Learning Journey: Year 12 Maths

Teacher 1	Teacher 2
Ch 3: Quadratic Functions	Ch 2: Surds & Indices
Ch 4: Equations & Inequalities	Ch 9: The Binomial Expansion
Ch 5: Coordinate Geometry	Ch 6: Trigonometry
Ch 10: Differentiation	Ch 7: Polynomials
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Chapter 1: Problem Solving	
Understand the problem solving cycle	
Know that simplifying a problem can help you to begin problem solving	
Use algebra to formulate and solve problems	
Write your mathematics using appropriate language and symbols • Necessary and sufficient • If… and then … • $\Leftrightarrow$, $\Leftarrow$, $\Rightarrow$ and $\therefore$ • Converse of a statement	
Prove statements by deduction	
Prove statements by exhaustion	
Disprove statements by finding a counter-example	
Interpret your solution in the context pf the problem	
Generalise your solution to extend your understanding of a wider problem	

Specification: OCR Mathematics B (MEI) H640

Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
PURE MATHEMATICS: PROOF (1)					
Proof	Mp1	Understand and be able to use the structure of mathematical proof. Use methods of proof, including proof by deduction and proof by exhaustion.	Proceeding from given assumptions through a series of logical steps to a conclusion.		
	p2	Be able to disprove a conjecture by the use of a counter example.			

Mathematical Notation

Set Notation	
$\in$	is an element of
$\notin$	is not an element of
$\subseteq$	is a subset of
$\subset$	is a proper subset of
$\{x_1, x_2, \ldots\}$	the set with elements $x_1, x_2, \ldots$
$\{x : \ldots\}$	the set of all x such that …
$\mathrm{n}(A)$	the number of elements in set A
$\varnothing$	the empty set
ε	the universal set
A'	the complement of the set A
$\mathbb{N}$	the set of natural numbers, $\{1, 2, 3, \ldots\}$
$\mathbb{Z}$	the set of integers, $\{0, \pm1, \pm2, 3, \ldots\}$
$\mathbb{Z}^+$	the set of positive integers, $\{1, 2, 3, \ldots\}$
$\mathbb{Z}_0^+$	the set of non-negative integers, $\{0, 1, 2, 3, \ldots\}$
$\mathbb{R}$	the set of real numbers
$\mathbb{Q}$	the set of rational numbers, $\left\{\frac{p}{q} : p \in \mathbb{Z}, q \in \mathbb{Z}^+\right\}$
$\cup$	union
$\cap$	intersection
(x, y)	the ordered pair x, y
$[a, b]$	the closed interval $\{x \in \mathbb{R} : a \le x \le b\}$
$[a, b)$	the interval $\{x \in \mathbb{R} : a \le x < b\}$
$(a, b]$	the interval $\{x \in \mathbb{R} : a < x \le b\}$
(a, b)	the open interval $\{x \in \mathbb{R} : a < x < b\}$

Miscellaneous Symbols	
$=$	is equal to
$\neq$	is not equal to
$\equiv$	is identical to or is congruent to
$\approx$	is approximately equal to
∞	infinity
$\propto$	is proportional to
$\therefore$	therefore
$\because$	because
$<$	is less than
$\leqslant, \le$	is less than or equal to, is not greater than
$>$	is greater than
$\geqslant, \ge$	is greater than or equal to, is not less than
$p \Rightarrow q$	p implies q (if p then q)
$p \Leftarrow q$	p is implied by q (if q then p)
$p \Leftrightarrow q$	p implies and is implied by q (p is equivalent to q)

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Chapter 2: Surds & Indices	
Simplify surds of single numbers	
Simplify surd expressions requiring addition and subtraction	
Simplify surd expressions requiring multiplying out brackets	
Simplify fractions with a surd as a denominator	
Simplify fractions with an expression including a surd in the denominator	
Rationalise the denominator of an expression	
Use the laws of indices to simplify expressions	
Understand the use of fractional indices for roots	
Understand the use of negative indices for reciprocals	

Formulas to learn

Laws of Indices

$$a^x a^y = a^{x+y}$$

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

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

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Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
Surds Indices	a10	Be able to use and manipulate surds.			
	a11	Be able to rationalise the denominator of a surd.	e.g. $\frac{1}{5+\sqrt{3}} = \frac{5-\sqrt{3}}{22}$		
	a12	Understand and be able to use the laws of indices for all rational exponents.	$x^a \times x^b = x^{a+b}, x^a \div x^b = x^{a-b}, (x^a)^n = x^{an}$		
	a13	Understand and be able to use negative, fractional and zero indices.	$x^{-a} = \frac{1}{x^a}, x^0 = 1\,(x \neq 0), x^{\frac{1}{a}} = \sqrt[a]{x}$		

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Chapter 3: Quadratic Functions	
Draw and sketch quadratic graphs	
Factorise quadratic expressions	
Solve quadratic equations by factorising	
Solve quadratic equations by using the quadratic formula $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$	
Solve quadratic equations by completing the square	
Use completed square form to find the vertex and line of symmetry of a quadratic graph	
Use the discriminant $b^2 - 4ac$ to investigate roots of a quadratic equation	
Use quadratic equations in problem solving	

Formulas to Learn

Quadratic Equations

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

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Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
	C3	Understand and be able to use the method of completing the square to find the line of symmetry and turning point of the graph of a quadratic function and to sketch a quadratic curve (parabola).	The curve $y = a(x+p)^2 + q$ has • a minimum at $(-p, \ q)$ for $a > 0$ or a maximum at $(-p, \ q)$ for $a < 0$ • a line of symmetry $x = -p$.		

Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
	Ma2	Be able to solve quadratic equations.	By factorising, completing the square, using the formula and graphically. Includes quadratic equations in a function of the unknown.		
	a3	Be able to find the discriminant of a quadratic function and understand its significance.	The condition for distinct real roots of $ax^2 + bx + c = 0$ is: Discriminant > 0. The condition for repeated roots is: Discriminant $= 0$. The condition for no real roots is: Discriminant < 0.	For $ax^2 + bx + c = 0$ the discriminant is $b^2 - 4ac$.	Complex roots.

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Chapter 4: Equations and Inequalities	
Change the subject of a formula and be able to rearrange an equation	
Solve linear simultaneous equations using substitution or elimination	
Solve simultaneous equations where one is quadratic and the other linear	
Solve linear inequalities and illustrate the solution graphically	
Solve quadratic inequalities	
Represent inequalities such as $y < ax + b$ or $y > ax^2 + bx + cy$ graphically	
Use set notation ∪ for union (or) and ∩ for intersection (and)	

Mathematical notation

$\{x_1, x_2, \ldots\}$	the set with elements x_1, x_2, …
$\{x : \ldots\}$	the set of all x such that …
$\cup$	union
$\cap$	intersection
$<$	is less than
$\leqslant, \le$	is less than or equal to, is not greater than
$>$	is greater than
$\geqslant, \ge$	is greater than or equal to, is not less than

Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
Solution of equations	*	Be able to solve linear equations in one unknown.	Including those containing brackets, fractions and the unknown on both sides of the equation.		
	*	Be able to change the subject of a formula.	Including cases where the new subject appears on both sides of the original formula, and cases involving squares, square roots and reciprocals.		
	a4	Be able to solve linear simultaneous equations in two unknowns.	By elimination and by substitution.		
	a5	Be able to solve simultaneous equations in two unknowns with one equation linear and one quadratic.	By elimination and by substitution.		
Inequalities	Ma7	Be able to solve linear inequalities in one variable. Be able to represent and interpret linear inequalities graphically e.g. $y > x + 1$.	Including those containing brackets and fractions.		
	a8	Be able to solve quadratic inequalities in one variable. Be able to represent and interpret quadratic inequalities graphically e.g. $y > ax^2 + bx + c$.	Algebraic and graphical treatment of solution of quadratic inequalities. For regions defined by inequalities learners must state clearly which regions are included and whether the boundaries are included. No particular shading convention is expected.		Complex roots
	a9	Be able to express solutions of inequalities through correct use of 'and' and 'or', or by using set notation.	Learners will be expected to express solutions to quadratic inequalities in an appropriate version of one of the following ways. • $x \le 1$ or $x \ge 4$ • $\{x : x \le 1\} \cup \{x : ax \ge 4\}$ • $2 < x < 5$ • $x < 5$ and $x > 2$ • $\{x : x < 5\} \cap \{x : x > 2\}$	$\{x : x > 4\}$	

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Chapter 5: Coordinate Geometry	
Solve problems involving finding the midpoint of two points $\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right)$	
Solve problems involving finding the distance between two points $\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$	
Understand gradient as the rate of change and find the gradient of a line joining two points $\frac{y_2-y_1}{x_2-x_1}$	
Recall and use relationships between gradients for parallel and perpendicular lines	
Draw or sketch a line, given its equation	
Find the equation of a line	
Solve real life problems that can be modelled by a linear function	
Solve problems with parallel and perpendicular lines	
Find the intersection of two lines	
Find the centre and radius of a circle from its equation in the form $(x-a)^2+(y-b)^2 = r^2$	
Find the centre and radius of a circle from its equation when the equation needs to be rewritten in completed square form	
Find the equation of a circle given the radius and centre	
Find the equation of a circle using circle theorems to find centre and radius	
Find the equation of a tangent to a circle using circle theorems	
Find the points of intersection of a line and a curve	
Understand the significance of a repeated root in the case of a line which is a tangent to the curve	
Understand the significance of having no roots in the case of a line which does not intersect the curve	
Find the intersection points of curves in simple cases	

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Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
PURE MATHEMATICS: COORDINATE GEOMETRY (1)					
The coordinate geometry of straight lines	*	Understand and use the equation $y = mx + c$.			
	Mg1	Know and be able to use the relationship between the gradients of parallel lines and perpendicular lines.	For parallel lines $m_1 = m_2$. For perpendicular lines $m_1 m_2 = -1$.		
	g2	Be able to calculate the distance between two points.			
	g3	Be able to find the coordinates of the midpoint of a line segment joining two points.			
	g4	Be able to form the equation of a straight line.	Including $y - y_1 = m(x - x_1)$ and $ax + by + c = 0$		
	g5	Be able to draw a line given its equation.	By using gradient and intercept or intercepts with axes as well as by plotting points.		
	g6	Be able to find the point of intersection of two lines.	By solution of simultaneous equations.		
	g7	Be able to use straight line models.	In a variety of contexts; includes considering the assumptions that lead to a straight line model.		

Equations of straight lines

Many learners taking A Level Mathematics will be familiar with the equation of a straight line in the form $y = mx + c$. Their understanding at A Level should extend to different forms of the equation of a straight line including $y - y_1 = m(x - x_1)$, $ax + by + c = 0$ and $\frac{y - y_1}{y_2 - y_1} = \frac{x - x_1}{x_2 - x_1}$.

Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
PURE MATHEMATICS: COORDINATE GEOMETRY (1)					
The coordinate geometry of curves	Mg8	Be able to find the point(s) of intersection of a line and a curve or of two curves.			
	g9	Be able to find the point(s) of intersection of a line and a circle.			
	g10	Understand and use the equation of a circle in the form $(x - a)^2 + (y - b)^2 = r^2$.	Includes completing the square to find the centre and radius.		
	g11	Know and be able to use the following properties: • the angle in a semicircle is a right angle; • the perpendicular from the centre of a circle 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.	These results may be used in the context of coordinate geometry.		

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Chapter 6: Trigonometry	
Right-angled trigonometry	
Know and use exact values for sin, cos, tan of 0, 30, 45, 60 and 90 (sin/cos only)	
Use exact values in surd questions	
Recall the graphs of sin, cos and tan and be able to sketch them	
Use identities $\sin^2\theta + \cos^2\theta = 1$ and $\tan\theta = \frac{\sin\theta}{\cos\theta}$ to solve equations	
Solve trigonometric equations giving all the solutions in a given range	
Use the sine rule $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$ to find an unknown side or angle, including the cases where there are 2 possible values	
Use the cosine rule $a^2 = b^2 + c^2 - 2bc\cos A$ to find an unknown side and angle	
Use the formula that the area of a triangle is $\frac{1}{2}ab\sin C$	

Formulas to Learn

Trigonometry

In the triangle ABC

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

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

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

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

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Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
Basic trigonometry	*	Know how to solve right-angled triangles using trigonometry.			
Trig. functions	Mt1	Be able to use the definitions of $\sin\theta$, $\cos\theta$ and $\tan\theta$ for any angle.	By reference to the unit circle, $\sin\theta = y,\ \cos\theta = x,\ \tan\theta = \dfrac{y}{x}$.		
	t2	Know and use the graphs of $\sin\theta$, $\cos\theta$ and $\tan\theta$ for all values of θ, their symmetries and periodicities.	Stretches, translations and reflections of these graphs. Combinations of these transformations.	Period.	
	*	Know and be able to use the exact values of $\sin\theta$ and $\cos\theta$ for $\theta = 0°, 30°, 45°, 60°$ and $90°$ and the exact value of $\tan\theta$ for $\theta = 0°, 30°, 45°$ and $60°$.			
Area of triangle; sine and cosine rules	t3	Know and be able to use the fact that the area of a triangle is given by $\frac{1}{2}ab\sin C$.			
	t4	Know and be able to use the sine and cosine rules.	Use of bearings may be required.		
Identities	t5	Understand and be able to use $\tan\theta = \dfrac{\sin\theta}{\cos\theta}$.	e.g. solve $\sin\theta = 3\cos\theta$ for $0° \le \theta \le 360°$.		
	t6	Understand and be able to use the identity $\sin^2\theta + \cos^2\theta = 1$.	e.g. solve $\sin^2\theta = \cos\theta$ for $0° \le \theta \le 360°$.		
Equations	t7	Be able to solve simple trigonometric equations in given intervals and know the principal values from the inverse trigonometric functions.	e.g. $\sin\theta = 0.5$, in $[0°, 360°]$ $\Leftrightarrow \theta = 30°, 150°$ Includes equations involving multiples of the unknown angle e.g. $\sin 2\theta = 3\cos 2\theta$. Includes quadratic equations.	$\arcsin x$ $\sin^{-1}x$ $\arccos x$ $\cos^{-1}x$ $\arctan x$ $\tan^{-1}x$	General solutions.

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Chapter 7: Polynomials	
Understand the terms polynomial and its order	
Add and subtract polynomials	
Multiply polynomials by expanding brackets	
Understand the points where the graph crosses the axes in a graph of a polynomial	
Understand turning points in a graph of a polynomial	
Understand the behaviour for large values of x in a graph of a polynomial	
Sketch a polynomial from its factorised form	
Divide a polynomial by a linear expression	
Use the factor theorem to identify factors of a polynomial	
Solve polynomial equations by factorising	
Use the factor theorem to find unknown coefficients in an expression given a factor	

Formulas to Learn

Factor Theorem

$\mathrm{f}(a)=0 \Leftrightarrow (x-a)$ is a factor of $\mathrm{f}(x)$.

