STUDY FORMULA BOOKLET

Edexcel IAL Maths Unit FP2 (WFM02): further pure mathematics 2

The booklet prints de Moivre, Euler's relation, the polar area formula and the Maclaurin and Taylor series. Learn first the method of differences, the integrating factor, second-order solutions, the loci results and the tangent conditions for polar curves.

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

Built by CuratedPrep from 14 past question papers for Unit FP2 in our question bank, January 2021 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.

Series and the method of differences

Method of differences

Write the partial fractions, list the first few and last few terms and cancel. When the gap is 2, as in f(r) - f(r + 2), the first two and last two terms stay. Used in: Jan 2026 Q1(b); Jan 2026 (A) Q4(b); Jun 2024 Q3(b).

$$\sum_{r=1}^{n}\left[f(r)-f(r+1)\right]=f(1)-f(n+1)$$

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Sum of the first n integers

The specification says knowledge of FP1 and its formulae is assumed. It is needed together with the next two rows when a difference of powers is summed. Used in: Oct 2021 Q9(b), the sum of r^4 from n^5 - $(n - 1)^5$.

$$\sum_{r=1}^{n} r=\tfrac{1}{2}n(n+1)$$

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Sum of squares

Combine with the other standard sums when the method of differences gives a power of r. Used in: Oct 2021 Q9(b).

$$\sum_{r=1}^{n} r^2=\tfrac{1}{6}n(n+1)(2n+1)$$

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Sum of cubes

Needed to sum r^3 in the same way. Used in: Oct 2021 Q9(b).

$$\sum_{r=1}^{n} r^3=\tfrac{1}{4}n^2(n+1)^2$$

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tan of a sum or difference

Take tan of both sides to prove arctan A - arctan B = arctan((A - B)/(1 + AB)), then use it as the difference in the next part. Used in: Jan 2022 Q6(a).

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

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Further complex numbers

Euler's relation

Converts modulus-argument form to r e^{i θ}. Used in: Jun 2025 Q1(b); Jan 2022 Q1(b); Oct 2021 Q1.

$$e^{i\theta}=\cos\theta+i\sin\theta$$

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Modulus-argument form

Pick the quadrant from a sketch and give θ in the range the question sets, for example -pi < θ <= pi or 0 <= θ < 2 pi. Used in: Jun 2025 Q1(a); Jan 2024 Q2(a); Jan 2022 Q1(a).

$$z=r(\cos\theta+i\sin\theta),\quad r=\sqrt{x^2+y^2},\quad\tan\theta=\frac{y}{x}$$

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De Moivre's theorem

Use it forwards for powers, backwards for roots, and with an expanded (cos θ + i sin θ)^n to get cos n θ and sin n θ. Used in: Jun 2025 Q9(a); Jun 2024 Q9(a); Jan 2024 Q2(b).

$$\{r(\cos\theta + i\sin\theta)\}^n = r^n(\cos n\theta + i\sin n\theta)$$

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Binomial expansion for powers of complex numbers

Expand (cos θ + i sin θ)^n or (z - 1/z)^n, then compare real and imaginary parts; the coefficients come from Pascal's triangle. The questions did not name the theorem, but each needed the expansion. Used in: Jan 2026 Q7(a), (e^{i θ} - e^{-i θ})^4; Jan 2026 (A) Q7(a); Jun 2022 Q8(a), sin 5 θ.

$$(a+b)^n = a^n + \binom{n}{1}a^{n-1}b + \binom{n}{2}a^{n-2}b^2 + \cdots + \binom{n}{r}a^{n-r}b^r + \cdots + b^n \quad (n \in \mathbb{N})$$

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Cos and sin from z and 1/z

Not on the sheet: the question printed it. Every question in our bank that needed this printed it in an earlier part, so you can quote it. The specification says students should be familiar with cos θ = 1/2 (e^{i θ} + e^{-i θ}) and sin θ = (e^{i θ} - e^{-i θ})/(2i). Used in: Jan 2026 (A) Q7(b); Jun 2025 (A) Q8(a); Jan 2021 Q8(a).

