topics	What students need to learn:			
	Content		**Guidance**	**Content exemplification**
2 **Algebra and functions** *continued*	2.8	Understand and use composite functions; inverse functions and their graphs.	The concept of a function as a one-one or many-one mapping from $\mathbb{R}$ (or a subset of $\mathbb{R}$) to $\mathbb{R}$. The notation $\mathrm{f} : x \mapsto$ and $\mathrm{f}(x)$ will be used. Domain and range of functions. Students should know that fg will mean 'do g first, then f' and that if f^{-1} exists, then $\mathrm{f}^{-1}\mathrm{f}(x) = \mathrm{ff}^{-1}(x) = x$ They should also know that the graph of $y = \mathrm{f}^{-1}(x)$ is the image of the graph of $y = \mathrm{f}(x)$ after reflection in the line $y = x$	
	2.9	**Understand the effect of simple transformations on the graph of $y = \mathrm{f}(x)$, including sketching associated graphs:** $y = a\mathrm{f}(x)$, $y = \mathrm{f}(x) + a$, $y = \mathrm{f}(x + a)$, $y = \mathrm{f}(ax)$ and combinations of these transformations	Students should be able to find the graphs of $y = \lvert \mathrm{f}(x) \rvert$ and $y = \lvert \mathrm{f}(-x) \rvert$, given the graph of $y = \mathrm{f}(x)$. Students should be able to apply a combination of these transformations to any of the functions in the A Level specification (quadratics, cubics, quartics, reciprocal, $\frac{a}{x^2}$, $\lvert x \rvert$, $\sin x$, $\cos x$, $\tan x$, e^x and a^x) and sketch the resulting graph. Given the graph of $y = \mathrm{f}(x)$, students should be able to sketch the graph of, e.g. $y = 2\mathrm{f}(3x)$, or $y = \mathrm{f}(-x) + 1$, and should be able to sketch (for example) $y = 3 + \sin 2x$, $y = -\cos\left(x + \frac{\pi}{4}\right)$	This may include the graph of $y = \mathrm{f}(ax + b)$.

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
2 **Algebra and functions** *continued*	2.10	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).	Partial fractions to include denominators such as $(ax + b)(cx + d)(ex + f)$ and $(ax + b)(cx + d)^2$. Applications to integration, differentiation and series expansions.	
	2.11	Use of functions in modelling, including consideration of limitations and refinements of the models.	For example, use of trigonometric functions for modelling tides, hours of sunlight, etc. Use of exponential functions for growth and decay (see Paper 1, Section 6.7). Use of reciprocal function for inverse proportion (e.g. pressure and volume).	
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.**	

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
3 **Coordinate geometry in the (x, y) plane** *continued*	3.2	**Understand and use the coordinate geometry of the circle including using the equation of a circle in the form** $(x - a)^2 + (y - b)^2 = r^2$	**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** $x^2 + y^2 + 2fx + 2gy + c = 0$	
		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.**	**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.**	

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
3 **Coordinate geometry in the (x, y) plane** *continued*	3.3	Understand and use the parametric equations of curves and conversion between Cartesian and parametric forms.	For example: $x = 3\cos t,\ \ y = 3\sin t$ describes a circle centre O radius 3 $x = 2 + 5\cos t,\ \ y = -4 + 5\sin t$ describes a circle centre $(2, -4)$ with radius 5 $x = 5t,\ \ y = \frac{5}{t}$ describes the curve $xy = 25$ (or $y = \frac{25}{x}$) $x = 5t$, $y = 3t^2$ describes the quadratic curve $25y = 3x^2$ and other familiar curves covered in the specification. Students should pay particular attention to the domain of the parameter t, as a specific section of a curve may be described.	Students may be required to sketch a graph which is defined by its parametric equations. For example: $x = t^2,\ \ y = t^3,\ \ t \in \mathbb{R}$ or $x = 2 + 3\cos\theta,\ y = 4 + 3\sin\theta,\ \ 0 \leqslant \theta < 2\pi$
	3.4	Use parametric equations in modelling in a variety of contexts.	A shape may be modelled using parametric equations or students may be asked to find parametric equations for a motion. For example, an object moves with constant velocity from $(1, 8)$ at $t = 0$ to $(6, 20)$ at $t = 5$. This may also be tested in Paper 3, section 7 (kinematics).	