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Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
Polynomials	Mf1	Be able to add, subtract, multiply and divide polynomials.	Expanding brackets and collecting like terms.		Division by non-linear expressions.
	f2	Understand the factor theorem and be able to use it to factorise a polynomial or to determine its zeros.	$f(a)=0 \Leftrightarrow (x-a)$ is a factor of $f(x)$. Including when solving a polynomial equation.		Equations of degree > 4.

Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
Graphs	MC1	Understand and use graphs of functions.			
Sketching curves	C2	Understand how to find intersection points of a curve with coordinate axes.	Including relating this to the solution of an equation.		
	C4	Be able to sketch and interpret the graphs of simple functions including polynomials.	Including cases of repeated roots for polynomials.		
	C5	Be able to use stationary points when curve sketching.	Including distinguishing between maximum and minimum turning points.		

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Chapter 8: Graphs and Transformations	
Understand and use function notation	
Recognise and sketch reciprocal graphs of $y = \frac{a}{x}$ and $y = \frac{a}{x^2}$	
Understand asymptotes	
Understand direct, inverse and other proportion	
Sketch the image of any graph after a reflection in the axes	
Sketch the image of any graph after a translation	
Sketch the image of any graph after a stretch	
Link changes in the equations of graphs to the transformations they produce	
Write the equation of a transformed graph	
Sketch the transformed graph from its equation	
Use completed square form to translate quadratic graphs	
Sketch transformations of trigonometric graphs	
Understand the change to the period and maximum/minimum values of a trigonometric graph	

Rules to Learn

$y = f(x) + a$ is a translation of $y = f(x)$ by $\binom{0}{a}$

$y = f(x - a)$ is a translation of $y = f(x)$ by $\binom{a}{0}$

$y = af(x)$ is a stretch of $y = f(x)$ by scale factor a parallel to the $y - axis$

$y = f(ax)$ is a stretch of $y = f(x)$ by scale factor $\frac{1}{a}$ parallel to the $x - axis$

$y = -f(x)$ is a reflection of $y = f(x)$ in the $x - axis$

$y = f(-x)$ is a reflection of $y = f(x)$ in the $y - axis$

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Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
PURE MATHEMATICS: GRAPHS (1)					
Graphs	MC1	Understand and use graphs of functions.			
	C6	Be able to sketch and interpret the graphs of $y=\frac{a}{x}$ and $y=\frac{a}{x^2}$.	Including their vertical and horizontal asymptotes and recognising them as graphs of proportional relationships.		

Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
PURE MATHEMATICS: GRAPHS (1)					
Transformations	MC7	Be able to sketch curves of the forms $y=af(x)$, $y=f(x)+a$, $y=f(x+a)$ and $y=f(ax)$, given the curve of $y=f(x)$ and describe the associated transformations. Be able to form the equation of a graph following a single transformation.	Including working with sketches of graphs where functions are not defined algebraically.	Map(s) onto. Translation, stretch, reflection	
	t2	Know and use the graphs of $\sin\theta$, $\cos\theta$ and $\tan\theta$ for all values of θ, their symmetries and periodicities.	Stretches, translations and reflections of these graphs. Combinations of these transformations.	Period.	

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Chapter 9: Binomial Expansion	
Use the binomial expansion to expand brackets to a positive integer power using Pascal's triangle	
Use the binomial expansion to expand brackets to a positive integer power using binomial coefficients	
Use the beginning of a binomial expansion to give an approximation	
Understand how binomial coefficients are related to solving problems involving selections: permutations where the order is important	
Understand how binomial coefficients are related to solving problems involving selections: combinations where the order is not important	

Formula Sheet Extract

Binomial series

$$(a+b)^n = a^n + {}^nC_1 a^{n-1}b + {}^nC_2 a^{n-2}b^2 + \ldots + {}^nC_r a^{n-r}b^r + \ldots + b^n \qquad (n \in \mathbb{N}),$$

$$\text{where } {}^nC_r = {}_nC_r = \binom{n}{r} = \frac{n!}{r!(n-r)!}$$

$$(1+x)^n = 1 + nx + \frac{n(n-1)}{2!}x^2 + \ldots + \frac{n(n-1)\ldots(n-r+1)}{r!}x^r + \ldots \quad (|x| < 1,\ n \in \mathbb{R})$$

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Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
PURE MATHEMATICS: SEQUENCES AND SERIES (1)					
Binomial expansions	Ms1	Understand and use the binomial expansion of $(a+bx)^n$ where n is a positive integer.			
	s2	Know the notations $n!$ and ${}_nC_r$ and that ${}_nC_r$ is the number of ways of selecting r distinct objects from n.	The meaning of the term factorial. n a positive integer. Link to binomial probabilities.	${}_nC_r = \frac{n!}{r!(n-r)!}$ $n! = 1.2.3...n$ ${}_nC_0 = {}_nC_n = 1$ $0! = 1$ ${}^nC_r, \binom{n}{r}$	${}_nC_r$ will only be used in the context of binomial expansions and binomial probabilities.

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Ch 3: Quadratic Functions	Ch 2: Surds & Indices
Ch 4: Equations & Inequalities	Ch 9: The Binomial Expansion
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Personalised Learning Checklist (PLC): Year 12 Maths

Chapter 10: Differentiation	
Understand that the gradient of a curve at a point is the gradient of the tangent at that point	
Understand that the gradient of the tangent can be found as the limit of a sequence of gradients of chords of decreasing length by looking at data on a table or spreadsheet	
Understand that the gradient of the tangent can be found from first principles using $f'(x) = \lim_{h\to\infty}\left(\frac{f(x+h)-f(x)}{h}\right)$	
Differentiate polynomial functions to find the gradient function using $\frac{dy}{dx}$ notation, $f'(x)$ notation and using variables other than y and x	
Differentiate functions that need first to be rewritten as polynomials	
Use the gradient function to find the gradient at a given point	
Find the equation of a tangent at a given point	
Find the equation of a normal at a given point	
Use $\frac{dy}{dx}$ to investigate increasing and decreasing functions	
Use $\frac{dy}{dx}$ to find turning points	
Distinguish maximum and minimum points by looking at the gradient either side of the turning point and by looking at $\frac{d^2y}{dx^2}$	
Sketch gradient functions	
Differentiate functions involving fractional or negative powers	
Use differentiation to solve practical problems involving maximum and minimum values	

Formula Sheet Extract

Differentiation from first principles

$$f'(x) = \lim_{h\to 0}\frac{f(x+h)-f(x)}{h}$$

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Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
PURE MATHEMATICS: CALCULUS (1)					
Basic differentiation	Mc1	Know and use that the gradient of a curve at a point is given by the gradient of the tangent at the point.			
	c2	Know and use that the gradient of the tangent at a point A on a curve is given by the limit of the gradient of chord AP as P approaches A along the curve.			The modulus function.
	c3	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). Know that the gradient function $\frac{\mathrm{d}y}{\mathrm{d}x}$ gives the gradient of the curve and measures the rate of change of y with respect to x.	Be able to deduce the units of rate of change for graphs modelling real situations. The term derivative of a function.	$\frac{\mathrm{d}y}{\mathrm{d}x} = \operatorname*{Lim}_{\delta x \to 0} \frac{\delta y}{\delta x}$ $\mathrm{f}'(x) = \operatorname*{Lim}_{h \to 0}\left(\frac{\mathrm{f}(x+h) - \mathrm{f}(x)}{h}\right)$	
	c4	Be able to sketch the gradient function for a given curve.			
Differentiation of functions	c5	Be able to differentiate $y = kx^n$ where k is a constant and n is rational, including related sums and differences.	Differentiation from first principles for small positive integer powers.		
Applications of differentiation to functions and graphs	c6	Understand and use the second derivative as the rate of change of gradient.		$\mathrm{f}''(x) = \frac{\mathrm{d}^2 y}{\mathrm{d}x^2}$	
	c7	Be able to use differentiation to find stationary points on a curve: maxima and minima.	Distinguish between maximum and minimum turning points.		
	c8	Understand the terms increasing function and decreasing function and be able to find where the function is increasing or decreasing.	In relation to the sign of $\frac{\mathrm{d}y}{\mathrm{d}x}$.		
	c9	Be able to find the equation of the tangent and normal at a point on a curve.			

