Calculus

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Inverse Function Theorem

$$g'(x) = \frac{1}{f'(g(x))}$$

1. A function is increasing on an open interval if the derivative is positive on that interval.
2. A function is decreasing on an open interval if the derivative is negative on that interval.
3. If f is continuous on $[a,b]$ and $f'(x)$ exists on (a,b), then there is a point c in (a,b) such that $f'(c) = \frac{f(b)-f(a)}{b-a}$.

Limits

$$\lim_{x \to a} \frac{f(x)}{g(x)} = \lim_{x \to a} \frac{f'(x)}{g'(x)}$$

Derivatives of Trig Functions

$$\frac{d}{dx}\sin(x) = \cos(x)$$

$$\frac{d}{dx}\cos(x) = -\sin(x)$$

$$\frac{d}{dx}\tan(x) = \sec^2(x)$$

$$\frac{d}{dx}\cot(x) = -\csc^2(x)$$

$$\frac{d}{dx}\sec(x) = \sec(x)\tan(x)$$

$$\frac{d}{dx}\csc(x) = -\csc(x)\cot(x)$$

Definition of Derivative

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

L'Hospital's Rule

$$\lim_{x \to a} \frac{f(x)}{g(x)} = \lim_{x \to a} \frac{f'(x)}{g'(x)}$$

Derivatives of $\sec(x)$, $\csc(x)$ and $\cot(x)$ are not shown. Memorizing these (below, except $\cot$) or memorizing tangents. Example: if you memorize $\sin$, $\cos$ and $\tan$, you can derive $\sec$ and $\csc$.

Derivatives of Inverse Functions

$$\frac{d}{dx}\sin^{-1}x = \frac{1}{\sqrt{1-x^2}} \qquad \frac{d}{dx}\csc^{-1}x = -\frac{1}{|x|\sqrt{x^2-1}}$$

$$\frac{d}{dx}\cos^{-1}x = -\frac{1}{\sqrt{1-x^2}} \qquad \frac{d}{dx}\sec^{-1}x = \frac{1}{|x|\sqrt{x^2-1}}$$

$$\frac{d}{dx}\tan^{-1}x = \frac{1}{1+x^2} \qquad \frac{d}{dx}\cot^{-1}x = -\frac{1}{1+x^2}$$

Slope and Lines

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

Point-Slope Form:
$y - y_1 = m(x - x_1)$

Slope-Intercept Form:
$y = mx + b$

Parallel Lines:
$m_1 = m_2$

Perpendicular Lines:
$m_1 = -\frac{1}{m_2}$

Derivatives of Log Functions

$$\frac{d}{dx}\ln|x| = \frac{1}{x}, \quad x \neq 0$$

$$\frac{d}{dx}\log_a|x| = \frac{1}{x \ln a}, \quad x \neq 0$$

$$\frac{d}{dx}a^x = a^x \ln(a)$$

$$\frac{d}{dx}e^x = e^x$$

$$\frac{d}{dx}\ln(x) = \frac{1}{x}, \quad x > 0$$

Implicit Differentiation solve for y' or $\frac{dy}{dx}$

This allows you to find the derivative of pretty much any equation. Key: a method having to solve the given equation for y.

Each time you differentiate a y, multiply that derivative by $\frac{dy}{dx}$ (since you are differentiating y with respect to x). Then factor out $\frac{dy}{dx}$, then solve the equation for y' (DONE).

$$6x^2 + 3y^2 = 12$$

$$12x + 6y\frac{dy}{dx} = 0$$

$$6y\frac{dy}{dx} = -12x$$

$$\frac{dy}{dx} = -\frac{2x}{y}$$

Linear Approximations $L(x) = f(a) + f'(a)(x - a)$

Used to approximate the y-value of a function at a point after point a.

1) Find $f(a)$
2) Find $f'(a)$
3) Plug in the a's

$$L(x) = f(a) + f'(a)(x - a)$$

$$f(x) = \sin^{-1}x, \quad a = 0$$

$$f(a) = f(0) = \sin^{-1}(0) = 0$$

$$f'(a) = f'(0) = \frac{1}{\sqrt{1-0^2}} = 1$$

$$L(x) = 0 + 1(x - 0) = x$$

Mean Value Theorem

The slope of the tangent line (secant on $[a,b]$) is the same as the secant slope between $f(a)$ and $f(b)$. At some point, the instantaneous change (tangent line) is equal to the average change between a and b.

Increasing/Decreasing Extrema Max/Min

$$y = x^3 - 3x \qquad \text{on } [-2, 2]$$

$$y' = 3x^2 - 3 = 0$$

$$x = \pm 1$$

$$y(-2) = -2, \quad y(-1) = 2, \quad y(1) = -2, \quad y(2) = 2$$

Absolute Max: $(-1, 2)$ and $(2, 2)$
Absolute Min: $(1, -2)$ and $(-2, -2)$

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Sabine Zange

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