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
4 **Sequences and series**	4.1	**Understand and use the binomial expansion of $(a+bx)^n$ for positive integer n; the notations $n!$ and ^nC_r link to binomial probabilities.**	**Use of Pascal's triangle.** **Relation between binomial coefficients.** **Also be aware of alternative notations such as $\binom{n}{r}$ and ^nC_r** **Considered further in Paper 3 Section 4.1.**	
		Extend to any rational n, including its use for approximation; be aware that the expansion is valid for $\left\lvert\frac{bx}{a}\right\rvert < 1$ (proof not required)	May be used with the expansion of rational functions by decomposition into partial fractions May be asked to comment on the range of validity.	

Topics	What students need to learn:			Content exemplification
	Content		Guidance	
4 **Sequences and series** *continued*	4.2	Work with sequences including those given by a formula for the nth term and those generated by a simple relation of the form $x_{n+1} = \mathrm{f}(x_n)$; increasing sequences; decreasing sequences; periodic sequences.	For example $u_n = \frac{1}{3n+1}$ describes a decreasing sequence as $u_{n+1} < u_n$ for all integer n $u_n = 2^n$ is an increasing sequence as $u_{n+1} > u_n$ for all integer n $u_{n+1} = \frac{1}{u_n}$ for $n > 1$ and $u_1 = 3$ describes a periodic sequence of order 2	
	4.3	Understand and use sigma notation for sums of series.	Knowledge that $\sum_{1}^{n} 1 = n$ is expected	
	4.4	Understand and work with arithmetic sequences and series, including the formulae for nth term and the sum to n terms	The proof of the sum formula for an arithmetic sequence should be known including the formula for the sum of the first n natural numbers.	

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
	4.5	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	The proof of the sum formula should be known. Given the sum of a series students should be able to use logs to find the value of n. The sum to infinity may be expressed as S_∞	
	4.6	Use sequences and series in modelling.	Examples could include amounts paid into saving schemes, increasing by the same amount (arithmetic) or by the same percentage (geometric) or could include other series defined by a formula or a relation.	
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 $\frac{1}{2}ab\sin C$** Work with radian measure, including use for arc length and area of sector.	**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.** Use of the formulae $s = r\theta$ and $A = \frac{1}{2}r^2\theta$ for arc lengths and areas of sectors of a circle.	

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
5 **Trigonometry** *continued*	5.2	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.	Students should be able to approximate, e.g. $\frac{\cos 3x - 1}{x \sin 4x}$ when x is small, to $-\frac{9}{8}$	
	5.3	**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.	**Knowledge of graphs of curves with equations such as $y = \sin x$, $y = \cos(x + 30°)$, $y = \tan 2x$ is expected.**	

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
5 **Trigonometry** *continued*	5.4	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.	Angles measured in both degrees and radians.	
	5.5	**Understand and use** $\tan\theta = \dfrac{\sin\theta}{\cos\theta}$ **Understand and use** $\sin^2\theta + \cos^2\theta = 1$ $\sec^2\theta = 1 + \tan^2\theta$ and $\mathrm{cosec}^2\theta = 1 + \cot^2\theta$	**These identities may be used to solve trigonometric equations** and angles may be in degrees or radians. **They may also be used to prove further identities.**	
	5.6	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 $r\sin(\theta \pm \alpha)$	To include application to half angles. Knowledge of the $\tan(\frac{1}{2}\theta)$ formulae will *not* be required. Students should be able to solve equations such as $a\cos\theta + b\sin\theta = c$ in a given interval.	

Topics	What students need to learn:			Content exemplification
	Content		Guidance	
5 **Trigonometry** *continued*	5.7	**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** $\sin(x + 70°) = 0.5$ **for** $0 < x < 360°$, $3 + 5\cos 2x = 1$ **for** $-180° < x < 180°$ $6\cos^2 x + \sin x - 5 = 0, 0 \leqslant x < 360°$ These may be in degrees or radians and this will be specified in the question.	
	5.8	Construct proofs involving trigonometric functions and identities.	Students need to prove identities such as $\cos x \cos 2x + \sin x \sin 2x \equiv \cos x$.	
	5.9	Use trigonometric functions to solve problems in context, including problems involving vectors, kinematics and forces.	Problems could involve (for example) wave motion, the height of a point on a vertical circular wheel, or the hours of sunlight throughout the year. Angles may be measured in degrees or in radians.	