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Chapter 11: Integration	
Understand integration as the reverse of differentiation	
Understand that indefinite integration involves an arbitrary constant	
Use standard results to integrate polynomials	
Use additional information in the question to find the value for the arbitrary constant	
Integrate functions that need first to be rewritten as the sum of powers of x	
Use the gradient function and one point on a curve to find the equation of a curve	
Evaluate definite integrals	
Use definite integration to find the area between a curve and the x-axis	
Understand that area below the axis is negative	
Find the total area of a region which is partly above and partly below the axis	
Integrate using negative or fractional powers of x (not -1)	
Solve problems, including using rectangles to estimate the area below a curve	

Formulas to Learn

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 $= \int_a^b y\,dx\ (y \geq 0)$

Differentiation

Function	Derivative
x^n	nx^{n-1}
$f(x)+g(x)$	$f'(x)+g'(x)$

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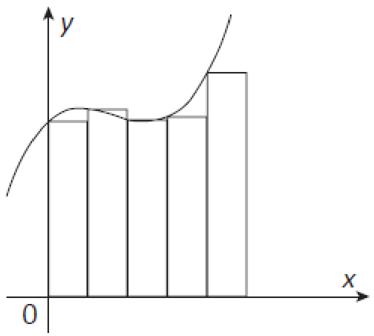
Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
PURE MATHEMATICS: CALCULUS (1)					
Integration as reverse of differentiation	Mc19	Know that integration is the reverse of differentiation.	Fundamental Theorem of Calculus.		
	c20	Be able to integrate functions of the form kx^n where k is a constant and $n \neq -1$.	Including related sums and differences.		
	c21	Be able to find a constant of integration given relevant information.	e.g. Find y as a function of x given that $\frac{dy}{dx} = x^2 + 2$ and $y = 7$ when $x = 1$.		
Integration to find area under a curve	c22	Know what is meant by indefinite and definite integrals. Be able to evaluate definite integrals.	e.g. $\int_1^3 (3x^2 + 5x - 1)\,dx$.		
	c23	Be able to use integration to find the area between a graph and the x-axis.	Includes areas of regions partly above and partly below the x-axis. General understanding that the area under a graph can be found as the limit of a sum of areas of rectangles.		Formal understanding of the continuity conditions required for the Fundamental Theorem of Calculus.

The Fundamental Theorem of Calculus



One way to define the integral of a function is as follows.

The area under the graph of the function is approximately the sum of the areas of narrow rectangles (as shown). The limit of this sum as the rectangles become narrower (and there are more of them) is the integral. The fundamental theorem of calculus says that this is the same as doing the reverse of differentiation.

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Chapter 12: Vectors	
Understand the terms vector and scalar	
Understand vectors in two dimensions, and express them in magnitude-direction form, using i and j vectors, column vectors and arrow notation	
Convert from component form to magnitude-direction form and vice-versa	
Understand equal vectors	
Understand the link between the coordinates of a point and its position vector	
Multiply a vector by a scalar	
Add and subtract vectors	
Find a unit vector in the direction of a given vector by dividing the components by the magnitude of the vector	
Understand when vectors are parallel	
Use vectors in geometry problems	

Mathematical Notation

Vectors	
$\mathbf{a}$, $\underline{a}$, $\underset{\sim}{a}$	the vector $\mathbf{a}$, $\underline{a}$, $\underset{\sim}{a}$; these alternatives apply throughout section 9
$\overrightarrow{AB}$	the vector represented in magnitude and direction by the directed line segment AB
$\hat{\mathbf{a}}$	a unit vector in the direction of $\mathbf{a}$
$\mathbf{i}$, $\mathbf{j}$, $\mathbf{k}$	unit vectors in the directions of the cartesian coordinate axes
$\lvert \mathbf{a} \rvert$, a	the magnitude of $\mathbf{a}$
$\lvert \overrightarrow{AB} \rvert$, AB	the magnitude of $\overrightarrow{AB}$
$\begin{pmatrix} a \\ b \end{pmatrix}$, $a\mathbf{i} + b\mathbf{j}$	column vector and corresponding unit vector notation

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Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
PURE MATHEMATICS: VECTORS (1)					
General vectors	Mv1	Understand the language of vectors in two dimensions.	Scalar, vector, modulus, magnitude, direction, position vector, unit vector, cartesian components, equal vectors, parallel vectors, collinear.	Vectors printed in **bold**. Unit vectors $\mathbf{i}$, $\mathbf{j}$, $\hat{\mathbf{r}}$ The magnitude of the vector $\mathbf{a}$ is written $\|\mathbf{a}\|$ or a. $\mathbf{a} = \begin{pmatrix} a_1 \\ a_2 \end{pmatrix}$	
	v2	Be able to add and subtract vectors using a diagram or algebraically, multiply a vector by a scalar, and express a vector as a combination of others.	Geometrical interpretation. Includes general vectors not expressed in component form.		
	v3	Be able to calculate the magnitude and direction of a vector and convert between component form and magnitude-direction form.		Magnitude-direction	
Position vectors	v4	Understand and use position vectors.	Including interpreting components of a position vector as the cartesian coordinates of the point. $\overrightarrow{AB} = \mathbf{b} - \mathbf{a}$	$\overrightarrow{OB}$ or $\mathbf{b}$. $\mathbf{r} = \begin{pmatrix} x \\ y \end{pmatrix}$	
	v5	Be able to calculate the distance between two points represented by position vectors.			
Using vectors	v6	Be able to use vectors to solve problems in pure mathematics and in context, including problems involving forces.	Includes interpreting the sum of vectors representing forces as the resultant force.		

