# Mapping Guide: Legacy AS and A2 units 7895 to H640

## Unshaded content is AS content.

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **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.  Notes  Proceeding from given assumptions through a series of logical steps to a conclusion. | C3p1 | Proof by exhaustion is now at AS. |
| p2 | Be able to disprove a conjecture by the use of a counter example. | C3p2 | Use of counterexample is now at AS. |
| **PURE MATHEMATICS: PROOF (2)** | | | | |
| Proof | p3 | Understand and be able to use proof by contradiction.  Notes  Including proof of the irrationality of  and the infinity of primes, and application to unfamiliar proofs. | C3p1 | The examples of proof by contradiction are new. |

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| **PURE MATHEMATICS: ALGEBRA (1)** | | | | |
| Algebraic language | Ma1 | Know and be able to use vocabulary and notation appropriate to the subject at this level.  Notes  Vocabulary includes constant, coefficient, expression, equation, function, identity, index, term, variable, unknown.  Notation | C1a1 |  |
| Solution of equations | \* | Be able to solve linear equations in one unknown.  Notes  Including those containing brackets, fractions and the unknown on both sides of the equation. | C1a2, C4a4 | There is no explicit learning outcome relating to equations with algebraic fractions but they are not excluded. |
| \* | Be able to change the subject of a formula.  Notes  Including cases where the new subject appears on both sides of the original formula, and cases involving squares, square roots and reciprocals. | C1a3 | Formulae with reciprocals has been explicitly added to the Notes. |
| a2 | Be able to solve quadratic equations.  Notes  By factorising, completing the square, using the formula and graphically.  Includes quadratic equations in a function of the unknown. | C1a5 |  |

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| Solution of equations | Ma3 | Be able to find the discriminant of a quadratic function and understand its significance.  Notes  The condition for distinct real roots of  is:  Discriminant > 0. The condition for repeated roots is: Discriminant = 0.  The condition for no real roots is: Discriminant < 0.  Notation  For  the discriminant is .  Exclusions  Complex roots. | C1a6 |  |
| a4 | Be able to solve linear simultaneous equations in two unknowns.  Notes  By elimination and by substitution. | C1a8 |  |
| a5 | Be able to solve simultaneous equations in two unknowns with one equation linear and one quadratic.  Notes  By elimination and by substitution. | C1a9 |  |
| a6 | Know the significance of points of intersection of two graphs with relation to the solution of equations.  Notes  Including simultaneous equations. | C1a4, C1a8, C1a10 | Although repeated roots are not explicitly mentioned in the new specification, there is no reduction of content here. |

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| Inequalities | Ma7 | Be able to solve linear inequalities in one variable. Be able to represent and interpret linear inequalities graphically e.g.  Notes  Including those containing brackets and fractions. | C1a11 | Explicit statement of requirement to represent linear inequalities graphically is new. |
| a8 | Be able to solve quadratic inequalities in one variable. Be able to represent and interpret quadratic inequalities graphically e.g. .  Notes  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.  Exclusions  Complex roots | C1a12 | The note about boundaries and shading is new. |
| a9 | Be able to express solutions of inequalities through correct use of ‘and’ and ‘or’, or by using set notation.  Notes  Learners will be expected to express solutions to quadratic inequalities in an appropriate version of one of the following ways.   * or  * *x* < 5 and *x* > 2   Notation  {*x*: *x* > 4} |  | This is new. |
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| Surds  Indices | Ma10 | Be able to use and manipulate surds. | C1a13 |  |
| a11 | Be able to rationalise the denominator of a surd.  Notes  e.g. | C1a14 |  |
| a12 | Understand and be able to use the laws of indices for all rational exponents.  Notes | C1a15 |  |
| a13 | Understand and be able to use negative, fractional and zero indices.  Notes  ( ). | C1a16 |  |
| Proportion | a14 | Understand and use proportional relationships and their graphs.  Notes  For one variable directly or inversely proportional to a power or root of another. |  | This is new but builds on GCSE work. |

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| **PURE MATHEMATICS: ALGEBRA (2)** | | | | |
| Partial fractions | Ma15 | Be able to express algebraic fractions as partial fractions.  Notes  Fractions with constant or linear numerators and denominators up to three linear terms. Includes squared linear terms in denominator.  Exclusions  Fractions with a quadratic or cubic which cannot be factorised in the denominator. | C4a5 | Possible denominators for fractions now includes three linear terms but excludes factors such as .  Improper fractions are not excluded. |
| Rational expressions | a16 | Be able to simplify rational expressions.  Notes  Including factorising, cancelling and simple algebraic division. Any correct method of algebraic division may be used.  Exclusions  Division by non-linear expressions. | C4a3 |  |

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| **PURE MATHEMATICS: FUNCTIONS (1)** | | | | |
| Polynomials | Mf1 | Be able to add, subtract, multiply and divide polynomials.  Notes  Expanding brackets and collecting like terms.  Exclusions  Division by non-linear expressions. | C1f1 |  |
| f2 | Understand the factor theorem and be able to use it to factorise a polynomial or to determine its zeros.  Notes  is a factor of .  Including when solving a polynomial equation.  Exclusions  Equations of degree > 4. | C1f2, C1f3 | The remainder theorem is not included. |
| **PURE MATHEMATICS: FUNCTIONS (2)** | | | | |
| The language of functions | f3 | Understand the definition of a function, and be able to use the associated language.  Notes  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 f(*x*) = *y*. The range is the set of all possible values of f(*x*).  Notation  Many-to-one, one-to-one, domain, range. | C3f1 | Odd, even and periodic functions are no longer included. |

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| The language of functions | Mf4 | Understand and use composite functions.  Notes  Includes finding the correct domain of gf given the domains of f and g.  Notation | C3f5 |  |
| f5 | Understand and be able to use inverse functions and their graphs. Know the conditions necessary for the inverse of a function to exist and how to find it.  Notes  Includes using reflection in the line  and finding domain and range of an inverse function. e.g.  () is the inverse of .  Notation | C3f6 |  |
| The modulus function | f6 | Understand and be able to use the modulus function.  Notes  Graphs of the modulus of linear functions involving a single modulus sign. | C3f9 |  |
| f7 | Be able to solve simple inequalities containing a modulus sign.  Notes  Including the use of inequalities of the form  to express upper and lower bounds, , for the value of *x*.  Exclusions  Inequalities involving more than one modulus sign or modulus of non-linear functions. | C3f10 |  |
| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Modelling | Mf8 | Be able to use functions in modelling.  Notes  Including consideration of limitations and refinements of the models. |  | The specific requirement to use functions in modelling is new. |
| **PURE MATHEMATICS: GRAPHS (1)** | | | | |
| Graphs | MC1 | Understand and use graphs of functions. |  | This is a new statement but the content was implicit in the legacy specification. |
| Sketching curves | C2 | Understand how to find intersection points of a curve with coordinate axes.  Notes  Including relating this to the solution of an equation. | C1a4 |  |
| 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).  Notes  The curve  has   * a minimum at  for  or a maximum at  for *a* < 0 * a line of symmetry . | C1a7, C1C2 |  |
| C4 | Be able to sketch and interpret the graphs of simple functions including polynomials.  Notes  Including cases of repeated roots for polynomials. | C1f6, C1C1, C1C3 |  |
| C5 | Be able to use stationary pointswhen curve sketching.  Notes  Including distinguishing between maximum and minimum turning points. | C2C1 |  |
| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Sketching curves | MC6 | Be able to sketch and interpret the graphs of  and .  Notes  Including their vertical and horizontal asymptotes and recognising them as graphs of proportional relationships. |  | This is new; it builds on GCSE work. |
| Transform-ations | C7 | Be able to sketch curves of the forms  and , given the curve of  and describe the associated transformations. Be able to form the equation of a graph following a single transformation.  Notes  Including working with sketches of graphs where functions are not defined algebraically.  Notation  Map(s) onto.  Translation, stretch, reflection | C1C4, C2C2 |  |