$$z = \cos\theta + i\sin\theta: \quad z^n + \frac{1}{z^n} = 2\cos n\theta, \quad z^n - \frac{1}{z^n} = 2i\sin n\theta$$

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Roots of z^n = 1

For $z^5 = 32$, multiply by the modulus: z = 2e^{2 pi k i/5}. Used in: Jan 2026 (A) Q1.

$$z = e^{\frac{2\pi k i}{n}}, \quad k = 0, 1, 2, \ldots, n-1$$

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nth roots of a complex number

Write the number in modulus-argument form first, take the nth root of the modulus and divide the argument plus 2k pi by n. Used in: Jun 2025 Q1(b); Jan 2022 Q1(b); Oct 2021 Q1.

$$z^n = re^{i\theta} \Rightarrow z = r^{1/n}e^{i(\theta+2k\pi)/n}, \quad k = 0, 1, \ldots, n-1$$

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Loci in the Argand diagram

Circle

|z| = r is a circle centred at the origin. Used in: Jun 2025 Q3(a), |z| = 1; Jun 2023 Q2(b), a shaded region; Jun 2025 (A) Q4(a), reading a from the diagram.

$$|z-a| = r \ \text{(centre } a, \text{ radius } r), \qquad |z-a| \leqslant r \ \text{(inside and on the circle)}$$

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Perpendicular bisector

The locus is the perpendicular bisector of the line joining the points a and b. For an equation, put z = x + iy and square both sides. Used in: Jun 2024 Q1(a); Jan 2023 Q6(a); Jun 2025 (A) Q4(a).

$$|z-a| = |z-b|$$

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Half-line from a point

A half-line from the point a at angle beta to the real axis, not including a. Used in: Oct 2021 Q6(b); Jun 2023 Q2(b); Jun 2025 (A) Q4(a).

$$\arg(z-a) = \beta$$

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First order differential equations

Integrating factor

Divide through first so the coefficient of dy/dx is 1. The specification says the integrating factor may be quoted without proof, but it is not in the booklet. Used in: Jan 2026 (A) Q3(a); Jan 2025 Q1(a); Oct 2021 Q4(a).

$$\frac{dy}{dx} + Py = Q \Rightarrow \text{I.F.} = e^{\int P\,dx}, \quad y\,e^{\int P\,dx} = \int Q\,e^{\int P\,dx}\,dx$$

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Integral of tan x

Gives integrating factors such as e^{-3 ln|sec x|} = $\cos^3 x$, using e^{ln a} = a. Used in: Jan 2026 (A) Q3(a); Jan 2025 Q1(a); Jun 2022 Q4(a).

$$\int \tan x \, dx = \ln |\sec x|$$

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Integral of sec squared kx

Used when the right-hand side holds $\sec^2 x$ after dividing through. Used in: Jan 2026 (A) Q3(a).

$$\int \sec^2 kx \, dx = \frac{1}{k} \tan kx$$

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Product rule

For substitutions such as y = xv or u = xy. For a second derivative, apply it again to the first derivative. Used in: Jan 2026 Q8(a); Jun 2022 Q7(a).

$$\frac{d}{dx}(uv) = u\frac{dv}{dx} + v\frac{du}{dx}$$

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Chain rule

For substitutions such as u = y^{-4} or z = y^{-2}, and for a change of variable such as x = t^2. Used in: Jan 2026 Q3(a); Jun 2023 Q7(a); Oct 2021 Q7(a).