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
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 $a > 1$** To include the graph of $y = e^{ax+b} + c$	
	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.**	
	6.3	**Know and use the definition of $\log_a x$ as the inverse of a^x, where a is positive and $x \geqslant 0$.** **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.**	

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
6 **Exponentials and logarithms** *continued*	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, e.g.** $2^{3x-1} = 3$	
	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** $\log b$	

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
6 **Exponentials and logarithms** *continued*	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 an improved model may be required.**	**Students may be asked to explain how a given model could be improved to better fit the situation.**
7 **Differentiation**	7.1	**Understand and use the derivative of $\mathrm{f}(x)$ as the gradient of the tangent to the graph of $y = \mathrm{f}(x)$ 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**	**Know that $\frac{\mathrm{d}y}{\mathrm{d}x}$ is the rate of change of y with respect to x.** **The notation $\mathrm{f}'(x)$ may be used for the first derivative and $\mathrm{f}''(x)$ may be used for the second derivative.** **Given for example the graph of $y = \mathrm{f}(x)$, sketch the graph of $y = \mathrm{f}'(x)$ using given axes and scale. This could relate speed and acceleration for example.**	

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
7 **Differentiation** *continued*	7.1 *cont.*	**differentiation from first principles for small positive integer powers of x** and for $\sin x$ and $\cos x$	**For example, students should be able to use, for $n = 2$ and $n = 3$, the gradient expression** $$\lim_{h \to 0}\left(\frac{(x+h)^n - x^n}{h}\right)$$ **Students may use δx or h**	**Variables other than x may be used.**
		Understand and use the second derivative as the rate of change of gradient;	**Use the condition $f''(x) > 0$ implies a minimum and $f''(x) < 0$ implies a maximum for points where $f'(x) = 0$**	
		connection to convex and concave sections of curves and points of inflection.	Know that at an inflection point $f''(x)$ changes sign. Consider cases where $f''(x) = 0$ and $f'(x) = 0$ where the point may be a minimum, a maximum or a point of inflection (e.g. $y = x^n, n > 2$)	A function is concave on a given interval if $f''(x) < 0$ (or $f''(x) \leq 0$) for all values of x in that interval. A function is convex on a given interval if $f''(x) > 0$ (or $f''(x) \geq 0$) for all values of x in that interval. A point of inflection is a point where $f''(x)$ changes sign.
	7.2	**Differentiate x^n, for rational values of n, and related constant multiples, sums and differences.**	**For example, the ability to differentiate expressions such as** $(2x+5)(x-1)$ **and** $\dfrac{x^2+3x-5}{4x^{\frac{1}{2}}}, x > 0,$ **is expected.**	

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
7 **Differentiation** *continued*	7.2 *cont.*	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 $\ln x$	Knowledge and use of the result $\frac{\mathrm{d}}{\mathrm{d}x}(a^{kx}) = ka^{kx}\ln a$ is expected.	
	7.3	**Apply differentiation to find gradients, tangents and normals** **maxima and minima and stationary points.** points of inflection **Identify where functions are increasing or decreasing.**	**Use of differentiation to find equations of tangents and normals at specific points on a curve.** **To include applications to curve sketching. Maxima and minima problems may be set in the context of a practical problem.** **To include applications to curve sketching.**	**A function is increasing on a given interval if $f'(x) > 0$ (or $f'(x) \geq 0$) for all values of x in that interval.** **A function is decreasing on a given interval if $f'(x) < 0$ (or $f'(x) \leq 0$) for all values of x in that interval.**

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
7 Differentiation *continued*	7.4	Differentiate using the product rule, the quotient rule and the chain rule, including problems involving connected rates of change and inverse functions.	Differentiation of $\operatorname{cosec} x$, $\cot x$ and $\sec x$. Differentiation of functions of the form $x = \sin y, x = 3 \tan 2y$ and the use of $\frac{dy}{dx} = \frac{1}{\left(\frac{dx}{dy}\right)}$ Use of connected rates of change in models, e.g. $\frac{dV}{dt} = \frac{dV}{dr} \times \frac{dr}{dt}$ Skill will be expected in the differentiation of functions generated from standard forms using products, quotients and composition, such as $2x^4 \sin x, \frac{e^{3x}}{x}, \cos^2 x$ and $\tan^2 2x$.	
	7.5	Differentiate simple functions and relations defined implicitly or parametrically, for first derivative only.	The finding of equations of tangents and normals to curves given parametrically or implicitly is required.	Students are not required to differentiate functions such as $y = \arcsin x$ or $y = \frac{1}{3}\arctan x$, but they may be asked to differentiate implicitly functions such as $x = \sin y$ or $x = \tan 3y$.
	7.6	Construct simple differential equations in pure mathematics and in context, (contexts may include kinematics, population growth and modelling the relationship between price and demand).	Set up a differential equation using given information. For example: In a simple model, the rate of decrease of the radius of the mint is inversely proportional to the square of the radius.	

