

Grade C checklist

157 skills. Tick each one when you can do it. For grade C you need the skills for the grades below it too.

Pure mathematics

- ☐ **Prove a statement by exhaustion** Split all possibilities into a finite set of cases (e.g. n even and n odd) and prove each one. (Proof by deduction, exhaustion and counter-example)

- ☐ **Prove an algebraic result by deduction** Expand and factorise to show, for example, that an expression equals $8 \times$ an integer. (Proof by deduction, exhaustion and counter-example)

- ☐ **Write the opening assumption correctly** Assume the negation of the statement, e.g. for 'there is no greatest odd number' assume there is a greatest odd number, N . (Proof by contradiction)

- ☐ **Write expressions as powers of x** e.g. $\frac{3}{\sqrt{x}} = 3x^{-\frac{1}{2}}$, ready to differentiate or integrate. (Laws of indices)

- ☐ **Split a fraction into separate powers** e.g. $\frac{x^2+4}{2\sqrt{x}} = \frac{1}{2}x^{\frac{3}{2}} + 2x^{-\frac{1}{2}}$. (Laws of indices)

- ☐ **Rationalise a single-surd denominator** Multiply top and bottom by the surd: $\frac{6}{\sqrt{3}} = \frac{6\sqrt{3}}{3} = 2\sqrt{3}$. (Surds)

- ☐ **Use the discriminant to count real roots** $b^2 - 4ac > 0$: two distinct real roots; $= 0$: one repeated root; < 0 : no real roots. (Quadratics and the discriminant)

- ☐ **Find the coordinates of intersection points** Solve for one variable, then substitute each value into the linear equation to get the pairs. (Simultaneous equations)

- ☐ **Interpret solutions as intersections of graphs** Two solutions: the line crosses the curve twice; one: it is a tangent; none: they do not meet. (Simultaneous equations)

- ☐ **Write solutions using set notation** e.g. $\{x : x < -2\} \cup \{x : x > 5\}$ for two regions, $\{x : -2 < x < 5\}$ for one. (Inequalities)

- ☐ **Find values satisfying two inequalities together** Show both solution sets on a number line and find where they overlap. (Inequalities)

- ☐ **Define a region using inequalities** Decide which side of each line or curve the region is on, and whether the boundary is included. (Inequalities)

- ☐ **Divide a cubic by a linear factor** Use long division or compare coefficients to find the quadratic factor. (Polynomials, algebraic division and the factor theorem)

- ☐ **Factorise a cubic completely** Find one factor with the factor theorem, divide, then factorise the quadratic quotient. (Polynomials, algebraic division and the factor theorem)

- ☐ **Simplify algebraic fractions by factorising** Factorise the top and bottom fully, then cancel common factors (whole brackets only). (Polynomials, algebraic division and the factor theorem)

- ☐ **Sketch the modulus graph of a linear function** Reflect the part of $y = ax + b$ below the x -axis to make a V shape, vertex at $x = -\frac{b}{a}$. (Curve sketching and the modulus function)

- ☐ **Use intersections to count solutions** The number of points where $y = f(x)$ and $y = g(x)$ meet is the number of real solutions of $f(x) = g(x)$. (Curve sketching and the modulus function)