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| **PURE MATHEMATICS: GRAPHS (2)** | | | | |
| Transform-ations | MC8 | Understand the effect of combined transformations on a graph and be able to form the equation of the new graph and to sketch it. Be able to recognise the transformations that have been applied to a graph from the graph or its equation.  Notation  Vector notation may be used for a translation. , | C3f2, C3f3 |  |
| Sketching curves | C9 | Be able to use stationary points of inflection when curve sketching. | C2c6, C2C1 |  |

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| **PURE MATHEMATICS: COORDINATE GEOMETRY (1)** | | | | |
| The coordinate geometry of straight lines | \* | Understand and use the equation . | C1g1 |  |
| Mg1 | Know and be able to use the relationship between the gradients of parallel lines and perpendicular lines.  Notes  For parallel lines . For perpendicular lines . | C1g3 |  |
| g2 | Be able to calculate the distance between two points. | C1g4 |  |
| g3 | Be able to find the coordinates of the midpoint of a line segment joining two points. | C1g5 |  |
| g4 | Be able to form the equation of a straight line.  Notes  Including  and | C1g6 |  |
| g5 | Be able to draw a line given its equation.  Notes  By using gradient and intercept or intercepts with axes as well as by plotting points. | C1g7 |  |
| g6 | Be able to find the point of intersection of two lines.  Notes  By solution of simultaneous equations. | C1g8 |  |
| g7 | Be able to use straight line models.  Notes  In a variety of contexts; includes considering the assumptions that lead to a straight line model. |  | The explicit requirement to use straight line models is new. |
| **Equations of straight lines** | | | | |
| Many learners taking A level Mathematics will be familiar with the equation of a straight line in the form . Their understanding at A level should extend to different forms of the equation of a straight line including , and . | | | | |
| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| 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. | C1g10, C1g11 | Although plotting of a curve is no longer explicitly stated, understanding how to do this continues to be assumed knowledge. |
| g9 | Be able to find the point(s) of intersection of a line and a circle. | C1g10 |  |
| g10 | Understand and use the equation of a circle in the form  Notes  Includes completing the square to find the centre and radius. | C1g12, C1g13 |  |
| 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   Notes  These results may be used in the context of coordinate geometry. | C1g14 |  |
| **PURE MATHEMATICS: COORDINATE GEOMETRY (2)** | | | | |
| Parametric equations | g12 | Understand the meaning of the terms parameter and parametric equations. | C4g1 |  |
| g13 | Be able to convert between cartesian and parametric forms of equations.  Notes  When converting from cartesian to parametric form, guidance will be given as to the choice of parameter. | C4g2 | Converting from cartesian to parametric form is new. |

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| Parametric equations | Mg14 | Understand and use the equation of a circle written in parametric form. | C4g3 |  |
| g15 | Be able to find the gradient of a curve defined in terms of a parameter by differentiation. Notes    Exclusions  Second and higher derivatives | C4g4 | Explicit exclusion of second and higher derivatives is new but they were not included in the legacy specification. Stationary points are not excluded. |
| g16 | Be able to use parametric equations in modelling.  Notes  Contexts include kinematics and projectiles in mechanics. Including modelling with a parameter with a restricted domain. |  | The explicit requirement to use parametric equations in modelling is new. |

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| **PURE MATHEMATICS: SEQUENCES AND SERIES (1)** | | | | |
| Binomial expansions | Ms1 | Understand and use the binomial expansion of  where *n* is a positive integer. | C1f7, C1f9 | Knowledge of Pascal’s triangle is not required but teachers may want to use it as a precursor to the formal notation . |
| s2 | Know the notations *n*! and  and that is the number of ways of selecting *r* distinct objects from *n.*  Notes  The meaning of the term factorial.  *n* a positive integer.  Link to binomial probabilities.  Notation  Exclusions  will only be used in the context of binomial expansions and binomial probabilities. | C1f8, C1f9, S1H4, S1H5 |  |
| **PURE MATHEMATICS: SEQUENCES AND SERIES (2)** | | | | |
| Binomial expansions | s3 | Use the binomial expansion of  where *n* is any rational number.  Notes  For  when  is not a positive integer.  Exclusions  General term. | C4a1 |  |
| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Binomial expansions | Ms4 | Be able to write  in the form *an*  and hence expand .  Notes  when *n* is not a positive integer.  Exclusions  Proof of convergence. | C4a2 | There is no explicit learning outcome about the use of partial fractions with binomial expansions but this is not excluded. |
| s5 | Be able to use binomial expansions with  rational to find polynomials which approximate .  Notes  Includes finding approximations to rational powers of numbers. |  | This explicit requirement is new. |
| Sequences | s6 | Know what a sequence of numbers is and the meaning of finite and infinite with reference to sequences. | C2s1 | Note that this is no longer in AS Mathematics. |
| s7 | Be able to generate a sequence using a formula for the *k*th term, or a recurrence relation of the form .  Notes  e.g. ;  with .  Notation  *k*th term: | C2s2 |  |
| s8 | Know that a series is the sum of consecutive terms of a sequence.  Notes  Starting from the first term. | C2s3 |  |
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| Sequences | Ms9 | Understand and use sigmanotation.  Notation | C2s4 |  |
| s10 | Be able to recognise increasing, decreasing and periodic sequences. | C2s5 | Requirement to recognise increasing and decreasing sequences has been added. |
| s11 | Know the difference between convergent and divergent sequences.  Notes  Including when using a sequence as a model or when using numerical methods.  Notation  Limit to denote the value to which a sequence converges.  Exclusions  Formal tests for convergence. | C2s6 |  |
| Arithmetic series | s12 | Understand and use arithmetic sequences and series.  Notes  The term arithmetic progression (AP) may also be used for an arithmetic sequence.  Notation  First term, *a* Last term, *l* Common difference, *d*. | C2s7 |  |
| s13 | Be able to use the standard formulae associated with arithmetic sequences and series.  Notes  The *n*th term, the sum to *n* terms.  Including the sum of the first *n* natural numbers.  Notation  *Sn* | C2s8 |  |
| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Geometric series | Ms14 | Understand and use geometric sequences and series.  Notes  The term geometric progression (GP) may also be used for a geometric sequence.  Notation  First term, *a* Common ratio, *r.* | C2s9 |  |
| s15 | Be able to use the standard formulae associated with geometric sequences and series.  Notes  The *n*th term, the sum to *n* terms.  Notation  *Sn* | C2s10 |  |
| s16 | Know the condition for a geometric series to be convergent and be able to find its sum to infinity.  Notation | C2s11 |  |
| Modelling | s17 | Be able to use sequences and series in modelling. | C2s12 | The explicit link to modelling is new. |