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
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 $\frac{(x+2)^2}{x^{\frac{1}{2}}}$ 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 $y = f(x)$.**	
		Integrate e^{kx}, $\frac{1}{x}$, $\sin kx$, $\cos kx$ and related sums, differences and constant multiples.	To include integration of standard functions such as $\sin 3x$, $\sec^2 2x$, $\tan x$, e^{5x}, $\frac{1}{2x}$. Students are expected to be able to use trigonometric identities to integrate, for example, $\sin^2 x$, $\tan^2 x$, $\cos^2 3x$.	Students are expected to be able to use the integrals of the standard functions given in the formula booklet.

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
	8.3	**Evaluate definite integrals; use a definite integral to find the area under a curve** and the area between two curves	**Students will be expected to be able to evaluate the area of a region bounded by a curve and given straight lines,** or between two curves. This includes curves defined parametrically. **For example, find the finite area bounded by the curve $y = 6x - x^2$ and the line $y = 2x$** Or find the finite area bounded by the curve $y = x^2 - 5x + 6$ and the curve $y = 4 - x^2$.	**This may include the example of finding the area between a curve and a given straight line.** Students are expected to integrate (to find areas) using the parametric equations. It is acceptable to convert from parametric to Cartesian form before integrating, but this may lead to much more complicated integrals.
	8.4	Understand and use integration as the limit of a sum.	Recognise $\int_a^b \mathrm{f}(x)\,\mathrm{d}x = \lim_{\delta x \to 0} \sum_{x=a}^{b} \mathrm{f}(x)\,\delta x$	Students may be asked to calculate $\lim_{\delta x \to 0} \sum_{x=a}^{b} \mathrm{f}(x)\,\delta x$ for a given function and they are expected to recognise that this is equal to $\int_a^b \mathrm{f}(x)\,\mathrm{d}x$ for that function.

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
8 **Integration** *continued*	8.5	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.)	Students should recognise integrals of the form $\int \frac{f'(x)}{f(x)} dx = \ln f(x) + c$. The integral $\int \ln x \, dx$ is required	Students are expected to know how to integrate functions such as $\tan kx$, $\cot kx$ and $\sin^3 x \cos x$; they can be thought of as 'function and derivative' or reverse chain rule types where students are expected to think of integration as the opposite of differentiation.
	8.6	Integrate using partial fractions that are linear in the denominator.	Integration of rational expressions such as those arising from partial fractions, e.g. $\frac{2}{3x+5}$ Note that the integration of other rational expressions, such as $\frac{x}{x^2+5}$ and $\frac{2}{(2x-1)^4}$ is also required (see previous paragraph).	

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
8 **Integration** *continued*	8.7	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.)	Students may be asked to sketch members of the family of solution curves.	
	8.8	Interpret the solution of a differential equation in the context of solving a problem, including identifying limitations of the solution; includes links to kinematics.	The validity of the solution for large values should be considered.	

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
9 **Numerical methods**	9.1	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.	Students should know that sign change is appropriate for continuous functions in a small interval. When the interval is too large sign may not change as there may be an even number of roots. If the function is not continuous, sign may change but there may be an asymptote (not a root).	When concluding there is a root, students should state the function is continuous, but they do not need to demonstrate this.
	9.2	Solve equations approximately using simple iterative methods; be able to draw associated cobweb and staircase diagrams.	Understand that many mathematical problems cannot be solved analytically, but numerical methods permit solution to a required level of accuracy. Use an iteration of the form $x_{n+1} = f(x_n)$ to find a root of the equation $x = f(x)$ and show understanding of the convergence in geometrical terms by drawing cobweb and staircase diagrams.	
	9.3	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.	For the Newton-Raphson method, students should understand its working in geometrical terms, so that they understand its failure near to points where the gradient is small.	Students should be aware that when the gradient is zero, the tangent to the curve will not meet the x-axis and therefore the method fails.

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
9 **Numerical methods** *continued*	9.4	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.	For example, evaluate $\int_0^1 \sqrt{\quad x+1)}\ \mathrm{d}x$ using the values of $\sqrt{(2x+\quad}$ at $x=0$, $0.25, 0.5, 0.75$ and 1 and use a sketch on a given graph to determine whether the trapezium rule gives an over-estimate or an under-estimate.	The trapezium rule is the only numerical method of integration required in this specification. Students may be told either the number of strips to use or the width of the strips.
	9.5	Use numerical methods to solve problems in context.	Iterations may be suggested for the solution of equations not soluble by analytic means.	Questions will always state when iterative methods are required.
10 **Vectors**	10.1	**Use vectors in two dimensions** and in three dimensions	**Students should be familiar with column vectors and with the use of i and j unit vectors in two dimensions** and **i, j** and **k** unit vectors in three dimensions.	**Questions may be set in two dimensions** and three dimensions.
	10.2	**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 $\lvert\mathbf{a}\rvert$.**	**Questions may be set in two dimensions** and three dimensions.
	10.3	**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.**	**Questions may be set in two dimensions** and three dimensions.