- ☐ **State the range of a function** Use a sketch over the given domain; write the range in terms of $f(x)$, e.g. $f(x) \geq 2$. (Composite and inverse functions)
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- ☐ **Sketch a function and its inverse** The graph of $y = f^{-1}(x)$ is the reflection of $y = f(x)$ in the line $y = x$. (Composite and inverse functions)
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- ☐ **Find where points and asymptotes move** Apply the transformation to coordinates, e.g. under $y = 2f(x)$, $(3, 4)$ moves to $(3, 8)$. (Transformations of graphs)
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- ☐ **Describe a single transformation fully** Name it and give every detail: the vector, or the direction and scale factor, or the mirror line. (Transformations of graphs)
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- ☐ **Find the constants by substitution** Multiply through by the denominator and substitute the roots, e.g. $x = a$, to find A and B quickly. (Partial fractions)
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- ☐ **Handle three distinct linear factors** Use $\frac{A}{x-a} + \frac{B}{x-b} + \frac{C}{x-c}$ and substitute each root in turn. (Partial fractions)
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- ☐ **Interpret constants and features in context** e.g. the value at $t = 0$ is the starting value; the vertex of a quadratic is a greatest height. (Modelling with functions)
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- ☐ **State a sensible domain for a model** Only values that make sense, e.g. from $t = 0$ until the object hits the ground. (Modelling with functions)
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- ☐ **Find midpoints, lengths and intersections** Use the midpoint and distance formulae, and solve the equations of two lines simultaneously. (Straight lines)
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- ☐ **Use straight-line models in context** Interpret the gradient as a rate of change and the intercept as a starting or fixed value. (Straight lines)
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- ☐ **Complete the square to find centre and radius** e.g. $x^2 + y^2 - 6x + 4y - 12 = 0$ becomes $(x - 3)^2 + (y + 2)^2 = 25$: centre $(3, -2)$, radius 5. (Circles)
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- ☐ **Find the equation of a tangent** The tangent is perpendicular to the radius at that point, so use the negative reciprocal of the radius gradient. (Circles)
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- ☐ **Find where a curve meets an axis or line** Set $y = 0$ or $x = 0$, or substitute $x(t)$ and $y(t)$ into the line's equation, then solve for t . (Parametric equations)
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- ☐ **Convert trigonometric parametric equations** Use identities such as $\sin^2 t + \cos^2 t = 1$ or $\cos 2t = 1 - 2\sin^2 t$ to eliminate t . (Parametric equations)
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- ☐ **Find when a condition is met** e.g. set $y = 0$ to find when a ball lands, and choose the root that fits the context. (Parametric equations in modelling)
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- ☐ **Interpret constants and the parameter** e.g. the coefficient of t in $x = 18t$ is a constant horizontal speed of 18 m s^{-1} . (Parametric equations in modelling)
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- ☐ **Find an unknown constant from a coefficient** Write the coefficient in terms of the constant, set it equal to the given value and solve, e.g. $28k^2 = 252$. (Binomial expansion)
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- ☐ **Expand $(1 + x)^n$ for negative or fractional n** Use $1 + nx + \frac{n(n-1)}{2!}x^2 + \dots$ to give the first few terms, valid for $|x| < 1$. (Binomial expansion)
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- ☐ **Find unknown constants in a recurrence relation** Write the terms in terms of the constant, form an equation from a given term and solve it. (Sequences and recurrence relations)
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- ☐ **Evaluate an arithmetic series in sigma notation** A linear rule such as $3r + 2$ gives an arithmetic series: find the first term, last term and number of terms, then use S_n . (Sigma notation)
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- ☐ **Find a and d from given information** Turn each fact into an equation in a and d, then solve the equations simultaneously. (Arithmetic sequences and series)
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- ☐ **Use consecutive terms to find an unknown** If p, q and r are consecutive terms, then $q - p = r - q$. (Arithmetic sequences and series)
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- ☐ **Find a and r from two terms** Divide one term equation by the other to eliminate a, e.g. $\frac{ar^4}{ar} = r^3$. (Geometric sequences and series)
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- ☐ **Find a total over several periods** Use S_n when the question asks for a total, e.g. the total distance run over 12 weeks. (Modelling with sequences and series)
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- ☐ **Find both angles in the ambiguous case** If the sine rule gives $\sin B = k$, the angle could be B or $180^\circ - B$; check whether both fit in the triangle. (Sine and cosine rules, radians, arcs and sectors)
