STUDY FORMULA BOOKLET

Edexcel IAL Maths Unit P3 (WMA13): pure mathematics 3

The booklet prints the addition formulae, the derivatives of tan kx and sec x, and the quotient rule. Learn first the double angle formulae, the three identities, R cos(θ + alpha), the product and chain rules, and the log graph rules.

GIVEN printed in the formula booklet LEARN IT not in the booklet: learn it

Built by CuratedPrep from 19 past question papers for Unit P3 in our question bank, January 2020 to January 2026. Given means it is in the Mathematical Formulae and Statistical Tables booklet (Issue 2, 2021) handed out in every unit exam. Learn it means a past question needed it and the exam did not print it.

Algebra and functions

None of these is printed in the booklet, so all of them are Learn it. P3 assumes the P1 and P2 specifications and their formulae.

Composite function

The specification says fg means do g first, then f, so substitute g(x) into f. gf is the other order. Used in: Jun 2025 Q1(a), the value of gf(1); Oct 2022 Q2(c), fg(-pi); Jan 2020 Q2(a), fg(e^2).

$$\mathrm{fg}(x) = \mathrm{f}(\mathrm{g}(x))$$

LEARN IT

Inverse function

Write y = f(x), make x the subject, then swap x and y. The domain of f^{-1} is the range of f. Used in: Jan 2026 Q5(b), $f^{-1}(12)$; Jan 2020 Q2(b), finding f^{-1}; Oct 2022 Q2(b), $f^{-1}(x)$ and its domain.

$$\mathrm{f}^{-1}\mathrm{f}(x) = \mathrm{f}\,\mathrm{f}^{-1}(x) = x$$

LEARN IT

Modulus function

Solve |ax + b| = c as ax + b = c and ax + b = -c, then check both. The graph of y = |ax + b| has its vertex where ax + b = 0. Used in: Jan 2020 Q6(b), solving f(x) = 3x - 2; Oct 2022 Q7(b), where C1 meets the x-axis; Jun 2025 Q10(b), the x values satisfying an inequality.

$$|x| = x\ (x \geq 0), \quad |x| = -x\ (x < 0); \qquad |a| = b \iff a = \pm b\ (b \geq 0)$$

LEARN IT

Discriminant

Use it on the quadratic you get from setting a derivative to 0, to count stationary points. Used in: Oct 2025 Q7, two distinct turning points and the range of k.

$$b^2 - 4ac > 0 \text{ (two real roots)}, \quad b^2 - 4ac = 0 \text{ (one repeated root)}, \quad b^2 - 4ac < 0 \text{ (no real roots)}$$

LEARN IT

Trigonometry

The booklet prints the addition formulae for sin, cos and tan, and it also prints sums and differences of sines and cosines, which these P3 questions did not use. The specification lists the identities and the double angle formulae as formulae you must know.

Reciprocal trigonometric functions

Rewrite sec, cosec and cot in sin and cos before you use an identity or solve. Used in: Jan 2025 Q8(i), 3 cosec θ = 8 cos θ; Jan 2022 Q2(a), 8 cos θ = 3 cosec θ; Jun 2022 Q7(a), an equation with cot, sec and sin.

$$\sec\theta = \frac{1}{\cos\theta}, \quad \operatorname{cosec}\theta = \frac{1}{\sin\theta}, \quad \cot\theta = \frac{1}{\tan\theta} = \frac{\cos\theta}{\sin\theta}$$

LEARN IT

Pythagorean identity

Rearrange to $\cos^2$ = 1 - $\sin^2$ or $\sin^2$ = 1 - $\cos^2$ to get a quadratic in one ratio. Used in: Oct 2023 Q3(a), proving cos 2A = 2 $\cos^2$ A - 1; Oct 2022 Q9(a), proving an identity; Oct 2022 Q6, a proof about dy/dx.

