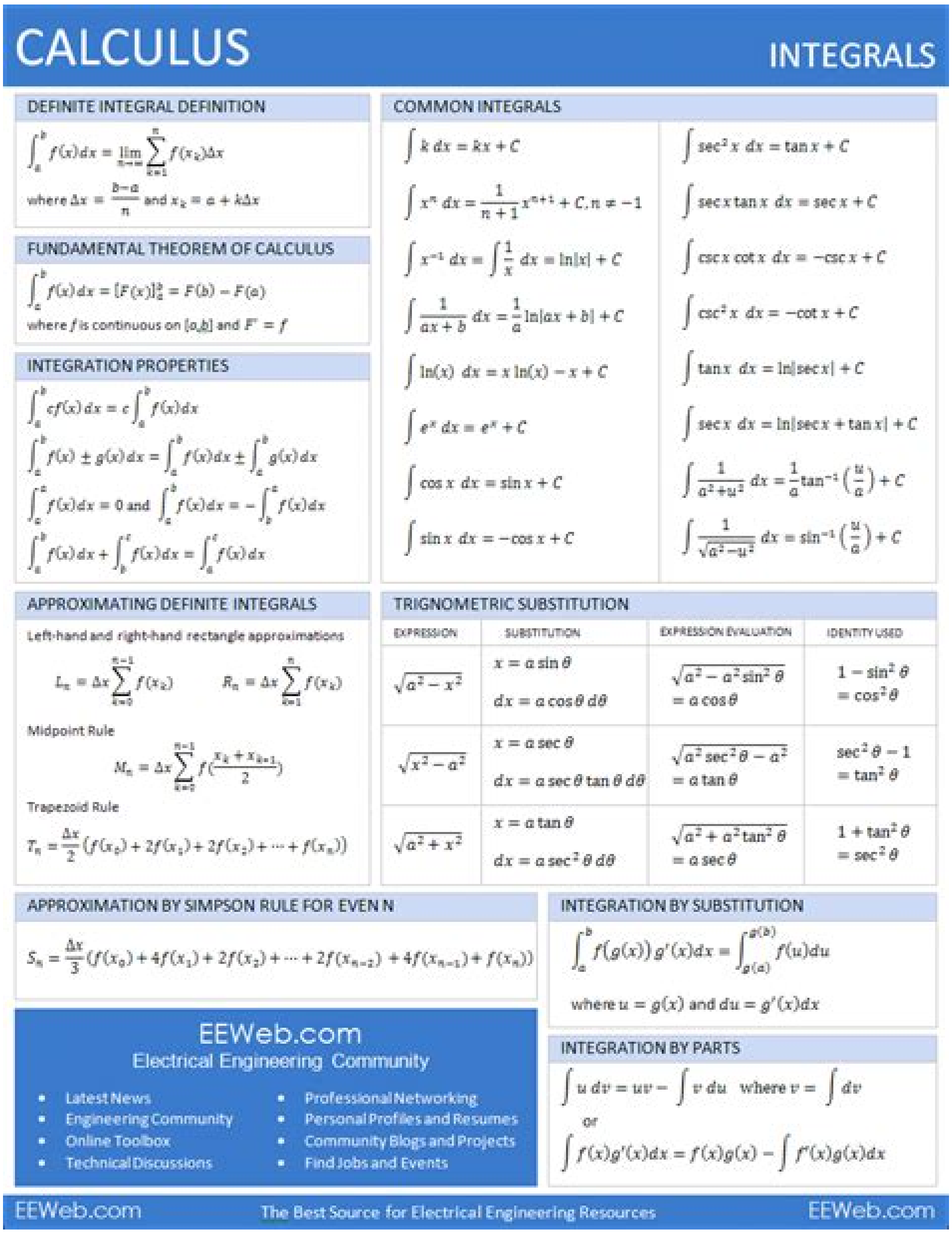
Calculus Integrals Cheat Sheet



CALCULUS INTEGRALS

DEFINITE INTEGRAL DEFINITION

$$\int_a^b f(x)\,dx = \lim_{n\to\infty}\sum_{k=1}^{n} f(x_k)\Delta x$$

where $\Delta x = \frac{b-a}{n}$ and $x_k = a + k\Delta x$

FUNDAMENTAL THEOREM OF CALCULUS

$$\int_a^b f(x)\,dx = [F(x)]_a^b = F(b) - F(a)$$

where f is continuous on $[a,b]$ and $F' = f$

INTEGRATION PROPERTIES

$$\int_a^b cf(x)\,dx = c\int_a^b f(x)\,dx$$

$$\int_a^b f(x) \pm g(x)\,dx = \int_a^b f(x)\,dx \pm \int_a^b g(x)\,dx$$

$$\int_a^a f(x)\,dx = 0 \text{ and } \int_a^b f(x)\,dx = -\int_b^a f(x)\,dx$$

$$\int_a^b f(x)\,dx + \int_b^c f(x)\,dx = \int_a^c f(x)\,dx$$

COMMON INTEGRALS

$$\int k\,dx = kx + C$$

$$\int x^n\,dx = \frac{1}{n+1}x^{n+1} + C, n \neq -1$$

$$\int x^{-1}\,dx = \int \frac{1}{x}\,dx = \ln|x| + C$$

$$\int \frac{1}{ax+b}\,dx = \frac{1}{a}\ln|ax+b| + C$$

$$\int \ln(x)\,dx = x\ln(x) - x + C$$

$$\int e^x\,dx = e^x + C$$

$$\int \cos x\,dx = \sin x + C$$

$$\int \sin x\,dx = -\cos x + C$$

$$\int \sec^2 x\,dx = \tan x + C$$

$$\int \sec x \tan x\,dx = \sec x + C$$

$$\int \csc x \cot x\,dx = -\csc x + C$$

$$\int \csc^2 x\,dx = -\cot x + C$$

$$\int \tan x\,dx = \ln|\sec x| + C$$

$$\int \sec x\,dx = \ln|\sec x + \tan x| + C$$

$$\int \frac{1}{a^2+u^2}\,dx = \frac{1}{a}\tan^{-1}\left(\frac{u}{a}\right) + C$$

$$\int \frac{1}{\sqrt{a^2-u^2}}\,dx = \sin^{-1}\left(\frac{u}{a}\right) + C$$

APPROXIMATING DEFINITE INTEGRALS

Left-hand and right-hand rectangle approximations

$$L_n = \Delta x\sum_{k=0}^{n-1} f(x_k) \qquad R_n = \Delta x\sum_{k=1}^{n} f(x_k)$$

Midpoint Rule

$$M_n = \Delta x\sum_{k=0}^{n-1} f\left(\frac{x_k + x_{k+1}}{2}\right)$$

Trapezoid Rule

