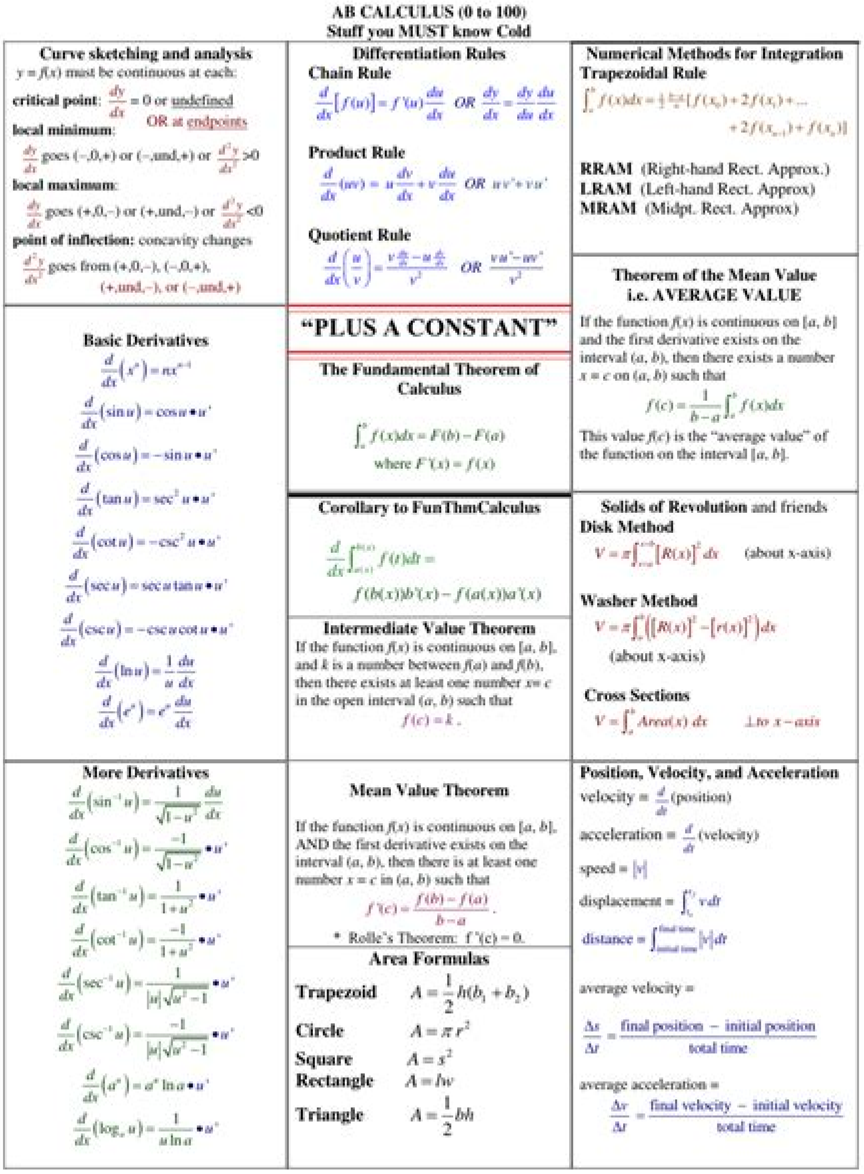
Cheat Sheet Calculus Formulas



AB CALCULUS (0 to 100)
Stuff you MUST know Cold

Curve sketching and analysis
$y = f(x)$ must be continuous at each:
critical point: $\frac{dy}{dx} = 0$ or undefined OR at endpoints
local minimum: $\frac{dy}{dx}$ goes $(-,0,+)$ or $(-,und,+)$ or $\frac{d^2y}{dx^2} > 0$
local maximum: $\frac{dy}{dx}$ goes $(+,0,-)$ or $(+,und,-)$ or $\frac{d^2y}{dx^2} < 0$
point of inflection: concavity changes
$\frac{d^2y}{dx^2}$ goes from $(+,0,-)$, $(-,0,+)$, $(+,und,-)$, or $(-,und,+)$