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

LEARN IT

Secant identity

Use it to turn an equation in sec and tan into a quadratic in tan or in sec. Used in: Jan 2022 Q9(i), an equation in tan x and $\sec^2$ x; Jun 2021 Q2(b).

$$\sec^2 A \equiv 1 + \tan^2 A$$

LEARN IT

Cosecant identity

Use it to turn an equation in cot and cosec into a quadratic in one of them. Used in: Jun 2022 Q7(a), 3 cosec^2 2 θ - 13 cosec 2 θ - 10 = 0; Jan 2021 Q7(b), an equation with $\cot^2$ 2 θ and cosec 2 θ.

$$\text{cosec}^2 A \equiv 1 + \cot^2 A$$

LEARN IT

Double angle formula for sine

Also sin 3A and other multiples by writing 3A as 2A + A. Used in: Jan 2022 Q2(a), writing 8 cos θ = 3 cosec θ as sin 2 θ = k; Jun 2024 Q4(a), 8 sin x cos x in terms of sin 2x; Oct 2025 Q9(a), terms of sin 2 θ and cos 2 θ.

$$\sin 2A \equiv 2 \sin A \cos A$$

LEARN IT

Double angle formula for cosine

Choose the form that leaves one ratio: 1 - 2 $\sin^2$ for an equation in sin, 2 $\cos^2$ - 1 for one in cos. Rearranged, they integrate $\sin^2$ and $\cos^2$. Used in: Jun 2023 Q5(ii), 10 sin θ = 3 cos 2 θ; Oct 2025 (A) Q4(a), differentiating ln(1 - cos 2x); Oct 2023 Q3(a).

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

LEARN IT

Double angle formula for tangent

Use it when an equation has tan 2x and tan x together. Used in: Jan 2020 Q5(a), 12 tan 2x + 5 cot x $\sec^2$ x = 0 written as a quartic in tan x; Jun 2025 Q8(a), proving a result for tan 3x.

$$\tan 2A \equiv \frac{2\tan A}{1 - \tan^2 A}$$

LEARN IT

sin of a sum or difference

Use it to expand sin(x + 45 degrees) or sin 3x = sin(2x + x), then divide by cos to reach tan. Used in: Jun 2024 Q7(a), 2 sin(x + 45) = cos(x - 60); Oct 2021 Q4(a), 2 sin(θ - 30) = 5 cos θ.

$$\sin(A \pm B) \equiv \sin A \cos B \pm \cos A \sin B$$

GIVEN

cos of a sum or difference

The sign changes between the two sides. Also cos 2A = cos(A + A). Used in: Oct 2023 Q3(a), proving cos 2A from cos(A + B); Jun 2024 Q7(a), expanding cos(x - 60).

$$\cos(A \pm B) \equiv \cos A \cos B \mp \sin A \sin B$$

GIVEN

tan of a sum or difference

Used as tan 3x = tan(2x + x), with tan 2x from the double angle formula. Used in: Jun 2025 Q8(a), proving a result for tan 3x.

$$\tan(A \pm B) \equiv \frac{\tan A \pm \tan B}{1 \mp \tan A \tan B} \quad \left(A \pm B \neq \left(k + \tfrac{1}{2}\right)\pi\right)$$

GIVEN

Harmonic form with cosine

For R cos(θ + alpha) with a cos θ - b sin θ, tan alpha = b/a. Expand R cos(θ + alpha) with the cos(A + B) formula and compare coefficients; the maximum is then R and the minimum is -R. Used in: Jun 2025 Q2(a), 7 cos x - 24 sin x; Oct 2025 (A) Q8(a), 10 cos θ - 3 sin θ; Jan 2020 Q9(a), R cos(θ + alpha).

$$a\cos\theta + b\sin\theta = R\cos(\theta - \alpha), \quad R = \sqrt{a^2 + b^2},\ \tan\alpha = \frac{b}{a}$$

LEARN IT

Harmonic form with sine

Expand R sin(θ - alpha) = R sin θ cos alpha - R cos θ sin alpha and compare coefficients. Used in: Oct 2022 Q8(a), 8 sin x - 15 cos x; Jun 2021 Q9(a), 12 sin x - 5 cos x; Jun 2024 Q4(b), R sin(2x + alpha) + c.

$$a\sin\theta - b\cos\theta = R\sin(\theta - \alpha), \quad R = \sqrt{a^2 + b^2},\ \tan\alpha = \frac{b}{a}$$

LEARN IT

Exponentials and logarithms

The three laws of logarithms are from P2 and are not in the booklet. The booklet's e^(x ln a) row appears in no P3 question in the dump.

