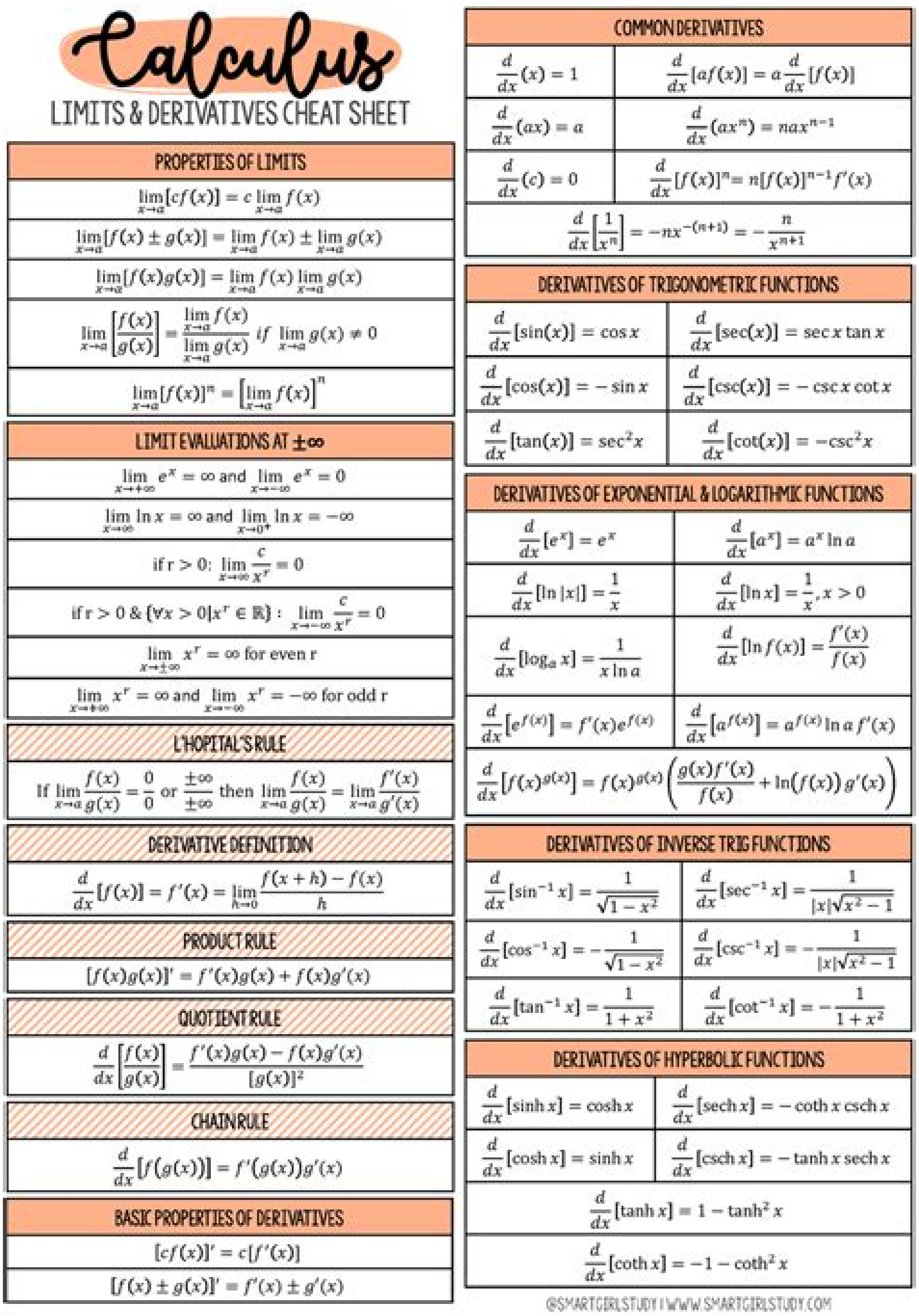
Calculus Limits Cheat Sheet



Calculus

LIMITS & DERIVATIVES CHEAT SHEET

PROPERTIES OF LIMITS

$\lim_{x\to a}[cf(x)] = c\lim_{x\to a} f(x)$

$\lim_{x\to a}[f(x) \pm g(x)] = \lim_{x\to a} f(x) \pm \lim_{x\to a} g(x)$

$\lim_{x\to a}[f(x)g(x)] = \lim_{x\to a} f(x) \lim_{x\to a} g(x)$

$\lim_{x\to a}\left[\frac{f(x)}{g(x)}\right] = \frac{\lim_{x\to a} f(x)}{\lim_{x\to a} g(x)}$ if $\lim_{x\to a} g(x) \neq 0$