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| **PURE MATHEMATICS: TRIGONOMETRY (1)** | | | | |
| Basic trigonometry | \* | Know how to solve right-angled triangles using trigonometry. | C2t1 |  |
| Trig. functions | Mt1 | Be able to use the definitions of sin *θ*, cos*θ* and tan*θ* for any angle.  Notes  By reference to the unit circle,  . | C2t2 |  |
| t2 | Know and use the graphs of sin*θ*, cos*θ* and tan*θ*for all values of *θ*, their symmetries and periodicities.  Notes  Stretches, translations and reflections of these graphs.  Combinations of these transformations.  Notation  Period | C2t3, C3f4 |  |
| \* | Know and be able to use the exact values of sin*θ* and cos*θ* for *θ* = 0, 30, 45 , 60 and 90 and the exact values of tan*θ* for *θ* = 0, 30, 45 and 60. | C2t4 |  |
| 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 ½. | C2t8 |  |
| t4 | Know and be able to use the sine and cosine rules.  Notes  Use of bearings may be required. | C2t9 |  |
| Identities | t5 | Understand and be able to use .  Notes  e.g. solve  for . | C2t5 |  |
| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Identities | Mt6 | Understand and be able to use the identity .  Notes  e.g. solve  for . | C2t6 |  |
| Equations | t7 | Be able to solve simple trigonometric equations in given intervals and know the principal values from the inverse trigonometric functions.  Notes  e.g. , in [0o, 360o]  Includes equations involving multiples of the unknown angle e.g. .  Includes quadratic equations.  Notation  arcsin *x* sin-1*x* arccos *x* cos-1*x* arctan *x* tan-1*x*  Exclusions  General solutions. | C2t7 | Explicit inclusion of quadratic equations and equations involving multiples of the unknown angle is new. |

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| **PURE MATHEMATICS: TRIGONOMETRY (2)** | | | | |
| Trig. functions | Mt8 | Know and be able to use exact values of  for and multiples thereof and  for  and multiples thereof. |  | The explicit requirement to know the exact values for angles in radians is new. |
| t9 | Understand and use the definitions of the functions arcsin, arccos and arctan, their relationship to sin, cos and tan, their graphs and their ranges and domains. | C3f7 |  |
| Radians | t10 | Understand and use the definition of a radian and be able to convert between radians and degrees. | C2t10 |  |
| t11 | Know and be able to find the arc length and area of a sector of a circle, when the angle is given in radians.  Notes  The results  and  where *θ* is measured in radians. | C2t11 |  |
| t12 | Understand and use the standard small angle approximations of sine, cosine and tangent.  Notes  where  is in radians. |  | This is new. |
| Secant, cosecant and cotangent | t13 | Understand and use the definitions of the sec, cosec and cot functions.  Notes  Including knowledge of the angles for which they are undefined. | C4t1 |  |

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| Secant, cosecant and cotangent | Mt14 | Understand relationships between the graphs of the sin, cos, tan, cosec, sec and cot functions.  Notes  Including domains and ranges. | C4t2 |  |
| t15 | Understand and use the relationships  and *.* | C4t3 |  |
| **Radians** | | | | |
| Radian angle  *r*  *r*  *r* | A radian is the angle subtended at the centre of a circle by an arc of length equal to the radius of the circle. | | | |
| Compound angle formulae | t16 | Understand and use the identities for , , .  Notes  Includes understanding geometric proofs. The starting point for the proof will be given.  Exclusions  Proofs using de Moivre’s theorem will not be accepted. | C4t4 | The requirement to understand geometric proofs is new. |
| t17 | Know and use identities for , , *.*  Notes  Includes understanding derivations from , , . | C4t5 | The requirement to understand derivations is new. |
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| Compound angle formulae | Mt18 | Understand and use expressions for  in the equivalent forms and.  Notes  Includes sketching the graph of the function, finding its maximum and minimum values and solving equations. | C3f4, C4t7 |  |
| Equations | t19 | Use trigonometric identities, relationships and definitions in solving equations. | C4t6 |  |
| Proofs and problems | t20 | Construct proofs involving trigonometric functions and identities. |  | This is new. |
| t21 | Use trigonometric functions to solve problems in context, including problems involving vectors, kinematics and forces.  Notes  The argument of the trigonometric functions is not restricted to angles. |  | The explicit requirement to use trigonometric functions in problem solving is new. |

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| **PURE MATHEMATICS: EXPONENTIALS AND LOGARITHMS (1)** | | | | |
| Exponentials and Logarithms | ME1 | Know and use the function and its graph.  Notes  For . | C2a5 |  |
| E2 | Be able to convert from an index to a logarithmic form and vice versa.  Notes  for  and . | C2a4 |  |
| E3 | Understand a logarithm as the inverse of the appropriate exponential function and be able to sketch the graphs of exponential and logarithmic functions.  Notes  for  and  .  Includes finding and interpreting asymptotes. | C2a1 |  |
| E4 | Understand the laws of logarithms and be able to apply them, including to taking logs of both sides of an equation. Notes    Including, for example  and  Exclusions  Change of base of logarithms. | C2a2 |  |

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| Exponentials and Logarithms | ME5 | Know and use the values of  and .  Notes  , | C2a3 |  |
| E6 | Be able to solve an equation of the form .  Notes  Includes solving related inequalities. | C2a6 |  |
| E7 | Know how to reduce the equations and  to linear form and, using experimental data, to use a graph to estimate values of the parameters.  Notes  By taking logarithms of both sides and comparing with the equation .  Learners may be given graphs and asked to select an appropriate model. | C2a7 | The requirement to draw a graph in legacy 7895 has become a requirement to use a graph to estimate values of parameters. |
| Exponentials and natural logarithms | E8 | Know and be able to use the function and its graph. | C3a1, C3a3 | Note that  and natural logarithms are now AS. |
| E9 | Know that the gradient of  is  and hence understand why the exponential model is suitable in many applications. |  | This is new at AS – including the connection to the usefulness of the exponential model. |
| E10 | Know and be able to use the function and its graph. Know the relationship between  and .  Notes  is the inverse function of .  Notation | C3a1, C3a2, C3a3 |  |