Differentiation Rules
Chain Rule
$\frac{d}{dx}[f(u)] = f'(u)\frac{du}{dx}$ OR $\frac{dy}{dx} = \frac{dy}{du}\frac{du}{dx}$
Product Rule
$\frac{d}{dx}(uv) = u\frac{dv}{dx} + v\frac{du}{dx}$ OR $uv' + vu'$
Quotient Rule
$\frac{d}{dx}\left(\frac{u}{v}\right) = \frac{v\frac{du}{dx} - u\frac{dv}{dx}}{v^2}$ OR $\frac{vu' - uv'}{v^2}$

Numerical Methods for Integration
Trapezoidal Rule
$\int_a^b f(x)dx = \frac{1}{2}\frac{b-a}{n}[f(x_0) + 2f(x_1) + \ldots + 2f(x_{n-1}) + f(x_n)]$
RRAM (Right-hand Rect. Approx.)
LRAM (Left-hand Rect. Approx)
MRAM (Midpt. Rect. Approx)

Basic Derivatives
$\frac{d}{dx}(x^n) = nx^{n-1}$
$\frac{d}{dx}(\sin u) = \cos u \bullet u'$
$\frac{d}{dx}(\cos u) = -\sin u \bullet u'$
$\frac{d}{dx}(\tan u) = \sec^2 u \bullet u'$
$\frac{d}{dx}(\cot u) = -\csc^2 u \bullet u'$
$\frac{d}{dx}(\sec u) = \sec u \tan u \bullet u'$
$\frac{d}{dx}(\csc u) = -\csc u \cot u \bullet u'$
$\frac{d}{dx}(\ln u) = \frac{1}{u}\frac{du}{dx}$
$\frac{d}{dx}(e^u) = e^u\frac{du}{dx}$

"PLUS A CONSTANT"

The Fundamental Theorem of Calculus
$\int_a^b f(x)dx = F(b) - F(a)$
where $F'(x) = f(x)$

Theorem of the Mean Value i.e. AVERAGE VALUE
If the function $f(x)$ is continuous on $[a, b]$ and the first derivative exists on the interval (a, b), then there exists a number $x = c$ on (a, b) such that
$f(c) = \frac{1}{b-a}\int_a^b f(x)dx$
This value $f(c)$ is the "average value" of the function on the interval $[a, b]$.

Corollary to FunThmCalculus
$\frac{d}{dx}\int_{a(x)}^{b(x)} f(t)dt = f(b(x))b'(x) - f(a(x))a'(x)$

Intermediate Value Theorem
If the function $f(x)$ is continuous on $[a, b]$, and k is a number between $f(a)$ and $f(b)$, then there exists at least one number $x = c$ in the open interval (a, b) such that $f(c) = k$.

Solids of Revolution and friends
Disk Method
$V = \pi\int_{x=a}^{x=b}[R(x)]^2 dx$ (about x-axis)
Washer Method
$V = \pi\int_a^b([R(x)]^2 - [r(x)]^2)dx$ (about x-axis)
Cross Sections
$V = \int_a^b Area(x)\,dx$ $\perp$ to $x-axis$

More Derivatives
$\frac{d}{dx}(\sin^{-1}u) = \frac{1}{\sqrt{1-u^2}}\frac{du}{dx}$
$\frac{d}{dx}(\cos^{-1}u) = \frac{-1}{\sqrt{1-u^2}} \bullet u'$
$\frac{d}{dx}(\tan^{-1}u) = \frac{1}{1+u^2} \bullet u'$
$\frac{d}{dx}(\cot^{-1}u) = \frac{-1}{1+u^2} \bullet u'$
$\frac{d}{dx}(\sec^{-1}u) = \frac{1}{|u|\sqrt{u^2-1}} \bullet u'$
$\frac{d}{dx}(\csc^{-1}u) = \frac{-1}{|u|\sqrt{u^2-1}} \bullet u'$
$\frac{d}{dx}(a^u) = a^u \ln a \bullet u'$
$\frac{d}{dx}(\log_a u) = \frac{1}{u \ln a} \bullet u'$

Mean Value Theorem
If the function $f(x)$ is continuous on $[a, b]$, AND the first derivative exists on the interval (a, b), then there is at least one number $x = c$ in (a, b) such that
$f'(c) = \frac{f(b) - f(a)}{b - a}$.
* Rolle's Theorem: $f'(c) = 0$.