$\lim_{x\to a}[f(x)]^n = \left[\lim_{x\to a} f(x)\right]^n$

LIMIT EVALUATIONS AT $\pm\infty$

$\lim_{x\to+\infty} e^x = \infty$ and $\lim_{x\to-\infty} e^x = 0$

$\lim_{x\to\infty} \ln x = \infty$ and $\lim_{x\to 0^+} \ln x = -\infty$

if r > 0: $\lim_{x\to\infty} \frac{c}{x^r} = 0$

if r > 0 & $\{\forall x > 0 | x^r \in \mathbb{R}\}$: $\lim_{x\to-\infty} \frac{c}{x^r} = 0$

$\lim_{x\to\pm\infty} x^r = \infty$ for even r

$\lim_{x\to+\infty} x^r = \infty$ and $\lim_{x\to-\infty} x^r = -\infty$ for odd r

L'HOPITAL'S RULE

If $\lim_{x\to a}\frac{f(x)}{g(x)} = \frac{0}{0}$ or $\frac{\pm\infty}{\pm\infty}$ then $\lim_{x\to a}\frac{f(x)}{g(x)} = \lim_{x\to a}\frac{f'(x)}{g'(x)}$

DERIVATIVE DEFINITION

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

PRODUCT RULE

$[f(x)g(x)]' = f'(x)g(x) + f(x)g'(x)$

QUOTIENT RULE

$\frac{d}{dx}\left[\frac{f(x)}{g(x)}\right] = \frac{f'(x)g(x) - f(x)g'(x)}{[g(x)]^2}$

CHAIN RULE

$\frac{d}{dx}[f(g(x))] = f'(g(x))g'(x)$

BASIC PROPERTIES OF DERIVATIVES

$[cf(x)]' = c[f'(x)]$

$[f(x) \pm g(x)]' = f'(x) \pm g'(x)$

COMMON DERIVATIVES

$\frac{d}{dx}(x) = 1$	$\frac{d}{dx}[af(x)] = a\frac{d}{dx}[f(x)]$
$\frac{d}{dx}(ax) = a$	$\frac{d}{dx}(ax^n) = nax^{n-1}$
$\frac{d}{dx}(c) = 0$	$\frac{d}{dx}[f(x)]^n = n[f(x)]^{n-1}f'(x)$

$\frac{d}{dx}\left[\frac{1}{x^n}\right] = -nx^{-(n+1)} = -\frac{n}{x^{n+1}}$

DERIVATIVES OF TRIGONOMETRIC FUNCTIONS

$\frac{d}{dx}[\sin(x)] = \cos x$	$\frac{d}{dx}[\sec(x)] = \sec x \tan x$
$\frac{d}{dx}[\cos(x)] = -\sin x$	$\frac{d}{dx}[\csc(x)] = -\csc x \cot x$
$\frac{d}{dx}[\tan(x)] = \sec^2 x$	$\frac{d}{dx}[\cot(x)] = -\csc^2 x$

DERIVATIVES OF EXPONENTIAL & LOGARITHMIC FUNCTIONS

$\frac{d}{dx}[e^x] = e^x$	$\frac{d}{dx}[a^x] = a^x \ln a$
$\frac{d}{dx}[\ln\lvert x\rvert] = \frac{1}{x}$	$\frac{d}{dx}[\ln x] = \frac{1}{x}, x > 0$
$\frac{d}{dx}[\log_a x] = \frac{1}{x\ln a}$	$\frac{d}{dx}[\ln f(x)] = \frac{f'(x)}{f(x)}$
$\frac{d}{dx}[e^{f(x)}] = f'(x)e^{f(x)}$	$\frac{d}{dx}[a^{f(x)}] = a^{f(x)}\ln a\, f'(x)$

$\frac{d}{dx}[f(x)^{g(x)}] = f(x)^{g(x)}\left(\frac{g(x)f'(x)}{f(x)} + \ln(f(x))g'(x)\right)$