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| Exponential growth and decay | ME11 | Be able to solve problems involving exponential growth and decay; be able to consider limitations and refinements of exponential growth and decay models.  Notes  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. | C3a4 | Consideration of limitations and refinements is new. |
| **Graphs with gradient proportional to one of the coordinates** | | | | |
| results in a quadratic graph.  results in an exponential graph.  Quadratic graph Exponential graph | | | | |

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| **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. | C2c1 |  |
| 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.  Exclusions  The modulus function | C2c2 |  |
| c3 | Understand and use the derivative of f(*x*) as the gradient of the tangent to the graph of *y* = f(*x*) at a general point (*x*, *y*).Know that the gradient functiongives the gradient of the curve and measures the rate of change of *y* with respect to *x.*  Notes  Be able to deduce the units of rate of change for graphs modelling real situations. The term derivative of a function.  Notation | C2c3 | The requirement to be able to deduce units of rate of change for graphs modelling real situations is new. |
| c4 | Be able to sketch the gradient function for a given curve. |  | This is new. |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Differentiation of functions | Mc5 | Be able to differentiate  where *k* is a constant and *n* is rational, including related sums and differences.  Notes  Differentiation from first principles for small positive integer powers. | C2c4 |  |
| Applications of differentiation to functions and graphs | c6 | Understand and use the second derivative as the rate of change of gradient.  Notation | C2c5 |  |
| c7 | Be able to use differentiation to find stationary points on a curve: maxima and minima.  Notes  Distinguish between maximum and minimum turning points. | C2c6 | Stationary points of inflection are no longer included in AS. |
| c8 | Understand the terms increasing function and decreasing function and be able to find where the function is increasing or decreasing.  Notes  In relation to the sign of . | C2c7 |  |
| c9 | Be able to find the equation of the tangent and normal at a point on a curve. | C2c8 |  |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **PURE MATHEMATICS: CALCULUS (2)** | | | | |
| Differentiation of functions | Mc10 | Be able to differentiate,  and *.*  Notes  Including related sums, differences and constant multiples | C3c7 | Differentiation of  is new. |
| c11 | Be able to differentiate the trigonometrical functions: ; ; for *x* in radians.  Notes  Including their constant multiples, sums and differences. Differentiation from first principles for and . | C3c8 |  |
| Product, quotient and chain rules | c12 | Be able to differentiate the product of two functions.  Notes  The product rule:  ,  *Or* | C3c1 |  |
| c13 | Be able to differentiate the quotient of two functions.  Notes  ,  *Or* | C3c2 |  |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Product, quotient and chain rules | Mc14 | Be able to differentiate composite functions using the chain rule.  Notes  *or* | C3c3 |  |
| c15 | Be able to find rates of change using the chain rule, including connected rates of change and differentiation of inverse functions.  Notes | C3c4, C3c5 |  |
| Implicit differentiation | c16 | Be able to differentiate a function or relation defined implicitly.  Notes  e.g. .  Exclusions  Second and higher derivatives. | C3c6 |  |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Applications of differentiation to functions and graphs | Mc17 | Understand that a section of curve which has increasing gradient (and so positive second derivative) is concave upwards. Understand that a section of curve which has decreasing gradient (and so negative second derivative) is concave downwards.  Notes  concave upwards (convex downwards)  concave downwards (convex upwards)  Notation  The wording “concave upwards” or “concave downwards” will be used in examination questions. |  | This is new – note that the specification defines the wording to be used in examination questions but that candidates can use alternative wording. Note also that “concave” or convex” alone is not enough. |
| c18 | Understand that a point of inflection on a curve is where the curve changes from concave upwards to concave downwards (or vice versa) and hence that the second derivative at a point of inflection is zero.  Be able to use differentiation to find stationary and non-stationary points of inflection.  Notes  Learners are expected to be able to find and classify points of inflection as stationary or non-stationary.  Distinguish between maxima, minima and stationary points of inflection. | C2c6 | Non-stationary points of inflection are new. |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **PURE MATHEMATICS: CALCULUS (1)** | | | | |
| Integration as reverse of differentiation | Mc19 | Know that integration is the reverse of differentiation.  Notes  Fundamental Theorem of Calculus. | C2c9 | The requirement to know the Fundamental Theorem of Calculus is new. |
| c20 | Be able to integrate functions of the form  where *k* is a constant and .  Notes  Including related sums and differences | C2c10 |  |
| c21 | Be able to find a constant of integration given relevant information.  Notes  e.g. Find *y* as a function of  given that  and  when . | C2c13 |  |
| Integration to find area under a curve | c22 | Know what is meant by indefinite and definite integrals.  Be able to evaluate definite integrals.  Notes  e.g. . | C2c11, C2c12 |  |
| c23 | Be able to use integration to find the area between a graph and the *x*-axis.  Notes  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.  Exclusions  Formal understanding of the continuity conditions required for the Fundamental Theorem of Calculus. | C2c14, C2c15 |  |
| **The Fundamental Theorem of Calculus** | | | | |
| Area graph | | 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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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **PURE MATHEMATICS: CALCULUS (2)** | | | | |
| Integration as inverse of differentiation | Mc24 | Be able to integrate **,** , *,* and related sums, differences and constant multiples.  Notes    *x* in radians for trigonometrical integrals.  Exclusions  Integrals involving inverse trigonometrical functions. | C3c11, C3c12, C3c13 |  |
| Integration to find area under a curve | c25 | Understand integration as the limit of a sum.  Notes  Know that |  | Volumes of revolution are no longer in A level Mathematics. |
| c26 | Be able to use integration to find the area between two curves.  Notes  Learners should also be able to find the area between a curve and the *y*-axis, including integrating with respect to *y*. |  | This is new. |
| Integration by substitution | c27 | Be able to use integration by substitution in cases where the process is the reverse of the chain rule (including finding a suitable substitution).  Notes  e.g. , , ,  Learners can recognise the integral, they need not show all the working for the substitution. | C3c9 |  |
| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Integration by substitution | Mc28 | Be able to use integration by substitution in other cases.  Notes  Learners will be expected to find a suitable substitution in simple cases e.g..  Exclusions  Integrals requiring more than one substitution before they can be integrated. | C3c10 |  |
| Integration by parts | c29 | Be able to use the method of integration by parts in simple cases.  Notes  Includes cases where the process is the reverse of the product rule.  e.g. . More than one application of the method may be required.  Includes being able to apply integration by parts to *.*  Exclusions  Reduction formulae. | C3c14, C3c15 |  |
| Partial fractions | c30 | Be able to integrate using partial fractions that are linear in the denominator. | C4c2 |  |
| Differential equations | c31 | Be able to formulate first order differential equations using information about rates of change.  Notes  Contexts may include kinematics, population growth and modelling the relationship between price and demand. | C4c4 |  |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Differential equations | Mc32 | Be able to find general or particular solutions of first order differential equations analytically by separating variables.  Notes  Equations may need to be factorised using a common factor before variables can be separated. | C4c5 |  |
|  | c33 | Be able to interpret the solution of a differential equation in the context of solving a problem, including identifying limitations of the solution.  Notes  Includes links to kinematics. |  | The interpretation of solutions and consideration of their limitations is new. |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **PURE MATHEMATICS: NUMERICAL METHODS (2)** | | | | |
| Solution of equations | Me1 | Be able to locate the roots of  by considering changes of sign of  in an interval of *x* in which  is sufficiently well-behaved.  Notes  Finding an interval in which a root lies.  This is often used as a preliminary step to find a starting value for the methods in Me3 and Me4. | C3e1 | Error bounds are not explicitly included but note that the evaluation of accuracy of numerical solutions is included in mathematical problem solving. |
| e2 | Be aware of circumstances under which change of sign methods may fail.  Notes  e.g. when the curve of  touches the *x*-axis. e.g. when the curve of  has a vertical asymptote.  e.g. there may be several roots in the interval. | C3e2 |  |
| e3 | Be able to carry out a fixed point iteration after rearranging an equation into the form  and be able to draw associated staircase and cobweb diagrams.  Notes  e.g. write  as  and use the iteration  with an appropriate starting value.  Includes use of ANS key on calculator.  Notation  iteration, iterate | C3e3, C3e7 |  |
| e4 | Be able to use the Newton-Raphson method to find a root of an equation and represent the process on a graph. | C3e5, C3e7 |  |
| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Solution of equations | Me5 | Understand that not all iterations converge to a particular root of an equation.  Notes  Know how Newton-Raphson and fixed point iteration can fail and be able to show this graphically. | C3e4 |  |
| Integration | Mc34 | Be able to find an approximate value of a definite integral using the trapezium rule, and decide whether it is an over- or an under-estimate.  Notes  In an interval where the curve is either concave upwards or concave downwards.  Notation  Number of strips. | C2c16, C4c1 | Note that the trapezium rule is not in AS. The requirement to find an integral to a given level of accuracy (from C4) is no longer in but note that the evaluation of accuracy of numerical solutions is included under mathematical problem solving. |
| c35 | Use the sum of a series of rectangles to find an upper and/or lower bound on the area under a curve. |  | This is new. |
| Problem solving | Me6 | Use numerical methods to solve problems in context. |  | This explicit requirement is new. |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **PURE MATHEMATICS: VECTORS (1)** | | | | |
| General vectors | Mv1 | Understand the language of vectors in two dimensions.  Notes  Scalar, vector, modulus, magnitude, direction, position vector, unit vector, cartesian components, equal vectors, parallel vectors, collinear. Notation  Vectors printed in **bold**.Unit vectors **i**, **j**, The magnitude of the vector **a** is written |**a**| or *a*. | C4v1, M1v1 | Scalar product and vector equations of lines and planes are no longer included in A level Mathematics. |
| 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.  Notes  Geometrical interpretation. Includes general vectors not expressed in component form. | C4v2, M1v4 | Note that for AS Mathematics, only 2-D vectors are required. |
| v3 | Be able to calculate the magnitude and direction of a vector and convert between component form and magnitude-direction form.  Notation  Magnitude-direction | M1v2, M1v3 |  |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Position vectors | Mv4 | Understand and use position vectors  Notes  Including interpreting components of a position vector as the cartesian coordinates of the point.    Notation  or **b**. | M1v1 | This statement also makes explicit content which was previously part of work on equations of lines and planes. |
| v5 | Be able to calculate the distance between two points represented by position vectors. | C4v4 | Midpoint and other points on a line are not explicitly included here but note that the midpoint is included under coordinate geometry and so is still expected when working with position vectors. |
| Using vectors | v6 | Be able to use vectors to solve problems in pure mathematics and in context, including problems involving forces.  Notes  Includes interpreting the sum of vectors representing forces as the resultant force. | M1v5 | The explicit requirement to use vectors for problems in pure mathematics is new. |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **PURE MATHEMATICS: VECTORS (2)** | | | | |
| General vectors | Mv7 | Understand the language of vectors in three dimensions.  Notes  Extend the work of Mv2 to Mv6 to include vectors in three dimensions.  Notation  Unit vectors **i**, **j**, **k**, | C4v1, M1v1 |  |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **STATISTICS: SAMPLING (1)** | | | | |
| Population and sample | Mp21 | Understand and use the terms population and sample. | S1p5 |  |
| p22 | Be able to use samples to make informal inferences about a population, recognising that different samples might lead to different conclusions.  Notes  e.g. using sample mean or variance as an estimate of population mean or variance. | S3I3,S3I4 |  |
| Sampling techniques | p23 | Understand and be able to use the concept of random sampling.  Notes  Simple random sampling. Every sample of the required size has the same probability of being selected. | S1p6, S3I1 |  |
| p24 | Understand and be able to use a variety of sampling techniques.  Notes  Opportunity sampling, systematic sampling, stratified sampling, quota sampling, cluster sampling, self-selected samples.  Any other techniques will be explained in the question. | S3I2 |  |
| p25 | Be able to select or evaluate sampling techniques in the context of solving a statistical problem.  Notes  Includes recognising possible sources of bias and being aware of the practicalities of implementation. |  | This is new. |