Natural logarithm and exponential

To solve e^(kt) = c take ln of both sides, giving t = (ln c)/k. Used in: Jan 2020 Q1(b), the t at which N = 420; Jun 2025 Q6(b), the k from two temperatures; Jan 2026 Q10(b), k from the population model.

$$e^{\ln x} = x, \qquad \ln e^x = x$$

LEARN IT

Laws of logarithms

They hold for ln as well as for log_a. Use them to turn a model into the form p x^q or a b^t. Used in: Jan 2026 Q4(b), the model written as h = p m^q; Jan 2020 Q3(b), y in the form p x^q; Jun 2025 Q3(b), y in the form p x^q.

$$\log_a x + \log_a y = \log_a(xy), \quad \log_a x - \log_a y = \log_a \frac{x}{y},$$
$$k\log_a x = \log_a x^k$$

LEARN IT

Log graph for a power law

Plot log y against log x. The gradient is n and the vertical intercept is log a. Used in: Jun 2025 Q3, line through (-3.5, 0) and (0, -2); Jun 2023 Q2(b), an equation linking T and x; Oct 2021 Q7(b), M in the form p r^q.

$$y = ax^n \Rightarrow \log y = n\log x + \log a$$

LEARN IT

Log graph for an exponential

Plot log y against x. The gradient is log b and the vertical intercept is log k, so b = 10^gradient and k = 10^intercept for log base 10. Used in: Jan 2023 Q3, a line through (0, 1.5) and (-4.8, 0); Oct 2025 Q3(b); Jun 2022 Q4, N = a b^t.

$$y = kb^x \Rightarrow \log y = x\log b + \log k$$

LEARN IT

Differentiation

The booklet prints the derivatives of tan kx, sec x, cot x and cosec x and the quotient rule. The other rules here are on the specification's list of formulae you must know.

Derivatives of e^(kx) and ln x

Also d/dx(ln kx) = 1/x. Used in: Jan 2026 Q10(a), the rate of growth of an insect population; Jun 2025 Q6(c), the rate at which a temperature falls; Oct 2025 Q6(i), differentiating ln(2x^2 + 5).

$$\frac{d}{dx}\left(e^{kx}\right) = ke^{kx}, \qquad \frac{d}{dx}(\ln x) = \frac{1}{x}$$

LEARN IT

Derivatives of sin kx and cos kx

x must be in radians. Used in: Jan 2020 Q4(ii), g(x) = x sin 4x; Jun 2025 Q7(a), y = e^(-x^2 sin 3x; Oct 2025 (A) Q4(a), ln(1 - cos 2x).

$$\frac{d}{dx}(\sin kx) = k\cos kx, \qquad \frac{d}{dx}(\cos kx) = -k\sin kx$$

LEARN IT

Derivative of a^x

Used when the base is a number other than e. Used in: Jan 2022 Q8(c), the rate of change of an exponential in t at t = 5; Oct 2022 Q4(b), differentiating 10^y with respect to y.

$$\frac{d}{dx}\left(a^x\right) = a^x \ln a$$

LEARN IT

Derivative of tan kx

Used with the chain rule for tan (x/2) or tan kx. Used in: Oct 2025 (A) Q2(a), a product that includes tan.

$$\frac{d}{dx}(\tan kx) = k\sec^2 kx$$

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Derivative of sec x

Used with the chain rule for sec 2y. Used in: Jan 2021 Q10(a), dx/dy for x = 3 sec 2y.

