E A O ticks = printed in that board's formulae booklet (Edexcel 9MA0 · AQA 7357 · OCR A H240). No tick: learn it.

Algebra & functions

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

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

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

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

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

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

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

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

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

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

Perpendicular gradients:
$m_1 m_2 = -1$

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

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

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

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

Sequences & series

Arithmetic nth term:
$u_n = a + (n-1)d$

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

Geometric nth term:
$u_n = ar^{n-1}$

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

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

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

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

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

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

Exponentials & logarithms

Definition:
$a^x = b \iff x = \log_a b$

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

Change of base:
$\log_a x = \frac{\log_b x}{\log_b a}$

Exponential form: $a^x = e^{x \ln a}$

Inverses: $e^{\ln x} = x$, $\ln e^x = x$

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

Trigonometry

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

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

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

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

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

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

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

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

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

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

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

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

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

Radians: π rad $= 180°$

Differentiation

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

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

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

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

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

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

Inverse; parametric:
$\frac{dy}{dx} = \frac{1}{dx/dy}$; $\frac{dy}{dx} = \frac{dy/dt}{dx/dt}$

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

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

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

Integration

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

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

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

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

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

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

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

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

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

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

Numerical methods & vectors

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

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

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

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

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

Mechanics

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

... in vectors: $\mathbf{v} = \mathbf{u} + \mathbf{a}t$, $\mathbf{r} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$

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

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

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

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

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

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

Statistics & probability

Mean: $\bar{x} = \frac{\sum x}{n} = \frac{\sum fx}{\sum f}$

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

Outliers (common rule):
$< Q_1 - 1.5(Q_3 - Q_1)$ or $> Q_3 + 1.5(Q_3 - Q_1)$

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

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

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

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

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

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

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

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

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

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

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

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

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