

Limits	
AVERAGE RATE OF CHANGE	$\frac{f(b) - f(a)}{b - a}$
SLOPE OF THE TANGENT	$m = \lim_{h \rightarrow 0} \frac{f(a + h) - f(a)}{h}$
LIMIT LAWS	$\lim_{x \rightarrow a} [f(x) \pm g(x)] = \lim_{x \rightarrow a} f(x) \pm \lim_{x \rightarrow a} g(x)$ Products, quotients (nonzero denominator) and constant multiples work the same way.
LIMIT EXISTS	$\lim_{x \rightarrow a} f(x) = L \iff \lim_{x \rightarrow a^-} f(x) = \lim_{x \rightarrow a^+} f(x) = L$
CONTINUITY AT A POINT	$\lim_{x \rightarrow a} f(x) = f(a)$
LIMITS AT INFINITY	$\lim_{x \rightarrow \pm\infty} \frac{1}{x^n} = 0$ For $n > 0$. Divide by the highest power of x in the denominator.

Derivatives	
FIRST PRINCIPLES	$f'(x) = \lim_{h \rightarrow 0} \frac{f(x + h) - f(x)}{h}$
CONSTANT AND POWER RULES	$\frac{d}{dx}(c) = 0 \qquad \frac{d}{dx}(x^n) = nx^{n-1}$
CONSTANT MULTIPLE AND SUM	$(cf)' = cf' \qquad (f \pm g)' = f' \pm g'$
PRODUCT RULE	$(fg)' = f'g + fg'$
QUOTIENT RULE	$\left(\frac{f}{g}\right)' = \frac{f'g - fg'}{g^2}$
CHAIN RULE	$\frac{d}{dx}f(g(x)) = f'(g(x))g'(x) \qquad \frac{dy}{dx} = \frac{dy}{du} \cdot \frac{du}{dx}$
TANGENT LINE	$y - f(a) = f'(a)(x - a)$ The normal line has slope $-\frac{1}{f'(a)}$.
MOTION	$v(t) = s'(t) \qquad a(t) = v'(t) = s''(t)$
BUSINESS	$R(x) = xp(x) \qquad P(x) = R(x) - C(x)$ Marginal cost, revenue and profit are $C'(x)$, $R'(x)$ and $P'(x)$.
IMPLICIT DIFFERENTIATION	$\frac{d}{dx}(y^n) = ny^{n-1} \frac{dy}{dx}$

Curve Sketching	
INCREASING AND DECREASING	$f'(x) > 0 \Rightarrow f$ increasing $\qquad f'(x) < 0 \Rightarrow f$ decreasing
CRITICAL NUMBER	$f'(c) = 0$ or $f'(c)$ undefined
CONCAVITY	$f''(x) > 0 \Rightarrow$ up $\qquad f''(x) < 0 \Rightarrow$ down A point of inflection is where f'' changes sign.
SECOND DERIVATIVE TEST	$f''(c) > 0 \Rightarrow$ local min $\qquad f''(c) < 0 \Rightarrow$ local max At a critical number c with $f'(c) = 0$.
ABSOLUTE EXTREMA ON [A, B]	compare $f(a)$, $f(b)$, $f(c)$ c is each critical number in $[a, b]$; the largest value is the max, the smallest the min.

Optimization	
OPTIMIZE	$f'(x) = 0$ Then check critical numbers and endpoints of the domain.
RELATED RATES	$\frac{dV}{dt} = \frac{dV}{dr} \cdot \frac{dr}{dt}$ Differentiate the equation linking the quantities with respect to t .
CYLINDER	$V = \pi r^2 h \qquad SA = 2\pi r^2 + 2\pi rh$
CONE	$V = \frac{1}{3}\pi r^2 h$
SPHERE	$V = \frac{4}{3}\pi r^3 \qquad SA = 4\pi r^2$

Derivatives of Trig, Exp and Log	
EXPONENTIAL	$\frac{d}{dx}e^x = e^x \qquad \frac{d}{dx}b^x = b^x \ln b$
LOGARITHMIC	$\frac{d}{dx} \ln x = \frac{1}{x} \qquad \frac{d}{dx} \log_b x = \frac{1}{x \ln b}$
CHAIN RULE WITH E	$\frac{d}{dx}e^{g(x)} = e^{g(x)}g'(x)$
SINE AND COSINE	$\frac{d}{dx} \sin x = \cos x \qquad \frac{d}{dx} \cos x = -\sin x$
TANGENT	$\frac{d}{dx} \tan x = \sec^2 x$
KEY LIMIT	$\lim_{x \rightarrow 0} \frac{\sin x}{x} = 1$ x in radians.