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- ☐ **Recall the three small angle approximations** $\sin \theta \approx \theta$, $\tan \theta \approx \theta$ and $\cos \theta \approx 1 - \frac{\theta^2}{2}$, for small θ in radians. (Small angle approximations)
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- ☐ **Use symmetry to find related angles** e.g. $\sin(180^\circ - x) = \sin x$, $\cos(-x) = \cos x$ and $\tan(x + 180^\circ) = \tan x$. (Graphs of sin, cos and tan)
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- ☐ **Sketch translated and stretched trig graphs** e.g. $y = \cos(x + 30^\circ)$ is $y = \cos x$ translated 30° to the left. (Graphs of sin, cos and tan)
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- ☐ **Define sec, cosec and cot** $\sec x = \frac{1}{\cos x}$, $\operatorname{cosec} x = \frac{1}{\sin x}$ and $\cot x = \frac{1}{\tan x} = \frac{\cos x}{\sin x}$. (sec, cosec, cot and inverse trig functions)
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- ☐ **Find exact values of reciprocal and inverse functions** e.g. $\sec \frac{\pi}{3} = 2$ and $\arccos\left(-\frac{1}{2}\right) = \frac{2\pi}{3}$. (sec, cosec, cot and inverse trig functions)
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- ☐ **Find exact values using $\sin^2 \theta + \cos^2 \theta = 1$** Given one ratio and the quadrant, find the other ratios with the correct signs. (Pythagorean identities)
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- ☐ **Find exact values using compound angles** e.g. $\sin 75^\circ = \sin(45^\circ + 30^\circ) = \frac{\sqrt{6} + \sqrt{2}}{4}$. (Compound and double angles; $R \cos(\theta \pm \alpha)$)
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- ☐ **Use the double angle formulae** Know $\sin 2A$, the three forms of $\cos 2A$ and $\tan 2A$, and choose the most useful form. (Compound and double angles; $R \cos(\theta \pm \alpha)$)
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- ☐ **Solve equations with multiple angles** For $\cos 2x = k$, solve for $2x$ in the doubled interval, then halve. (Solving trigonometric equations)
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- ☐ **Solve equations with a shifted angle** For $\cos(x - \alpha) = k$, shift the interval by α , solve, then add α back on. (Solving trigonometric equations)
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- ☐ **Prove simple identities using $\sin^2 x + \cos^2 x = 1$** e.g. show that $(1 - \cos x)(1 + \cos x) \equiv \sin^2 x$. (Proving trigonometric identities)
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- ☐ **Solve bearings problems using sine and cosine rules** Draw north lines, find the angle inside the triangle, then use the right rule. (Trigonometry in context)
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- ☐ **Know the graphs of $y = e^x$ and $y = e^{-x}$** $e \approx 2.718$, so $y = e^x$ lies between $y = 2^x$ and $y = 3^x$; $y = e^{-x}$ is its reflection in the y-axis. (Exponential functions and graphs)
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- ☐ **Find the gradient at a given point** Differentiate first, then substitute, giving exact answers such as $2e$.
(The function e^x and its gradient)
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- ☐ **Solve equations using $\ln$ and e** Take $\ln$ of both sides of $e^{3x+1} = 10$, or write $2y - 1 = e^4$ when $\ln(2y - 1) = 4$. (Logarithms)
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- ☐ **Sketch $y = \ln x$** Through $(1, 0)$, increasing, defined only for $x > 0$, with the y-axis as a vertical asymptote. (Logarithms)
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- ☐ **Write an expression as a single logarithm** Use the power law first, then combine, writing plain numbers as logs, e.g. $2 = \log_3 9$. (Laws of logarithms)
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- ☐ **Express logarithms in terms of given logs** Given $\log_a 2 = p$ and $\log_a 3 = q$, write $\log_a 12 = 2p + q$. (Laws of logarithms)
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- ☐ **Solve $a^{px+q} = b$** Bring the whole bracket down: $(px + q) \ln a = \ln b$, then rearrange. (Solving exponential equations)
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- ☐ **Choose the right axes for a straight line** Power law: $\log y$ against $\log x$. Exponential: $\log y$ against x .
(Using log graphs to estimate parameters)
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- ☐ **Find when a quantity reaches a value** Rearrange to $e^{kt} = \dots$, then take $\ln$ of both sides. (Exponential growth and decay models)
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- ☐ **Give a limitation of a model** E.g. a growth model predicts that a population increases without limit, which is unrealistic. (Exponential growth and decay models)
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- ☐ **Sketch the gradient function of a curve** Where the curve has a stationary point, $y = f'(x)$ meets the x-axis; where the curve increases, $f'(x) > 0$. (First principles, second derivatives and concavity)
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- ☐ **Differentiate e^{kx} , $\sin kx$ and $\cos kx$** ke^{kx} , $k \cos kx$ and $-k \sin kx$, with x in radians. (Differentiating standard functions)