Topics	What students need to learn:			Content exemplification
	Content		Guidance	
10 **Vectors** *continued*	10.4	**Understand and use position vectors; calculate the distance between two points represented by position vectors.**	$\overrightarrow{OB} - \overrightarrow{OA} = \overrightarrow{AB} = \mathbf{b} - \mathbf{a}$ **The distance d between two points (x_1, y_1) and (x_2, y_2) is given by** $d^2 = (x_1 - x_2)^2 + (y_1 - y_2)^2$ In three dimensions, the distance d between two points (x_1, y_1, z_1) and (x_2, y_2, z_2) is given by $d^2 = (x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2$	**Questions may be set in two dimensions** and three dimensions.
	10.5	**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.** **Contexts such as velocity, displacement, kinematics and forces will be covered in Paper 3, Sections 6.1, 7.3 and 8.1 – 8.4**	**Questions may be set in two dimensions** and three dimensions.

Paper 3: Statistics and Mechanics

All the Pure Mathematics content is assumed knowledge for Paper 3 and may be tested in parts of questions.

To support the co-teaching of this qualification with the AS Mathematics qualification, common content has been highlighted in bold.

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
1 **Statistical sampling**	1.1	**Understand and use the terms 'population' and 'sample'.** **Use samples to make informal inferences about the population.**	**Students will be expected to comment on the advantages and disadvantages associated with a census and a sample.**	
		Understand and use sampling techniques, including simple random sampling and opportunity sampling.	**Students will be expected to be familiar with: simple random sampling, stratified sampling, systematic sampling, quota sampling and opportunity (or convenience) sampling.**	**Students will not be expected to be familiar with any other sampling techniques.** **In systematic sampling where the population is not divisible by the sample size (i.e. $\frac{N}{n}$ is non-integer), the key points are to take a random starting point and a systematic selection thereafter.** **For example, a sample of size 50 from a population of size 498 could be taken by first selecting at random from amongst those members numbered 1 to 8 inclusive and then selecting every 10th member after that.**

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
1 **Statistical sampling** *continued*	1.1 *cont.*	**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 should be aware that different samples could lead to different conclusions.** **For example, if two people each take a sample to test a hypothesis about a population, one sample may lead to a significant result whereas the other sample may not.**
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.**	**Students will not be expected to be familiar with any other diagrams for single-variable data.** **If students are required to draw a cumulative frequency diagram, either a frequency polygon or a curve is acceptable.**
	2.2	**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).**	**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 to make predictions within the range of values of the explanatory variable.** Change of variable may be required, e.g. using knowledge of logarithms to reduce a relationship of the form $y = ax^n$ or $y = kb^x$ into linear form to estimate a and n or k and b.	**Where students are required to interpret a graph or a result, they are expected to comment on values within the context of the question.**

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
2 **Data presentation and interpretation** *continued*	2.2 *cont.*	**Understand informal interpretation of correlation.** **Understand that correlation does not imply causation.**	**Use of terms such as positive, negative, zero, strong and weak are expected.**	**Where students are asked to interpret a correlation, they are expected to give an answer using the context of the question.** **Where students are asked to describe a correlation, they are not expected to give an answer using the context of the question.**
	2.3	**Interpret measures of central tendency and variation, extending to standard deviation.**	**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.**	**For data in a list or a (non-grouped) frequency table, use the following to find the position:** **Q1:** $\frac{n}{4}$ **and** • **round up if a decimal** • $+\,0.5$ **if an integer** **Median:** $\frac{n}{2}$ **and** • **round up if a decimal** • $+\,0.5$ **if an integer** **Q3:** $\frac{3n}{4}$ **and** • **round up if decimal** • $+\,0.5$ **if integer** **This is considered the "main" method. However, other sensible approaches are accepted and, because this is a contentious area, data sets are typically chosen so that all sensible methods give the same answer.**

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
2 **Data presentation and interpretation** *continued*	2.3 *cont.*			**For data in a grouped frequency table, a histogram or cumulative frequency graph:** **Q1: $\frac{n}{4}$ th position** **Median: $\frac{n}{2}$ th position** **Q3: $\frac{3n}{4}$ th position** **(Using linear interpolation if necessary.)** **Grouped data is always regarded as continuous no matter what the nature of the underlying variable may be, so we would usually ask students to "use interpolation to estimate..." in these circumstances. Similarly, a list of individual data values or data in a (non-grouped) frequency table is always regarded as discrete.** **The alternative approach using $\frac{(n+1)}{4}$ etc. will also be allowed.**