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Chapter 13: Exponentials & Logarithms	
Understand the terms exponential growth and exponential decay	
Sketch graphs of exponential functions, showing where the graph crosses the axes and the horizontal asymptote	
Use exponential models for real life situations	
Understand that the logarithm function is the inverse of the exponential function	
Use the laws of logarithms to rewrite combinations of logs as the log of a single expression	
Use the laws of logarithms to split up a single log into a combination of logs	
Sketch the graphs of logarithmic functions	
Use logarithms to solve equations and inequalities with an unknown power	
Rewrite log statements as exponential statements and vice versa	
Use the number e and the exponential function in context	
Sketch the transformation of the graph of $y = e^x$	
Differentiate $y = e^{kx}$ y and use $\frac{dy}{dx}$ in problems	
Know that the gradient of $y = e^{kx}$ is $y = ke^{kx}$	
Solve problems and sketch graphs involving exponentials.	
Understand and use the natural logarithm function $y = ln\, x$	
Solve problems and sketch graphs involving logarithms	
Model curves by plotting $ln\, y$ against $ln\, x$ for curves of the form $y = kx^n$ using the gradient and intercept of the new graph to find the values of k and n	
Model curves by plotting $ln\, y$ against x for curves of the form $y = ka^x$ using the gradient and intercept of the new graph to find the values of k and a	

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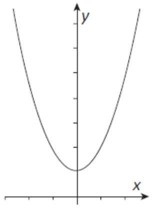
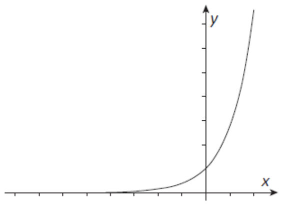
Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
PURE MATHEMATICS: EXPONENTIALS AND LOGARITHMS (1)					
Exponentials and Logarithms	ME1	Know and use the function $y = a^x$ and its graph.	For $a > 0$.		
	E2	Be able to convert from an index to a logarithmic form and vice versa.	$x = a^y \Leftrightarrow y = \log_a x$ for $a > 0$ and $x > 0$.		
	E3	Understand a logarithm as the inverse of the appropriate exponential function and be able to sketch the graphs of exponential and logarithmic functions.	$y = \log_a x \Leftrightarrow a^y = x$ for $a > 0$ and $x > 0$. Includes finding and interpreting asymptotes.		
	E4	Understand the laws of logarithms and be able to apply them, including to taking logarithms of both sides of an equation.	$\log_a(xy) = \log_a x + \log_a y$ $\log_a\left(\frac{x}{y}\right) = \log_a x - \log_a y$ $\log_a(x^k) = k\log_a x$ Including, for example $k = -1$ and $k = -\frac{1}{2}$		Change of base of logarithms.
	E5	Know and use the values of $\log_a a$ and $\log_a 1$.	$\log_a a = 1$, $\log_a 1 = 0$		
	E6	Be able to solve an equation of the form $a^x = b$.	Includes solving related inequalities.		
	E7	Know how to reduce the equations $y = ax^n$ and $y = ab^x$ to linear form and, using experimental data, to use a graph to estimate values of the parameters.	By taking logarithms of both sides and comparing with the equation $y = mx + c$. Learners may be given graphs and asked to select an appropriate model.		
Exponentials and natural logarithms	ME8	Know and be able to use the function $y = e^x$ and its graph.			
	E9	Know that the gradient of e^{kx} is ke^{kx} and hence understand why the exponential model is suitable in many applications.			
	E10	Know and be able to use the function $y = \ln x$ and its graph. Know the relationship between $\ln x$ and e^x.	$\ln x$ is the inverse function of e^x.	$\log_e x = \ln x$	
Exponential growth and decay	E11	Be able to solve problems involving exponential growth and decay; be able to consider limitations and refinements of exponential growth and decay models.	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. Finding long term values.		

Graphs with gradient proportional to one of the coordinates

$\frac{dy}{dx} \propto x$ results in a quadratic graph.



$\frac{dy}{dx} \propto y$ results in an exponential graph.



Formulas to Learn

Laws of Logarithms

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

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

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

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

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Chapter 14: Data Collection	
Understand the problem solving cycle in statistics	
Know how to clean a data set by dealing with outliers and errors	
Understand and use the terms: population, census, sample, outlier, sampling frame, sampling fraction, bias, sample error, random variable, parameter	
Understand sampling techniques and know their advantages and disadvantages: • simple random sample • stratified sample and proportional stratified sample • cluster sampling • systematic sampling • quota sampling • opportunity sampling • self-selecting sample	
Calculate the numbers from each group in a stratified sample	

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Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
STATISTICS: SAMPLING (1)					
Population and sample	Mp21	Understand and use the terms population and sample.			
	p22	Be able to use samples to make informal inferences about a population, recognising that different samples might lead to different conclusions.	e.g. using sample mean or variance as an estimate of population mean or variance.		
Sampling techniques	p23	Understand and be able to use the concept of random sampling.	Simple random sampling. Every sample of the required size has the same probability of being selected.		
	p24	Understand and be able to use a variety of sampling techniques.	Opportunity sampling, systematic sampling, stratified sampling, quota sampling, cluster sampling, self-selected samples. Any other techniques will be explained in the question.		
	p25	Be able to select or evaluate sampling techniques in the context of solving a statistical problem.	Includes recognising possible sources of bias and being aware of the practicalities of implementation.		

Population and sample

Population in statistics means all the individuals we are interested in for a particular investigation e.g. all cod in an area of the sea. A population can be infinite e.g. all possible tosses of a particular coin. A probability distribution can be used to model some characteristic of the population which is of interest e.g a Normal distribution could be used to model lengths of cod.

A **sample** is a set of items chosen from a population. When sampling from an infinite population it does not matter whether the sampling is with or without replacement. When taking a sample of individuals, e.g. for a sample survey, it is usual to sample without replacement to avoid getting data from the same individual more than once.

	D14	Be able to clean data including dealing with missing data, errors and outliers.			

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Chapter 15: Data Processing, Presentation & Interpretation	
Process and represent data collected in order to solve a problem	
Recognise different types of data • categorical • ranked • numerical (both discrete and continuous) • bivariate	
Work with grouped and ungrouped data	
Select, use and interpret data displays appropriate to the type of data and context • bar charts, dot plots, pie charts, pictograms • stem and leaf, box and whisker plots, vertical line charts • frequency charts, histograms • cumulative frequency curves	
Scatter diagrams and lines of best fit (concept of regression line but no calculations)	
Select, use and interpret summary measures appropriate to the type of data and context • modal class • mean, mode, median, mid-range, weighted mean • range, interquartile range, semi-interquartile range • standard deviation and variance	
Correlation coefficients	
Identify outliers	
Calculate standard deviation (single, frequency, grouped) • using a calculator • using summary statistics	

Formula Sheet Extract

Sample Variance

$$s^2 = \frac{1}{n-1}S_{xx} \text{ where } S_{xx} = \Sigma(x_i - \bar{x})^2 = \Sigma x_i^2 - \frac{(\Sigma x_i)^2}{n} = \Sigma x_i^2 - n\bar{x}^2$$