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- ☐ **Differentiate $\ln x$ and $\ln kx$** Both give $\frac{1}{x}$, because $\ln kx = \ln k + \ln x$. (Differentiating standard functions)
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- ☐ **Find stationary points** Solve $\frac{dy}{dx} = 0$, then find each y-coordinate from the curve's equation. (Tangents, normals and stationary points)
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- ☐ **Classify stationary points** $\frac{d^2y}{dx^2} > 0$: minimum; $\frac{d^2y}{dx^2} < 0$: maximum; if it is 0, test the gradient on each side. (Tangents, normals and stationary points)
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- ☐ **Differentiate composite exponential, log and trig functions** $e^{f(x)} \rightarrow f'(x)e^{f(x)}$, $\ln f(x) \rightarrow \frac{f'(x)}{f(x)}$, $\sin f(x) \rightarrow f'(x) \cos f(x)$. (Product, quotient and chain rules)
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- ☐ **Use the product rule** $\frac{d}{dx}(uv) = u \frac{dv}{dx} + v \frac{du}{dx}$. (Product, quotient and chain rules)
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- ☐ **Write a rate using derivative notation** 'Volume increasing at $3 \text{ cm}^3 \text{ s}^{-1}$ ' means $\frac{dV}{dt} = 3$; a decrease gives a negative derivative. (Connected rates of change)
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- ☐ **Connect rates with the chain rule** E.g. $\frac{dA}{dt} = \frac{dA}{dr} \times \frac{dr}{dt}$. (Connected rates of change)
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- ☐ **Differentiate parametric equations** $\frac{dy}{dx} = \frac{dy/dt}{dx/dt}$, giving an answer in terms of t . (Implicit and parametric differentiation)
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- ☐ **Differentiate terms in y implicitly** Differentiate with respect to y and multiply by $\frac{dy}{dx}$: $\frac{d}{dx}(y^3) = 3y^2 \frac{dy}{dx}$.
(Implicit and parametric differentiation)
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- ☐ **Translate 'rate of change' into derivative notation** 'The rate of change of P with respect to time' is $\frac{dP}{dt}$.
(Constructing differential equations)
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- ☐ **Write 'proportional to' using a constant** 'Proportional to P ' becomes kP ; 'inversely proportional to $\sqrt{h}$ ' becomes $\frac{k}{\sqrt{h}}$. (Constructing differential equations)
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- ☐ **Use a negative sign for a decrease** A decreasing quantity gives, for example, $\frac{dm}{dt} = -km$, where $k > 0$.
(Constructing differential equations)
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- ☐ **Evaluate a definite integral as $F(b) - F(a)$** Find an integral F , substitute the upper limit and subtract its value at the lower limit; no constant is needed. (The fundamental theorem of calculus)
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- ☐ **Integrate $\sin kx$ and $\cos kx$ in radians** $\int \cos kx \, dx = \frac{1}{k} \sin kx + c$ and $\int \sin kx \, dx = -\frac{1}{k} \cos kx + c$.
(Integrating standard functions)
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- ☐ **Integrate functions of a linear expression** If $\int f(x) \, dx = F(x) + c$, then $\int f(ax + b) \, dx = \frac{1}{a} F(ax + b) + c$, e.g. $\int \frac{1}{3x-2} \, dx = \frac{1}{3} \ln |3x-2| + c$. (Integrating standard functions)
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- ☐ **Find the limits where a curve meets the axis** Solve $y = 0$ to find where a region bounded by the curve and the x -axis starts and ends. (Definite integrals and areas under curves)
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- ☐ **Find the area between a curve and a line** Integrate (top – bottom), or subtract the area of a triangle or trapezium from the area under the curve. (Areas between curves and parametric areas)
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- ☐ **Interpret $f(x)\delta x$ as a rectangle's area** Each term is a thin strip of height $f(x)$ and width δx . (Integration as the limit of a sum)
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- ☐ **Write a limit of a sum as an integral** Keep the same function and limits, and replace $\sum$ and δx by $\int$ and dx . (Integration as the limit of a sum)
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- ☐ **Integrate $f'(x)/f(x)$ by inspection** When the numerator is a multiple of the derivative of the denominator, the answer is a multiple of $\ln |f(x)|$. (Integration by substitution)
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- ☐ **Integrate $f'(x)[f(x)]^n$ by inspection** $\int f'(x)[f(x)]^n \, dx = \frac{[f(x)]^{n+1}}{n+1} + c$ for $n \neq -1$; adjust the constant if only a multiple of the derivative is there. (Integration by substitution)
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- ☐ **Choose u and dv/dx , then apply the formula** Pick u so that $\frac{du}{dx}$ is simpler, and $\frac{dv}{dx}$ so that it is easy to integrate. (Integration by parts)
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- ☐ **Integrate x times an exponential or trig function** Let $u = x$, so $\frac{du}{dx} = 1$ and the new integral is a standard one. (Integration by parts)
