If $y = f(x)$, the **differential** dy is $dy = f'(x)dx$. Compare with $\Delta y = f(a + \Delta x) - f(a)$.
$f(a + \Delta x) = f(a) + \Delta y \approx f(a) + dy = f(a) + f'(a)dx$

The Mean Value Theorem : If f is continuous on the closed interval $[a,\ b]$ and differentiable on the open interval $(a,\ b)$, then there is a $c \in (a,\ \ b)$ such that $f'(c) = \dfrac{f(b) - f(a)}{b - a}$

Asymptotes: The line $x = a$ is a **vertical asymptote** of the graph of a function f if $\lim_{x \to a^+} f(x) = \infty \ \ or \ \ -\infty$ or $\lim_{x \to a^-} f(x) = \infty \ \ or \ \ -\infty$. In particular, if $f(x) = \frac{P(x)}{Q(x)}$ when P, Q are polynomial functions, then the line $x = a$ is a vertical asymptote of f if $Q(a) = 0$ but $P(a) \neq 0$.

The line $y = b$ is an **horizontal asymptote** of the graph of a function f if $\lim_{x\to\infty} f(x) = b$ or $\lim_{x\to(-\infty)} f(x) = b$

A **critical point** of a function f is any point x in the domain of f such that $f'(x) = 0$ or $f'(x)$ does not exist.

For **absolute extrema** of a continuous function on a closed interval $[a,\ b]$:
Compare the value of the function for all the critical points in the interval $(a,\ b)$ and for the two endpoints $x = a$ and $x = b$.

Local extremum tests:
First derivative test at a critical point c of f: if sign of f' changes at c from - to + as x increases, then f has a local min at c; if sign of f' changes from + to -, then f has a local max at c.
Second derivative test at a critical point c of f: if $f''(c) > 0$, then f is concave up at c and has a local min there; if $f''(c) < 0$, then f is concave down at c and has a local max there.

If $(x\ ,\ f(x)\ )$ is an **inflection point** of a function f then x is in the domain of f and the concavity changes at $(x, f(x))$ (which requires either $f''(x) = 0$ or $f''(x)$ does not exist).

Basic log and exp laws: $e^{\ln x} = x \quad for \ \ x > 0$ $\qquad \ln e^x = x$ for all real numbers x

$\ln(mn) = \ln m + \ln n \qquad \ln\dfrac{m}{n} = \ln m - \ln n \qquad \ln(m^n) = n \ln m \qquad \ln 1 = 0 \qquad \ln e = 1$

$e^a e^b = e^{(a+b)} \qquad \dfrac{e^a}{e^b} = e^{(a-b)} \qquad (e^a)^b = e^{(ba)} \qquad 1 = e^0 \qquad e = e^1$

Basic trig identities: $\sin^2\theta + \cos^2\theta = 1 \qquad \sin(-x) = -\sin x \qquad \cos(-x) = \cos x$

$\sin(2\pi + x) = \sin x \qquad \cos(2\pi + x) = \cos x \qquad 360$ degrees $= 2\pi$ radians

$\tan x = \dfrac{\sin x}{\cos x} \qquad \cot x = \dfrac{\cos x}{\sin x} \qquad \sec x = \dfrac{1}{\cos x} \qquad \csc x = \dfrac{1}{\sin x}$

Basic differentiation rules plus chain rule (both forms) for trig, log, and exp functions:

$$\frac{d}{dx}(\sin x) = \cos x \qquad \frac{d}{dx}[\sin(f(x))] = [\cos(f(x))]f'(x) \qquad \frac{d}{dx}(\sin u) = (\cos u)\frac{du}{dx}$$

$$\frac{d}{dx}(\cos x) = -\sin x \qquad \frac{d}{dx}[\cos(f(x))] = -[\sin(f(x))]f'(x) \qquad \frac{d}{dx}(\cos u) = -(\sin u)\frac{du}{dx}$$

$$\frac{d}{dx}(e^x) = e^x \qquad \frac{d}{dx}\left(e^{f(x)}\right) = [e^{f(x)}]f'(x) \qquad \frac{d}{dx}(e^u) = e^u\frac{du}{dx}$$

$$\frac{d}{dx}(\ln|x|) = \frac{1}{x} \quad (x \neq 0) \qquad \frac{d}{dx}(\ln f(x)) = \frac{f'(x)}{f(x)} \quad (f(x) > 0) \qquad \frac{d}{dx}(\ln|u|) = \frac{1}{u}\frac{du}{dx} \quad (u \neq 0)$$

$$\frac{d}{dx}(\tan x) = \sec^2 x \qquad \frac{d}{dx}[\tan(f(x))] = [\sec^2(f(x))]f'(x) \qquad \frac{d}{dx}(\tan u) = (\sec^2 u)\frac{du}{dx}$$