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AS Maths Formulae Sheet

Shapes	
Area of Triangle	$\frac{1}{2}$ x base x height
Area of Parallelogram	base x height
Area of Rectangle	$length \times width$
Area of Trapezoid	$\frac{1}{2}$(sum of parallel sides) x height
Circumference & Area: Circle	$c = 2\pi r,\ A = \pi r^2$
Cuboid Surface area	$SA = 2xy + 2xz + 2yz$ Where $x, y,$ and z are side lengths
Cuboid Volume	$V = xyz$ where $x, y,$ and z are side lengths
Cylinder Surface Area	$SA = 2\pi rh + 2\pi r^2$ Note: Curved part: $2\pi rh$
Cylinder Volume	$V = \pi r^2 h$
Cone Surface Area	$SA = \pi rl + \pi r^2$ Note: Curved part: πrl where l is slant length
Cone Volume	$V = \frac{1}{3}\pi r^2 h$
Sphere Surface Area	$SA = 4\pi r^2$ Note: Hemisphere= $2\pi r^2 + \pi r^2 = 3\pi r^2$
Sphere Volume	$v = \frac{4}{3}\pi r^3$ Note: Hemisphere= $\frac{2}{3}\pi r^3$
Prism Volume	V =Area of cross section x height
Pyramid Volume	$V = \frac{1}{3} \times base\ area \times h$

Indices	
Multiplication	$x^a \times x^b = x^{a+b}$ $(x^a)^b = x^{ab}$ $(cx^a y^b)^d = c^d x^{ad} y^{bd}$
Division	$x^a \div x^b = \frac{x^a}{x^b} = x^{a-b}$
Negative Powers	$x^{-n} = \frac{1}{x^n}$
Fractions	$\left(\frac{x}{y}\right)^n = \frac{x^n}{y^n}$ $\left(\frac{x}{y}\right)^{-n} = \frac{y^n}{x^n}$
Rational Powers	$a^{\frac{n}{m}} = \begin{cases} (a^{\frac{1}{m}})^n = (\sqrt[m]{a})^n \\ (a^n)^{\frac{1}{m}} = \sqrt[m]{a^n} \end{cases}$

Series	
Binomial Theorem: integer powers	$(a+b)^n$ $= a^n + \binom{n}{1}a^{n-1}b + \cdots + \binom{n}{r}a^{n-r}b^r + \ldots + b^n$
Binomial Coefficient	$\binom{n}{r} = nc_r = \frac{n!}{(n-r)!\,r!}$

Geometry	
Straight Line: Equation (gradient means slope) Parallel$\Longrightarrow$ same slope Perpendicular$\Longrightarrow$ "flip fraction and change the sign" (slopes multiply to make -1)	• Slope intercept form: $y = mx + c$ • General form: $ax + by + d = 0$ • Point slope form: $y - y_1 = m(x - x_1)$
Straight Line: Gradient	$m = \frac{y_2 - y_1}{x_2 - x_1}$
Distance between 2 points $(x_1, y_1), (x_2, y_2)$	$\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
Coordinates of midpoint of $(x_1, y_1), (x_2, y_2)$	$\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right)$
Circles	$(x-a)^2 + (y-b)^2 = r^2$ centre (a, b), radius r

Quadratics	
Quadratic Function: Solutions to $ax^2 + bx + c = 0$	$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a},\ a \neq 0$
Quadratic Function: Axis of Symmetry	$f(x) = x^2 + bx + c \Longrightarrow x = -\frac{b}{2a}$
Quadratic Function: Discriminant	$\Delta = b^2 - 4ac$ • > 0 (2 real distinct roots) • $= 0$ (2real repeated/double roots) • < 0 (no real roots)
Completing The Square $ax^2 \pm bx + c = 0$	$a\left(x \pm \frac{b}{2a}\right)^2 + c - \frac{b^2}{4a}$
Max/Min Value	$c - \frac{b^2}{4a}$
Exponential and Logarithmic Functions	$a^x = e^{x \ln a}$, $log_a a^x = x = a^{log_a x}$ where, $a, x > 0, a \neq 1$
Exponentials & Logarithm Rules`	• $c\,log_a b \Leftrightarrow log_a b^c$ • $\log_a b = c \Leftrightarrow a^c = b,\ a, b, > 0, a \neq 1$ • $\log_a b + \log_a c \Leftrightarrow \log_a bc$ • $\log_a b - \log_a c \Leftrightarrow \log_a \frac{b}{c}$ • $\log_a b \Leftrightarrow \frac{\log_c b}{\log_c a}$ • Solving a power of x: log both sides if 2 terms or use substitution if 3 terms • Solving an exponential : In both sides • Solving a logarithm: raise e both sides or write as $\log_e$ as procced as usual for log