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- ☐ **Split into partial fractions with distinct factors** Write $\frac{px+q}{(ax+b)(cx+d)} = \frac{A}{ax+b} + \frac{B}{cx+d}$ and find A and B by substituting values or comparing coefficients. (Integration using partial fractions)
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- ☐ **Integrate $A/(ax + b)$ to a logarithm** $\int \frac{A}{ax+b} \, dx = \frac{A}{a} \ln |ax + b| + c$. (Integration using partial fractions)
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- ☐ **Separate the variables correctly** Get every y on the side with dy and every x on the side with dx .
(Separable differential equations)
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- ☐ **Find a general solution with one constant** Integrate both sides and add a single constant, usually on the x side. (Separable differential equations)
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- ☐ **Solve exponential growth and decay models** $\frac{dN}{dt} = kN$ gives $N = N_0 e^{kt}$; $k > 0$ means growth and $k < 0$ decay. (Differential equations in context: interpreting solutions)
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- ☐ **Use given data to find the constants** An initial value gives the constant of integration; a second data point gives k , usually by taking logs. (Differential equations in context: interpreting solutions)
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- ☐ **Show a root is correct to given accuracy** Test the bounds of the rounding interval, e.g. 1.2515 and 1.2525 for a root of 1.252 to 3 d.p. (Locating roots by change of sign)
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- ☐ **Draw staircase and cobweb diagrams** Go vertically to the curve $y = g(x)$, then horizontally to the line $y = x$, and repeat. (Iteration and staircase/cobweb diagrams)
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- ☐ **Confirm a root with a sign change** After iterating, use a change of sign in $f(x)$ to show the root to the accuracy required. (Iteration and staircase/cobweb diagrams)
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- ☐ **Apply one Newton–Raphson step** Substitute x_0 into $x_0 - \frac{f(x_0)}{f'(x_0)}$, showing the values of $f(x_0)$ and $f'(x_0)$. (The Newton–Raphson method)
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- ☐ **Find the strip width h** $h = \frac{b-a}{n}$ for n strips; there are $n + 1$ values of y . (Numerical integration: the trapezium rule)
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- ☐ **Estimate totals from data with the trapezium rule** Distance = $\int v \, dt$, volume = $\int (\text{flow rate}) \, dt$, cross-section area = $\int (\text{depth}) \, dx$. (Numerical methods in context)
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- ☐ **Solve contextual equations numerically** Use a given iteration or Newton–Raphson, and a change of sign to locate or confirm the root. (Numerical methods in context)
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- ☐ **Find unknowns by equating components** If two vectors are equal, each pair of components is equal, giving equations to solve. (Vectors in 2D and 3D)
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- ☐ **Recognise parallel vectors** Parallel vectors are scalar multiples of each other: every component is multiplied by the same number. (Vectors in 2D and 3D)
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- ☐ **Find a unit vector in a given direction** Divide the vector by its magnitude: $\hat{\mathbf{a}} = \frac{\mathbf{a}}{|\mathbf{a}|}$. (Magnitude and direction)
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- ☐ **Convert magnitude and angle to components** A vector of magnitude r at angle θ anticlockwise from $\mathbf{i}$ is $r \cos \theta \mathbf{i} + r \sin \theta \mathbf{j}$. (Magnitude and direction)
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- ☐ **Show that two vectors are parallel** Show that one is a scalar multiple of the other, e.g. $4\mathbf{a} - 6\mathbf{b} = 2(2\mathbf{a} - 3\mathbf{b})$. (Vector arithmetic and geometry)
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- ☐ **Use a ratio to locate a point** If $AP : PB = m : n$, then $\overrightarrow{AP} = \frac{m}{m+n} \overrightarrow{AB}$. (Vector arithmetic and geometry)
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- ☐ **Find the distance between two points** $AB = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}$. (Position vectors and distances)
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- ☐ **Find a midpoint or dividing point** $\overrightarrow{OM} = \frac{1}{2}(\mathbf{a} + \mathbf{b})$; for $AP : PB = m : n$, $\overrightarrow{OP} = \mathbf{a} + \frac{m}{m+n}(\mathbf{b} - \mathbf{a})$. (Position vectors and distances)
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- ☐ **Use equilibrium: resultant force is zero** Set the sum of all the forces equal to $\mathbf{0}$ and solve for the unknown force. (Vector problems)
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- ☐ **Find position with constant velocity** $\mathbf{r} = \mathbf{r}_0 + \mathbf{v}t$, where $\mathbf{r}_0$ is the position when $t = 0$. (Vector problems)
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Statistics

