## 2f. Detailed Content of A Level Mathematics A (H240)

### 1 – Pure Mathematics

When this course is being co-taught with AS Level Mathematics A (H230) the 'Stage 1' column indicates the common content between the two specifications and the 'Stage 2' column indicates content which is particular to this specification.

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
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| **1.01 Proof** | | | | |
| 1.01a<br>1.01d | Proof | a) Understand and be able to use the structure of mathematical proof, proceeding from given assumptions through a series of logical steps to a conclusion.<br>*In particular, learners should use methods of proof including proof by deduction and proof by exhaustion.* | d) Understand and be able to use proof by contradiction.<br>*In particular, learners should understand a proof of the irrationality of* $\sqrt{2}$ *and the infinity of primes.*<br>*Questions requiring proof by contradiction will be set on content with which the learner is expected to be familiar e.g. through study of GCSE (9–1), AS or A Level Mathematics.* | MA1 |
| 1.01b | | b) Understand and be able to use the logical connectives $\equiv$, $\Rightarrow$, $\Leftrightarrow$.<br>*Learners should be familiar with the language associated with the logical connectives: "congruence", "if..... then" and "if and only if" (or "iff").* | | |
| 1.01c | | c) Be able to show disproof by counter example.<br>*Learners should understand that this means that, given a statement of the form "if* $P(x)$ *is true then* $Q(x)$ *is true", finding a single* $x$ *for which* $P(x)$ *is true but* $Q(x)$ *is false is to offer a disproof by counter example.*<br>*Questions requiring proof will be set on content with which the learner is expected to be familiar e.g. through study of GCSE (9–1) or AS Level Mathematics.*<br>*Learners are expected to understand and be able to use terms such as "integer", "real", "rational" and "irrational".* | | |

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| **1.02 Algebra and Functions** | | | | |
| 1.02a | Indices | a) Understand and be able to use the laws of indices for all rational exponents.<br>*Includes negative and zero indices.*<br>*Problems may involve the application of more than one of the following laws:*<br>$x^a \times x^b = x^{a+b}, x^a \div x^b = x^{a-b}, (x^a)^b = x^{ab}$<br>$x^{-a} = \frac{1}{x^a}, \quad x^{\frac{m}{n}} = \sqrt[n]{x^m}, \quad x^0 = 1.$ | | MB1 |
| 1.02b | Surds | b) Be able to use and manipulate surds, including rationalising the denominator.<br>*Learners should understand and use the equivalence of surd and index notation.* | | MB2 |
| 1.02c | Simultaneous equations | c) Be able to solve simultaneous equations in two variables by elimination and by substitution, including one linear and one quadratic equation.<br>*The equations may contain brackets and/or fractions.*<br>*e.g.*<br>$y = 4 - 3x$ *and* $y = x^2 + 2x - 2$<br>$2xy + y^2 = 4$ *and* $2x + 3y = 9$ | | MB4 |

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| 1.02d | Quadratic functions | d) Be able to work with quadratic functions and their graphs, and the discriminant (*D* or $\Delta$) of a quadratic function, including the conditions for real and repeated roots.<br>*i.e. Use the conditions:*<br>*1.* $b^2 - 4ac > 0 \Rightarrow$ *real distinct roots*<br>*2.* $b^2 - 4ac = 0 \Rightarrow$ *repeated roots*<br>*3.* $b^2 - 4ac < 0 \Rightarrow$ *roots are not real*<br>*to determine the number and nature of the roots of a quadratic equation and relate the results to a graph of the quadratic function.* | | MB3 |
| 1.02e | | e) Be able to complete the square of the quadratic polynomial $ax^2 + bx + c$.<br>*e.g. Writing* $y = ax^2 + bx + c$ *in the form* $y = a(x+p)^2 + q$ *in order to find the line of symmetry* $x = -p$*, the turning point* $(-p,\ q)$ *and to determine the nature of the roots of the equation* $ax^2 + bx + c = 0$ *for example* $2(x+3)^2 + 4 = 0$ *has no real roots because* $4 > 0$. | | |
| 1.02f | | f) Be able to solve quadratic equations including quadratic equations in a function of the unknown.<br>*e.g.* $x^4 - 5x^2 + 6 = 0$, $x^{\frac{2}{3}} - 5x^{\frac{1}{3}} + 4 = 0$ *or* $\dfrac{5}{(2x-1)^2} - \dfrac{10}{2x-1} = 1$. | | |

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| 1.02g | Inequalities | g) Be able to solve linear and quadratic inequalities in a single variable and interpret such inequalities graphically, including inequalities with brackets and fractions.<br>*e.g.* $10 < 3x + 1 < 16$, $(2x+5)(x+3) > 0$.<br>[*Quadratic equations with complex roots are excluded*.] | | MB5 |
| 1.02h | | h) Be able to express solutions through correct use of 'and' and 'or', or through set notation.<br>*Familiarity is expected with the correct use of set notation for intervals, e.g.*<br>$\{x : x > 3\}$,<br>$\{x : -2 \le x \le 4\}$,<br>$\{x : x > 3\} \cup \{x : -2 \le x \le 4\}$,<br>$\{x : x > 3\} \cap \{x : -2 \le x \le 4\}$,<br>$\varnothing$.<br>*Familiarity is expected with interval notation, e.g.*<br>$(2, 3)$, $[2, 3)$ *and* $[2, \infty)$. | | |
| 1.02i | | i) Be able to represent linear and quadratic inequalities such as $y > x + 1$ and $y > ax^2 + bx + c$ graphically. | | |

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| 1.02j<br>1.02k | Polynomials | j) Be able to manipulate polynomials algebraically.<br>*Includes expanding brackets, collecting like terms, factorising, simple algebraic division and use of the factor theorem.*<br>*Learners should be familiar with the terms "quadratic", "cubic" and "parabola".*<br>*Learners should be familiar with the factor theorem as:*<br>*1.* $\mathrm{f}(a)=0 \Leftrightarrow (x-a)$ *is a factor of* $\mathrm{f}(x)$;<br>*2.* $\mathrm{f}(\frac{b}{a})=0 \Leftrightarrow (ax-b)$ *is a factor of* $\mathrm{f}(x)$.<br>*They should be able to use the factor theorem to find a linear factor of a polynomial normally of degree* $\leq 3$. *They may also be required to find factors of a polynomial, using any valid method, e.g. by inspection.* | k) Be able to simplify rational expressions.<br>*Includes factorising and cancelling, and algebraic division by linear expressions.*<br>*e.g. Rational expressions may be of the form*<br>$\frac{x^3-x-2}{2x+1}$ *or* $\frac{(x^2-x-6)(x^2+4x+3)}{(x^2-9)(x+3)}$.<br>*Learners should be able to divide a polynomial of degree* $\geq 2$ *by a linear polynomial of the form* $(ax-b)$*, identify the quotient and remainder and solve equations of degree* $\leq 4$.<br>*The use of the factor theorem and algebraic division may be required.* | MB6 |
| 1.02l | The modulus function | | l) Understand and be able to use the modulus function, including the notation $\|x\|$, and use relations such as $\|a\|=\|b\| \Leftrightarrow a^2=b^2$ and $\|x-a\|<b \Leftrightarrow a-b<x<a+b$ in the course of solving equations and inequalities.<br>*e.g. Solve* $\|x+2\| \leq \|2x-1\|$. | MB7 |

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| 1.02m<br>1.02s<br><br>1.02n<br><br>1.02t<br><br>1.02o<br><br>1.02p<br><br>1.02q<br><br>1.02r | Curve sketching | m) Understand and be able to use graphs of functions.<br>*The difference between plotting and sketching a curve should be known. See Section 2b.*<br>n) Be able to sketch curves defined by simple equations including polynomials.<br>*e.g. Familiarity is expected with sketching a polynomial of degree* $\le 4$ *in factorised form, including repeated roots.*<br>*Sketches may require the determination of stationary points and, where applicable, distinguishing between them.*<br>o) Be able to sketch curves defined by $y=\frac{a}{x}$ and $y=\frac{a}{x^2}$ (including their vertical and horizontal asymptotes).<br>p) Be able to interpret the algebraic solution of equations graphically.<br>q) Be able to use intersection points of graphs to solve equations.<br>*Intersection points may be between two curves one or more of which may be a polynomial, a trigonometric, an exponential or a reciprocal graph.*<br>r) Understand and be able to use proportional relationships and their graphs.<br>*i.e. Understand and use different proportional relationships and relate them to linear, reciprocal or other graphs of variation.* | s) Be able to sketch the graph of the modulus of a linear function involving a single modulus sign.<br>*i.e. Given the graph of* $y=ax+b$ *sketch the graph of* $y=\lvert ax+b\rvert$.<br>[*Graphs of the modulus of other functions are excluded.*]<br>t) Be able to solve graphically simple equations and inequalities involving the modulus function. | MB7 |