$$T_n = \frac{\Delta x}{2}\left(f(x_0) + 2f(x_1) + 2f(x_2) + \cdots + f(x_n)\right)$$

TRIGNOMETRIC SUBSTITUTION

EXPRESSION	SUBSTITUTION	EXPRESSION EVALUATION	IDENTITY USED
$\sqrt{a^2-x^2}$	$x = a\sin\theta$ $dx = a\cos\theta\,d\theta$	$\sqrt{a^2-a^2\sin^2\theta}$ $= a\cos\theta$	$1-\sin^2\theta$ $=\cos^2\theta$
$\sqrt{x^2-a^2}$	$x = a\sec\theta$ $dx = a\sec\theta\tan\theta\,d\theta$	$\sqrt{a^2\sec^2\theta-a^2}$ $= a\tan\theta$	$\sec^2\theta-1$ $=\tan^2\theta$
$\sqrt{a^2+x^2}$	$x = a\tan\theta$ $dx = a\sec^2\theta\,d\theta$	$\sqrt{a^2+a^2\tan^2\theta}$ $= a\sec\theta$	$1+\tan^2\theta$ $=\sec^2\theta$

APPROXIMATION BY SIMPSON RULE FOR EVEN N

$$S_n = \frac{\Delta x}{3}\left(f(x_0) + 4f(x_1) + 2f(x_2) + \cdots + 2f(x_{n-2}) + 4f(x_{n-1}) + f(x_n)\right)$$

INTEGRATION BY SUBSTITUTION

$$\int_a^b f(g(x))\,g'(x)\,dx = \int_{g(a)}^{g(b)} f(u)\,du$$

where $u = g(x)$ and $du = g'(x)\,dx$

INTEGRATION BY PARTS

$$\int u\,dv = uv - \int v\,du \quad \text{where } v = \int dv$$

or

$$\int f(x)g'(x)\,dx = f(x)g(x) - \int f'(x)g(x)\,dx$$

Calculus integrals cheat sheet is an essential resource for students and professionals alike who wish to understand the fundamental principles of calculus and its applications. Integrals are a core concept in calculus, representing the area under curves and the accumulation of quantities. This comprehensive guide will cover various integral types, techniques for solving integrals, and commonly used integral formulas. Whether you're preparing for a calculus exam or brushing up on your skills, this cheat sheet will provide you with the necessary tools to tackle integral problems effectively.

Understanding Integrals

Integrals can be classified into two main categories: definite integrals and indefinite integrals.