$$\frac{d}{dx}(\sec x) = \sec x \tan x$$

GIVEN

Product rule

Take out common factors before you set the derivative to 0. Used in: Jan 2022 Q1, y = (2x + 5)e^{3}x); Oct 2022 Q3(a), f(x) = (x - 2)^2 e^{3}x); Jun 2025 Q7(a), y = e^(-x^2 sin 3x.

$$\frac{d}{dx}\big(f(x)g(x)\big) = f'(x)g(x) + f(x)g'(x)$$

LEARN IT

Quotient rule

Check the order: f'g - fg' in the numerator, g^2 in the denominator. Used in: Jan 2026 Q2(ii), the derivative of a fraction with e^{2}x); Jan 2020 Q4(i), f'(x) as a fraction with factorised quadratics; Oct 2025 (A) Q7(b), the rate of change of a fraction model.

$$\frac{d}{dx}\left(\frac{f(x)}{g(x)}\right) = \frac{f'(x)g(x) - f(x)g'(x)}{(g(x))^2}$$

GIVEN

Chain rule

Differentiate the outside function first, then multiply by the derivative of the inside. Used in: Jun 2022 Q1(a), a power of (3x - 2); Oct 2025 Q6(i), ln(2x^2 + 5); Jun 2023 Q3(i), a logarithm of sin 3x.

$$\frac{d}{dx}f(g(x)) = f'(g(x))\,g'(x)$$

LEARN IT

Derivative of the inverse

When x is given as a function of y, differentiate for dx/dy and invert, then write the answer in terms of y or x as asked. Used in: Jan 2021 Q10(a); Oct 2022 Q4(b).

$$\frac{dy}{dx} = \frac{1}{\dfrac{dx}{dy}}$$

LEARN IT

Integration

The booklet prints the integrals of sec^2 kx, tan x and cot x, which these P3 questions did not use. These rows are on the specification's list of formulae you must know.

Integral of e^(kx)

Divide by the coefficient of x in the power. Used in: Jun 2022 Q8(b), the distance run by a sprinter from an exponential velocity.

$$\int e^{kx}\,dx = \frac{1}{k}e^{kx} + c$$

LEARN IT

Integrals of sin kx and cos kx

For sin^2 or cos^2 first rewrite using the double angle formula, then integrate. Used in: Oct 2021 Q10(b), the area under (1 + 2 cos 2x)^2; Oct 2023 Q3(b), an integral that needs the cos 2A identity.

$$\int \sin kx\,dx = -\frac{1}{k}\cos kx + c, \qquad \int \cos kx\,dx = \frac{1}{k}\sin kx + c$$

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Integral of 1/x and of f'(x)/f(x)

So the integral of 1/(ax + b) is (1/a) ln|ax + b|. Used in: Jan 2022 Q3(ii), an integral that gives ln; Oct 2022 Q1(b), after algebraic division, giving p + ln q; Jun 2024 Q2(b), an integral that gives ln 3.

$$\int \frac{1}{x}\,dx = \ln|x| + c, \qquad \int \frac{f'(x)}{f(x)}\,dx = \ln|f(x)| + c$$

LEARN IT

Integral of a function of a linear function

The special case of the reverse chain rule: int f'(g(x))g'(x) dx = f(g(x)) + c. Used in: Oct 2025 (A) Q1(i)(a), the integral of (2x + 3) to a power.

$$\int (ax+b)^n \, dx = \frac{(ax+b)^{n+1}}{a(n+1)} + c, \quad n \neq -1$$

LEARN IT

Also learn these

Transformations of graphs

y = af(x) stretches by a in the y direction, y = f(x) + a translates up, y = f(x + a) translates left, y = f(ax) stretches by 1/a in the x direction, y = -f(x) reflects in the x-axis; apply them in order. Used in: Jun 2025 (A) Q1; Oct 2022 Q8(c)(d); Jan 2026 Q7(d).

Graphs of modulus functions

y = |ax + b| is a V with its vertex on the x-axis; for y = a|bx + c| + d the vertex is at x = -c/b and y = d. Used in: Jan 2020 Q6(a); Oct 2022 Q7(a); Jun 2025 Q10(a).