Functions	
Transformations $af(bx+c)+d$ "anything in a bracket affects x and does the opposite"	a=vertical stretch sf a, b=horizontal stretch sf $\frac{1}{b}$ c=translation c units x direction d=translation d units in y direction $f(-x)$=reflection in y, axis $-f(x)$=reflection in x axis

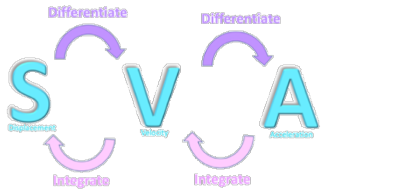
Trigonometry	
Sine Rule	Finding a side: $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$ Finding an angle: $\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$
Cosine Rule	inding a side: $a^2 = b^2 + c^2 - 2bc\cos A$ Finding an angle: $A = \cos^{-1}\left(\frac{b^2 + c^2 - a^2}{2bc}\right)$
Area of Triangle	$\frac{1}{2}absinC$
Degrees $\longleftrightarrow$ radians	D to R: $\times \frac{\pi}{180}$ R to D: $\times \frac{180}{\pi}$
Small Angle Approximations	$\sin\theta \approx \theta$ $\cos\theta \approx 1 - \frac{\theta^2}{2}$ $\tan\theta \approx \theta$
Pythagorean identity 1	$sin^2 x + cos^2 x = 1$
Cofunction	$\cos x = \sin(90 - x)$ $\sin x = \cos(90 - x)$
Identity of tan x	$\tan x = \frac{\sin x}{\cos x}$

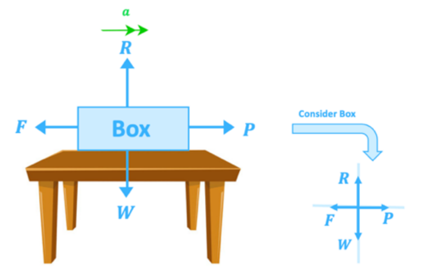
Vectors: 2D vectors $\binom{a}{b}$ year 1 and 3D vectors $\begin{pmatrix}a\\b\\c\end{pmatrix}$ year 2	
Vector Form	$a\boldsymbol{i} + b\boldsymbol{j} + c\boldsymbol{k} \equiv \begin{pmatrix}a\\b\\c\end{pmatrix}$
Properties (addition/subtraction, multiplication and scalar product)	$\begin{pmatrix}a\\b\\c\end{pmatrix} \pm \begin{pmatrix}d\\e\\f\end{pmatrix} = \begin{pmatrix}a \pm d\\b \pm e\\c \pm f\end{pmatrix}$ $\lambda\begin{pmatrix}a\\b\\c\end{pmatrix} = \begin{pmatrix}\lambda a\\\lambda b\\\lambda c\end{pmatrix}$ $\begin{pmatrix}a\\b\\c\end{pmatrix} \cdot \begin{pmatrix}d\\e\\f\end{pmatrix} = ad + be + cf$ (last formula not in syllabus but useful to know)
Magnitude of a vector	$\left\lvert\begin{pmatrix}a\\b\\c\end{pmatrix}\right\rvert = \sqrt{a^2 + b^2 + c^2}$
Unit Vector	Unit vector of $\begin{pmatrix}a\\b\\c\end{pmatrix} = \frac{1}{\sqrt{a^2 + b^2 + c^2}}\begin{pmatrix}a\\b\\c\end{pmatrix}$
Midpoint $of \begin{pmatrix}a\\b\\c\end{pmatrix}$ and $\begin{pmatrix}d\\e\\f\end{pmatrix}$	$\left(\frac{a+d}{2}, \frac{b+e}{2}, \frac{c+f}{2}\right)$
Scalar Product (not in syllabus but useful to know)	$\begin{pmatrix}a\\b\\c\end{pmatrix} \cdot \begin{pmatrix}d\\e\\f\end{pmatrix} = \left\lvert\begin{pmatrix}a\\b\\c\end{pmatrix}\right\rvert \left\lvert\begin{pmatrix}d\\e\\f\end{pmatrix}\right\rvert \cos\theta$ where, θ is the angle between $\begin{pmatrix}a\\b\\c\end{pmatrix}$ and $\begin{pmatrix}d\\e\\f\end{pmatrix}$
Angle Between 2 vectors This is just a re-arrangement of above. (not in syllabus but useful to know)	$\theta = \cos^{-1}\left(\frac{\begin{pmatrix}a\\b\\c\end{pmatrix} \cdot \begin{pmatrix}d\\e\\f\end{pmatrix}}{\left\lvert\begin{pmatrix}a\\b\\c\end{pmatrix}\right\rvert \left\lvert\begin{pmatrix}d\\e\\f\end{pmatrix}\right\rvert}\right)$
Vector Equation of a line (not in syllabus but useful to know)	$r = \begin{pmatrix}a\\b\\c\end{pmatrix} + \lambda\begin{pmatrix}d\\e\\f\end{pmatrix}$