Topics	What students need to learn:			
	Content		**Guidance**	**Content exemplification**
2 **Data presentation and interpretation** *continued*	2.3 *cont.*	**Be able to calculate standard deviation, including from summary statistics.**	**Students should be able to use the statistic x** $S_{xx} = \sum(x-\bar{x})^2 = \sum x^2 - \frac{(\sum x)^2}{n}$ **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.**	
	2.4	**Recognise and interpret possible outliers in data sets and statistical diagrams.**	**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 mean** $\pm 3 \times$ **standard deviation.**	
		Select or critique data presentation techniques in the context of a statistical problem.	**Students will be expected to draw simple inferences and give interpretations to measures of central tendency and variation.** Significance tests, other than those mentioned in Section 5, will not be expected.	
		Be able to clean data, including dealing with missing data, errors and outliers.	**For example, students may be asked to identify possible outliers on a box plot or scatter diagram.**	**Students may be asked to consider possible reasons for outliers or missing data. They should also be aware of the possible implications of omitting or including outliers from a data set.**

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
3 **Probability**	3.1	**Understand and use mutually exclusive and independent events when calculating probabilities.**	**Venn diagrams or tree diagrams may be used.** Set notation to describe events may be used. Use of $P(B\|A) = P(B)$, $P(A\|B) = P(A)$, $P(A \cap B) = P(A)\,P(B)$ in connection with independent events.	
		Link to discrete and continuous distributions.	**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.**	
	3.2	Understand and use conditional probability, including the use of tree diagrams, Venn diagrams, two-way tables. Understand and use the conditional probability formula $P(A\|B) = \dfrac{P(A \cap B)}{P(B)}$	Understanding and use of $P(A') = 1 - P(A)$, $P(A \cup B) = P(A) + P(B) - P(A \cap B)$, $P(A \cap B) = P(A)\,P(B \mid A)$.	
	3.3	Modelling with probability, including critiquing assumptions made and the likely effect of more realistic assumptions.	For example, questioning the assumption that a die or coin is fair.	

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
4 **Statistical distributions**	4.1	**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.**	**Students will be expected to use distributions to model a real-world situation and to comment critically on the appropriateness.** **Students should know and be able to identify the discrete uniform distribution.** **The notation $X \sim B(n, p)$ may be used.** **Use of a calculator to find individual or cumulative binomial probabilities.**	**Students are expected to have an understanding of the assumptions required for a binomial distribution to be applicable and be able to comment on these within the context of the question.**
	4.2	Understand and use the Normal distribution as a model; find probabilities using the Normal distribution	The notation $X \sim N(\mu, \sigma^2)$ may be used. Knowledge of the shape and the symmetry of the distribution is required. Knowledge of the probability density function is not required. Derivation of the mean, variance and cumulative distribution function is not required. Questions may involve the solution of simultaneous equations. Students will be expected to use their calculator to find probabilities connected with the normal distribution.	A formal understanding of skewness is not required, but students should be aware that if a distribution is not symmetric it may not be suitable to be modelled by a normal distribution. Students are expected to be able to standardise the Normal distribution. For example, if asked to find σ given that $X \sim N(25, \sigma^2)$ and $P(X > 34) = 0.35$, they would need to standardise and look up or work out the *z*-value corresponding to $P\left(Z < \frac{34-25}{\sigma}\right) = 0.65$ and solve to find σ.

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
4 **Statistical distributions** *continued*	4.2 *cont.*			Students may use either tables or calculators to work out z-values, but they should work to at least the same degree of accuracy as can be achieved using tables. Inverse Normal values can be found using either a calculator or table of values.
		Link to histograms, mean, standard deviation, points of inflection	Students should know that the points of inflection on the normal curve are at $x = \mu \pm \sigma$ The derivation of this result is not expected.	
		and the binomial distribution.	Students should know that when n is large and p is close to 0.5 the distribution $\mathrm{B}(n, p)$ can be approximated by $\mathrm{N}(np, np[1-p])$ The application of a continuity correction is expected.	When asked for a condition for this approximation, students are expected to state "n is large and p is close to 0.5". A response of "$np > 5$ and $nq > 5$" will only be given credit if it is accompanied by a statement that "n should be large". Now that students have calculators that will calculate binomial probabilities, questions may also require students to find the error when using the approximation.
	4.3	Select an appropriate probability distribution for a context, with appropriate reasoning, including recognising when the binomial or Normal model may not be appropriate.	Students should know under what conditions a binomial distribution or a Normal distribution might be a suitable model.	