DERIVATIVES OF INVERSE TRIG FUNCTIONS

$\frac{d}{dx}[\sin^{-1} x] = \frac{1}{\sqrt{1-x^2}}$	$\frac{d}{dx}[\sec^{-1} x] = \frac{1}{\lvert x\rvert\sqrt{x^2-1}}$
$\frac{d}{dx}[\cos^{-1} x] = -\frac{1}{\sqrt{1-x^2}}$	$\frac{d}{dx}[\csc^{-1} x] = -\frac{1}{\lvert x\rvert\sqrt{x^2-1}}$
$\frac{d}{dx}[\tan^{-1} x] = \frac{1}{1+x^2}$	$\frac{d}{dx}[\cot^{-1} x] = -\frac{1}{1+x^2}$

DERIVATIVES OF HYPERBOLIC FUNCTIONS

$\frac{d}{dx}[\sinh x] = \cosh x$	$\frac{d}{dx}[\operatorname{sech} x] = -\coth x \operatorname{csch} x$
$\frac{d}{dx}[\cosh x] = \sinh x$	$\frac{d}{dx}[\operatorname{csch} x] = -\tanh x \operatorname{sech} x$

$\frac{d}{dx}[\tanh x] = 1 - \tanh^2 x$

$\frac{d}{dx}[\coth x] = -1 - \coth^2 x$

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Calculus limits cheat sheet is an essential resource for students and professionals alike who wish to master the foundational concepts of calculus. Understanding limits is crucial as they form the bedrock of calculus, paving the way for derivative and integral concepts. This article serves as a comprehensive guide, providing a concise overview of limits, including definitions, properties, types, and techniques for calculating limits, all of which you can refer to as your cheat sheet.

Understanding Limits

At its core, a limit describes the behavior of a function as it approaches a particular point from either side. This concept is fundamental in calculus and is used to define continuity, derivatives, and integrals.

Definition of a Limit

A limit can be defined mathematically as follows:

- The limit of a function $f(x)$ as x approaches c is denoted as:
$$
\lim_{x \to c} f(x) = L
$$
This means that as x gets arbitrarily close to c, $f(x)$ approaches L.

Limit Notation

In calculus, various notations are used to express limits:

1. One-Sided Limits:
- Left-hand limit: $\lim_{x \to c^-} f(x)$
- Right-hand limit: $\lim_{x \to c^+} f(x)$

2. Infinite Limits:
- $\lim_{x \to c} f(x) = \infty$ indicates that $f(x)$ increases without bound as x approaches c.

3. Limits at Infinity:
- $\lim_{x \to \infty} f(x)$ describes the behavior of $f(x)$ as x grows larger than any finite number.

Properties of Limits

Understanding basic properties of limits can simplify many calculations. Here are some key properties:

1. Sum Rule:
$$
\lim_{x \to c} [f(x) + g(x)] = \lim_{x \to c} f(x) + \lim_{x \to c} g(x)
$$

2. Difference Rule:
$$
\lim_{x \to c} [f(x) - g(x)] = \lim_{x \to c} f(x) - \lim_{x \to c} g(x)
$$

3. Product Rule:
$$
\lim_{x \to c} [f(x) \cdot g(x)] = \lim_{x \to c} f(x) \cdot \lim_{x \to c} g(x)
$$

4. Quotient Rule:
$$
\lim_{x \to c} \frac{f(x)}{g(x)} = \frac{\lim_{x \to c} f(x)}{\lim_{x \to c} g(x)} \quad \text{if } \lim_{x \to c} g(x) \neq 0
$$

5. Constant Multiple Rule:
$$
\lim_{x \to c} [k \cdot f(x)] = k \cdot \lim_{x \to c} f(x) \quad \text{for any constant } k
$$

Types of Limits

Limits can be classified into several types based on their behavior:

Finite Limits

These limits approach a specific finite value as x approaches c. For example,
$$
\lim_{x \to 2} (3x + 1) = 7
$$

Infinite Limits

In some cases, the limit of $f(x)$ approaches infinity:
$$
\lim_{x \to 0} \frac{1}{x} = \infty
$$

Limits at Infinity

These limits describe the behavior of functions as x approaches infinity or negative infinity:

- For example:

$$
\lim_{x \to \infty} \frac{1}{x} = 0
$$

- Another example:

$$
\lim_{x \to \infty} (3x^2 + 2x - 1) = \infty
$$

Techniques for Calculating Limits

Several techniques can be employed to compute limits effectively. Here are some commonly used methods:

1. Direct Substitution

The simplest method to find limits is direct substitution. If $f(c)$ is defined, then:

$$
\lim_{x \to c} f(x) = f(c)
$$

2. Factoring

If direct substitution results in an indeterminate form (like $\frac{0}{0}$), try factoring:

- Example:

$$
\lim_{x \to 3} \frac{x^2 - 9}{x - 3} \quad \text{can be factored as } \frac{(x - 3)(x + 3)}{x - 3} = x + 3
$$

3. Rationalizing

If dealing with square roots, rationalize the expression:

- Example:

\[
\lim_{x \to 0} \frac{\sqrt{x + 1} - 1}{x} \quad \text{can be rationalized to

find the limit.}
\]

4. L'Hôpital's Rule

If you encounter an indeterminate form \(\frac{0}{0} \) or \(\frac{\infty}{\infty} \), you can apply L'Hôpital's Rule:
- Differentiate the numerator and denominator:
\[
\lim_{x \to c} \frac{f(x)}{g(x)} = \lim_{x \to c} \frac{f'(x)}{g'(x)}
\]

Common Limit Forms and Their Results

Familiarizing yourself with common limit forms can expedite calculations. Here are some essential limits to remember:

1. Limit of a Constant:
\[
\lim_{x \to c} k = k
\]

2. Limit of \(x \):
\[
\lim_{x \to c} x = c
\]

3. Limit of \(x^n \) (for any integer \(n \)):
\[
\lim_{x \to c} x^n = c^n
\]

4. Sine and Cosine Limits:
\[
\lim_{x \to 0} \frac{\sin x}{x} = 1
\]
\[
\lim_{x \to 0} \frac{1 - \cos x}{x^2} = \frac{1}{2}
\]

5. Exponential Limit:
\[
\lim_{x \to 0} \frac{e^x - 1}{x} = 1
\]

Conclusion

A calculus limits cheat sheet is an indispensable tool for anyone studying calculus. By summarizing the definitions, properties, types, and techniques for calculating limits, this guide provides a solid foundation for tackling more complex calculus concepts. Mastering limits not only enhances your understanding of calculus but also prepares you for advanced mathematical studies. Keep this cheat sheet handy as a quick reference to solidify your knowledge and improve your problem-solving skills in calculus.

Frequently Asked Questions

What is a calculus limits cheat sheet?

A calculus limits cheat sheet is a condensed reference guide that summarizes key concepts, formulas, and techniques related to limits in calculus, making it easier for students to study and solve problems.

What are the main topics covered in a calculus limits cheat sheet?

Main topics typically include the definition of limits, limit laws, techniques for finding limits (like substitution, factoring, and L'Hôpital's Rule), one-sided limits, and limits at infinity.

How do you use a calculus limits cheat sheet effectively?

To use a calculus limits cheat sheet effectively, familiarize yourself with the key concepts, practice applying the formulas to example problems, and refer to it while studying or doing homework to reinforce your understanding.

What is L'Hôpital's Rule and when is it used?

L'Hôpital's Rule is a method used to evaluate limits that produce an indeterminate form like 0/0 or ∞/∞. It states that the limit of a quotient of functions can be found by taking the limit of their derivatives.

What are one-sided limits and why are they important?

One-sided limits refer to the limits of a function as it approaches a specific point from the left (denoted as 'lim x->c-') or from the right (denoted as 'lim x->c+'). They are important for understanding the behavior of functions at points of discontinuity.

Can a limit exist if the left and right limits do not match?

No, a limit at a point exists only if both the left and right limits are equal. If they do not match, the limit at that point does not exist.

What is the significance of limits at infinity?

Limits at infinity help determine the behavior of a function as the input approaches positive or negative infinity, which is crucial for understanding horizontal asymptotes and end behavior of functions.

What is the squeeze theorem and how is it applied?

The squeeze theorem states that if a function is trapped between two other functions that converge to the same limit at a point, then the squeezed function must also converge to that limit. It's often used for functions that are difficult to evaluate directly.

What are common mistakes to avoid when calculating limits?

Common mistakes include misapplying limit laws, neglecting to check for indeterminate forms, failing to simplify expressions before evaluating limits, and overlooking one-sided limits.

Where can I find reliable calculus limits cheat sheets?

Reliable calculus limits cheat sheets can be found in textbooks, educational websites, online tutoring resources, or by searching for PDF downloads from academic institutions.

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