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| 1.02u<br><br>1.02v | Functions | *Within Stage 1, learners should understand and be able to apply functions and function notation in an informal sense in the context of the factor theorem (1.02j), transformations of graphs (1.02w), differentiation (Section 1.07) and the Fundamental Theorem of Calculus (1.08a).* | u) Understand and be able to use the definition of a function.<br>*The vocabulary and associated notation is expected i.e. the terms many-one, one-many, one-one, mapping, image, range, domain.*<br>*Includes knowing that a function is a mapping from the domain to the range such that for each $x$ in the domain, there is a unique $y$ in the range with $\mathrm{f}(x) = y$. The range is the set of all possible values of $\mathrm{f}(x)$; learners are expected to use set notation where appropriate.*<br>v) Understand and be able to use inverse functions and their graphs, and composite functions. Know the condition for the inverse function to exist and be able to find the inverse of a function either graphically, by reflection in the line $y = x$, or algebraically.<br>*The vocabulary and associated notation is expected*<br>*e.g.* $\mathrm{gf}(x) = \mathrm{g}(\mathrm{f}(x))$, $\mathrm{f}^2(x)$, $\mathrm{f}^{-1}(x)$. | MB8<br>OT1.1<br>OT1.4 |
| 1.02w<br>1.02x | Graph transformations | w) Understand the effect of simple transformations on the graph of $y = \mathrm{f}(x)$ including sketching associated graphs, describing transformations and finding relevant equations: $y = a\mathrm{f}(x)$, $y = \mathrm{f}(x) + a$, $y = \mathrm{f}(x + a)$ and $y = \mathrm{f}(ax)$, for any real $a$.<br>*Only single transformations will be requested.*<br>*Translations may be specified by a two-dimensional column vector.* | x) Understand the effect of combinations of transformations on the graph of $y = \mathrm{f}(x)$ including sketching associated graphs, describing transformations and finding relevant equations.<br>*The transformations may be combinations of* $y = a\mathrm{f}(x)$, $y = \mathrm{f}(x) + a$, $y = \mathrm{f}(x + a)$ *and* $y = \mathrm{f}(ax)$, *for any real* $a$, *and* $\mathrm{f}$ *any function defined in the Stage 1 or Stage 2 content.* | MB9 |

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| 1.02y | Partial fractions | | y) Be able to 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).<br>*i.e. The denominator is no more complicated than* $(ax+b)(cx+d)^2$ *or* $(ax+b)(cx+d)(ex+f)$ *and the numerator is either a constant or linear term.*<br>*Learners should be able to use partial fractions with the binomial expansion to find the power series for an algebraic fraction or as part of solving an integration problem.* | MB10 |
| 1.02z | Models in context | | z) Be able to use functions in modelling.<br>*Includes consideration of modelling assumptions, limitations and refinements of models, and comparing models.* | MB11 |

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| **1.03 Coordinate Geometry in the $x$–$y$ Plane** | | | | |
| 1.03a | Straight lines | a) Understand and be able to use the equation of a straight line, including the forms $y = mx + c, y - y_1 = m(x - x_1)$ and $ax + by + c = 0$.<br>*Learners should be able to draw a straight line given its equation and to form the equation given a graph of the line, the gradient and one point on the line, or at least two points on the line.*<br>*Learners should be able to use straight lines to find:*<br>*1. the coordinates of the midpoint of a line segment joining two points,*<br>*2. the distance between two points and*<br>*3. the point of intersection of two lines.* | | MC1 |
| 1.03b | | b) Be able to use the gradient conditions for two straight lines to be parallel or perpendicular.<br>*i.e. For parallel lines* $m_1 = m_2$ *and for perpendicular lines* $m_1 m_2 = -1$. | | |
| 1.03c | | c) Be able to use straight line models in a variety of contexts.<br>*These problems may be presented within realistic contexts including average rates of change.* | | |

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| 1.03d | Circles | d) Understand and be able to use the coordinate geometry of a circle including using the equation of a circle in the form $(x-a)^2+(y-b)^2=r^2$.<br>*Learners should be able to draw a circle given its equation or to form the equation given its centre and radius.* | | MC2 |
| 1.03e | | e) Be able to complete the square to find the centre and radius of a circle. | | |
| 1.03f | | f) Be able to use the following circle properties in the context of problems in coordinate geometry:<br>1. the angle in a semicircle is a right angle,<br>2. the perpendicular from the centre of a circle to a chord bisects the chord,<br>3. the radius of a circle at a given point on its circumference is perpendicular to the tangent to the circle at that point.<br>*Learners should also be able to investigate whether or not a line and a circle or two circles intersect.* | | |
| 1.03g | Parametric equations of curves | | g) Understand and be able to use the parametric equations of curves and be able to convert between cartesian and parametric forms.<br>*Learners should understand the meaning of the terms parameter and parametric equation.*<br>*Includes sketching simple parametric curves.*<br>*See also Section 1.07s.* | MC3 |

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| 1.03h | Parametric equations in context | | h) Be able to use parametric equations in modelling in a variety of contexts.<br>*The contexts may be within pure mathematics or in realistic contexts, for example those involving related rates of change.* | MC4 |
| **1.04 Sequences and Series** | | | | |
| 1.04a<br>1.04c<br><br><br><br><br><br><br>1.04b<br>1.04d | Binomial expansion | a) Understand and be able to use the binomial expansion of $(a+bx)^n$ for positive integer $n$ and the notations $n!$ and ${}^n\mathrm{C}_r$, ${}_n\mathrm{C}_r$ or $\binom{n}{r}$, with ${}^n\mathrm{C}_0 = {}^n\mathrm{C}_n = 1$.<br>*e.g. Find the coefficient of the $x^3$ term in the expansion of $(2-3x)^7$.*<br>*Learners should be able to calculate binomial coefficients. They should also know the relationship of the binomial coefficients to Pascal's triangle and their use in a binomial expansion.*<br>*They should also know that $0! = 1$.*<br>b) Understand and know the link to binomial probabilities. | c) Be able to extend the binomial expansion of $(a+bx)^n$ to any rational $n$, including its use for approximation.<br>*Learners may be asked to find a particular term, but the general term will not be required.*<br>*Learners should be able to write $(a+bx)^n$ in the form $a^n\left(1+\frac{bx}{a}\right)^n$ prior to expansion.*<br>d) Know that the expansion is valid for $\left\|\frac{bx}{a}\right\| < 1$.<br>[*The proof is not required.*]<br>*e.g. Find the coefficient of the $x^3$ term in the expansion of $(2-3x)^{\frac{1}{3}}$ and state the range of values for which the expansion is valid.* | MD1 |

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| 1.04e<br><br><br><br><br><br><br>1.04f | Sequences | | e) Be able to work with sequences including those given by a formula for the $n$th term and those generated by a simple relation of the form $x_{n+1} = \mathrm{f}(x_n)$.<br>*Learners may be asked to generate terms, find $n$th terms and comment on the mathematical behaviour of the sequence.*<br>f) Understand the meaning of and work with increasing sequences, decreasing sequences and periodic sequences.<br>*Learners should know the difference between and be able to recognise:*<br>*1. a sequence and a series,*<br>*2. finite and infinite sequences.* | MD2 |
| 1.04g | Sigma notation | | g) Understand and be able to use sigma notation for sums of series. | MD3 |
| 1.04h | Arithmetic sequences | | h) Understand and be able to work with arithmetic sequences and series, including the formulae for the $n$th term and the sum to $n$ terms.<br>*The term arithmetic progression (AP) may also be used.*<br>*The first term will usually be denoted by $a$, the last term by $l$ and the common difference by $d$.*<br>*The sum to $n$ terms will usually be denoted by $S_n$.* | MD4 |