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
5 **Statistical hypothesis testing**	5.1	**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;**	**An informal appreciation that the expected value of a binomial distribution is given by np may be required for a 2-tail test.**	**There are two possible approaches to finding critical regions: selecting a region where the probability will be less than the significance level (or half of this for a 2-tail test) or selecting a region where the probability is as close as possible to the required significance level. Unless both approaches lead to the same answer, it will be made clear in the question which approach students should use.** **Questions will be worded to give suitable indication as to whether a 1-tail or 2-tail test is required. For example, using phrases such as:** • **evidence of an increase in the proportion (1-tail)** • **evidence of a change in the proportion (2-tail)** **It cannot be assumed that all students have a calculator with the facility to find critical regions and so tables are provided for this purpose. However, where they do have a calculator with this function, students may use it to find the critical region.** **The p-value for a 1-tail test is the probability in the tail of interest. For a 2-tail test that probability is simply doubled. For example, when calculating the appropriate probability for a 2-tailed test using a 5% significance level, you would compare this probability to 2.5% and if you double the probability you get the p-value which should be compared with 5%.**

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
5 **Statistical hypothesis testing** *continued*	5.1 *cont.*			**The language used in the conclusion to hypothesis tests should be non-assertive (e.g. "There is insufficient evidence to reject H_0") and contextual (e.g. "This supports the manager's belief that…").**
		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).	Students should know that the product moment correlation coefficient r satisfies $\lvert r \rvert \le 1$ and that a value of $r = \pm 1$ means the data points all lie on a straight line. Students will be expected to calculate a value of *r* using their calculator but use of the formula is not required. Hypotheses should be stated in terms of ρ with a null hypothesis of $\rho = 0$ where ρ represents the population correlation coefficient. Tables of critical values or a p-value will be given.	Students are expected to be able to find summary statistics using a calculator, so given a table of x and y values they should know how to enter these into their calculator to find the value of r. If p-values are required in connection with testing a correlation coefficient then these would have to be given in the question. However, since students are expected to be able to calculate probabilities connected with a binomial distribution or a normal distribution, then they could be asked to calculate the p-value in these cases.

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
5 **Statistical hypothesis testing** *continued*	5.2	**Conduct a statistical hypothesis test for the proportion in the binomial distribution and interpret the results in context.**		**Hypothesis tests can be answered using either a probability approach or by finding the critical region.** **If finding the critical region is required, it will be possible to use the table of values to do this.** **If finding the critical region has not been specified, then it may not be possible using the table of values, but the question can still be answered in this way by students who have access to these values using a calculator.**
		Understand that a sample is being used to make an inference about the population.	**Hypotheses should be expressed in terms of the population parameter p**	
		and		
		appreciate that the significance level is the probability of incorrectly rejecting the null hypothesis.	**A formal understanding of Type I errors is not expected.**	

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
5 **Statistical hypothesis testing** *continued*	5.3	Conduct a statistical hypothesis test for the mean of a Normal distribution with known, given or assumed variance and interpret the results in context.	Students should know that: If $X \sim \mathrm{N}(\mu, \sigma^2)$ then $\overline{X} \sim \mathrm{N}\left(\mu, \frac{\sigma^2}{n}\right)$ and that a test for μ can be carried out using: $\frac{\overline{X} - \mu}{\sigma / \sqrt{n}} \sim \mathrm{N}(0, 1^2)$. No proofs required. Hypotheses should be stated in terms of the population mean μ. Knowledge of the Central Limit Theorem or other large sample approximations is not required.	
6 **Quantities and units in mechanics**	6.1	**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**.**	**Students may be required to convert one unit into another e.g. km h^{-1} into m s^{-1}**	Students should appreciate that there are equivalent units; for example, N s and kg m s^{-1} for impulse (or momentum).

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
7 **Kinematics**	7.1	**Understand and use the language of kinematics: position; displacement; distance travelled; velocity; speed; acceleration.**	**Students should know that distance and speed must be positive.**	**Students should know the difference between distance and displacement.**
	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.**	**Graphical solutions to problems may be required.**	**Speed–time graphs may also be required.**
	7.3	**Understand, use and derive the formulae for constant acceleration for motion in a straight line.** Extend to 2 dimensions using vectors.	**Derivation may use knowledge of sections 7.2 and/or 7.4** Understand and use *suvat* formulae for constant acceleration in 2-D, e.g. $\mathbf{v} = \mathbf{u} + \mathbf{a}t$, $\mathbf{r} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$ with vectors given in $\mathbf{i} - \mathbf{j}$ or column vector form. Use vectors to solve problems.	**Problems involving vertical motion under gravity could be set.**