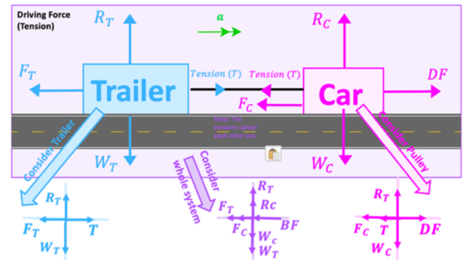
Probability and Statistics	
Mean	If no frequency: $\bar{x} = \frac{\sum x}{n}$, If frequency: $\bar{x} = \frac{\sum fx}{\sum f}$
Variance	If no frequency: $\sigma^2 = \frac{\sum x^2}{n} - \bar{x}^2 = \frac{\sum(x-\mu)^2}{n}$ If frequency: $\sigma^2 = \frac{\sum fx^2}{\sum f} - \bar{x}^2 = \frac{\sum f(x-\mu)^2}{\sum f}$ Note: can also use the formula $\frac{S_{xx}}{n}$
Standard Deviation	$\sigma = \sqrt{variance}$
S_{xx}	$\sum(x_i - \bar{x})^2 = \sum x_i^2 - \frac{(\sum x_i)^2}{n}$
Probability of event A	$P(A) = \frac{n(A)}{n(U)} = \frac{number\ \ of\ favourable\ outcomes}{number\ of\ possible\ outcomes}$
Complementary Events	P(A')=1−P(A) i.e. probabilities add to 1
Combined Events (Addition Rule)	P(A∪B)=P(A)+P(B)−P(A ∩ B)
Mutually Exclusive Events	P(A ∩ B) = 0 Addition rule becomes: P(A∪B)=P(A)+P(B)
Independent Events	P(A ∩ B) = P(A)P(B) Addition rule becomes:P(A∪B)=P(A)+P(B)−P(A)P(B) To find whether independent: Find P(A), P(B) and P(A ∩ B) and see whether the former 2 multiply to make the latter or show that $P(A\|B) = P(A)$
Binomial Distribution Binompd (=) Binomcd (≤)	$x \sim B(n, p)$ E(X)=Mean= np, Var(X)= $np(1-p)$ $P(X = x) = \binom{n}{x}p^x(1-p)^x$
Interquartile Range	IQR= $Q_3 - Q_1$
Outliers	Any values $>$ UQ + 1.5(IQR) or $<$ LQ − 1.5(IQR)