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| 1.04i | Geometric sequences | | i) Understand and be able to work with geometric sequences and series including the formulae for the $n$th term and the sum of a finite geometric series.<br>*Learners should know the difference between convergent and divergent geometric sequences and series.* | MD5 |
| 1.04j | | | j) Understand and be able to work with the sum to infinity of a convergent geometric series, including the use of $\|r\| < 1$ and the use of modulus notation in the condition for convergence.<br>*The term geometric progression (GP) may also be used. The first term will usually be denoted by $a$ and the common ratio by $r$.*<br>*The sum to $n$ terms will usually be denoted by $S_n$ and the sum to infinity by $S_\infty$.* | |
| 1.04k | Modelling | | k) Be able to use sequences and series in modelling.<br>*e.g. Contexts involving compound and simple interest on bank deposits, loans, mortgages, etc. and other contexts in which growth or decay can be modelled by an arithmetic or geometric sequence.*<br>*Includes solving inequalities involving exponentials and logarithms.* | MD6 |

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| **1.05 Trigonometry** | | | | |
| 1.05a<br>1.05d<br>1.05b<br><br><br>1.05c | sin, cos and tan for all arguments<br>Sine and cosine rules<br>Radians | a) Understand and be able to use the definitions of sine, cosine and tangent for all arguments.<br>b) Understand and be able to use the sine and cosine rules.<br>*Questions may include the use of bearings and require the use of the ambiguous case of the sine rule.*<br>c) Understand and be able to use the area of a triangle in the form $\frac{1}{2}ab\sin C$. | d) Be able to work with radian measure, including use for arc length and area of sector.<br>*Learners should know the formulae* $s = r\theta$ *and* $A = \frac{1}{2}r^2\theta$.<br>*Learners should be able to use the relationship between degrees and radians.* | ME1 |
| 1.05e | Small angle approximations | | e) Understand and be able to use the standard small angle approximations of sine, cosine and tangent:<br>1. $\sin\theta \approx \theta$,<br>2. $\cos\theta \approx 1 - \frac{1}{2}\theta^2$,<br>3. $\tan\theta \approx \theta$,<br>where $\theta$ is in radians.<br>*e.g. Find an approximate expression for* $\frac{\sin 3\theta}{1+\cos\theta}$ *if* $\theta$ *is small enough to neglect terms in* $\theta^3$ *or above.* | ME2 |
| 1.05f<br>1.05g | Graphs of the basic trigonometric functions<br>Exact values of trigonometric functions | f) Understand and be able to use the sine, cosine and tangent functions, their graphs, symmetries and periodicities.<br>*Includes knowing and being able to use exact values of* $\sin\theta$ *and* $\cos\theta$ *for* $\theta = 0^\circ, 30^\circ, 45^\circ, 60^\circ, 90^\circ, 180^\circ$ *and multiples thereof and exact values of* $\tan\theta$ *for* $\theta = 0^\circ, 30^\circ, 45^\circ, 60^\circ, 180^\circ$ *and multiples thereof.* | g) Know and be able to use exact values of $\sin\theta$ and $\cos\theta$ for $\theta = 0, \frac{1}{6}\pi, \frac{1}{4}\pi, \frac{1}{3}\pi, \frac{1}{2}\pi, \pi$ and multiples thereof, and exact values of $\tan\theta$ for $\theta = 0, \frac{1}{6}\pi, \frac{1}{4}\pi, \frac{1}{3}\pi, \pi$ and multiples thereof. | ME3 |

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| 1.05h<br><br>1.05i | Inverse and reciprocal trigonometric ratios | | h) Understand and be able to use the definitions of secant ($\sec\theta$), cosecant ($\operatorname{cosec}\theta$) and cotangent ($\cot\theta$) and of $\arcsin\theta$, $\arccos\theta$ and $\arctan\theta$ and their relationships to $\sin\theta$, $\cos\theta$ and $\tan\theta$ respectively.<br><br>i) Understand the graphs of the functions given in 1.05h, their ranges and domains.<br><br>*In particular, learners should know that the principal values of the inverse trigonometric relations may be denoted by* $\arcsin\theta$ *or* $\sin^{-1}\theta$, $\arccos\theta$ *or* $\cos^{-1}\theta$, $\arctan\theta$ *or* $\tan^{-1}\theta$ *and relate their graphs (for the appropriate domain) to the graphs of* $\sin\theta$, $\cos\theta$ *and* $\tan\theta$. | ME4 |
| 1.05j<br>1.05k | Trigonometric identities | j) Understand and be able to use $\tan\theta \equiv \dfrac{\sin\theta}{\cos\theta}$ and $\sin^2\theta + \cos^2\theta \equiv 1$.<br><br>*In particular, these identities may be used in solving trigonometric equations and simple trigonometric proofs.* | k) Understand and be able to use $\sec^2\theta \equiv 1 + \tan^2\theta$ and $\operatorname{cosec}^2\theta \equiv 1 + \cot^2\theta$.<br><br>*In particular, the identities in 1.05j and 1.05k may be used in solving trigonometric equations, proving trigonometric identities or in evaluating integrals.* | ME5 |

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| 1.05l<br><br><br><br><br><br><br>1.05m<br><br>1.05n | Further trigonometric identities | | l) Understand and be able to use double angle formulae and the formulae for $\sin(A \pm B)$, $\cos(A \pm B)$ and $\tan(A \pm B)$.<br>*Learners may be required to use the formulae to prove trigonometric identities, simplify expressions, evaluate expressions exactly, solve trigonometric equations or find derivatives and integrals.*<br>m) Understand the geometrical proofs of these formulae.<br>n) Understand and be able to use expressions for $a\cos\theta + b\sin\theta$ in the equivalent forms of $R\cos(\theta \pm \alpha)$ or $R\sin(\theta \pm \alpha)$.<br>*In particular, learners should be able to:*<br>*1. sketch graphs of* $a\cos\theta + b\sin\theta$*,*<br>*2. determine features of the graphs including minimum or maximum points and*<br>*3. solve equations of the form* $a\cos\theta + b\sin\theta = c$. | ME6 |
| 1.05o | Trigonometric equations | o) Be able to solve simple trigonometric equations in a given interval, including quadratic equations in $\sin\theta$, $\cos\theta$ and $\tan\theta$ and equations involving multiples of the unknown angle.<br>*e.g.*<br>$\sin\theta = 0.5$ for $0 \le \theta < 360°$<br>$6\sin^2\theta + \cos\theta - 4 = 0$ for $0 \le \theta < 360°$<br>$\tan 3\theta = -1$ for $-180° < \theta < 180°$ | *Extend their knowledge of trigonometric equations to include radians and the trigonometric identities in Stage 2.* | ME7 |

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| 1.05p | Proof involving trigonometric functions | | p) Be able to construct proofs involving trigonometric functions and identities.<br>*e.g. Prove that*<br>$\cos^2(\theta + 45°) - \frac{1}{2}(\cos 2\theta - \sin 2\theta) = \sin^2\theta$.<br>*Includes constructing a mathematical argument as described in Section 1.01.* | ME8 |
| 1.05q | Trigonometric functions in context | | q) Be able to use trigonometric functions to solve problems in context, including problems involving vectors, kinematics and forces.<br>*Problems may include realistic contexts, e.g. movement of tides, sound waves, etc. as well as problems in vector form which involve resolving directions and quantities in mechanics.* | ME9 |
| **1.06 Exponentials and Logarithms** | | | | |
| 1.06a | Properties of the exponential function | a) Know and use the function $a^x$ and its graph, where $a$ is positive.<br>Know and use the function $\mathrm{e}^x$ and its graph.<br>*Examples may include the comparison of two population models or models in a biological or financial context. The link with geometric sequences may also be made.* | | MF1 |
| 1.06b | Gradient of $\mathrm{e}^{kx}$ | b) Know that the gradient of $\mathrm{e}^{kx}$ is equal to $k\mathrm{e}^{kx}$ and hence understand why the exponential model is suitable in many applications.<br>*See 1.07j for explicit differentiation of* $\mathrm{e}^x$. | | MF2 |

