A Level Math Revision
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FORMULA SHEET

A Level Mathematics (UK)

v2 Oct 2026

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alevel-frontend/formula-sheet-uk
Interactive version

E A O = printed in that board's formulae booklet (Edexcel 9MA0 · AQA 7357 · OCR A H240). E A O grey = not printed: learn it for that board.

Algebra & functions

E A O **Quadratic formula:**
$x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$

E A O **Discriminant** b^2-4ac: >0 two real roots, $=0$ one repeated root, <0 no real roots

E A O **Completing the square:**
$ax^2+bx+c = a\left(x+\frac{b}{2a}\right)^2 + c - \frac{b^2}{4a}$

E A O **Indices:**
$a^m a^n = a^{m+n}$,
$(a^m)^n = a^{mn}$, $a^{-n} = \frac{1}{a^n}$,
$a^{\frac{m}{n}} = \sqrt[n]{a^m}$

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E A O **Surds:** $\sqrt{ab} = \sqrt{a}\sqrt{b}$,
$\frac{1}{\sqrt{a}+\sqrt{b}} = \frac{\sqrt{a}-\sqrt{b}}{a-b}$

E A O **Factor theorem:**
$f(a)=0 \iff (x-a)$ is a factor

E A O **Partial fractions:**
$\frac{px+q}{(x-a)(x-b)} = \frac{A}{x-a} + \frac{B}{x-b}$, $\frac{\dots}{(x-a)^2(x-b)}$
$= \frac{A}{x-a} + \frac{B}{(x-a)^2} + \frac{C}{x-b}$

E A O **Modulus; composite; inverse:**
$|x|<a \iff -a<x<a$;
$fg(x) = f(g(x))$; $ff^{-1}(x) = x$

E A O **Transformations:** $f(x)+a$ up a; $f(x+a)$ left a; $af(x)$ vertical $\times a$; $f(ax)$ horizontal $\times \frac{1}{a}$

Coordinate geometry

E A O **Line; gradient:**
$y-y_1 = m(x-x_1)$, $m = \frac{y_2-y_1}{x_2-x_1}$

E A O **Perpendicular gradients:** $m_1 m_2 = -1$

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E A O **Midpoint; distance:**
$\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right)$,
$\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$

E A O **Circle, centre** (a,b)**, radius** r**:**
$(x-a)^2+(y-b)^2 = r^2$

E A O **Circles:** tangent $\perp$ radius; angle in a semicircle is 90°; perpendicular from centre bisects a chord

E A O **Parametric → Cartesian:** eliminate t, e.g. with $\sin^2 t + \cos^2 t = 1$

E A O **Sphere; cone (curved surface, slant** l**):** $A = 4\pi r^2$; $A = \pi r l$

Sequences & series

E A O **Arithmetic** n**th term:**
$u_n = a + (n-1)d$

E A O **Arithmetic series:**
$S_n = \frac{1}{2}n(a+l) = \frac{1}{2}n[2a+(n-1)d]$

E A O **Geometric** n**th term:** $u_n = ar^{n-1}$

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E A O **Geometric series:**
$S_n = \frac{a(1-r^n)}{1-r}$,
$S_\infty = \frac{a}{1-r}$ $(|r|<1)$

E A O **Binomial,** $n \in \mathbb{N}$**:**
$(a+b)^n = a^n + \binom{n}{1}a^{n-1}b + \binom{n}{2}a^{n-2}b^2 + \cdots + b^n$

E A O **Binomial coefficient:**
$\binom{n}{r} = {}^nC_r = \frac{n!}{r!(n-r)!}$

E A O **Binomial,** $|x|<1$, $n \in \mathbb{Q}$**:**
$(1+x)^n = 1 + nx + \frac{n(n-1)}{1\times 2}x^2 + \cdots$

E A O $(a+bx)^n = a^n(1+\frac{b}{a}x)^n$, valid for $|x| < \left|\frac{a}{b}\right|$

E A O **Sigma; recurrence:**
$\sum_{r=1}^{n} r = \frac{1}{2}n(n+1)$; $u_{n+1} = f(u_n)$

Exponentials & logarithms

E A O **Definition:**
$a^x = b \iff x = \log_a b$

E A O **Laws:**
$\log_a xy = \log_a x + \log_a y$,
$\log_a \frac{x}{y} = \log_a x - \log_a y$,
$\log_a x^k = k\log_a x$

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E A O **Change of base:** $\log_a x = \frac{\log_b x}{\log_b a}$

E A O **Exponential form:** $a^x = e^{x\ln a}$

E A O **Inverses:** $e^{\ln x} = x$, $\ln e^x = x$

E A O **Linearising:** $y = ax^n \Rightarrow \log y = \log a + n\log x$; $y = kb^x \Rightarrow \log y = \log k + x\log b$

Integration

E A O **Standard:** $\int x^n\,dx = \frac{x^{n+1}}{n+1} + c$,
$\int \frac{1}{x}\,dx = \ln|x| + c$,
$\int e^{kx}\,dx = \frac{1}{k}e^{kx} + c$