Area Formulas
Trapezoid $A = \frac{1}{2}h(b_1 + b_2)$
Circle $A = \pi r^2$
Square $A = s^2$
Rectangle $A = lw$
Triangle $A = \frac{1}{2}bh$

Position, Velocity, and Acceleration
velocity $= \frac{d}{dt}$(position)
acceleration $= \frac{d}{dt}$(velocity)
speed $= |v|$
displacement $= \int_{t_0}^{t_f} v\,dt$
distance $= \int_{initial\ time}^{final\ time}|v|dt$
average velocity $=$
$\frac{\Delta s}{\Delta t} = \frac{\text{final position} - \text{initial position}}{\text{total time}}$
average acceleration $=$
$\frac{\Delta v}{\Delta t} = \frac{\text{final velocity} - \text{initial velocity}}{\text{total time}}$

Cheat sheet calculus formulas are essential tools for students and professionals alike, providing quick access to fundamental concepts and techniques in calculus. Calculus is the mathematical study of continuous change, and it plays a crucial role in various fields, including physics, engineering, economics, and biology. This article aims to present a comprehensive cheat sheet of calculus formulas that can assist learners in mastering the subject and serve as a handy reference during exams or problem-solving.

Fundamental Concepts in Calculus

Before diving into the formulas, it is essential to understand some fundamental concepts that form the backbone of calculus.

Limits

Limits are foundational to calculus and describe the behavior of functions as they approach a particular point. The notation for limits is as follows:

- $\lim_{x \to c} f(x) = L$ means that as x approaches c, $f(x)$ approaches L.

Key limit properties include:

1. $\lim_{x \to c} [f(x) + g(x)] = \lim_{x \to c} f(x) + \lim_{x \to c} g(x)$
2. $\lim_{x \to c} [f(x) \cdot g(x)] = \lim_{x \to c} f(x) \cdot \lim_{x \to c} g(x)$
3. $\lim_{x \to c} \frac{f(x)}{g(x)} = \frac{\lim_{x \to c} f(x)}{\lim_{x \to c} g(x)}$ (provided $\lim_{x \to c} g(x) \neq 0$)

Derivatives

Derivatives represent the rate of change of a function and are defined as follows:

- The derivative of $f(x)$ is denoted by $f'(x)$ or $\frac{df}{dx}$.

The formal definition of the derivative is:

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

Common derivative rules include:

- Power Rule: $\frac{d}{dx} x^n = nx^{n-1}$
- Product Rule: $\frac{d}{dx} [f(x)g(x)] = f'(x)g(x) + f(x)g'(x)$
- 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: $\frac{d}{dx} f(g(x)) = f'(g(x))g'(x)$

Key Calculus Formulas

This section outlines essential formulas and theorems that are vital for solving calculus problems.

Limits

- Limit of a Constant: $\lim_{x \to c} k = k$
- Limit of Identity: $\lim_{x \to c} x = c$
- Squeeze Theorem: If $f(x) \leq g(x) \leq h(x)$ for all x in some interval around c, and $\lim_{x \to c} f(x) = \lim_{x \to c} h(x) = L$, then $\lim_{x \to c} g(x) = L$.

Derivatives

The following formulas are frequently used in differentiating various functions:

1. Trigonometric Functions:
- $\frac{d}{dx} \sin x = \cos x$
- $\frac{d}{dx} \cos x = -\sin x$
- $\frac{d}{dx} \tan x = \sec^2 x$

2. Exponential and Logarithmic Functions:
- $\frac{d}{dx} e^x = e^x$
- $\frac{d}{dx} \ln x = \frac{1}{x}$

3. Inverse Trigonometric Functions:
- $\frac{d}{dx} \sin^{-1} x = \frac{1}{\sqrt{1 - x^2}}$
- $\frac{d}{dx} \cos^{-1} x = -\frac{1}{\sqrt{1 - x^2}}$
- $\frac{d}{dx} \tan^{-1} x = \frac{1}{1 + x^2}$

Integrals

Integration is the reverse process of differentiation and is used to calculate areas under curves.

