STUDY FORMULA BOOKLET

Cambridge 9709 Maths Paper 2: pure mathematics 2

MF19 gives the addition and double angle formulae, the squared identities, the derivatives of ln, e^x and the trig functions, and the product, quotient and parametric rules. Learn first the modulus relations, factor theorem, laws of logarithms, trapezium rule and chain rule.

GIVEN printed in the formula list (MF19) LEARN IT not in MF19: learn it

Built by CuratedPrep from 41 past question papers for Paper 2 in our question bank, March 2020 to November 2025. Given means it is in the List of formulae and statistical tables (MF19) given in every paper. Learn it means a past question needed it and the exam did not print it.

Modulus and polynomials

MF19 prints neither the modulus relations nor the factor and remainder theorems, so both are Learn it.

Modulus equations and inequalities

Either square both sides, or solve the two linear cases where the expressions have opposite signs. Used in: Nov 2025 paper 21 Q3(a), a modulus equation (the dump has lost the modulus bars from the question text); Nov 2025 paper 22 Q3(a), a modulus inequality; Jun 2025 paper 21 Q2(bc), an inequality and then the integers that satisfy it.

$$|a| = |b| \iff a^2 = b^2, \qquad |x - a| < b \iff a - b < x < a + b$$

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Factor and remainder theorems

Substitute the root, equate to 0 for a factor or to the remainder, and solve the equations for the unknown constants. Used in: Nov 2025 paper 21 Q7(a), (x + 2) a factor and k to find; Jun 2025 paper 21 Q5(ab), a factor and a remainder of -15 giving a and b; Nov 2024 paper 22 Q5(b), then factorising.

$$\mathrm{p}(a) = 0 \iff (x - a) \text{ is a factor;} \qquad \text{remainder on dividing by } (ax + b) = \mathrm{p}\left(-\tfrac{b}{a}\right)$$

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Discriminant of a quadratic

After dividing out a known root or substituting a value, show that the remaining quadratic has no real roots, or the given value of y does not occur. Used in: Jun 2025 paper 22 Q6(a), no point on a curve with a given y-coordinate; Nov 2024 paper 22 Q5(b), exactly one real root.

$$b^2 - 4ac < 0 \text{ (no real roots)}$$

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Logarithms and exponentials

Laws of logarithms

Combine or split logarithms before you solve, and give exact answers in terms of ln when asked. Used in: Nov 2025 paper 22 Q1, a difference of two logarithms; Nov 2025 paper 21 Q5(a), showing a coordinate is ln 2; Jun 2025 paper 21 Q6(b), 2 ln(3t + 4) = ln 100.

$$\ln a + \ln b = \ln(ab), \quad \ln a - \ln b = \ln \frac{a}{b}, \quad \ln a^k = k \ln a$$

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Logarithms and indices

Take ln of both sides when x is in a power. Used in: Jun 2025 paper 21 Q2(a), an inequality with x in an index; Nov 2025 paper 22 Q3(b), the largest integer N from a power inequality; Nov 2025 paper 21 Q2, x = 1/2 ln 12 from e^{2x}.

$$a^x = b \iff x = \frac{\ln b}{\ln a}, \qquad e^{\ln x} = x, \qquad \ln e^x = x$$

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Exponential model in linear form

Plot ln y against x: the gradient is ln a and the intercept is ln k. Used in: Nov 2024 paper 21 Q1(a), showing the gradient of the straight line; Nov 2024 paper 21 Q1(b), finding a and k from two points on the line.

$$y = ka^x \Rightarrow \ln y = x \ln a + \ln k$$

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Trigonometry

MF19 prints the identities for sec, cosec and cot squared, the addition formulae and the double angle formulae, but not the definitions of sec, cosec and cot.

Reciprocal trigonometric functions

Rewrite in sin, cos and tan before solving, and remember sec and cosec are undefined where cos or sin is 0. Used in: Nov 2025 paper 21 Q3(b), solving an equation in sec; Nov 2025 paper 21 Q4, an equation in cot and tan; Jun 2025 paper 21 Q5(c), cosec of an angle.

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

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Tangent and secant identity

Use it to turn an equation in $\tan^2$ and sec into a quadratic in sec or cos. Used in: Nov 2025 paper 22 Q2, $\tan^2\theta$ and sec θ in one equation.