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

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Second order differential equations

Auxiliary equation and general solution

Solve the auxiliary equation for the complementary function, find a particular integral, then add them. Used in: Jan 2026 (A) Q6(a); Jan 2025 Q6(a); Jan 2024 Q6(a).

$$a\frac{d^2y}{dx^2} + b\frac{dy}{dx} + cy = f(x): \quad a\lambda^2 + b\lambda + c = 0, \quad y = \text{CF} + \text{PI}$$

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Complementary function by type of root

Distinct real roots, equal roots and complex roots. Used in: Jan 2026 (A) Q6(a), distinct roots; Jun 2023 Q4(a), equal roots; Jan 2025 Q6(a), complex roots.

$$\lambda_1 \neq \lambda_2: \; Ae^{\lambda_1 x} + Be^{\lambda_2 x}; \quad \lambda_1 = \lambda_2 = \lambda: \; (A + Bx)e^{\lambda x};$$
$$\lambda = p \pm iq: \; e^{px}(A\cos qx + B\sin qx)$$

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Particular integral to try

Multiply the trial by x if it already appears in the complementary function. Differentiate the trial twice and equate coefficients. Used in: Jan 2026 (A) Q6(a), a polynomial; Jan 2025 Q6(a), an exponential; Jan 2021 Q6(a), cos x.

$$f(x) = ke^{px}: \; \lambda e^{px}; \quad \text{polynomial}: \; \text{same degree};$$
$$m\cos\omega x + n\sin\omega x: \; p\cos\omega x + q\sin\omega x$$

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Maclaurin and Taylor series

Maclaurin series

Find f(0), f'(0), f''(0) and f'''(0), by differentiating the function or the differential equation. Also used for a series solution in ascending powers of x. Used in: Jan 2026 Q2(c); Jun 2024 Q7(b); Jan 2026 (A) Q5(b).

$$f(x) = f(0) + xf'(0) + \frac{x^2}{2!}f''(0) + \ldots + \frac{x^r}{r!}f^{(r)}(0) + \ldots$$

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Taylor series in powers of (x - a)

Differentiate again and again, substitute x = a, then build the series. Used in: Jan 2026 Q4(b); Jan 2025 Q3(b); Jun 2025 Q2.

$$f(x) = f(a) + (x-a)f'(a) + \frac{(x-a)^2}{2!}f''(a) + \ldots + \frac{(x-a)^r}{r!}f^{(r)}(a) + \ldots$$

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Series for e^x

To expand e^{3x} put 3x in place of x; one question printed this series as well. Used in: Jun 2025 (A) Q3(c).

$$e^x = \exp(x) = 1 + x + \frac{x^2}{2!} + \ldots + \frac{x^r}{r!} + \ldots \quad \text{for all } x$$

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Derivatives of exponentials and logarithms Needed to start a Maclaurin or Taylor series. Used in: Jan 2026 Q2(a); Jun 2024 Q7(a), e^{sin x}; Jan 2023 Q1(a), ln(5 + 3x).	$\frac{d}{dx}e^{f(x)} = f'(x)e^{f(x)}, \quad \frac{d}{dx}\ln f(x) = \frac{f'(x)}{f(x)}$	LEARN IT
Derivative of tan kx tan x has derivative sec^2 x; the next derivatives need the product and chain rules. Used in: Jan 2024 Q4(a); Oct 2021 Q5(a).	$\frac{d}{dx}(\tan kx) = k\sec^2 kx$	GIVEN
Derivative of sec x Derivative of sec x. Used in: Jun 2023 Q6(a).	$\frac{d}{dx}(\sec x) = \sec x \tan x$	GIVEN
Derivative of arcsin x Derivative of arcsin x, with the chain rule for arcsin 2x. Used in: Jun 2025 (A) Q3(a).	$\frac{d}{dx}(\arcsin x) = \frac{1}{\sqrt{1-x^2}}$	GIVEN
Laws of logarithms Turns a log of a quotient into two series you already have. Used in: Jan 2023 Q1(d).	$\ln a - \ln b = \ln \frac{a}{b}$	LEARN IT