Standard deviation, $s = \sqrt{\text{variance}}$

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Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
STATISTICS: DATA PRESENTATION AND INTERPRETATION (1)					
Data presentation for single variable	MD1	Be able to recognise and work with categorical, discrete, continuous and ranked data. Be able to interpret standard diagrams for grouped and ungrouped single-variable data.	Includes knowing this vocabulary and deciding what data presentation methods are appropriate: bar chart, dot plot, histogram, vertical line chart, pie chart, stem-and-leaf diagram, box-and-whisker diagram (box plot), frequency chart. Learners may be asked to add to diagrams in examinations in order to interpret data.	A frequency chart resembles a histogram with equal width bars but its vertical axis is frequency. A dot plot is similar to a bar chart but with stacks of dots in lines to represent frequency.	Comparative pie charts with area proportional to frequency.
	D2	Understand that the area of each bar in a histogram is proportional to frequency. Be able to calculate proportions from a histogram and understand them in terms of estimated probabilities.	Includes use of area scale and calculation of frequency from frequency density.		
	D3	Be able to interpret a cumulative frequency diagram.			
	D4	Be able to describe frequency distributions.	Symmetrical, unimodal, bimodal, skewed (positively and negatively).		Measures of skewness.
Data presentation	MD5	Understand that diagrams representing unbiased samples become more representative of theoretical probability distributions with increasing sample size.	e.g. A bar chart representing the proportion of heads and tails when a fair coin is tossed tends to have the proportion of heads increasingly close to 50% as the sample size increases.		
	D6	Be able to interpret a scatter diagram for bivariate data, interpret a regression line or other best fit model, including interpolation and extrapolation, understanding that extrapolation might not be justified.	Including the terms association, correlation, regression line. Leaners should be able to interpret other best fit models produced by software (e.g. a curve). Learners may be asked to add to diagrams in examinations in order to interpret data.		Calculation of equation of regression line from data or summary statistics.
	D7	Be able to recognise when a scatter diagram appears to show distinct sections in the population. Be able to recognise and comment on outliers in a scatter diagram.	An outlier is an item which is inconsistent with the rest of the data. Outliers in scatter diagrams should be judged by eye.		
	D8	Be able to recognise and describe correlation in a scatter diagram and understand that correlation does not imply causation.	Positive correlation, negative correlation, no correlation, weak/strong correlation.		
	D9	Be able to select or critique data presentation techniques in the context of a statistical problem.	Including graphs for time series.		
Bivariate data, association and correlation					
Bivariate data consists of two variables for each member of the population or sample. An **association** between the two variables is some kind of relationship between them. **Correlation** measures linear relationships. At A Level, learners are expected to judge relationships from scatter diagrams by eye and may be asked to interpret given correlation coefficients – see MAH10.					

Statistical Notation

μ	population mean
σ^2	population variance
σ	population standard deviation
$\bar{x}$	sample mean
s^2	sample variance
s	sample standard deviation

Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
STATISTICS: DATA PRESENTATION AND INTERPRETATION (1)					
Summary measures	MD10	Know the standard measures of central tendency and be able to calculate and interpret them and to decide when it is most appropriate to use one of them.	Median, mode, (arithmetic) mean, midrange. The main focus of questions will be on interpretation rather than calculation. Includes understanding when it is appropriate to use a weighted mean e.g. when using populations as weights.	Mean = $\bar{x}$	
	D11	Know simple measures of spread and be able to use and interpret them appropriately.	Range, percentiles, quartiles, interquartile range.		

Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
STATISTICS: DATA PRESENTATION AND INTERPRETATION (1)					
Summary measures	MD12	Know how to calculate and interpret variance and standard deviation for raw data, frequency distributions, grouped frequency distributions. Be able to use the statistical functions of a calculator to find mean and standard deviation.	sample variance: $s^2 = \frac{S_{xx}}{n-1}$ (†) where $S_{xx} = \sum_{i=1}^{n}(x_i - \bar{x})^2$ sample standard deviation: $s = \sqrt{\text{variance}}$ (‡)	s^2 s	Corrections for class interval in these calculations.
	D13	Understand the term outlier and be able to identify outliers. Know that the term outlier can be applied to an item of data which is: • at least 2 standard deviations from the mean; OR • at least $1.5 \times \text{IQR}$ beyond the nearer quartile.	An outlier is an item which is inconsistent with the rest of the data.		
	D14	Be able to clean data including dealing with missing data, errors and outliers.			

Notation for sample variance and sample standard deviation

The notations s^2 and s for sample variance and sample standard deviation, respectively, are written into both British Standards (BS3534-1, 2006) and International Standards (ISO 3534). The definitions are those given above in equations (†) and (‡). The calculations are carried out using divisor $(n-1)$.

In this specification, the usage will be consistent with these definitions. Thus the meanings of 'sample variance', denoted by s^2, and 'sample standard deviation', denoted by s, are defined to be calculated with divisor $(n-1)$.

In early work in statistics it is common practice to introduce these concepts with divisor n rather than $(n-1)$. However there is no recognised notation to denote the quantities so derived.

Students should be aware of the variations in notation used by manufacturers on calculators and know what the symbols on their particular models represent.

Calculating correlation

Learners are expected to use technology to work with real data, including the pre-release data. Calculators, spreadsheets and other software will calculate correlation coefficients. Learners may be asked to interpret such correlation coefficients in the examination. The following points should be noted:

- A correlation coefficient measures the strength of a linear relationship. A correlation between the ranks of the data values may be used for a more general relationship.
- Correlation coefficients will only be used for data where both variables are random (not, for example, for time series data where one variable occurs at set intervals).
- Outliers or distinct sections of data in the scatter diagram can affect the value of the correlation coefficient.

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Chapter 16: Probability	
Measure probability using the number of ways an event can happen and the number of equally likely outcomes	
Estimate probability using a number of trials	
Interpret probabilities of 0 and 1	
Find the probability of the complement of an event $P(A') = 1 - P(A)$	
Calculate expected frequency using np	
Use set notation and Venn diagrams in probability problems	
Understand the term mutually exclusive	
Know that the sum of probabilities of mutually exclusive events is 1	
Use $P(A \cup B) = P(A) + P(B)$ for mutually exclusive events	
Use $P(A \cup B) = P(A) + P(B) - P(A \cap B)$ for non-mutually exclusive events	
Use a sample space diagram to solve probability problems with two events	
Use a tree diagram to solve probability problems with two events	
Understand independent and dependent events and use $P(A \cap B) = P(A) \times P(B)$	
Understand risk notation as '1 in …'	
Work with simple probability distributions	
Understand the terms random variables and expectation	
Know the mean is also called the expectation and $E(x) = \sum(x \times P(X = x))$	

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Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
STATISTICS: PROBABILITY (1)					
Probability of events in a finite sample space	*	Be able to calculate the probability of an event.	Using modelling assumptions such as equally likely outcomes.	$\mathrm{P}(A)$	
	*	Understand the concept of a complementary event and know that the probability of an event may be found by means of finding that of its complementary event.		A' is the event "not-A".	
Probability of two or more events	*	Be able to calculate the expected frequency of an event given its probability.		Expected frequency $= n\mathrm{P}(A)$	
	*	Be able to use appropriate diagrams to assist in the calculation of probabilities.	E.g. tree diagrams, sample space diagrams, Venn diagrams.		
	Mu1	Understand and use mutually exclusive events and independent events.			
	u2	Know to add probabilities for mutually exclusive events.	E.g. to find $\mathrm{P}(A \text{ or } B)$.		
	u3	Know to multiply probabilities for independent events.	E.g. to find $\mathrm{P}(A \text{ and } B)$. Including the use of complementary events, e.g. finding the probability of at least one 6 in five throws of a dice.		