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

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Cotangent and cosecant identity

An alternative to rewriting cot and cosec in sin and cos. Used in: Nov 2020 paper 22 Q1, 7 cot θ = 3 cosec θ, as the scheme's alternative method.

$$\cot^2\theta + 1 \equiv \operatorname{cosec}^2\theta$$

GIVEN

Sine of a sum or difference

Substitute exact values for the standard angle, with sin and cos of the acute angle found from the given ratio. Used in: Nov 2023 paper 21 Q1, an acute angle with sin θ = 2/3 (the sum or difference part of the stem is not in the dump text).

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

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Cosine of a sum or difference

Expand both brackets, use exact values, then simplify to the given form. Used in: Nov 2024 paper 21 Q7(a), proving an identity for a product of cos(θ + 30) and cos(θ + 60).

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

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Tangent of a sum or difference

Use tan 45 degrees = 1 to turn tan(θ + 45) into an expression in tan θ. Used in: Nov 2025 paper 21 Q4, solving an equation in cot and tan(θ + 45); Jun 2024 paper 21 Q4(a), proving an identity with tan(θ + 45).

$$\tan(A \pm B) \equiv \frac{\tan A \pm \tan B}{1 \mp \tan A\tan B}$$

GIVEN

Double angle: sine

Write sin 2x as 2 sin x cos x before simplifying. Used in: Jun 2025 paper 21 Q7(a), proving an identity; Jun 2024 paper 22 Q7(a), an identity with cosec 2 θ and sec θ; Mar 2022 paper 22 Q4(ab), sin 2 θ cot θ - cos 2 θ.

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

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Double angle: cosine

Choose the form that fits the question: $2\cos^2 x - 1$ or $1 - 2\sin^2 x$ to integrate $\sin^2 x$ and $\cos^2 x$, rearranged as $\sin^2 x = 1/2(1 - \cos 2x)$. Used in: Nov 2025 paper 21 Q1, integrating a squared sine; Jun 2025 paper 21 Q7(c), an exact value of an integral; Mar 2022 paper 22 Q4(ab).

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

GIVEN

Solutions of a trigonometric equation in an interval

alpha is the calculator value. In radians use pi and 2 pi, and give no values outside the interval. Used in: Nov 2025 paper 22 Q2, four solutions between -180 and 180 degrees; Nov 2025 paper 21 Q4; Nov 2025 paper 21 Q3(b), the angle in the third quadrant.

$$\sin\theta = k:\ \alpha,\ 180^\circ - \alpha; \quad \cos\theta = k:\ \alpha,\ 360^\circ - \alpha; \quad \tan\theta = k:\ \alpha,\ \alpha + 180^\circ$$

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Differentiation

MF19 prints the derivatives of ln x, e^x, sin x, cos x and tan x, and the product, quotient and parametric rules. The chain rule and implicit differentiation are not printed.

Derivative of ln x

With the chain rule, d/dx ln(f(x)) = f'(x)/f(x). Used in: Jun 2025 paper 21 Q6(a), the y part of a parametric curve; Jun 2024 paper 21 Q2, a curve with ln y in its equation; Jun 2021 paper 21 Q5(abc), a quotient with ln x.

$$\frac{d}{dx}(\ln x) = \frac{1}{x}$$

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Derivative of e to the power x

With the chain rule, d/dx e^(kx) = k e^(kx). Used in: Nov 2025 paper 21 Q8, a stationary point of an exponential times a power of (3x - 1); Jun 2025 paper 21 Q4(a), the maximum point of $y = 6e^2x) - e^3x)$; Nov 2024 paper 21 Q6(a), a parametric curve with $e^2t)$.

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

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Derivative of sin x

Differentiating sin kx gives k cos kx. Used in: Nov 2025 paper 22 Q5(a), the maximum points of a curve; Mar 2025 paper 22 Q4(a), a quotient with sin x; Jun 2024 paper 22 Q4, a parametric curve.

$$\frac{d}{dx}(\sin x) = \cos x$$

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Derivative of cos x

Differentiating cos kx gives -k sin kx. Used in: Jun 2025 paper 21 Q1, a product with $\cos(x^2 + 1)$; Nov 2025 paper 22 Q5(a); Mar 2025 paper 22 Q4(a), where the denominator has cos 2x.

$$\frac{d}{dx}(\cos x) = -\sin x$$

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Derivative of tan x

Differentiating tan kx gives k $\sec^2$ kx. Used in: Nov 2023 paper 21 Q2, the gradient of y = 3 tan(x/2) cos 2x at a point; Nov 2021 paper 22 Q3, the stationary point of 5x - 2 tan 2x.