E A O **Trig:**
$\int \cos kx\,dx = \frac{1}{k}\sin kx + c$,

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

E A O **More trig:**
$\int \sec^2 kx\,dx = \frac{1}{k}\tan kx + c$,
$\int \tan kx\,dx = \frac{1}{k}\ln|\sec kx| + c$,
$\int \cot kx\,dx = \frac{1}{k}\ln|\sin kx| + c$

E A O **Reverse chain:** $\int \frac{f'(x)}{f(x)}\,dx = \ln|f(x)| + c$,
$\int f'(x)[f(x)]^n\,dx = \frac{[f(x)]^{n+1}}{n+1} + c$

E A O **Linear inside:**
$\int f(ax+b)\,dx = \frac{1}{a}F(ax+b) + c$

E A O **By parts:** $\int u\frac{dv}{dx}\,dx = uv - \int v\frac{du}{dx}\,dx$

E A O **Substitution:** $u = g(x)$, replace dx by $\frac{du}{g'(x)}$, change the limits

E A O **Area:** $\int_a^b y\,dx$;
between curves $\int_a^b (y_{\text{top}} - y_{\text{bottom}})\,dx$;
parametric $\int y\frac{dx}{dt}\,dt$

E A O **Identities to integrate:**
$\sin^2 x = \frac{1}{2}(1-\cos 2x)$,
$\cos^2 x = \frac{1}{2}(1+\cos 2x)$

E A O **Separable DE:** $\frac{dy}{dx} = f(x)g(y) \Rightarrow \int \frac{dy}{g(y)} = \int f(x)\,dx$

Numerical methods & vectors

E A O **Trapezium rule,** $h = \frac{b-a}{n}$**:**
$\int_a^b y\,dx \approx \frac{1}{2}h\{(y_0+y_n) + 2(y_1+\cdots+y_{n-1})\}$

E A O **Newton–Raphson:**
$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$

E A O **Sign change:** continuous f with $f(a)f(b)<0$ has a root in (a,b). Iteration $x_{n+1} = g(x_n)$: staircase/cobweb

E A O **Magnitude; unit vector:** $|x\mathbf{i}+y\mathbf{j}+z\mathbf{k}| = \sqrt{x^2+y^2+z^2}$, $\hat{\mathbf{a}} = \frac{\mathbf{a}}{|\mathbf{a}|}$

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E A O $\overrightarrow{AB}$; distance AB: $|\mathbf{b}-\mathbf{a}| = \sqrt{\Delta x^2+\Delta y^2+\Delta z^2}$

Trigonometry

E A O **Sine rule; cosine rule:**
$\frac{a}{\sin A} = \frac{b}{\sin B}$, $a^2 = b^2+c^2-2bc\cos A$

E A O **Area; arc; sector (radians):**
$\frac{1}{2}ab\sin C$; $s = r\theta$; $A = \frac{1}{2}r^2\theta$

E A O **Identities:**
$\tan\theta = \frac{\sin\theta}{\cos\theta}$,
$\sin^2\theta + \cos^2\theta = 1$

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E A O **Reciprocal:**
$\sec^2\theta = 1+\tan^2\theta$,
$\operatorname{cosec}^2\theta = 1+\cot^2\theta$

E A O **Double angle:**
$\sin 2A = 2\sin A\cos A$,
$\cos 2A = \cos^2 A - \sin^2 A$
$= 2\cos^2 A - 1 = 1 - 2\sin^2 A$

E A O **Double angle (tan):**
$\tan 2A = \frac{2\tan A}{1-\tan^2 A}$

E A O **Compound sin:**
$\sin(A\pm B) = \sin A\cos B \pm \cos A\sin B$

E A O **Compound cos:**
$\cos(A\pm B) = \cos A\cos B \mp \sin A\sin B$

E A O **Compound tan:**
$\tan(A\pm B) = \frac{\tan A \pm \tan B}{1 \mp \tan A\tan B}$

E A O **Harmonic form,** $R>0$**:**
$a\sin\theta + b\cos\theta = R\sin(\theta+\alpha)$,
$R = \sqrt{a^2+b^2}$, $\tan\alpha = \frac{b}{a}$

E A O **Small angles (radians):**
$\sin\theta \approx \theta$, $\cos\theta \approx 1 - \frac{\theta^2}{2}$, $\tan\theta \approx \theta$

E A O **Exact values:** $\sin 30° = \frac{1}{2}$, $\sin 45° = \frac{\sqrt{2}}{2}$, $\sin 60° = \frac{\sqrt{3}}{2}$, $\tan 30° = \frac{1}{\sqrt{3}}$, $\tan 60° = \sqrt{3}$

E A O **Inverse trig ranges:**
$\arcsin \in [-\frac{\pi}{2}, \frac{\pi}{2}]$, $\arccos \in [0,\pi]$, $\arctan \in (-\frac{\pi}{2}, \frac{\pi}{2})$

E A O **Radians:** π rad $= 180°$

Differentiation

E A O **First principles:**
$f'(x) = \lim_{h\to 0}\frac{f(x+h)-f(x)}{h}$

E A O **Standard:** $(x^n)' = nx^{n-1}$,
$(e^{kx})' = ke^{kx}$, $(\ln x)' = \frac{1}{x}$,
$(\sin kx)' = k\cos kx$,
$(\cos kx)' = -k\sin kx$