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| **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. |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **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.  Notes  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.  Notation  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.  Exclusions  Comparative pie charts with area proportional to frequency. | S1D1, S1D3, S1D4, S1D5, S1D6, S1D7 | The explicit inclusion of ranked data is new.  Note that the emphasis has changed and is now on understanding and interpretation of diagrams rather than on drawing them.  Note that frequency charts and dot plots are new. |
| 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.  Notes  Includes use of area scale and calculation of frequency from frequency density. | S1D5 |  |
| D3 | Be able to interpret a cumulative frequency diagram. | S1D8 |  |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Data presentation for single variable | MD4 | Be able to describe frequency distributions.  Notes  Symmetrical, unimodal, bimodal, skewed (positively and negatively).  Exclusions  Measures of skewness. | S1D9 | The explicit requirement to understand the terms unimodal and bimodal is new. |
| Data presentation | D5 | Understand that diagrams representing unbiased samples become more representative of theoretical probability distributions with increasing sample size.  Notes  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. |  | This is new. |
| 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.  Notes  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.  Exclusions  Calculation of equation of regression line from data or summary statistics. |  | This is an application of GCSE content to A level contexts and is new to the specification.  The requirement to interpret best fit models other than straight line models is new. |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Data presentation | MD7 | 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.  Notes  An outlier is an item which is inconsistent with the rest of the data.  Outliers in scatter diagrams should be judged by eye. |  | This is new. |
| D8 | Be able to recognise and describe correlation in a scatter diagram and understand that correlation does not imply causation.  Notes  Positive correlation, negative correlation, no correlation, weak/strong correlation. |  | This is an application of GCSE content to A level contexts and is new to the specification. |
| D9 | Be able to select or critique data presentation techniques in the context of a statistical problem.  Notes  Including graphs for time series. |  | This is new. |
| **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 MH10. | | | | |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| 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.  Notes  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.  Notation  Mean | S1D10, S1D11, S1D14 |  |
| D11 | Know simple measures of spread and be able to use and interpret them appropriately.  Notes  Range, percentiles, quartile, interquartile range. | S1D12 |  |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| 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.  Notes  sample variance: (†)  where  sample standard deviation:  (‡)  Notation  *,*  Exclusions  Corrections for class interval in these calculations. | S1D13, S1D14 | Note that mean squared deviation and root mean squared deviation are no longer included. |
| 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 × IQR beyond the nearer quartile.   Notes  An outlier is an item which is inconsistent with the rest of the data. | S1D16 |  |
| D14 | Be able to clean data including dealing with missing data, errors and outliers. |  | This is new. |