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

GIVEN

Product rule

Label u and v, find du/dx and dv/dx, then substitute. Used in: Jun 2025 paper 21 Q1, a product with a cosine of a bracket; Nov 2023 paper 21 Q2; Nov 2025 paper 21 Q8.

$$y = uv \ \Rightarrow\ \frac{dy}{dx} = v\frac{du}{dx} + u\frac{dv}{dx}$$

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Quotient rule

Label u and v and use the printed quotient rule, or rewrite the fraction as a product. Used in: Jun 2025 paper 22 Q3, the stationary points of a fraction; Jun 2025 paper 21 Q6(a), x as a fraction in t; Mar 2025 paper 22 Q4(a).

$$y = \frac{u}{v} \Rightarrow \frac{dy}{dx} = \frac{v\frac{du}{dx} - u\frac{dv}{dx}}{v^2}$$

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Parametric differentiation

Find dy/dt and dx/dt, divide, then substitute the parameter at the point. Used in: Nov 2025 paper 21 Q6(a), showing dy/dx in terms of θ; Jun 2025 paper 21 Q6(a); Nov 2024 paper 21 Q6(a).

$$x = \mathrm{f}(t),\ y = \mathrm{g}(t) \Rightarrow \frac{dy}{dx} = \frac{dy}{dt} \div \frac{dx}{dt}$$

GIVEN

Chain rule

Differentiate the outer function, then multiply by the derivative of the inside, for cos(x^2 + 1), e^{2}x) and (3x - 1)^n. Used in: Jun 2025 paper 21 Q1, cos(x^2 + 1); Jun 2025 paper 21 Q4(a), exponentials with a multiple of x; Nov 2025 paper 21 Q8.

$$\frac{dy}{dx} = \frac{dy}{du} \times \frac{du}{dx}$$

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Implicit differentiation

Differentiate every term with respect to x, put dy/dx on each y term, then collect and solve for dy/dx. Used in: Nov 2025 paper 22 Q7(a), the gradient at a point where y = 0; Jun 2025 paper 22 Q6(b), a tangent to a curve with (x^2 - 3) ln y in its equation; Nov 2024 paper 22 Q3.

$$\frac{d}{dx}\left(y^n\right) = ny^{n-1}\frac{dy}{dx}, \qquad \frac{d}{dx}(xy) = y + x\frac{dy}{dx}$$

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Tangent and normal

Find dy/dx at the point first. The normal is perpendicular to the tangent. Used in: Nov 2025 paper 21 Q6(b), the normal at a point on the x-axis; Jun 2025 paper 22 Q6(b), a tangent in the form y = mx + c; Jun 2024 paper 22 Q4, the normal to a parametric curve.

$$m_{\text{tangent}} = \frac{dy}{dx}, \qquad m_{\text{normal}} = -\frac{1}{dy/dx}, \qquad y - y_1 = m(x - x_1)$$

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Integration

Integrals of linear functions

Divide by a, the coefficient of x inside. MF19 prints only the plain forms (a = 1, b = 0). Used in: Nov 2025 paper 22 Q5(b), cos 2x and sin x for an exact area; Nov 2023 paper 21 Q3(a), a reciprocal integral giving ln a; Nov 2023 paper 21 Q3(b), the exact value of the integral of e^{2}x - 5).

$$\int e^{ax+b}dx = \tfrac{1}{a}e^{ax+b}, \quad \int \frac{1}{ax+b}dx = \tfrac{1}{a}\ln|ax+b|, \quad \int \sin(ax+b)dx = -\tfrac{1}{a}\cos(ax+b), \quad \int \cos(ax+b)dx = \tfrac{1}{a}\sin(ax+b), \quad \int \sec^2(ax+b)dx = \tfrac{1}{a}\tan(ax+b)$$

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Area under a curve

A region between a curve and a line is the integral of the curve minus the area of a triangle or rectangle. Used in: Nov 2025 paper 21 Q5(b), the area of a shaded region as a triangle minus an integral; Nov 2025 paper 22 Q5(b), a rectangle minus an integral; Jun 2025 paper 21 Q4(b), the area under y = 6e^{2}x) - e^{3}x).