Domain and range

The range of f is the set of outputs; use the shape of the graph and the domain to find it. The domain of f^{-1} is the range of f. Used in: Oct 2022 Q2(a); Oct 2025 (A) Q6(b); Oct 2025 Q1(a).

Algebraic division and rational expressions

Divide, or write the numerator as (Ax + B)(denominator) + C, to get Ax + B + C/(x + k), which integrates to give a logarithm. Used in: Oct 2022 Q1(a); Jan 2026 Q3(ii)(a).

Inverse trigonometric functions

arcsin x has range -pi/2 to pi/2, arccos x has range 0 to pi, and arctan x has range -pi/2 to pi/2 with horizontal asymptotes; their graphs are reflections of the restricted sin, cos and tan in y = x. Used in: Oct 2021 Q8(a), sketch of an arcsin curve; Jan 2026 (A) Q9(a), sketch of arctan.

Solving trigonometric equations

Reduce to one ratio, solve for the multiple angle, then divide and use the symmetry of the graph to find every solution in the range, scaling the interval for 2x or 3x. Used in: Jun 2023 Q5(ii); Oct 2021 Q4(b).

Proving trigonometric identities

Work on one side only. Replace sec, cosec and cot by sin and cos, use the double angle formulae, and finish on the other side. Used in: Oct 2023 Q8(a); Oct 2025 (A) Q5(a); Jan 2022 Q9(ii).

Maximum and minimum of a harmonic form

R cos(θ + alpha) ranges from -R to R. Set the bracket equal to 0 or pi for the first maximum or minimum. Used in: Jun 2025 Q2(b); Oct 2025 (A) Q8(b); Oct 2022 Q8(b).

Exponential growth and decay models

The initial value is at t = 0. For N = a - b e^(-kt) the limit as t grows is a. The rate of change is dN/dt, which you substitute the time into. Used in: Jan 2020 Q1(a) and (c); Oct 2023 Q4; Jan 2025 Q5.

Stationary points and increasing functions

At a stationary point dy/dx = 0; y is increasing where dy/dx is greater than 0, so solve the inequality. Used in: Oct 2022 Q3(a); Jan 2025 Q3; Jan 2020 Q4(i)(b).

Tangent and normal

Find f'(a) for the gradient, then use y - y1 = m(x - x1); the normal has gradient -1/m. Used in: Jun 2022 Q1(b); Jun 2024 Q6(a).

Change of sign

If f is continuous and f(a) and f(b) have opposite signs, there is a root between a and b; state the values, the sign change, continuity and a conclusion. Used in: Jan 2025 Q1(a); Oct 2023 Q1(a); Jun 2023 Q1(a).

Iteration

Rearrange f(x) = 0 into the form x = g(x) that the question gives, then use x_(n+1) = g(x_n) in radians, keep full calculator values and round to 4 decimal places at the end. Used in: Jun 2025 (A) Q2(b), rearranging; Jan 2026 Q1(c); Jun 2025 Q7(b).

Showing a root to a given accuracy

To show a root is 0.430 to 3 decimal places, state a suitable function and evaluate it at 0.4295 and 0.4305, showing a sign change. Used in: Jun 2025 Q7(c); Oct 2025 (A) Q2(c); Jan 2021 Q6(d).

Using the booklet in the exam

- Learn the double angle formulae, $\sec^2 = 1 + \tan^2$, $\text{cosec}^2 = 1 + \cot^2$ and the harmonic form; the booklet prints only the addition formulae for sin, cos and tan.
- For a log graph, write the straight line as log y = m x + c first, then put it back as y = a b^x or y = a x^n using the laws of logarithms.
- Differentiate with the product, quotient or chain rule and set the numerator to 0; for dx/dy questions invert the derivative at the end.
- In iteration questions keep your calculator in radians and use the answer values from the previous step without rounding.
- Many questions say calculator technology is not acceptable, so show every step of a proof, an exact answer or an integration.

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