1. Indefinite Integrals:
- $\int x^n \, dx = \frac{x^{n+1}}{n+1} + C$ (for $n \neq -1$)
- $\int e^x \, dx = e^x + C$
- $\int \sin x \, dx = -\cos x + C$
- $\int \cos x \, dx = \sin x + C$

2. Definite Integrals:
- Fundamental Theorem of Calculus:
$$
\int_{a}^{b} f(x) \, dx = F(b) - F(a)
$$
where F is any antiderivative of f.

3. Integration Techniques:
- Substitution Method: If $u = g(x)$, then $dx = \frac{du}{g'(x)}$.
- Integration by Parts:
$$
\int u \, dv = uv - \int v \, du
$$

Applications of Calculus

Calculus has numerous applications across various fields. Here are some prominent areas:

Physics

- Motion: Calculus is used to analyze motion through derivatives and integrals, calculating velocity and acceleration.
- Work: The work done by a force can be calculated using integrals of force over distance.

Economics

- Marginal Analysis: Derivatives are used to find marginal cost and marginal revenue, critical for decision-making.
- Consumer and Producer Surplus: Integrals help in calculating areas under demand and supply curves.

Biology

- Population Dynamics: Differential equations modeled using calculus help analyze population growth and decay.
- Enzyme Kinetics: Calculus is used to model reactions and the rates of enzymatic activity.

Tips for Mastering Calculus

1. Practice Regularly: Regular problem-solving helps in reinforcing concepts and formulas.
2. Understand Concepts: Focus on understanding the 'why' behind the formulas rather than rote memorization.
3. Use Visual Aids: Graphical representations can help in understanding how functions behave.
4. Study in Groups: Collaborative learning can provide different perspectives and problem-solving techniques.

Conclusion

A solid understanding of calculus concepts and their applications is vital for anyone pursuing advanced studies in mathematics, science, engineering, or economics. This cheat sheet of calculus formulas serves as a quick reference for key concepts, enabling students to approach problems with confidence. By mastering these formulas and the underlying principles, learners can unlock the vast potential of calculus in both theoretical and real-world applications. Remember, practice is key, and utilizing this cheat sheet will enhance your calculus skills and knowledge over time.

Frequently Asked Questions

What are the most essential calculus formulas to include in a cheat sheet?

Key formulas include the limit definitions, derivative rules (product, quotient, chain rules), integral formulas, the fundamental theorem of calculus, and common derivatives and integrals of trigonometric, exponential, and logarithmic functions.

How can I effectively organize my cheat sheet for calculus formulas?

Organize your cheat sheet by categorizing formulas into sections such as limits, derivatives, integrals, and applications. Use headings, bullet points, and color coding for easy reference during study and exams.

Are there specific calculus formulas that are frequently tested?

Yes, formulas related to differentiation (like the product rule and chain rule), integration techniques (such as substitution and integration by parts), and the derivatives of common functions are often emphasized in exams.

How can I memorize the calculus formulas for my cheat sheet?

Use mnemonic devices, practice problems that require you to apply the formulas, and regularly review the cheat sheet. Creating flashcards for each formula can also aid in memorization.

Is it allowed to use a cheat sheet during calculus exams?

This varies by institution and instructor. Always check the exam guidelines; some may allow a one-page cheat sheet, while others may not permit any additional materials.

What should I do if I forget a key formula during an exam?

Stay calm and try to recall the formula by thinking through related concepts. If you've practiced enough, using context clues from the problem may help you reconstruct the formula.

Can I create my own calculus cheat sheet?

Absolutely! Creating your own cheat sheet can enhance your understanding as you select and organize the formulas that are most relevant to you.

What resources can help me compile an effective calculus cheat sheet?

Textbooks, online calculus resources, lecture notes, and study guides are excellent places to find and compile essential formulas for your cheat sheet.

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