$$A = \int_a^b y\,dx$$

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Volume of revolution

Square y first and keep pi outside until the end. The squared integrand may need a double angle identity before you can integrate: the Jun 2024 paper 21 Q6(b) scheme integrates a cos 4x term. Used in: Jun 2024 paper 21 Q6(b), the exact volume when a shaded region is rotated about the x-axis; Mar 2024 paper 22 Q4(b), the exact volume for a curve with $e^{0}.5x$).

$$V = \pi \int_a^b y^2 \, dx \quad \text{(about the } x\text{-axis)}$$

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Trapezium rule

n intervals need n + 1 values of y. Work in radians for trigonometric curves. Used in: Nov 2024 paper 22 Q6(a), two intervals for an area; Jun 2024 paper 21 Q6(a), two intervals for a curve with sin x; Mar 2024 paper 22 Q4(a), three intervals.

$$\int_a^b y \, dx \approx \frac{h}{2}\{y_0 + 2\,(y_1 + y_2 + \cdots + y_{n-1}) + y_n\}, \quad h = \frac{b-a}{n}$$

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Numerical solution of equations

Iterative formula

Start from the given value and repeat until the answer is stable to the accuracy asked; give each iteration to the stated decimal places or significant figures. Nov 2025 paper 22 Q6(c) printed the formula in the question; the others ask you to rearrange the equation from the earlier part. Used in: Nov 2025 paper 22 Q6(c); Jun 2025 paper 21 Q3(bc), the x-coordinate of an intersection; Nov 2025 paper 21 Q7(cd), a root b of a cubic.

$$x_{n+1} = \mathrm{F}(x_n)$$

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Also learn these

Polynomial division

Divide by a linear factor to leave a quotient, then solve the quotient (usually a quadratic) for the other roots, using the quadratic formula for exact answers. Used in: Nov 2025 paper 22 Q4(a); Nov 2025 paper 22 Q4(b); Nov 2025 paper 21 Q7(b).

Equations quadratic in an exponential

Substitute for $e^{2}x$) or e^x, solve the quadratic, then take ln and reject a negative value of the exponential. Used in: Nov 2025 paper 21 Q2.

Exact answers with ln

Use the laws of logarithms to write a final answer in the form asked, such as ln p - q, with p and q integers. Used in: Nov 2025 paper 21 Q5(b); Nov 2025 paper 22 Q1; Nov 2023 paper 21 Q3(a).

Show a root lies in an interval

Evaluate the rearranged equation at both ends and state that the sign changes, so a root lies between them. Used in: Nov 2025 paper 21 Q7(cd); Nov 2025 paper 22 Q6(ab).

Over- or under-estimate

Compare the trapezia with the curve: if each top edge lies above the curve the estimate is an over-estimate. Used in: Jun 2021 paper 21 Q6(bcd).

No stationary point or vertical tangent

Set dy/dx = 0 and show the equation has no solution, or show that the denominator of dy/dx is never 0 to rule out a vertical tangent. Used in: Mar 2025 paper 22 Q8(b); Nov 2025 paper 22 Q7(b).

Stationary points

Set dy/dx = 0 and solve for x, then find y, leaving exact values when asked. Used in: Nov 2025 paper 21 Q8; Jun 2025 paper 21 Q4(a); Jun 2025 paper 22 Q3.

Sketching exponentials and sec

Sketch the two graphs on one diagram, marking the value 1 on the y-axis for sec x and drawing the exponential as a decreasing positive curve. Used in: Jun 2025 paper 21 Q3(a).

Using the booklet in the exam

- Learn the factor theorem, the reciprocal definitions (sec, cosec, cot), the laws of logarithms, the trapezium rule and the volume of revolution formula. MF19 prints none of them.
- MF19 prints the derivatives of ln x, e^x, sin x, cos x and tan x, the product, quotient and parametric rules, and the addition and double angle formulae. Use them, but add the chain-rule factor yourself.
- In integration, the page lists only the plain forms. For $e^{2}x$ - 5) or 1/(2x - 5), divide by the coefficient of x inside the bracket and write + c.
- Give exact answers (ln 2, pi, surds) whenever the question says exact; use radians for calculus with trigonometric functions.

- For an iterative formula, work in radian mode where there is a trigonometric term, and write each iteration to the number of figures the question asks for.

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