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| 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 .  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 .  In early work in statistics it is common practice to introduce these concepts with divisor *n* rather than . 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. |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **STATISTICS: PROBABILITY (1)** | | | | |
| Probability of events in a finite sample space | \* | Be able to calculate the probability of an event.  Notes  Using modelling assumptions such as equally likely outcomes.  Notation  P(*A*) | S1u1 |  |
| \* | 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.  Notation  *A´* is the event “not-*A*”. | S1u2 |  |
| Probability of two or more events | \* | Be able to calculate the expected frequency of an event given its probability.  Notation  Expected frequency = *n*P(*A*) | S1u4 |  |
| \* | Be able to use appropriate diagrams to assist in the calculation of probabilities.  Notes  e.g. tree diagrams, sample space diagrams, Venn diagrams. | S1u3, S1u8 |  |
| Mu1 | Understand and use mutually exclusive events and independent events. | S1u5 |  |
| u2 | Know to add probabilities for mutually exclusive events.  Notes  e.g. to find P(*A* or *B*). | S1u6 |  |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Probability of two or more events | Mu3 | Know to multiply probabilities for independent events.  Notes  e.g. to find P(*A* and *B*).  Including the use of complementary events, e.g. finding the probability of at least one 6 in five throws of a dice. | S1u7 |  |
| **STATISTICS: PROBABILITY (2)** | | | | |
| Probability of two or more events | u4 | Understand and use mutually exclusive events and independent events and associated notation and definitions.  Notes  For mutually exclusive events  for any pair of events. | S1u5, S1u6, S1u7 |  |
| u5 | Be able to use Venn diagrams to assist in the calculations of probabilities. Know how to calculate probabilities for two events which are not mutually exclusive.  Notes  Venn diagrams for up to three events.  Learners should understand the relation: .  Exclusions  Probability of a general or infinite number of events.  Formal proofs. | S1u9, S1u10 |  |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Conditional probability | Mu6 | Be able to calculate conditional probabilities by formula, from tree diagrams, two-way tables, Venn diagrams or sample space diagrams.  Notes    Notation    Exclusions  Finding reverse conditional probability i.e. calculating P(*B*|*A*) given P(*A*|*B*) and additional information. | S1u8, S1u10, S1u11 |  |
| u7 | Know that P(*B*|*A*) = P(*B*)  *B* and *A* are independent.  Notes  In this case . | S1u12 |  |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **STATISTICS: PROBABILITY DISTRIBUTIONS (1)** | | | | |
| Situations leading to a binomial distribution | MR1 | Recognise situations which give rise to a binomial distribution. | S1H1 |  |
| R2 | Be able to identify the probability of success, *p*, for the binomial distribution.  Notes  The binomial distribution as a model for observed data.  Notation  B(*n*, *p*),  *~* means ‘has the distribution’. | S1H2 |  |
| Calculations relating to binomial distribution | R3 | Be able to calculate probabilities using the binomial distribution.  Notes  Including use of calculator functions. | S1H3 |  |
| Mean and expected frequencies for binomial distribution | R4 | Understand and use mean = *np.*  Exclusions  Derivation of mean = *np* | S1H6 |  |
| R5 | Be able to calculate expected frequencies associated with the binomial distribution. | S1H7 |  |
| Discrete probability distributions | R6 | Be able to use probability functions, given algebraically or in tables. Know the term discrete random variable.  Notes  Restricted to simple finite distributions.  Notation  *X* for the random variable.  *x* or *r* for a value of the random variable. | S1R1 |  |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Discrete probability distributions | MR7 | Be able to calculate the numerical probabilities for a simple distribution. Understand the term discrete uniform distribution.  Notes  Restricted to simple finite distributions  Notation  ,  Exclusions  Calculation of E(*X*) or Var(X). | S1R2 |  |
| **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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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **STATISTICS: PROBABILITY DISTRIBUTIONS (2)** | | | | |
| Normal distribution | MR8 | Be able to use the Normal distribution as a model.  Notes  Includes recognising when a Normal distribution may not be appropriate.  Understand how and why a continuity correction is used when using a Normal distribution as a model for a distribution of discrete data.  Recognise from the shape of the distribution when a binomial distribution can be approximated by a Normal distribution.  Notation    Exclusions  Knowing conditions for Normal approximation to binomial. | S2N1 |  |
| R9 | Know the shape of the Normal curve and understand that histograms from increasingly large samples from a Normal distribution tend to the Normal curve.  Notes  Includes understanding that the area under the Normal curve represents probability. |  | This is new. |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Normal distribution | MR10 | Know that linear transformation of a Normal variable gives another Normal variable and know how the mean and standard deviation are affected. Be able to standardise a Normal variable.  Notes    Notation  Standard Normal    Exclusions  Proof | S1D15, S2N2 | Note that linear coding is now specifically in the context of Normal variables only. |
| R11 | Know that the line of symmetry of the Normal curve is located at the mean and the points of inflection are located one standard deviation away from the mean. |  | This is new. |
| R12 | Be able to calculate and use probabilities from a Normal distribution.  Notes  Including use of calculator functions. |  | Use of Normal tables to calculate Normal probabilities is not expected. |
| Modelling with probability | R13 | Be able to model with probability and probability distributions, including recognising when the binomial or Normal model may not be appropriate.  Notes  Including critiquing assumptions made and the likely effect of more realistic assumptions. |  | This is new as an explicit requirement, however, it was implicit in the legacy specification. |
| **Mean and variance of a Normal distribution** | | | | |
| The Normal distribution is a probability model; its mean and variance are calculated using techniques beyond the scope of A level Mathematics. At this level, students should understand the mean and variance of a Normal distribution as the limiting values from calculating the mean and variance of increasingly large samples from a Normal distribution. | | | | |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **STATISTICS: STATISTICAL HYPOTHESIS TESTING (1)** | | | | |
| Hypothesis testing | MH1 | Understand the process of hypothesis testing and the associated language.  Notes  Null hypothesis, alternative hypothesis. Significance level, test statistic, 1-tail test, 2-tail test. Critical value, critical region (rejection region), acceptance region, *p*-value. | S1H8, S1H11 |  |
| H2 | Understand when to apply 1- tail and 2- tail tests. | S1H13 |  |
| 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.  Notes  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. |  | This is new. |
| **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). | | | | |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Hypothesis testing for a binomial probability *p* | MH4 | Be able to identify null and alternative hypotheses (H0 and H1) when setting up a hypothesis test based on a binomial probability model.  Notes  H0 of form *p* = a particular value, with *p* a probability for the whole population.  Notation  H0, H1 | S1H9 |  |
| 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.  Exclusions  Normal approximation. | S1H10  S1H12 |  |
| H6 | Be able to identify the critical and acceptance regions. | S1H11 |  |
| **STATISTICS: STATISTICAL HYPOTHESIS TESTING (2)** | | | | |
| Hypothesis testing for a mean using Normal distribution | H7 | Know that random samples of size *n* from  have the sample mean Normally distributed with mean and variance .  Notation  Sample mean,  Particular value of sample mean,  Population mean,  Exclusions  Central Limit Theorem | S2N6 |  |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Hypothesis testing for a mean using Normal distribution | MH8 | Be able to carry out a hypothesis test for a single mean using the Normal distribution and be able to interpret the results in context.  Notes  In situations where either (a) the population variance is known or (b) the population variance is unknown but the sample size is large Learners may be asked to use a *p*‑value or a critical region.  H0 of form *µ* = a particular value, where *µ* is the population mean.  Significance level will be given. | S2N6 |  |
| H9 | Be able to identify the critical and acceptance regions. | S1H11 |  |