- ☐ **Calculate the numbers for a stratified sample** Sample each stratum in proportion to its size, then choose randomly within each stratum. (Sampling methods and the large data set)
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- ☐ **Estimate frequencies from histogram bar areas** Use area to find frequency, assuming values are spread evenly within a class for part of a bar. (Histograms, box plots and cumulative frequency)

- ☐ **Judge reliability: interpolation or extrapolation** Estimates within the range of the data are reasonably reliable; estimates outside it are not. (Correlation and regression)

- ☐ **Interpret r , knowing correlation is not causation** Relate r to how close the points are to a straight line, and recognise that a third variable may explain the link. (Correlation and regression)

- ☐ **Calculate standard deviation from summary statistics** Use $\sigma = \sqrt{\frac{\Sigma x^2}{n} - \bar{x}^2}$, or $\sqrt{\frac{S_{xx}}{n}}$. (Measures of location and spread)

- ☐ **Interpolate medians and percentiles from grouped data** Find the position, locate its class, then go the right fraction of the way through that class. (Measures of location and spread)

- ☐ **Find outlier limits using mean and standard deviation** Use the rule given, e.g. outside $\bar{x} \pm 2\sigma$. (Outliers and cleaning data)

- ☐ **Draw a box plot showing outliers** Mark outliers with crosses and end the whisker at the most extreme value that is not an outlier. (Outliers and cleaning data)

- ☐ **Use the addition rule for probabilities** $P(A \cup B) = P(A) + P(B) - P(A \cap B)$. (Mutually exclusive and independent events; Venn and tree diagrams)

- ☐ **Show whether two events are independent** Compare $P(A \cap B)$ with $P(A) \times P(B)$. (Mutually exclusive and independent events; Venn and tree diagrams)

- ☐ **Apply the conditional probability formula** $P(A | B) = \frac{P(A \cap B)}{P(B)}$, using a Venn diagram or given values. (Conditional probability)

- ☐ **Show independence using conditional probability** Check whether $P(A | B) = P(A)$ to decide whether A and B are independent. (Conditional probability)

- ☐ **Compare a model's predictions with observed data** Decide whether observed frequencies are close to the expected ones, and what that says about the model. (Modelling with probability)

- ☐ **Use cumulative binomial probabilities with inequalities** Rewrite 'more than', 'at least' and 'between' in terms of $P(X \leq r)$. (Discrete distributions, including the discrete uniform and the binomial)

- ☐ **State binomial conditions and assumptions in context** Fixed number of trials, two outcomes, independent trials, constant probability of success. (Discrete distributions, including the discrete uniform and the binomial)

- ☐ **Find a value from a given probability** Use inverse normal, remembering that most calculators work with the area to the left. (The normal distribution)

- ☐ **Use the points of inflection at $\mu \pm \sigma$** The mean is halfway between the points of inflection and σ is the distance from the mean to either one. (The normal distribution)

- ☐ **Find the parameters of the approximating normal** $\mu = np$ and $\sigma^2 = np(1 - p)$. (The normal approximation to the binomial; choosing a distribution)

- ☐ **Apply a continuity correction correctly** Extend half a unit beyond the end integers you want, e.g. $P(X \leq 40) \approx P(Y < 40.5)$. (The normal approximation to the binomial; choosing a distribution)