E A O **Exponential base** a**:**
$(a^{kx})' = ka^{kx}\ln a$

E A O **Trig:**
$(\tan kx)' = k\sec^2 kx$,
$(\sec kx)' = k\sec kx\tan kx$,
$(\cot kx)' = -k\operatorname{cosec}^2 kx$,
$(\operatorname{cosec} kx)' = -k\operatorname{cosec} kx\cot kx$

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E A O **Product; chain:**
$(uv)' = uv' + vu'$, $\frac{dy}{dx} = \frac{dy}{du}\cdot\frac{du}{dx}$

E A O **Quotient:** $\frac{d}{dx}\left(\frac{f}{g}\right) = \frac{f'g-fg'}{g^2}$

E A O **Inverse; parametric:**
$\frac{dy}{dx} = \frac{1}{dx/dy}$; $\frac{dy}{dx} = \frac{dy/dt}{dx/dt}$

E A O **Implicit:** $\frac{d}{dx}f(y) = f'(y)\frac{dy}{dx}$,
$\frac{d}{dx}(xy) = x\frac{dy}{dx} + y$

E A O **Stationary:** $f'=0$; max if $f''<0$, min if $f''>0$. Convex $f''>0$, concave $f''<0$; inflection: f'' changes sign

E A O **Tangent; normal:**
$y-y_1 = f'(x_1)(x-x_1)$;
$m_n = -\frac{1}{f'(x_1)}$

Mechanics

E A O **Constant acceleration:**
$v = u+at$, $s = ut + \frac{1}{2}at^2$,
$s = vt - \frac{1}{2}at^2$, $s = \frac{1}{2}(u+v)t$,
$v^2 = u^2 + 2as$

E A O **… in vectors:** $\mathbf{v} = \mathbf{u} + \mathbf{a}t$, $\mathbf{r} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$

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E A O **Variable acceleration:** $v = \frac{dr}{dt}$, $a = \frac{dv}{dt} = \frac{d^2r}{dt^2}$, $r = \int v\,dt$, $v = \int a\,dt$

E A O **Forces:** $F = ma$, $W = mg$, $F \le \mu R$ (limiting: $F = \mu R$)

E A O **Moments:** moment $= F \times d_\perp$; equilibrium: $\sum F = 0$, $\sum M = 0$

E A O **Projectiles (speed** U**, angle** α**):**
$x = Ut\cos\alpha$, $y = Ut\sin\alpha - \frac{1}{2}gt^2$

E A O **Slope at** θ**:** weight component $mg\sin\theta$ down the slope; $R = mg\cos\theta$ if nothing else acts perpendicular to it

E A O **Speed =** $|\mathbf{v}|$**; velocity–time graph:** gradient = acceleration, area = displacement

Statistics & probability

E A O **Mean:** $\bar{x} = \frac{\sum x}{n} = \frac{\sum fx}{\sum f}$

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E A O **Standard deviation:**
$\sigma = \sqrt{\frac{S_{xx}}{n}} = \sqrt{\frac{\sum x^2}{n} - \bar{x}^2}$

E A O **Outliers (common rule):**
$< Q_1 - 1.5(Q_3-Q_1)$ or
$> Q_3 + 1.5(Q_3-Q_1)$

E A O **Coding** $y = \frac{x-a}{b}$**:** $\bar{x} = a + b\bar{y}$, $\sigma_x = |b|\,\sigma_y$

E A O **Union:**
$P(A\cup B) = P(A) + P(B) - P(A\cap B)$

E A O **Intersection:**
$P(A\cap B) = P(A)\times P(B\mid A)$

E A O **Conditional:**
$P(A\mid B) = \frac{P(A\cap B)}{P(B)}$

E A O **Independent:**
$P(A\cap B) = P(A)P(B)$,
$P(A\mid B) = P(A)$

E A O **Binomial** $X \sim B(n,p)$**:**
$P(X=x) = \binom{n}{x}p^x(1-p)^{n-x}$

E A O **Binomial mean, variance:**
$E(X) = np$, $\operatorname{Var}(X) = np(1-p)$

E A O **Standard normal:**
$Z = \frac{X-\mu}{\sigma} \sim N(0,1)$

E A O **Normal: points of inflection at** $\mu\pm\sigma$**;** about 68%, 95%, 99.7% within 1, 2, 3 s.d.

E A O **Normal approx. to** $B(n,p)$ (n large, p near ½)**:** $N(np,\ np(1-p))$

E A O **Use a continuity correction, e.g.** $P(X\le 4) \approx P(Y<4.5)$

E A O **Sample mean:** $\bar{X} \sim N\left(\mu, \frac{\sigma^2}{n}\right)$, $Z = \frac{\bar{X}-\mu}{\sigma/\sqrt{n}}$

E A O **Tests: reject** H_0 **if** p**-value** $<\alpha$**;** two-tailed: $\alpha/2$ each tail; PMCC test H_0: $\rho = 0$

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