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| 1.06c<br><br><br><br><br>1.06d<br>1.06e | Properties of the logarithm | c) Know and use the definition of $\log_a x$ (for $x > 0$) as the inverse of $a^x$ (for all $x$),where $a$ is positive.<br>*Learners should be able to convert from index to logarithmic form and vice versa as $a = b^c \Leftrightarrow c = \log_b a$.*<br>*The values $\log_a a = 1$ and $\log_a 1 = 0$ should be known.*<br>d) Know and use the function $\ln x$ and its graph.<br>e) Know and use $\ln x$ as the inverse function of $e^x$.<br>*e.g. In solving equations involving logarithms or exponentials.*<br>*The values $\ln e = 1$ and $\ln 1 = 0$ should be known.* | | MF3 |
| 1.06f | Laws of logarithms | f) Understand and be able to use the laws of logarithms:<br>1. $\log_a x + \log_a y = \log_a (xy)$<br>2. $\log_a x - \log_a y = \log_a \left(\frac{x}{y}\right)$<br>3. $k \log_a x = \log_a x^k$<br>(including, for example, $k = -1$ and $k = -\frac{1}{2}$).<br>*Learners should be able to use these laws in solving equations and simplifying expressions involving logarithms.*<br>[*Change of base is excluded*.] | | MF4 |
| 1.06g | Equations involving exponentials | g) Be able to solve equations of the form $a^x = b$ for $a > 0$<br>*Includes solving equations which can be reduced to this form such as $2^x = 3^{2x-1}$, either by reduction to the form $a^x = b$ or by taking logarithms of both sides.* | | MF5 |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
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| 1.06h | Reduction to linear form | h) Be able to use logarithmic graphs to estimate parameters in relationships of the form $y = ax^n$ and $y = kb^x$, given data for $x$ and $y$.<br>*Learners should be able to reduce equations of these forms to a linear form and hence estimate values of $a$ and $n$, or $k$ and $b$ by drawing graphs using given experimental data and using appropriate calculator functions.* | | MF6 |
| 1.06i | Modelling using exponential functions | i) Understand and be able to use exponential growth and decay and use the exponential function in modelling.<br>*Examples may include the use of* e *in continuous compound interest, radioactive decay, drug concentration decay and exponential growth as a model for population growth. Includes consideration of limitations and refinements of exponential models.* | | MF7 |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
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| **1.07 Differentiation** | | | | |
| 1.07a | Gradients | a) Understand and be able to 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 $(x, y)$. | | MG1 |
| 1.07b | | b) Understand and be able to use the gradient of the tangent at a point where $x = a$ as:<br>1. the limit of the gradient of a chord as $x$ tends to $a$<br>2. a rate of change of $y$ with respect to $x$.<br><br>*Learners should be able to use the notation* $\frac{\mathrm{d}y}{\mathrm{d}x}$ *to denote the rate of change of* $y$ *with respect to* $x$.<br><br>*Learners should be able to use the notations* $\mathrm{f}'(x)$ *and* $\frac{\mathrm{d}y}{\mathrm{d}x}$ *and recognise their equivalence.* | | |
| 1.07c | | c) Understand and be able to sketch the gradient function for a given curve. | | |
| 1.07d<br>1.07f | | d) Understand and be able to find second derivatives.<br><br>*Learners should be able to use the notations* $\mathrm{f}''(x)$ *and* $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$ *and recognise their equivalence.* | f) Understand and be able to use the second derivative in connection to convex and concave sections of curves and points of inflection.<br><br>*In particular, learners should know that:*<br>*1. if* $\mathrm{f}''(x) > 0$ *on an interval, the function is convex in that interval;*<br>*2. if* $\mathrm{f}''(x) < 0$ *on an interval the function is concave in that interval;*<br>*3. if* $\mathrm{f}''(x) = 0$ *and the curve changes from concave to convex or vice versa there is a point of inflection.* | |
| 1.07e | | e) Understand and be able to use the second derivative as the rate of change of gradient.<br><br>*e.g. For distinguishing between maximum and minimum points.*<br><br>*For the application to points of inflection, see 1.07f.* | | |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
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| 1.07g<br>1.07h | Differentiation from first principles | g) Be able to show differentiation from first principles for small positive integer powers of $x$.<br>*In particular, learners should be able to use the definition* $\mathrm{f}'(x) = \lim_{h \to 0} \frac{\mathrm{f}(x+h) - \mathrm{f}(x)}{h}$ *including the notation.*<br>[*Integer powers greater than 4 are excluded.*] | h) Be able to show differentiation from first principles for $\sin x$ and $\cos x$. | MG1 |
| 1.07i<br>1.07j<br>1.07k<br>1.07l | Differentiation of standard functions | i) Be able to differentiate $x^n$, for rational values of $n$, and related constant multiples, sums and differences. | j) Be able to differentiate $\mathrm{e}^{kx}$ and $a^{kx}$, and related sums, differences and constant multiples.<br>k) Be able to differentiate $\sin kx$, $\cos kx$, $\tan kx$ and related sums, differences and constant multiples.<br>l) Understand and be able to use the derivative of $\ln x$. | MG2 |
| 1.07m<br>1.07p<br>1.07n<br>1.07o | Tangents, normals, stationary points, increasing and decreasing functions | m) Be able to apply differentiation to find the gradient at a point on a curve and the equations of tangents and normals to a curve.<br>n) Be able to apply differentiation to find and classify stationary points on a curve as either maxima or minima.<br>*Classification may involve use of the second derivative or first derivative or other methods.*<br>o) Be able to identify where functions are increasing or decreasing.<br>*i.e. To be able to use the sign of* $\frac{\mathrm{d}y}{\mathrm{d}x}$ *to determine whether the function is increasing or decreasing.* | p) Be able to apply differentiation to find points of inflection on a curve.<br>*In particular, learners should know that if a curve has a point of inflection at* $x$ *then* $\mathrm{f}''(x) = 0$ *and there is a sign change in the second derivative on either side of* $x$*; if also* $\mathrm{f}'(x) = 0$ *at that point, then the point of inflection is a stationary point, but if* $\mathrm{f}'(x) \neq 0$ *at that point, then the point of inflection is not a stationary point.* | MG3 |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
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| 1.07q<br><br>1.07r | Techniques of differentiation | | q) Be able to differentiate using the product rule and the quotient rule.<br><br>r) Be able to differentiate using the chain rule, including problems involving connected rates of change and inverse functions.<br><br>*In particular, learners should be able to use the following relations:*<br>$\frac{\mathrm{d}y}{\mathrm{d}x} = 1 \div \frac{\mathrm{d}x}{\mathrm{d}y}$ *and* $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{\mathrm{d}y}{\mathrm{d}u} \times \frac{\mathrm{d}u}{\mathrm{d}x}$. | MG4 |
| 1.07s | Parametric and implicit differentiation | | s) Be able to differentiate simple functions and relations defined implicitly or parametrically for the first derivative only.<br><br>*They should be able to find the gradient at a point on a curve and to use this to find the equations of tangents and normals, and to solve associated problems.*<br><br>*Includes differentiation of functions defined in terms of a parameter using the chain rule.* | MG5 |
| 1.07t | Constructing differential equations | | t) Be able to construct simple differential equations in pure mathematics and in context (contexts may include kinematics, population growth and modelling the relationship between price and demand). | MG6 |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| **1.08 Integration** | | | | |
| 1.08a | Fundamental theorem of calculus | a) Know and be able to use the fundamental theorem of calculus.<br>*i.e. Learners should know that integration may be defined as the reverse of differentiation and be able to apply the result that* $\int \mathrm{f}(x)\,\mathrm{d}x = \mathrm{F}(x) + c \Leftrightarrow \mathrm{f}(x) = \frac{\mathrm{d}}{\mathrm{d}x}(\mathrm{F}(x))$, *for sufficiently well-behaved functions.*<br>*Includes understanding and being able to use the terms indefinite and definite when applied to integrals.* | | MH1 |