Polar coordinates

Area of a sector (polar coordinates) The booklet prints the integral without limits. For the area between two curves use the outer r and the inner r, or split the region at the intersection. Used in: Jan 2026 Q9(b); Jan 2026 (A) Q8(b); Jun 2025 Q7(b).	$A = \frac{1}{2}\int r^2\, d\theta$	GIVEN
Tangent parallel or perpendicular to the initial line The specification says the ability to find tangents parallel to, or at right angles to, the initial line is expected. Used in: Jan 2023 Q8(a), parallel; Oct 2021 Q8(a), perpendicular; Jun 2023 Q8(b), parallel.	$x = r\cos\theta,\ y = r\sin\theta; \quad \text{parallel}: \frac{d(r\sin\theta)}{d\theta} = 0,$ $\text{perpendicular}: \frac{d(r\cos\theta)}{d\theta} = 0$	LEARN IT
Double angle formulae Squaring r gives sin^2 or cos^2 terms, so rewrite them before integrating. Also used to solve for the point where two curves meet. Used in: Jan 2026 Q9(a); Jun 2025 Q7(b); Jan 2022 Q4(b).	$\cos 2\theta \equiv 1 - 2\sin^2\theta \equiv 2\cos^2\theta - 1, \quad \sin 2\theta \equiv 2\sin\theta\cos\theta$	LEARN IT

Also learn these

Partial fractions
Write the form with one constant for each linear factor, then find the constants by substituting values or equating coefficients. Used in: Jan 2026 Q1(a); Jan 2026 (A) Q4(a); Jun 2024 Q3(a).

Modulus inequalities
Solve f(x) = g(x) and f(x) = -g(x) for the critical values, or square both sides, then test the regions. Used in: Jan 2026 (A) Q2.

Algebraic inequalities
Multiply both sides by the square of the denominator so the inequality does not reverse, and include the values that make the denominator zero as critical values. Used in: Jan 2026 Q5; Jan 2024 Q1; Jun 2024 Q5.

Mapping from the z-plane to the w-plane
Make z the subject, put z = x + iy or substitute into the locus equation, and turn the result into an equation in u and v. Used in: Jan 2024 Q7(a); Jun 2025 Q3(b); Jan 2023 Q6(b).

Invariant points
A point is invariant under the transformation when w = z, so solve z = f(z). Used in: Jan 2021 Q1.

Reducing a differential equation by a substitution
Replace y and its derivatives using the substitution, simplify to the printed equation, solve it, then substitute back for y. Used in: Jan 2026 Q8(b); Jan 2026 Q3(c); Oct 2021 Q7(c).

Particular solution

Find the general solution first, then use the initial conditions, differentiating the general solution when dy/dx is given. Used in: Jan 2026 (A) Q3(b); Jun 2025 Q4(c); Jan 2025 Q6(b).

Series solution of a differential equation

Differentiate the equation again and again with the product rule, substitute the starting values to find each derivative, then build the series. Used in: Jan 2026 (A) Q5; Jan 2026 Q4(a); Jun 2024 Q2(a).

Series for a related function

Replace x by -x or by 3x in a series you have already found, or add and subtract series. Used in: Jan 2023 Q1(c); Jun 2025 (A) Q3(c).

Intersection of polar curves

Equate the two values of r, solve for θ in the given range, then check the pole as well. Used in: Jan 2026 Q9(a); Jan 2026 (A) Q8(a); Jun 2025 Q7(a).

Using the booklet in the exam

- Learn the method of differences, the integrating factor, the three complementary functions and the particular integral trials. None is in the booklet, and the papers used them again and again.
- For a polar area, find where the curves meet first, then use A = 1/2 integral of r^2 d θ with the outer curve minus the inner curve, and rewrite $\sin^2$ and $\cos^2$ with double angles before you integrate.
- For a tangent parallel to the initial line differentiate r sin θ, and for one perpendicular to it differentiate r cos θ; set the derivative to 0 and use the given range of θ.
- In a differential equation, divide through to get dy/dx + P y = Q before you find the integrating factor, and use the initial conditions only after the general solution is complete.
- For a locus, put z = x + iy and square the moduli, then name the shape. When a question says calculator technology is not acceptable, show the algebra for critical values and roots.

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