Learning Journey: Year 12 Maths

Teacher 1	Teacher 2
Ch 3: Quadratic Functions	Ch 2: Surds & Indices
Ch 4: Equations & Inequalities	Ch 9: The Binomial Expansion
Ch 5: Coordinate Geometry	Ch 6: Trigonometry
Ch 10: Differentiation	Ch 7: Polynomials
Ch 11: Integration	Ch 8: Graphs & Transformations
Ch 13: Exponentials & Logarithms	Ch 1: Problem Solving
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Ch 15: Data Processing	Ch 19: Kinematics
Ch 16: Probability	Ch 20: Forces & Newton's Laws
Ch 17: Binomial Distribution	Ch 21: Variable Acceleration
Ch 18: Hypothesis Testing	

Personalised Learning Checklist (PLC): Year 12 Maths

Chapter 17: Binomial Distribution	
Recognise a situation which gives a random variable which can be modelled by a binomial distribution: • you are conducting trials on random samples of size n • there are two possible outcomes, referred to as success and failure • both outcomes have fixed probabilities p and q, where $p + q = 1$	
Know that for the binomial distribution to be a good model, these assumptions are needed: • the outcome of each trial is independent of the outcome of any other trial • the probability of success is the same on each trial	
Know the notation used for the binomial distribution $B(n, p)$	
Use the formula $P(X = r) = {}^nC_r\, p^r q^{n-r}$ to calculate the probability of r successes	
Know that for binomial distribution, the expected number of successes is $E(X) = np$	
Calculate the number of trials needed to give the probability of at least one success	

Formula Sheet Extract

The Binomial Distribution

If $X \sim B(n, p)$ then $P(X = r) = {}^nC_r p^r q^{n-r}$ where $q = 1 - p$

Mean of X is np

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Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
STATISTICS: PROBABILITY DISTRIBUTIONS (1)					
Situations leading to a binomial distribution	MR1	Recognise situations which give rise to a binomial distribution.			
	R2	Be able to identify the probability of success, p, for the binomial distribution.	The binomial distribution as a model for observed data.	$\mathrm{B}(n, p)$, $q = 1 - p$ ~ means 'has the distribution'.	
Calculations relating to binomial distribution	R3	Be able to calculate probabilities using the binomial distribution.	Including use of calculator functions.		
Mean and expected frequencies for binomial distribution	R4	Understand and use mean $= np$.			Derivation of mean $= np$
	R5	Be able to calculate expected frequencies associated with the binomial distribution.			
Discrete probability distributions	R6	Be able to use probability functions, given algebraically or in tables. Know the term discrete random variable.	Restricted to simple finite distributions.	X for the random variable. x or r for a value of the random variable.	
	R7	Be able to calculate the numerical probabilities for a simple distribution. Understand the term discrete uniform distribution.	Restricted to simple finite distributions.	$\mathrm{P}(X = x)$ $\mathrm{P}(X \le x)$	Calculation of $\mathrm{E}(X)$ or $\mathrm{Var}(X)$.

Situations which give rise to a binomial distribution

- An experiment or trial is conducted a fixed number of times.
- There are exactly 2 outcomes, which can be thought of as "success" or "failure".
- The probability of "success" is the same each time.
- The probability of "success" on any trial is independent of what has happened in previous trials.
- The random variable of interest is "the number of successes".

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- Ch 18: Hypothesis Testing

Teacher 2

- Ch 2: Surds & Indices
- Ch 9: The Binomial Expansion
- Ch 6: Trigonometry
- Ch 7: Polynomials
- Ch 8: Graphs & Transformations
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- Ch 19: Kinematics
- Ch 20: Forces & Newton's Laws
- Ch 21: Variable Acceleration

Personalised Learning Checklist (PLC): Year 12 Maths

Chapter 18: Hypothesis Testing using Binomial Distribution	
Perform a hypothesis test by • Defining a null hypothesis H_0 (the default position that nothing special has occurred) • Choosing an alternative hypothesis H_1 (that there has been a change in position) • Choosing a significance level (the level at which you say there is enough evidence to reject the null hypothesis) • Calculating the p-value, the probability of the outcome of the test or a more extreme value • Comparing the p-value with the significance level • Stating the conclusion of the test	
Use a calculator or cumulative probability tables to find $P(X \le r)$ for $X \sim B(n, p)$	
Understand and use the terms critical values, critical region and acceptance region in hypothesis testing	
Recognise a situation which gives a 2-tailed hypothesis test and perform the test as above	
Know that the significance level is the probability of incorrectly rejecting the null hypothesis (ie rejecting H_0 when it is actually correct)	

Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
STATISTICS: STATISTICAL HYPOTHESIS TESTING (1)					
Hypothesis testing	MH1	Understand the process of hypothesis testing and the associated language.	Null hypothesis, alternative hypothesis. Significance level, test statistic, 1-tail test, 2-tail test. Critical value, critical region (rejection region), acceptance region, p-value.		
	H2	Understand when to apply 1- tail and 2- tail tests.			
	H3	Understand that a sample is being used to make an inference about the population and appreciate that the significance level is the probability of incorrectly rejecting the null hypothesis.	For a binomial hypothesis test, the probability of the test statistic being in the rejection region will always be less than or equal to the intended significance level of the test, and will usually be less than the significance level of the test. Learners will not be tested on this distinction. If asked to give the probability of incorrectly rejecting the null hypothesis for a particular binomial test, either the intended significance level or the probability of the test statistic being in the rejection region will be acceptable.		
Null and alternative hypotheses					
The null hypothesis for a hypothesis test is the default position which will only be rejected in favour of the alternative hypothesis if the evidence is strong enough. Assuming the null hypothesis is true, as a default position, allows the calculation of values of the test statistic which would be unlikely (have low probability) if the null hypothesis were true; this is the critical region (rejection region).					

Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
STATISTICS: STATISTICAL HYPOTHESIS TESTING (1)					
Hypothesis testing for a binomial probability p	H4	Be able to identify null and alternative hypotheses (H_0 and H_1) when setting up a hypothesis test based on a binomial probability model.	H_0 of form $p =$ a particular value, with p a probability for the whole population.	H_0, H_1	
	H5	Be able to conduct a hypothesis test at a given level of significance. Be able to draw a correct conclusion from the results of a hypothesis test based on a binomial probability model and interpret the results in context.			Normal approximation.
	H6	Be able to identify the critical and acceptance regions.			

Conclusion from a hypothesis test
Learners are expected to make non-assertive conclusions in context. E.g. “There is not enough evidence to conclude that the proportion of... has increased.” E.g. “There is enough evidence to indicate that the probability of ..... has changed.” E.g. “There is insufficient evidence to indicate that the true mean of ..... is lower than......” E.g. “There is sufficient evidence to suggest that there is positive correlation between..... and .....” E.g. “There is not sufficient evidence to suggest that there is association between ... and ....”

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Chapter 19: Kinematics	
Understand and use the terms: distance, displacement, position, speed, velocity, acceleration	
Understand and use the SI units for these quantities	
Know that displacement, position, velocity and acceleration are vector quantities with magnitude and direction	
Know that distance, speed and time are scalar quantities with magnitude only	
Calculate average speed by dividing total distance by total time taken	
Calculate average velocity by dividing displacement by time taken	
Calculate average acceleration by dividing the change in velocity by time taken	
Draw and interpret distance-time and displacement-time graphs • Use the gradient to find speed and velocity	
Draw and interpret speed-time and velocity-time graphs • Use the gradient to find acceleration • Use the area under the graph to find distance and displacement • Use the area below the axis for negative displacement	
Recall and use the constant acceleration equations (suvat) and use them in problem solving	
Solve problems for vertical motion under gravity using g • Using $u = 0$ (the object is dropped) • Using $v = 0$ (the highest point) • Using $s = 0$ (the object returns to its original position)	
Use simultaneous equations with the suvat equations to solve problems with two unknowns	
Deal with problems with a non-zero initial displacement	
Understand and use the idea of a mathematical model • Make simplifying assumptions • Define variables and set up the equations • Solve the equations to predict the outcome • Compare the model with the actual outcome and if necessary, think again	

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Formula Sheet Extract

Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
MECHANICS: MODELS AND QUANTITIES (1)					
Units and quantities	p33	Understand and use fundamental quantities and units in the S.I. system: length, time, mass.	Metre (m), second (s), kilogram (kg).		
	p34	Understand and use derived quantities and units: velocity, acceleration, force, weight.	Metre per second ($m\ s^{-1}$), metre per second per second ($m\ s^{-2}$), newton (N).		

Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
MECHANICS: KINEMATICS IN 1 DIMENSION (1)					
Motion in 1 dimension	Mk1	Understand and use the language of kinematics.	Position, displacement, distance travelled; speed, velocity; acceleration, magnitude of acceleration; relative velocity (in 1-dimension). Average speed = distance travelled ÷ elapsed time Average velocity = overall displacement ÷ elapsed time		
	k2	Know the difference between position, displacement, distance and distance travelled.			
	k3	Know the difference between velocity and speed, and between acceleration and magnitude of acceleration.			
Kinematics graphs	k4	Be able to draw and interpret kinematics graphs for motion in a straight line, knowing the significance (where appropriate) of their gradients and the areas underneath them.	Position-time, displacement-time, distance-time, velocity-time, speed-time, acceleration-time.		
Constant acceleration formulae	k7	Be able to recognise when the use of constant acceleration formulae is appropriate.	Learners should be able to derive the formulae.	$s = ut + \frac{1}{2}at^2$ $s = vt - \frac{1}{2}at^2$ $v = u + at$ $s = \frac{1}{2}(u+v)t$ $v^2 - u^2 = 2as$	
Problem solving	k8	Be able to solve kinematics problems using constant acceleration formulae and calculus for motion in a straight line.			

Kinematics

Motion in a straight line

$v = u + at$

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

$s = \frac{1}{2}(u+v)t$

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

$s = vt - \frac{1}{2}at^2$

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Chapter 20: Forces and Newton's Laws of Motion	
Draw and label force diagrams	
Understand and use the terms • Resultant Force • Equilibrium • Centre of mass • Friction • Smooth • Normal reaction	
Understand and use different types of force • Driving force • Braking force • Resistance • Tension • Thrust or compression	
Understand and use Newton's three laws of motion	
Understand and use the connection between mass and weight ($W = mg$)	
Form and solve equations of motion of connected particles • Where the objects are in equilibrium • Where both objects travel in the same direction • Where the objects are connected via a pulley and move in different directions • By looking at the system as a whole and by looking at each of the particles separately	
Understand the modelling assumptions needed for the model used in a problem	
Solve problems which combine information about forces and information about travel using acceleration to link two aspects	

Formulas to Learn

Forces and Equilibrium

Weight $=$ mass $\times\, g$

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

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Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
MECHANICS: MODELS AND QUANTITIES (1)					
Standard models in mechanics	Mp31	Know the language used to describe simplifying assumptions in mechanics.	Including the words: light; smooth; uniform; particle; inextensible; thin; rigid; long term.		
	p32	Understand and use the particle model.			

Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
MECHANICS: FORCES (1)					
Identifying and representing forces	MF1	Understand the language relating to forces.	Weight, tension, thrust or compression, normal reaction (or normal contact force), frictional force, resistance, driving force. Understand that the value of the normal reaction depends on the other forces acting. Understand that there may be frictional force when the surface is not smooth (i.e. is rough).		
	F2	Know that the acceleration due to gravity is not a universal constant but depends on location in the universe. Know that on earth, the acceleration due to gravity is often modelled to be a constant, g m s^{-2}.	$g \approx 10$, $g \approx 9.8$ Unless otherwise specified, in examinations the value of g should be taken to be 9.8.	Acceleration due to gravity, g m s^{-2}.	Inverse square law for gravitation.
	F3	Be able to identify the forces acting on a system and represent them in a force diagram. Understand the difference between external and internal forces and be able to identify the forces acting on part of the system.			
Vector treatment of forces	F4	Be able to find the resultant of several concurrent forces when the forces are parallel or in two perpendicular directions or in simple cases of forces given as 2-D vectors in component form.			
	F5	Understand the concept of equilibrium and know that a particle is in equilibrium if and only if the vector sum of the forces acting on it is zero in the cases where the forces are parallel or in two perpendicular directions or in simple cases of forces given as 2-D vectors in component form.			
Acceleration due to gravity					
The acceleration due to gravity (g m s^{-2}) varies on earth between 9.76 and 9.83. It depends on latitude and height above sea level. The standard acceleration due to gravity is internationally agreed to be 9.80665; this value is stored in some calculators.					

Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
MECHANICS: NEWTON'S LAWS OF MOTION (1)					
Newton's laws for a particle	Mn1	Know and understand the meaning of Newton's three laws.	Includes applying the laws to problems.		
	n2	Understand the term equation of motion.			
	n3	Be able to formulate the equation of motion for a particle moving in a straight line when the forces acting are parallel or in two perpendicular directions or in simple cases of forces given as 2-D vectors in component form.	Including motion under gravity.	$F = ma$ where F is the resultant force. $\mathbf{F} = m\mathbf{a}$ where $\mathbf{F}$ is the resultant force.	Variable mass.
Connected particles	n4	Be able to model a system as a set of connected particles.	e.g. simple smooth pulley systems, trains. Internal and external forces for the system.		
	n5	Be able to formulate the equations of motion for the individual particles within the system.			
	n6	Know that a system in which none of its components have any relative motion may be modelled as a single particle with the mass of the system.	e.g. Train.		

Newton's laws of motion
I An object continues in a state of rest or uniform motion in a straight line unless it is acted on by a resultant force.
II A resultant force $\mathbf{F}$ acting on an object of fixed mass m gives the object an acceleration $\mathbf{a}$ given by $\mathbf{F} = m\mathbf{a}$.
III When one object exerts a force on another, there is always a reaction which is equal in magnitude and opposite in direction to the acting force.

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Chapter 21: Variable Acceleration	
Sketch displacement-time graphs and velocity-time graphs where the acceleration is not constant	
Differentiate an expression in t for displacement s to obtain an expression for acceleration a	
Differentiate an expression in t for velocity v to obtain an expression for acceleration a	
Integrate an expression in t for velocity to obtain an expression for displacement • using the additional information in the question to obtain a value for the constant of integration • or using limits of integration	
Integrate an expression in t for acceleration to obtain an expression for velocity • using the additional information in the question to obtain a value for the constant of integration • or using limits of integration	
Solve problems where the motion has variable acceleration	

Formulas to Learn

Kinematics

For motion in a straight line with variable acceleration:

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

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

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Specification	Ref.	Learning outcomes	Notes	Notation	Exclusions
MECHANICS: KINEMATICS IN 1 DIMENSION (1)					
Calculus in kinematics	k5	Be able to differentiate position and velocity with respect to time and know what measures result.		$v = \frac{dr}{dt}, a = \frac{dv}{dt} = \frac{d^2r}{dt^2}$	
	k6	Be able to integrate acceleration and velocity with respect to time and know what measures result.		$r = \int v \, dt, v = \int a \, dt$	

Mechanics Notation

Mechanics	
kg	kilograms
m	metres
km	kilometres
m/s, m s^{-1}	metres per second (velocity)
m/s^2, m s^{-2}	metres per second per second (acceleration)
F	Force or resultant force
N	newton
N m	newton metre (moment of a force)
t	time
s	displacement
u	initial velocity
v	velocity or final velocity
a	acceleration
g	acceleration due to gravity
μ	coefficient of friction