| 1.08b<br>1.08c | Indefinite integrals | b) Be able to integrate $x^n$ where $n \neq -1$ and related sums, differences and constant multiples.<br>*Learners should also be able to solve problems involving the evaluation of a constant of integration e.g. to find the equation of the curve through* $(-1, 2)$ *for which* $\frac{\mathrm{d}y}{\mathrm{d}x} = 2x + 1$. | c) Be able to integrate $\mathrm{e}^{kx}$, $\frac{1}{x}$, $\sin kx$, $\cos kx$ and related sums, differences and constant multiples.<br>[*Integrals of* arcsin, arccos *and* arctan *will be given if required.*]<br>*This includes using trigonometric relations such as double-angle formulae to facilitate the integration of functions such as* $\cos^2 x$. | MH2 |
| 1.08d<br><br>1.08e<br>1.08f | Definite integrals and areas | d) Be able to evaluate definite integrals.<br>e) Be able to use a definite integral to find the area between a curve and the *x*-axis.<br>*This area is defined to be that enclosed by a curve, the x-axis and two ordinates. Areas may be included which are partly below and partly above the x-axis, or entirely below the x-axis.* | f) Be able to use a definite integral to find the area between two curves.<br>*This may include using integration to find the area of a region bounded by a curve and lines parallel to the coordinate axes, or between two curves or between a line and a curve.*<br>*This includes curves defined parametrically.* | MH3 |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
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| 1.08g | Integration as the limit of a sum | | g) Understand and be able to use integration as the limit of a sum.<br>*In particular, they should know that the area under a graph can be found as the limit of a sum of areas of rectangles.*<br>*See also 1.09f.* | MH4 |
| 1.08h | Integration by substitution | | h) Be able to carry out simple cases of integration by substitution.<br>*Learners should understand the relationship between this method and the chain rule.*<br>*Learners will be expected to integrate examples in the form* $\mathrm{f}'(x)(\mathrm{f}(x))^n$*, such as* $(2x+3)^5$ *or* $x(x^2+3)^7$*, either by inspection or substitution.*<br>*Learners will be expected to recognise an integrand of the form* $\frac{k\mathrm{f}'(x)}{\mathrm{f}(x)}$ *such as* $\frac{x^2+x}{2x^3+3x^2-7}$ *or* $\tan x$*.*<br>*Integration by substitution is limited to cases where one substitution will lead to a function which can be integrated. Substitutions may or may not be given.*<br>*Learners should be able to find a suitable substitution in integrands such as* $\frac{(4x-1)}{(2x+1)^5}$, $\sqrt{9-x^2}$ *or* $\frac{1}{1+\sqrt{x}}$. | MH5 |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
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| 1.08i | Integration by parts | | i) Be able to carry out simple cases of integration by parts.<br>*Learners should understand the relationship between this method and the product rule.*<br>*Integration by parts may include more than one application of the method e.g.* $x^2 \sin x$.<br>*Learners will be expected to be able to apply integration by parts to the integral of* $\ln x$ *and related functions.*<br>[*Reduction formulae are excluded*.] | MH5 |
| 1.08j | Use of partial fractions in integration | | j) Be able to integrate functions using partial fractions that have linear terms in the denominator.<br>*i.e. Functions with denominators no more complicated than the forms* $(ax+b)(cx+d)^2$ *or* $(ax+b)(cx+d)(ex+f)$. | MH6 |
| 1.08k | Differential equations with separable variables | | k) Be able to evaluate the analytical solution of simple first order differential equations with separable variables, including finding particular solutions.<br>*Separation of variables may require factorisation involving a common factor.*<br>*Includes: finding by integration the general solution of a differential equation involving separating variables or direct integration; using a given initial condition to find a particular solution.* | MH7 |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
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| 1.08l | Interpreting the solution of a differential equation | | l) Be able to interpret the solution of a differential equation in the context of solving a problem, including identifying limitations of the solution.<br>*Includes links to differential equations connected with kinematics.*<br>*e.g. If the solution of a differential equation is $v = 20 - 20\mathrm{e}^{-t}$, where $v$ is the velocity of a parachutist, describe the motion of the parachutist.* | MH8 |
| **1.09 Numerical Methods** | | | | |
| 1.09a | Sign change methods | | a) Be able to locate roots of $\mathrm{f}(x) = 0$ by considering changes of sign of $\mathrm{f}(x)$ in an interval of $x$ on which $\mathrm{f}(x)$ is sufficiently well-behaved.<br>*Includes verifying the level of accuracy of an approximation by considering upper and lower bounds.* | MI1 |
| 1.09b | | | b) Understand how change of sign methods can fail.<br>*e.g. when the curve $y = \mathrm{f}(x)$ touches the x-axis or has a vertical asymptote.* | |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
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| 1.09c<br><br>1.09d<br><br>1.09e | Formal iterative methods | | c) Be able to solve equations approximately using simple iterative methods, and be able to draw associated cobweb and staircase diagrams.<br><br>d) Be able to solve equations using the Newton-Raphson method and other recurrence relations of the form $x_{n+1} = \mathrm{g}(x_n)$.<br><br>e) Understand and be able to show how such methods can fail.<br><br>*In particular, learners should know that:*<br>*1. the iteration* $x_{n+1} = \mathrm{g}(x_n)$ *converges to a root at* $x = a$ *if* $\lvert \mathrm{g}'(a) \rvert < 1$*, and if* $x_1$ *is sufficiently close to* $a$*;*<br>*2. the Newton-Raphson method will fail if the initial value coincides with a stationary point.* | MI2 |
| 1.09f | Numerical integration | | f) Understand and be able to use numerical integration of functions, including the use of the trapezium rule, and estimating the approximate area under a curve and the limits that it must lie between.<br><br>*Learners will be expected to use the trapezium rule to estimate the area under a curve and to determine whether the trapezium rule gives an under- or over-estimate of the area under a curve.*<br><br>*Learners will also be expected to use rectangles to estimate the area under a curve and to establish upper and lower bounds for a given integral. See also 1.08g.*<br><br>[*Simpson's rule is excluded*] | MI3 |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
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| 1.09g | Use numerical methods in context | | g) Be able to use numerical methods to solve problems in context.<br>*i.e. for solving problems in context which lead to equations which learners cannot solve analytically.* | MI4 |
| **1.10 Vectors** | | | | |
| 1.10a<br>1.10b | Vectors | a) Be able to use vectors in two dimensions.<br>*i.e. Learners should be able to use vectors expressed as* $x\mathbf{i}+y\mathbf{j}$ *or as a column vector* $\begin{pmatrix}x\\y\end{pmatrix}$, *to use vector notation appropriately either as* $\overrightarrow{AB}$ *or* $\mathbf{a}$.<br>*Learners should know the difference between a scalar and a vector, and should distinguish between them carefully when writing by hand.* | b) Be able to use vectors in three dimensions.<br>*i.e. Learners should be able to use vectors expressed as* $x\mathbf{i}+y\mathbf{j}+z\mathbf{k}$ *or as a column vector* $\begin{pmatrix}x\\y\\z\end{pmatrix}$.<br>*Includes extending 1.10c to 1.10g to include vectors in three dimensions, excluding the direction of a vector in three dimensions.* | MJ1 |
| 1.10c | Magnitude and direction of vectors | c) Be able to calculate the magnitude and direction of a vector and convert between component form and magnitude/direction form.<br>*Learners should know that the modulus of a vector is its magnitude and the direction of a vector is given by the angle the vector makes with a horizontal line parallel to the positive x-axis. The direction of a vector will be taken to be in the interval* $[0°, 360°)$.<br>*Includes use of the notation* $\|\mathbf{a}\|$ *for the magnitude of* $\mathbf{a}$ *and* $\|\overrightarrow{OA}\|$ *for the magnitude of* $\overrightarrow{OA}$.<br>*Learners should be able to calculate the magnitude of a vector* $\begin{pmatrix}x\\y\end{pmatrix}$ *as* $\sqrt{x^2+y^2}$ *and its direction by using* $\tan^{-1}\begin{pmatrix}x\\y\end{pmatrix}$. | | MJ2 |