- ☐ **Define critical region and critical value** The critical region is the set of values that lead to rejecting H_0 ; the critical value is its boundary. (The language of hypothesis testing)

- ☐ **Use a p-value to reach a decision** Reject H_0 if the p-value is less than the significance level. (The language of hypothesis testing)

- ☐ **Find a one-tailed critical region** Find the boundary where the tail probability is no more than the significance level. (Binomial hypothesis tests)

- ☐ **Carry out a two-tailed correlation test** Use the one-tailed critical value for half the significance level and compare $|r|$ with it. (Tests for correlation and for the mean of a normal distribution)

- ☐ **State the distribution of the sample mean** If $X \sim N(\mu, \sigma^2)$, then $\bar{X} \sim N\left(\mu, \frac{\sigma^2}{n}\right)$. (Tests for correlation and for the mean of a normal distribution)

Mechanics

- ☐ **State what each modelling term means** For example, light means the mass is ignored and inextensible means the string does not stretch. (SI units and modelling assumptions)

- ☐ **Find speed and direction from a velocity vector** Speed is $\sqrt{a^2 + b^2}$ for $a\mathbf{i} + b\mathbf{j}$; find the direction using $\tan \theta$ and a sketch. (Displacement, velocity and acceleration)

- ☐ **Use area to find an unknown time** Write the total area in terms of the unknown and set it equal to the given distance. (Kinematics graphs)

- ☐ **Solve two-stage and two-object problems** The final velocity of one stage is the initial velocity of the next; objects meet when their displacements are equal. (Constant acceleration (suvat))

- ☐ **Integrate to find velocity or displacement** Integrate, then use the initial conditions to find the constant of integration. (Variable acceleration using calculus)

- ☐ **Find when a particle is at rest** Solve $v = 0$; for the greatest or least velocity, solve $a = 0$. (Variable acceleration using calculus)

- ☐ **Solve horizontal projection problems** Vertically $u = 0$ and the acceleration is g ; horizontally the velocity is constant; the time links them. (Projectiles)

- ☐ **Find time of flight, range and greatest height** At the greatest height the vertical velocity is zero; on landing the vertical displacement is known. (Projectiles)

- ☐ **Use equilibrium to find unknown forces** In equilibrium the resultant force is zero, so the components in each direction add to zero. (Forces, resultants and equilibrium of a particle)

- ☐ **Use $F = ma$ with forces as vectors** Add the force vectors and divide by the mass to get the acceleration vector. (Newton's second law and vectors)

- ☐ **Apply $F = ma$ to vertical motion** For an object lifted by a cable, $T - mg = ma$. (Weight and motion under gravity)

- ☐ **Find the reaction force in a lift** Apply $F = ma$ to the person; the force on the floor is equal and opposite (Newton's third law). (Newton's third law, connected particles and pulleys)

- ☐ **Solve problems with particles over a pulley** Apply $F = ma$ to each particle, with the same acceleration and the same tension. (Newton's third law, connected particles and pulleys)

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- ☐ **Find the acceleration on a smooth slope** Use $F = ma$ parallel to the slope; the forces perpendicular to the slope balance. (Resolving forces and inclined planes)
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- ☐ **Handle a pulling force at an angle** The horizontal component drives the motion; the vertical component changes the normal reaction. (Resolving forces and inclined planes)
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- ☐ **Understand when friction is limiting** Friction equals μR only when the object is moving or about to move; otherwise $F \leq \mu R$. (Friction)
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- ☐ **Include an angled force with friction** A force with a vertical component changes R , and so changes the limiting friction μR . (Friction)
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- ☐ **State the conditions for equilibrium of a rigid body** The resultant force is zero and the resultant moment about any point is zero. (Moments, beams and rods in equilibrium)
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- ☐ **Find the centre of mass of a non-uniform rod** Put the weight at an unknown distance x from one end and take moments. (Moments, beams and rods in equilibrium)
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- ☐ **Recognise when a beam is about to tilt** On the point of tilting about one support, the reaction at the other support is zero. (Ladders, tilting and limiting equilibrium)
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- ☐ **Find limits on loads without tilting** Take moments about the support it would tilt about, with the other reaction set to zero. (Ladders, tilting and limiting equilibrium)
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