| Informal hypothesis testing for correlation/ association | H10 | Understand correlation as a measure of how close data points lie to a straight line.  Understand that a rank correlation coefficient measures the correlation between the data ranks rather than actual data values.  Notes  Learners are not required to know the names of particular correlation coefficients.  Notation  *r*  Exclusions  Calculation of correlation coefficient |  | This is new. |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Informal hypothesis testing for correlation/ association | MH11 | Be able to use a given correlation coefficient for a sample to make an inference about correlation or association in the population for given *p*-value or critical value.  Notes  Association refers to a more general relationship between the variables.  The (often implicit) null hypothesis is of the form either that there is no correlation or no association in the population. Questions will use an appropriate correlation coefficient and indicate whether correlation or association is being tested for.  Notation  Questions may require understanding of notation from software; sufficient guidance will be given in the question.  Exclusions  Knowledge of bivariate Normal distribution |  | This is new. |
| **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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| **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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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **MECHANICS: MODELS AND QUANTITIES (1)** | | | | |
| Standard models in mechanics | Mp31 | Know the language used to describe simplifying assumptions in mechanics.  Notes  Including the words: light; smooth; uniform; particle; inextensible; thin; rigid; long term. | M1p3 |  |
| p32 | Understand and use the particle model. | M1p4 |  |
| Units and quantities | p33 | Understand and use fundamental quantities and units in the S.I. system: length, time, mass.  Notes  Metre (m), second (s), kilogram (kg). | M1p9 |  |
| p34 | Understand and use derived quantities and units: velocity, acceleration, force, weight.  Notes  Metre per second (m s-1), metre per second per second (m s-2), newton (N). | M1p9 |  |
| **MECHANICS: MODELS AND QUANTITIES (2)** | | | | |
| Units and quantities | p35 | Understand and use derived quantities and units: moment.  Notes  Newton metre (N m). |  | This is new. |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **MECHANICS: KINEMATICS IN 1 DIMENSION (1)** | | | | |
| Motion in 1 dimension | Mk1 | Understand and use the language of kinematics.  Notes  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 | M1k1 |  |
| k2 | Know the difference between position, displacement, distance and distance travelled. | M1k2 | Distance travelled has been added. |
| k3 | Know the difference between velocity and speed, and between acceleration and magnitude of acceleration. | M1k3 |  |
| 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.  Notes  Position-time, displacement-time, distance-time, velocity-time, speed-time, acceleration-time. | M1k4 |  |
| Calculus in kinematics | k5 | Be able to differentiate position and velocity with respect to time and know what measures result.  Notation | M1k5 |  |
| k6 | Be able to integrate acceleration and velocity with respect to time and know what measures result.  Notation | M1k6 |  |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Constant acceleration formulae | Mk7 | Be able to recognise when the use of constant acceleration formulae is appropriate.  Notes  Learners should be able to derive the formulae.  Notation | M1k7 |  |
| Problem solving | k8 | Be able to solve kinematics problems using constant acceleration formulae and calculus for motion in a straight line. | M1k8 |  |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **MECHANICS: KINEMATICS IN 2 DIMENSIONS (2)** | | | | |
| Motion in 2 dimensions | Mk9 | Understand the language of kinematics appropriate to motion in 2 dimensions. Know the difference between, displacement, distance from and distance travelled; velocity and speed, and between acceleration and magnitude of acceleration.  Notes  Position vector, relative position.  Average speed = distance travelled ÷ elapsed time  Average velocity = overall displacement ÷ elapsed time  Exclusions  Relative velocity | M1k9 | Motion in three dimensions is not included. |
| k10 | Be able to extend the scope of techniques from motion in 1 dimension to that in 2 dimensions by using vectors.  Notes  The use of calculus and the use of constant acceleration formulae.  Notation            Exclusions  Vector form of | M1k10 |  |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Motion in 2 dimensions | Mk11 | Be able to find the cartesian equation of the path of a particle when the components of its position vector are given in terms of time. | M1k11 |  |
| k12 | Be able to use vectors to solve problems in kinematics.  Notes  Includes relative position of one particle from another.  Includes knowing that the velocity vector gives the direction of motion and the acceleration vector gives the direction of resultant force. | M1v5, M1k12 |  |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **MECHANICS: PROJECTILES (2)** | | | | |
| Motion under gravity in 2 dimensions | My1 | Be able to model motion under gravity in a vertical plane using vectors. Be able to formulate the equations of motion of a projectile using vectors.  Notes  Standard modelling assumptions for projectile motion are as follows.   * No air resistance. * The projectile is a particle. * Horizontal distance travelled is small enough to assume that gravity is always in the same direction. * Vertical distance travelled is small enough to assume that gravity is constant.   Exclusions  Calculations involving air resistance | M1y1 | The explicit statement of the standard modelling assumptions is new – candidates are expected to know these. |
| y2 | Know how to find the position and velocity at any time of a projectile and find range and maximum height. | M1y2 |  |
| y3 | Be able to find the initial velocity of a projectile given sufficient information. | M1y3 |  |
| y4 | Be able to eliminate time from the component equations that give the horizontal and vertical displacement in terms of time to obtain the equation of the trajectory. | M1y4 |  |
| y5 | Be able to solve simple problems involving projectiles.  Exclusions  Maximum range on inclined plane  Bounding parabola | M1y5 |  |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **MECHANICS: FORCES (1)** | | | | |
| Identifying and representing forces | MF1 | Understand the language relating to forces  Notes  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). | M1d1 | Driving force has been added. |
| 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.  Notes  *g* ≈10, *g* ≈ 9.8  Unless otherwise specified, in examinations the value of *g* should be taken to be 9.8.  Notation  Acceleration due to gravity, *g* m s-2.  Exclusions  Inverse square law for gravitation. |  | This is new. |
| 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. | M1d2 |  |
| 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. | M1d4 |  |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Vector treatment of forces | MF5 | 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. | M1d5 |  |
| **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. | | | | |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **MECHANICS: FORCES (2)** | | | | |
| Vector treatment of forces | MF6 | Be able to resolve a force into components and be able to select suitable directions for resolution. Be able to find the resultant of several concurrent forces by resolving and adding components.  Notes  e.g. Horizontally and vertically, or parallel and perpendicular to an inclined plane. | M1d3, M1d4 |  |
| F7 | Know that a particle is in equilibrium if and only if the resultant of the forces acting on it is zero. Know that a body is in equilibrium under a set of concurrent forces if and only if their resultant is zero. | M1d5 |  |
| F8 | Know that vectors representing a set of forces in equilibrium sum to zero. Know that a closed figure may be drawn to represent the addition of the forces on an object in equilibrium. | M1d6 |  |
| F9 | Be able to formulate and solve equations for a particle in equilibrium: by resolving forces in suitable directions; by drawing and using a polygon of forces.  Notes  For example, a triangle of forces.  Exclusions  Non-coplanar forces | M1d7 |  |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| Frictional force and normal contact force | MF10 | Understand that the overall contact force between surfaces may be expressed in terms of a frictional force and a normal contact force and be able to draw an appropriate force diagram.  Understand that the normal contact force cannot be negative.  Notes  Understand the following modelling assumptions.   * Smooth is used to mean that friction may be ignored. * Rough indicates that friction must be taken into account.   Notation  Normal reaction. | M2d1, M2d2 |  |
| F11 | Understand that the frictional force may be modelled by  and that friction acts in the direction to oppose sliding. Model friction using  when sliding occurs.  Notation  Coefficient of friction = *μ*  Limiting friction, static equilibrium  Exclusions  The term angle of friction. | M2d3 |  |
| F12 | Be able to apply Newton's Laws to problems involving friction. | M2d4 |  |