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| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
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| 1.10d | Basic operations on vectors | d) Be able to add vectors diagrammatically and perform the algebraic operations of vector addition and multiplication by scalars, and understand their geometrical interpretations.<br>*i.e. Either a scaling of a single vector or a displacement from one position to another by adding one or more vectors, often in the form of a triangle of vectors.* | | MJ3 |
| 1.10e | Position vectors | e) Understand and be able to use position vectors.<br>*Learners should understand the meaning of displacement vector, component vector, resultant vector, parallel vector, equal vector and unit vector.* | | MJ4 |
| 1.10f | Distance between points | f) Be able to calculate the distance between two points represented by position vectors.<br>*i.e. The distance between the points* $a\mathbf{i}+b\mathbf{j}$ *and* $c\mathbf{i}+d\mathbf{j}$ *is* $\sqrt{(c-a)^2+(d-b)^2}$. | | |
| 1.10g<br>1.10h | Problem solving using vectors | g) Be able to use vectors to solve problems in pure mathematics and in context, including forces. | h) Be able to use vectors to solve problems in kinematics.<br>*e.g. The equations of uniform acceleration may be used in vector form to find an unknown. See section 3.02e.* | MJ5 |

## 2 – Statistics

When this course is being co-taught with AS Level Mathematics A (H230) the 'Stage 1' column indicates the common content between the two specifications and the 'Stage 2' column indicates content which is particular to this specification.