Geometric Vectors	
RESULTANT	$\vec{R} = \vec{u} + \vec{v}$ Tip to tail, or the diagonal of the parallelogram.
MAGNITUDE OF A SUM	$ \vec{u} + \vec{v} ^2 = \vec{u} ^2 + \vec{v} ^2 + 2 \vec{u} \vec{v} \cos \theta$ θ is the angle between $\vec{u}$ and $\vec{v}$ placed tail to tail.
EQUILIBRANT	$\vec{E} = -\vec{R}$
UNIT VECTOR	$\hat{u} = \frac{\vec{u}}{ \vec{u} }$
GROUND VELOCITY	$\vec{v}_{\text{ground}} = \vec{v}_{\text{air}} + \vec{v}_{\text{wind}}$

Cartesian Vectors	
MAGNITUDE	$ \vec{u} = \sqrt{u_1^2 + u_2^2 + u_3^2}$
VECTOR BETWEEN POINTS	$\vec{AB} = (x_2 - x_1, y_2 - y_1, z_2 - z_1)$
DOT PRODUCT	$\vec{u} \cdot \vec{v} = \vec{u} \vec{v} \cos \theta = u_1v_1 + u_2v_2 + u_3v_3$ $\vec{u} \cdot \vec{v} = 0$ when the vectors are perpendicular.
SCALAR PROJECTION OF U ON V	$ \vec{u} \cos \theta = \frac{\vec{u} \cdot \vec{v}}{ \vec{v} }$
VECTOR PROJECTION OF U ON V	$\text{proj}_{\vec{v}} \vec{u} = \left(\frac{\vec{u} \cdot \vec{v}}{\vec{v} \cdot \vec{v}} \right) \vec{v}$
CROSS PRODUCT	$\vec{u} \times \vec{v} = (u_2v_3 - u_3v_2, u_3v_1 - u_1v_3, u_1v_2 - u_2v_1)$
MAGNITUDE OF THE CROSS PRODUCT	$ \vec{u} \times \vec{v} = \vec{u} \vec{v} \sin \theta$ The area of the parallelogram the vectors span; half of it for the triangle.
WORK AND TORQUE	$W = \vec{F} \cdot \vec{d} \qquad \vec{\tau} = \vec{r} \times \vec{F} = \vec{r} \vec{F} \sin \theta$
COPLANAR VECTORS	$\vec{u} \cdot (\vec{v} \times \vec{w}) = 0$

Lines and Planes	
LINE, VECTOR FORM	$\vec{r} = \vec{r}_0 + t\vec{m}, t \in \mathbb{R}$
LINE, PARAMETRIC FORM	$x = x_0 + tm_1 \qquad y = y_0 + tm_2 \qquad z = z_0 + tm_3$
LINE, SYMMETRIC FORM	$\frac{x - x_0}{m_1} = \frac{y - y_0}{m_2} = \frac{z - z_0}{m_3}$ For $m_1, m_2, m_3 \neq 0$.
LINE IN 2D, SCALAR FORM	$Ax + By + C = 0$ Normal $\vec{n} = (A, B)$.
PLANE, VECTOR FORM	$\vec{r} = \vec{r}_0 + s\vec{a} + t\vec{b}, s, t \in \mathbb{R}$
PLANE, SCALAR FORM	$Ax + By + Cz + D = 0$ Normal $\vec{n} = (A, B, C) = \vec{a} \times \vec{b}$.
DISTANCE FROM A POINT TO A PLANE	$d = \frac{ Ax_0 + By_0 + Cz_0 + D }{\sqrt{A^2 + B^2 + C^2}}$
DISTANCE FROM A POINT TO A 2D LINE	$d = \frac{ Ax_0 + By_0 + C }{\sqrt{A^2 + B^2}}$
DISTANCE BETWEEN SKEW LINES	$d = \frac{\left \vec{P_1P_2} \cdot (\vec{m_1} \times \vec{m_2}) \right }{ \vec{m_1} \times \vec{m_2} }$