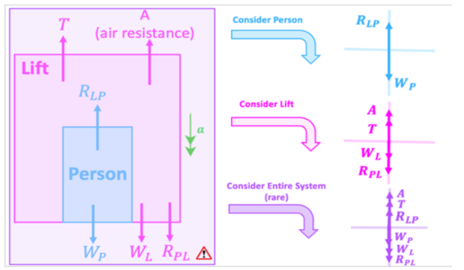
Calculus (Differentiation and Integration)	
Turning/Stationary Points (Max/Min)	Solve $\frac{dy}{dx} = 0$
Proving whether Max/Min	If $\frac{d^2y}{dx^2} > 0$ min and $\frac{d^2y}{dx^2} < 0$ max Or can do sign change test for $\frac{dy}{dx}$ using number line
Points of Inflection	solve $\frac{d^2y}{dx^2} = 0$
Increasing/Decreasing (use number line to solve)	To find where Increasing: solve $\frac{dy}{dx} > 0$ To find where decreasing: solve $\frac{dy}{dx} < 0$
Convex/Concave (use number line to solve)	To find where concave up/convex: solve $\frac{d^2y}{dx^2} > 0$ To find where concave down/concave: solve $\frac{d^2y}{dx^2} < 0$
Tangents and Normals	$y - y_1 = m(x - x_1)$ Differentiate to get m (tangent means ∥, Normal means ⊥)
Implicit	"every time we differentiate a y we write $\frac{dy}{dx}$"
Area between	curve & x axis: $\int_{x=a}^{x=b} y\,dx$ curve & y axis: $\int_{y=a}^{y=b} x\,dy$ (take + answer if neg) Between 2 curves: $\int_{x=a}^{x=b}$(top curve-bottom curve)dx Remember to split up if separate areas
Differentiation 1st Principles	$\frac{dy}{dx} = f'(x) = \lim_{h \to 0}\frac{f(x+h) - f(x)}{h}$
Chain Rule	$y = g(u), u = f(x) \Longrightarrow \frac{dy}{dx} = \frac{dy}{du} \times \frac{du}{dx}$
Product Rule	$y = uv \Longrightarrow \frac{dy}{dx} = u\frac{dv}{dx} + v\frac{du}{dx}$
Quotient rule	$y = \frac{u}{v} \Longrightarrow \frac{dy}{dx} = \frac{v\frac{du}{dx} - u\frac{dv}{dx}}{v^2}$
Derivatives	$x^n \Longrightarrow nx^{n-1}$
Integrals	$\int x^n dx = \frac{x^{n+1}}{n+1} + c, n \neq -1$

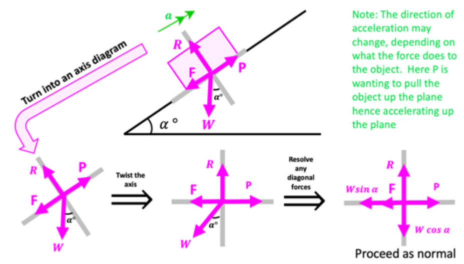
Mechanics	
SUVAT (5 formulae)	$v = u + at$ $s = \left(\frac{u+v}{2}\right)t$ $s = ut + \frac{1}{2}at^2$ $s = vt - \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
Kinematics:	Distance= $\int_{t_1}^{t_2} \lvert v(t) \rvert dt$, Displacement= $\int_{t_1}^{t_2} v(t)dt$ Velocity: $\int_{t_1}^{t_2} a(t)dt$ or $\frac{ds}{dt}$ Acceleration= $\frac{dv}{dt} = \frac{d^2s}{dt^2}$

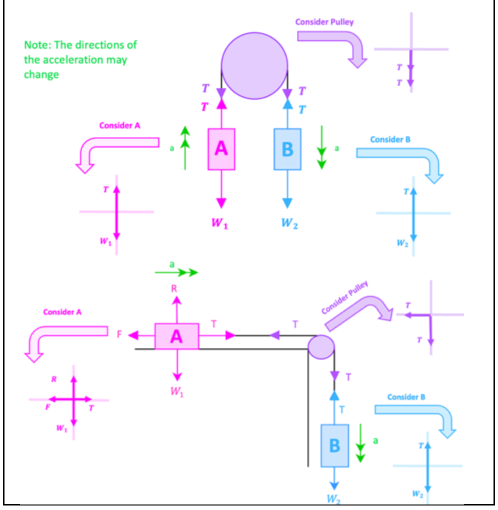












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