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| **2.01 Statistical Sampling** | | | | |
| 2.01a | Statistical sampling | a) Understand and be able to use the terms 'population' and 'sample'. | | MK1 |
| 2.01b | | b) Be able to use samples to make informal inferences about the population. | | |
| 2.01c | | c) Understand and be able to use sampling techniques, including simple random sampling and opportunity sampling.<br>*When considering random samples, learners may assume that the population is large enough to sample without replacement unless told otherwise.* | | |
| 2.01d | | d) Be able to 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.<br>*Learners should be familiar with (and be able to critique in context) the following sampling methods, but will not be required to carry them out: systematic, stratified, cluster and quota sampling.* | | |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| **2.02 Data Presentation and Interpretation** | | | | |
| 2.02a | Single variable data | a) Be able to interpret tables and diagrams for single-variable data.<br>*e.g. vertical line charts, dot plots, bar charts, stem-and-leaf diagrams, box-and-whisker plots, cumulative frequency diagrams and histograms (with either equal or unequal class intervals). Includes non-standard representations.* | | ML1 |
| 2.02b | | b) Understand that area in a histogram represents frequency.<br>*Includes the link between histograms and probability distributions.*<br>*Includes understanding, in context, the advantages and disadvantages of different statistical diagrams.* | | |
| 2.02c | Bivariate data | c) Be able to interpret scatter diagrams and regression lines for bivariate data, including recognition of scatter diagrams which include distinct sections of the population.<br>*Learners may be asked to add to diagrams in order to interpret data, but not to draw complete scatter diagrams.*<br>[*Calculation of equations of regression lines is excluded.*] | | ML2 |
| 2.02d | | d) Be able to understand informal interpretation of correlation. | | |
| 2.02e | | e) Be able to understand that correlation does not imply causation. | | |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| 2.02f | Measures of average and spread | f) Be able to calculate and interpret measures of central tendency and variation, including mean, median, mode, percentile, quartile, inter-quartile range, standard deviation and variance.<br>*Includes understanding that standard deviation is the root mean square deviation from the mean.*<br>*Includes using the mean and standard deviation to compare distributions.* | | ML3 |
| 2.02g | Calculations of mean and standard deviation | g) Be able to calculate mean and standard deviation from a list of data, from summary statistics or from a frequency distribution, using calculator statistical functions.<br>*Includes understanding that, in the case of a grouped frequency distribution, the calculated mean and standard deviation are estimates.*<br>*Learners should understand and be able to use the following formulae for standard deviation:*<br>$\sqrt{\frac{\Sigma(x-\overline{x})^2}{n}} = \sqrt{\frac{\Sigma x^2}{n} - \overline{x}^2}$,<br>$\sqrt{\frac{\Sigma f(x-\overline{x})^2}{\Sigma f}} = \sqrt{\frac{\Sigma fx^2}{\Sigma f} - \overline{x}^2}$<br>[*Formal estimation of population variance from a sample is excluded. Learners should be aware that there are different naming and symbol conventions for these measures and what the symbols on their calculator represent.*] | | ML3 |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| 2.02h<br><br>2.02i<br><br>2.02j | Outliers and cleaning data | h) Recognise and be able to interpret possible outliers in data sets and statistical diagrams.<br><br>i) Be able to select or critique data presentation techniques in the context of a statistical problem.<br><br>j) Be able to clean data, including dealing with missing data, errors and outliers.<br><br>*Learners should be familiar with definitions of outliers:*<br>*1. more than 1.5 $\times$ (interquartile range) from the nearer quartile*<br>*2. more than 2 $\times$ (standard deviation) away from the mean.* | | ML4 |
| **2.03 Probability** | | | | |
| 2.03a | Mutually exclusive and independent events | a) Understand and be able to use mutually exclusive and independent events when calculating probabilities.<br><br>*Includes understanding and being able to use the notation:*<br><br>$\mathrm{P}(A)$, $\mathrm{P}(A')$, $\mathrm{P}(X=2)$, $\mathrm{P}(X=x)$.<br><br>*Includes linking their knowledge of probability to probability distributions.* | | MM1 |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
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| 2.03b<br>2.03c<br><br><br><br><br><br><br><br><br>2.03d | Probability | b) Be able to use appropriate diagrams to assist in the calculation of probabilities.<br>*Includes tree diagrams, sample space diagrams, Venn diagrams.* | c) Understand and be able to use conditional probability, including the use of tree diagrams, Venn diagrams and two-way tables.<br>*Includes understanding and being able to use the notations:*<br>$A \cap B$, $A \cup B$, $A \mid B$.<br>*Includes understanding and being able to use the formulae:*<br>$\mathrm{P}(A \cap B) = \mathrm{P}(A) \times \mathrm{P}(B \mid A)$,<br>$\mathrm{P}(A \cup B) = \mathrm{P}(A) + \mathrm{P}(B) - \mathrm{P}(A \cap B)$.<br>d) Understand the concept of conditional probability, and calculate it from first principles in given contexts.<br>*Includes understanding and being able to use the conditional probability formula*<br>$\mathrm{P}(A \mid B) = \dfrac{\mathrm{P}(A \cap B)}{\mathrm{P}(B)}$.<br>[*Use of this formula to find* $\mathrm{P}(A \mid B)$ *from* $\mathrm{P}(B \mid A)$ *is excluded.*] | MM1<br>MM2 |
| 2.03e | Modelling with probability | | e) Be able to model with probability, including critiquing assumptions made and the likely effect of more realistic assumptions. | MM3 |


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| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| **2.04 Statistical Distributions** | | | | |
| 2.04a | Discrete probability distributions | a) Understand and be able to use simple, finite, discrete probability distributions, defined in the form of a table or a formula such as: $\mathrm{P}(X=x)=0.05x(x+1)$ for $x=1,2,3$.<br><br>[*Calculation of mean and variance of discrete random variables is excluded*.] | | MN1<br>MN2<br>MN3 |
| 2.04b<br>2.04d<br><br>2.04c | | b) Understand and be able to use the binomial distribution as a model.<br><br>c) Be able to calculate probabilities using the binomial distribution, using appropriate calculator functions.<br><br>*Includes understanding and being able to use the formula* $\mathrm{P}(X=x)=\binom{n}{x}p^x(1-p)^{n-x}$ *and the notation* $X\sim\mathrm{B}(n,p)$.<br><br>*Learners should understand the conditions for a random variable to have a binomial distribution, be able to identify which of the modelling conditions (assumptions) is/are relevant to a given scenario and be able to explain them in context. They should understand the distinction between conditions and assumptions.* | d) Know and be able to use the formulae $\mu=np$ and $\sigma^2=npq$ when choosing a particular normal model to use as an approximation to a binomial model. | |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
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| 2.04e<br><br><br><br>2.04f<br><br><br><br><br><br><br>2.04g | The normal distribution | | e) Understand and be able to use the normal distribution as a model.<br>*Includes understanding and being able to use the notation* $X \sim \mathrm{N}(\mu, \sigma^2)$.<br>f) Be able to find probabilities using the normal distribution, using appropriate calculator functions.<br>*This includes finding* $x$, *for a given normal variable, when* $\mathrm{P}(X < x)$ *is known.*<br>*Learners should understand the standard normal distribution,* $Z$, *and the transformation* $Z = \dfrac{X-\mu}{\sigma}$.<br>g) Understand links to histograms, mean and standard deviation.<br>*Learners should know and be able to use the facts that in a normal distribution,*<br>*1. about two-thirds of values lie in the range* $\mu \pm \sigma$,<br>*2. about 95% of values lie in the range* $\mu \pm 2\sigma$,<br>*3. almost all values lie in the range* $\mu \pm 3\sigma$ *and*<br>*4. the points of inflection in a normal curve occur at* $x = \mu \pm \sigma$.<br>[*The equation of the normal curve is excluded.*] | MN2 |
| 2.04h | Selecting an appropriate distribution | | h) Be able to select an appropriate probability distribution for a context, with appropriate reasoning, including recognising when the binomial or normal model may not be appropriate.<br>*Includes understanding that a given binomial distribution with large n can be approximated by a normal distribution.*<br>[*Questions explicitly requiring calculations using the normal approximation to the binomial distribution are excluded.*] | MN2<br>MN3 |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| **2.05 Statistical Hypothesis Testing** | | | | |
| 2.05a | The language of hypothesis testing | a) Understand and be able to use 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.<br>*Hypotheses should be stated in terms of parameter values (where relevant) and the meanings of symbols should be stated. For example,*<br>*"* $\mathrm{H}_0 : p = 0.7$*,* $\mathrm{H}_1 : p \neq 0.7$*, where* $p$ *is the population proportion in favour of the resolution".*<br>*Conclusions should be stated in such a way as to reflect the fact that they are not certain. For example,*<br>*"There is evidence at the 5% level to reject* $\mathrm{H}_0$*. It is likely that the mean mass is less than 500 g."*<br>*"There is no evidence at the 2% level to reject* $\mathrm{H}_0$*. There is no reason to suppose that the mean journey time has changed."*<br>*Some examples of incorrect conclusion are as follows:*<br>*"* $\mathrm{H}_0$ *is rejected. Waiting times have increased."*<br>*"Accept* $\mathrm{H}_0$*. Plants in this area have the same height as plants in other areas."* | | MO1 |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| 2.05b<br><br>2.05c | Hypothesis test for the proportion in a binomial distribution | b) Be able to conduct a statistical hypothesis test for the proportion in the binomial distribution and interpret the results in context.<br>c) 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.<br>*Learners should be able to use a calculator to find critical values.*<br>*Includes understanding that, where the significance level of a test is specified, the probability of the test statistic being in the rejection region will always be less than or equal to this level.*<br>[*The use of normal approximation is excluded*.] | | MO2 |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| 2.05d<br><br><br><br><br><br><br>2.05e | Hypothesis test for the mean of a normal distribution | | d) Recognise that a sample mean, $\overline{X}$, can be regarded as a random variable.<br>*Learners should know and be able to use the result that if* $X \sim \mathrm{N}(\mu, \sigma^2)$ *then* $\overline{X} \sim \mathrm{N}\left(\mu, \frac{\sigma^2}{n}\right)$.<br>[*The proof is excluded.*]<br>e) Be able to conduct a statistical hypothesis test for the mean of a normal distribution with known, given or assumed variance and interpret the results in context.<br>*Learners should be able to use a calculator to find critical values, but standard tables of the percentage points will be provided in the assessment.*<br>[*Test for the mean of a non-normal distribution is excluded.*]<br>[*Estimation of population parameters from a sample is excluded*] | MO3 |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| 2.05f<br><br><br>2.05g | Hypothesis test using Pearson's correlation coefficient | | f) Understand Pearson's product-moment correlation coefficient as a measure of how close data points lie to a straight line.<br><br>g) Use and be able to interpret Pearson's product-moment correlation coefficient in hypothesis tests, using either a given critical value or a *p*-value and a table of critical values.<br><br>*When using Pearson's coefficient in an hypothesis test, the data may be assumed to come from a bivariate normal distribution.*<br><br>*A table of critical values of Pearson's coefficient will be provided.*<br><br>[*Calculation of correlation coefficients is excluded.*] | MO1 |