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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **MECHANICS: NEWTON’S LAWS OF MOTION (1)** | | | | |
| Newton’s laws for a particle | Mn1 | Know and understand the meaning of Newton's three laws.  Notes  Includes applying the laws to problems. | M1n1 |  |
| n2 | Understand the term equation of motion. | M1n2 |  |
| 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.  Notes  Including motion under gravity.  Notation  where *F* is the resultant force.  where  is the resultant force.  Exclusions  Variable mass. | M1n3 |  |
| Connected particles | n4 | Be able to model a system as a set of connected particles.  Notes  e.g. simple smooth pulley systems, trains.  Internal and external forces for the system. | M1n5 |  |
| n5 | Be able to formulate the equations of motion for the individual particles within the system. | M1n5 |  |
| 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.  Notes  e.g. Train. | M1n5 |  |
| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **MECHANICS: NEWTON’S LAWS OF MOTION (2)** | | | | |
| Newton’s laws for a particle | Mn7 | Be able to formulate the equation of motion for a particle moving in a straight line or in a plane.  Notes  Including motion under gravity.  Notation  where *F* is the resultant force.  where **F** is the resultant force.  Exclusions  Variable mass. | M1n4 |  |
| **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 **F** acting on an object of fixed mass *m* gives the object an acceleration **a** given by **F** = *m***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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| **Spec. Content** | **Ref.** | **Learning outcomes, Notes, Notation, Exclusions** | **Legacy Unit and Ref.** | **Notes** |
| **MECHANICS: RIGID BODIES (2)** | | | | |
| This section is an introduction to moments in static contexts. The only situations considered are bodies that may be modelled as (possibly non-uniform) rods and rectangular laminas. The only forces considered are coplanar, and act perpendicular to the rod or to an edge of the lamina. The learning outcome should be read in the light of this restriction.  In more advanced work, moments are described as acting about an axis, and learners should be aware of this. Given the restrictions on the situations considered, however, moments may be described as acting about a point, with an implied axis perpendicular to the plane in which the forces are acting. This is consistent with the approach used to describe rotations in 2-D. | | | | |
| Rigid bodies in equilibrium | MF13 | Be able to calculate the moment of a force about a point or axis.  Notation  Units of moment are N m.  Exclusions  Vector treatment. | M2d7 |  |
| F14 | Understand that a rigid body is in equilibrium when the resultant force is zero and the sum of the moments about any one point is zero. | M2d8 |  |
| F15 | Understand that a system of forces can have a turning effect on a rigid body.  Notation  Moment | M2d6 |  |

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| Rigid bodies in equilibrium | MF16 | Know that, for the purpose of calculating its moment, the weight of a body can be taken as acting through a point.  Notes  The point is the centre of mass of the body.  Questions will be restricted to cases where the centre of mass is given or can be found using symmetry or can be found from consideration of moments.  Notation  Uniform  Exclusions  Finding the centre of mass of a composite body. | M2G2 |  |

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| Content from Legacy Units (C1, C2, C3, C4, S1, M1) which does not appear in the reformed A Level specification (H640):  C1 – Understand the remainder theorem and know how to use it.  C1 – Use Pascal’s triangle in binomial expansions.  C3 – Understand what is meant by the terms odd, even and periodic functions and the symmetries associated with them.  C4 – Expressing an algebraic fraction with a denominator of form  in partial fractions.  C4 – Volumes of revolution.  C4 – Scalar product.  C4 – Vector and cartesian equations of lines and planes in 3-D.  C4 – Intersection of lines and planes.  S1 – Drawing statistical diagrams (however, candidates may be asked to add to diagrams).  S1 – Mean squared deviation and root mean squared deviation.  S1 – Calculation of expectation and variance of discrete random variable.  M1 – Kinematics in three dimensions. |

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