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
7 **Kinematics** *continued*	7.4	**Use calculus in kinematics for motion in a straight line:** $$v=\frac{\mathrm{d}r}{\mathrm{d}t},\ a=\frac{\mathrm{d}v}{\mathrm{d}t}=\frac{\mathrm{d}^2r}{\mathrm{d}t^2}$$ $$r=\int v\ \mathrm{d}t,\ v=\int a\ \mathrm{d}t$$ Extend to 2 dimensions using vectors.	**The level of calculus required will be consistent with that in Sections 7 and 8 in the Pure Mathematics content.** Differentiation and integration of a vector with respect to time. e.g. Given $\mathbf{r}=t^2\mathbf{i}+t^{\frac{3}{2}}\mathbf{j}$, find $\dot{\mathbf{r}}$ and $\ddot{\mathbf{r}}$ at a given time.	**For example, given the distance of a particle P, which is moving in a straight line, from a point O at time t, find when:** **(a) P is at rest,** **(b) P stops accelerating.** For example, given the position vector of a particle, $\mathbf{r}$, at time t, find the time when it is moving in a given direction.
	7.5	Model motion under gravity in a vertical plane using vectors; projectiles.	Derivation of formulae for time of flight, range and greatest height and the derivation of the equation of the path of a projectile may be required.	Students may be required to use the equation of the path, for example to determine the required projection angle(s) to hit a given target using a given projection speed. Students should be aware of the modelling assumptions being made when modelling motion under gravity.

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
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);** extend to situations where forces need to be resolved (restricted to 2 dimensions).	**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.** **Problems may 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.** Extend to problems where forces need to be resolved, e.g. a particle moving on an inclined plane.	**For example, find the magnitude of the acceleration when the forces are given as vectors.** For example, find the acceleration of a particle moving on an inclined plane.
8 **Forces and Newton's laws** *continued*	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 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.)**	**The default value of g will be $9.8\ \mathrm{m\,s^{-2}}$ but some questions may specify another value, e.g. $g = 10\ \mathrm{m\,s^{-2}}$**	

Topics	What students need to learn:			
	Content		Guidance	Content exemplification
	8.4	**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 2-D vectors); application to problems involving smooth pulleys and connected particles;** resolving forces in 2 dimensions; equilibrium of a particle under coplanar forces.	**Connected particle problems could include problems with particles in contact e.g. lift problems.** Problems may be set where forces need to be resolved, e.g. at least one of the particles is moving on an inclined plane.	**For example, problems involving particles connected by a string which passes over a pulley, where either, both particles are moving vertically, or one is moving vertically and the other is moving horizontally. Students may be required to find the magnitude and direction of the force acting on the pulley.** **Students should be aware of the modelling assumptions, and the reasons why they are made, when considering pulley systems. For example, a light and inextensible string, a smooth and light pulley.** For example, problems involving particles connected by a string which passes over a pulley, where at least one of the particles is moving on an inclined plane.
8 **Forces and Newton's laws** *continued*	8.5	Understand and use addition of forces; resultant forces; dynamics for motion in a plane.	Students may be required to resolve a vector into two components or use a vector diagram, e.g. problems involving two or more forces, given in magnitude-direction form.	For example, finding the magnitude and direction of the resultant of two or more forces which are given in magnitude–direction form.
	8.6	Understand and use the $\mathrm{F} \le \mu R$ model for friction; coefficient of friction; motion of a body on a rough surface; limiting friction and statics.	An understanding of $\mathrm{F} = \mu R$ when a particle is moving. An understanding of $\mathrm{F} \le \mu R$ in a situation of equilibrium.	Students should know the difference between reaction and normal reaction and when they are different. Problems may be set involving a particle in limiting equilibrium.

Topics	What students need to learn:			Content exemplification
	Content		Guidance	
9 **Moments**	9.1	Understand and use moments in simple static contexts.	Equilibrium of rigid bodies. Problems involving parallel and non-parallel coplanar forces, e.g. ladder problems.	Examples may include situations where students are required to calculate an unknown force or an unknown coefficient of friction. Problems may include: • a ladder with one end on rough ground leaning against a rough wall • a rod with one end on rough ground and resting against a rough cylinder or a peg.

For information about Pearson Qualifications, including Pearson Edexcel, BTEC and LCCI qualifications visit qualifications.pearson.com

Edexcel and BTEC are registered trademarks of Pearson Education Limited

Pearson Education Limited. Registered in England and Wales No. 872828
Registered Office: 80 Strand, London WC2R 0RL

VAT Reg No GB 278 537121

Pearson
Edexcel