## 3 – Mechanics

When this course is being co-taught with AS Level Mathematics A (H230) the 'Stage 1' column indicates the common content between the two specifications and the 'Stage 2' column indicates content which is particular to this specification.

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| **3.01 Quantities and Units in Mechanics** | | | | |
| 3.01a | SI units | a) Understand and be able to use the fundamental quantities and units in the S.I. system: length (in metres), time (in seconds), mass (in kilograms).<br>*Learners should understand that these three base quantities are mutually independent.* | | MP1 |
| 3.01b<br>3.01c | | b) Understand and be able to use derived quantities and units: velocity (m/s or m $s^{-1}$), acceleration (m/$s^2$ or m $s^{-2}$), force (N), weight (N).<br>*Learners should be able to add the appropriate unit to a given quantity.* | c) Understand and be able to use the unit for moment (N m). | |
| **3.02 Kinematics** | | | | |
| 3.02a | Language of kinematics | a) Understand and be able to use the language of kinematics: position, displacement, distance, distance travelled, velocity, speed, acceleration, equation of motion.<br>*Learners should understand the vector nature of displacement, velocity and acceleration and the scalar nature of distance travelled and speed.* | | MQ1 |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| 3.02b<br><br>3.02c | Graphical representation | b) Understand, use and interpret graphs in kinematics for motion in a straight line.<br><br>c) Be able to interpret displacement-time and velocity-time graphs, and in particular understand and be able to use the facts that the gradient of a displacement-time graph represents the velocity, the gradient of a velocity-time graph represents the acceleration, and the area between the graph and the time axis for a velocity-time graph represents the displacement. | | MQ2 |
| 3.02d<br>3.02e | Constant acceleration | d) Understand, use and derive the formulae for constant acceleration for motion in a straight line:<br>$v = u + at$<br>$s = ut + \frac{1}{2}at^2$<br>$s = \frac{1}{2}(u + v)t$<br>$v^2 = u^2 + 2as$<br>$s = vt - \frac{1}{2}at^2$<br>*Learners may be required to derive the constant acceleration formulae using a variety of techniques:*<br>1. *by integration, e.g.* $v = \int a\,\mathrm{d}t \Rightarrow v = u + at$*,*<br>2. *by using and interpreting appropriate graphs, e.g. velocity against time,*<br>3. *by substitution of one (given) formula into another (given) formula, e.g. substituting* $v = u + at$ *into* $s = \frac{1}{2}(u + v)t$ *to obtain* $s = ut + \frac{1}{2}at^2$. | e) Be able to extend the constant acceleration formulae to motion in two dimensions using vectors:<br>$\mathbf{v} = \mathbf{u} + \mathbf{a}t$<br>$\mathbf{s} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$<br>$\mathbf{s} = \frac{1}{2}(\mathbf{u} + \mathbf{v})t$<br>$\mathbf{s} = \mathbf{v}t - \frac{1}{2}\mathbf{a}t^2$<br>*Questions set involving vectors may involve either column vector notation, e.g.* $\mathbf{u} = \begin{pmatrix} u_1 \\ u_2 \end{pmatrix}$ *or* $\mathbf{i}$, $\mathbf{j}$ *notation, e.g.* $\mathbf{u} = u_1\mathbf{i} + u_2\mathbf{j}$.<br>[*The formula* $\mathbf{v}\cdot\mathbf{v} = \mathbf{u}\cdot\mathbf{u} + 2\mathbf{a}\cdot\mathbf{s}$ *is excluded.*] | MQ3 |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| 3.02f<br>3.02g | Non uniform acceleration | f) Be able to use differentiation and integration with respect to time in one dimension to solve simple problems concerning the displacement, velocity and acceleration of a particle:<br>$v = \frac{\mathrm{d}s}{\mathrm{d}t}$<br>$a = \frac{\mathrm{d}v}{\mathrm{d}t} = \frac{\mathrm{d}^2 s}{\mathrm{d}t^2}$<br>$s = \int v\,\mathrm{d}t$ and $v = \int a\,\mathrm{d}t$ | g) Be able to extend the application of differentiation and integration to two dimensions using vectors:<br>$\mathbf{x} = \mathrm{f}(t)\mathbf{i} + \mathrm{g}(t)\mathbf{j}$<br>$\mathbf{v} = \frac{\mathrm{d}\mathbf{x}}{\mathrm{d}t} = \dot{\mathbf{x}} = \mathrm{f}'(t)\mathbf{i} + \mathrm{g}'(t)\mathbf{j}$<br>$\mathbf{a} = \frac{\mathrm{d}\mathbf{v}}{\mathrm{d}t} = \dot{\mathbf{v}} = \frac{\mathrm{d}^2\mathbf{x}}{\mathrm{d}t^2} = \mathrm{f}''(t)\mathbf{i} + \mathrm{g}''(t)\mathbf{j}$<br>$\mathbf{x} = \int \mathbf{v}\,\mathrm{d}t$ and $\mathbf{v} = \int \mathbf{a}\,\mathrm{d}t$<br>*Questions set may involve either column vector or* **i**, **j** *notation.* | MQ4 |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| 3.02h<br><br>3.02i | Gravity | | h) Be able to model motion under gravity in a vertical plane using vectors where $\mathbf{a} = \begin{pmatrix} 0 \\ -g \end{pmatrix}$ or $\mathbf{a} = -g\mathbf{j}$.<br>i) Be able to model the motion of a projectile as a particle moving with constant acceleration and understand the limitation of this model.<br>*Includes being able to:*<br>*1. Use horizontal and vertical equations of motion to solve problems on the motion of projectiles.*<br>*2. Find the magnitude and direction of the velocity at a given time or position.*<br>*3. Find the range on a horizontal plane and the greatest height achieved.*<br>*4. Derive and use the cartesian equation of the trajectory of a projectile.*<br>[*Projectiles on an inclined plane and problems with resistive forces are excluded.*] | MQ5 |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| **3.03 Forces and Newton's Laws** | | | | |
| 3.03a | Newton's first law | a) Understand the concept and vector nature of a force.<br>*A force has both a magnitude and direction and can cause an object with a given mass to change its velocity.*<br>*Includes using directed line segments to represent forces (acting in at most two dimensions).*<br>*Learners should be able to identify the forces acting on a system and represent them in a force diagram.* | | MR1 |
| 3.03b | | b) Understand and be able to use Newton's first law.<br>*A particle that is at rest (or moving with constant velocity) will remain at rest (or moving with constant velocity) until acted upon by an external force.*<br>*Learners should be able to complete a diagram with the force(s) required for a given body to remain in equilibrium.* | | |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| 3.03c<br>3.03e<br><br><br><br><br><br><br><br><br>3.03d | Newton's second law | c) Understand and be able to use Newton's second law ($F = ma$) for motion in a straight line for bodies of constant mass moving under the action of constant forces.<br>*e.g. A car moving along a road, a passenger riding in a lift or a crane lifting a weight.*<br>*For stage 1 learners, examples can be restricted to problems in which the forces acting on the body will be collinear, in two perpendicular directions or given as 2-D vectors.*<br>d) Understand and be able to use Newton's second law ($F = ma$) in simple cases of forces given as two dimensional vectors.<br>*e.g. Find in vector form the force acting on a body of mass 2 kg when it is accelerating at* $(4\mathbf{i} - 3\mathbf{j})$ *m s*$^{-2}$.<br>*Questions set involving vectors may involve either column vector notation* $\mathbf{F} = \begin{pmatrix} F_1 \\ F_2 \end{pmatrix}$ *or* $\mathbf{i}$, $\mathbf{j}$ *notation*<br>$\mathbf{F} = F_1\mathbf{i} + F_2\mathbf{j}$. | e) Be able to extend use of Newton's second law to situations where forces need to be resolved (restricted to two dimensions).<br>*e.g. A force acting downwards on a body at a given angle to the horizontal or the motion of a body projected down a line of greatest slope of an inclined plane.* | MR2 |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| 3.03f<br><br><br><br>3.03g | Weight | f) Understand and be able to use the weight ($W = mg$) of a body to model the motion in a straight line under gravity.<br>*e.g. A ball falling through the air.*<br>g) Understand the gravitational acceleration, *g*, and its value in S.I. units to varying degrees of accuracy.<br>*The value of g may be assumed to take a constant value of 9.8 ms* $^{-2}$ *but learners should be aware that g is not a universal constant but depends on location in the universe.*<br>[*The inverse square law for gravitation is not required.*] | | MR3 |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| 3.03h<br>3.03l | Newton's third law | h) Understand and be able to use Newton's third law.<br>*Every action has an equal and opposite reaction.*<br>*Learners should understand and be able to use the concept that a system in which none of its components have any relative motion may be modelled as a single particle.* | l) Be able to extend use of Newton's third law to situations where forces need to be resolved (restricted to two dimensions). | MR4 |
| 3.03i | | i) Understand and be able to use the concept of a normal reaction force.<br>*Learners should understand and use the result that when an object is resting on a horizontal surface the normal reaction force is equal and opposite to the weight of the object. This includes knowing that when* $R = 0$ *contact is lost.* | | |
| 3.03j | | j) Be able to use the model of a 'smooth' contact and understand the limitations of the model. | | |
| 3.03k<br>3.03m | | k) Be able to use the concept of equilibrium together with one dimensional motion in a straight line to solve problems that involve connected particles and smooth pulleys.<br>*e.g. A train engine pulling a train carriage(s) along a straight horizontal track or the vertical motion of two particles, connected by a light inextensible string passing over a fixed smooth peg or light pulley.* | m) Be able to use the principle that a particle is in equilibrium if and only if the sum of the resolved parts in a given direction is zero.<br>*Problems may involve the resolving of forces, including cases where it is sensible to:*<br>*1. resolve horizontally and vertically,*<br>*2. resolve parallel and perpendicular to an inclined plane,*<br>*3. resolve in directions to be chosen by the learner, or*<br>*4. use a polygon of forces.* | |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| 3.03n<br>3.03o | Newton's third law (continued) | n) Be able to solve problems involving simple cases of equilibrium of forces on a particle in two dimensions using vectors, including connected particles and smooth pulleys.<br>*e.g. Finding the required force* $\mathbf{F}$ *for a particle to remain in equilibrium when under the action of forces* $\mathbf{F}_1, \mathbf{F}_2, \ldots$<br>*For stage 1 learners, examples can be restricted to problems in which the forces acting on the body will be collinear, in two perpendicular directions or given as 2-D vectors.* | o) Be able to resolve forces for more advanced problems involving connected particles and smooth pulleys.<br>*e.g. The motion of two particles, connected by a light inextensible string passing over a light pulley placed at the top of an inclined plane.* | MR4 |
| 3.03p | Applications of vectors in a plane | | p) Understand the term 'resultant' as applied to two or more forces acting at a point and be able to use vector addition in solving problems involving resultants and components of forces.<br>*Includes understanding that the velocity vector gives the direction of motion and the acceleration vector gives the direction of resultant force.*<br>*Includes being able to find and use perpendicular components of a force, for example to find the resultant of a system of forces or to calculate the magnitude and direction of a force.*<br>[*Solutions will involve calculation, not scale drawing.*] | MR5 |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| 3.03q | | | q) Be able to solve problems involving the dynamics of motion for a particle moving in a plane under the action of a force or forces.<br>*e.g. At time* $t$ *s the force acting on a particle* P *of mass* 4 *kg is* $(4\mathbf{i}+t\mathbf{j})$ N. P *is initially at rest at the point with position vector* $(3\mathbf{i}-5\mathbf{j})$. *Find the position vector of* P *when* $t=3\,s$. | |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| 3.03r<br>3.03s | Frictional forces | r) Understand the concept of a frictional force and be able to apply it in contexts where the force is given in vector or component form, or the magnitude and direction of the force are given. | s) Be able to represent the contact force between two rough surfaces by two components (the ‘normal’ contact force and the ‘frictional’ contact force).<br>*Questions set will explicitly use the terms normal (contact) force, frictional (contact) force and magnitude of the contact force*. | MR6 |
| 3.03t | | | t) Understand and be able to use the coefficient of friction and the $F \le \mu R$ model of friction in one and two dimensions, including the concept of limiting friction.<br>[*Knowledge of the angle of friction is excluded.*] | |
| 3.03u | | | u) Understand and be able to solve problems regarding the static equilibrium of a body on a rough surface and solve problems regarding limiting equilibrium. | |
| 3.03v | | | v) Understand and be able to solve problems regarding the motion of a body on a rough surface.<br>*e.g. The motion of a body projected down a line of greatest slope on a rough inclined plane*.<br>[*Problems set on inclined planes will only consider motion along the line of greatest slope and therefore a vector consideration of the motion will not be required.*] | |

| OCR Ref. | Subject Content | Stage 1 learners should ... | Stage 2 learners additionally should ... | DfE Ref. |
|---|---|---|---|---|
| **3.04 Moments** | | | | |
| 3.04a | Statics | | a) Be able to calculate the moment of a force about an axis through a point in the plane of the body.<br>*For coplanar forces, moments may be described as being about a point.*<br>[*Understanding of the vector nature of moments is excluded.*] | MS1 |
| 3.04b | | | b) Understand that when a rigid body is in equilibrium the resultant moment is zero and the resultant force is zero. | |
| 3.04c | | | c) Be able to use moments in simple static contexts.<br>*e.g. To determine the forces acting on a horizontal beam or to determine the forces acting on a ladder resting on horizontal ground against a vertical wall.*<br>*Questions will be set in which the context of the problem can be modelled using rectangular laminas, uniform and non-uniform rods only*.<br>*Learners may assume that:*<br>*1. for a uniform rod the weight acts at the midpoint of the rod,*<br>*2. for a non-uniform rod the weight acts at either a specified given point or is to be determined by moments,*<br>*3. for a rectangular lamina the weight acts at its point of symmetry*. | |