1. Indefinite Integrals

Indefinite integrals, also known as antiderivatives, represent a family of functions whose derivative is the original function. The general form of an indefinite integral is:

$$
\int f(x) \, dx = F(x) + C
$$

where $F(x)$ is the antiderivative of $f(x)$, and C is the constant of integration.

2. Definite Integrals

Definite integrals calculate the area under a curve between two specified limits a and b. The general form of a definite integral is:

$$
\int_{a}^{b} f(x) \, dx = F(b) - F(a)
$$

where $F(x)$ is an antiderivative of $f(x)$.

Basic Integral Formulas

Here are some fundamental integral formulas that form the backbone of calculus:

- Power Rule:
  $$
  \int x^n \, dx = \frac{x^{n+1}}{n+1} + C, \quad (n \neq -1)
  $$

- Exponential Function:
  $$
  \int e^x \, dx = e^x + C
  $$

- Trigonometric Functions:
  $$
  \int \sin(x) \, dx = -\cos(x) + C

\]
\[
\int \cos(x) \, dx = \sin(x) + C
\]

- Logarithmic Function:
  \[
  \int \frac{1}{x} \, dx = \ln|x| + C
  \]

Techniques for Solving Integrals

There are several techniques for solving integrals, each suited to specific types of functions. Understanding these methods is crucial for mastering integral calculus.

1. Substitution Method

The substitution method is used when an integral contains a function and its derivative. It involves substituting a part of the integral with a new variable.

Steps:
- Choose a substitution \(u = g(x) \).
- Compute \(du = g'(x) \, dx \).
- Rewrite the integral in terms of \(u \).
- Integrate and substitute back to the original variable.

2. Integration by Parts

Integration by parts is based on the product rule of differentiation and is useful when integrating the product of two functions. The formula is:

\[
\int u \, dv = uv - \int v \, du
\]

Steps:
- Choose \(u \) and \(dv \).
- Differentiate \(u \) to find \(du \).
- Integrate \(dv \) to find \(v \).
- Substitute into the formula.

3. Partial Fraction Decomposition

This technique is used to integrate rational functions by breaking them down into simpler fractions.

Steps:
- Factor the denominator into linear or irreducible quadratic factors.
- Set up an equation with unknown coefficients.
- Solve for the coefficients and rewrite the integral.
- Integrate each term separately.

4. Trigonometric Substitution

Trigonometric substitution is useful for integrals involving square roots. By substituting a trigonometric function, you can simplify the integral.

Common Substitutions:
- For $\sqrt{a^2 - x^2}$, use $x = a \sin(\theta)$.
- For $\sqrt{a^2 + x^2}$, use $x = a \tan(\theta)$.
- For $\sqrt{x^2 - a^2}$, use $x = a \sec(\theta)$.

Common Integral Results

Below is a list of common integrals that you may encounter frequently:

- $\int \sin^2(x) \, dx = \frac{x}{2} - \frac{\sin(2x)}{4} + C$
- $\int \cos^2(x) \, dx = \frac{x}{2} + \frac{\sin(2x)}{4} + C$
- $\int e^{ax} \, dx = \frac{1}{a} e^{ax} + C$
- $\int \sec^2(x) \, dx = \tan(x) + C$
- $\int \csc^2(x) \, dx = -\cot(x) + C$

Practice Problems

To solidify your understanding of integrals, try solving the following practice problems:

1. Evaluate $\int (3x^2 - 2x + 1) \, dx$.
2. Find the area under the curve $y = x^3$ from $x = 1$ to $x = 3$.
3. Calculate $\int \frac{1}{x^2 + 1} \, dx$.
4. Use substitution to evaluate $\int (2x)(x^2 + 1)^3 \, dx$.

Conclusion

A **calculus integrals cheat sheet** is an invaluable tool for anyone studying calculus. By understanding the basic concepts, formulas, and techniques, you can simplify the process of solving integral problems. Regular practice with a variety of problems will further enhance your skills and confidence in tackling integrals. Whether you're a student or a professional, mastering integrals will deepen your understanding of calculus and its applications in various fields, including physics, engineering, and economics. Keep this cheat sheet handy for quick reference as you continue your journey through the world of calculus.

Frequently Asked Questions

What are the key formulas included in a calculus integrals cheat sheet?

A calculus integrals cheat sheet typically includes formulas for basic integral rules, integration by substitution, integration by parts, and common integral results for functions such as polynomials, trigonometric functions, exponential functions, and logarithmic functions.

How can I effectively use a calculus integrals cheat sheet while studying?

To effectively use a calculus integrals cheat sheet, familiarize yourself with the layout and key formulas. Practice identifying which formula to apply in various problems, and use the cheat sheet as a quick reference during practice problems or exams to reinforce your understanding.

Are there any online resources to find or create a calculus integrals cheat sheet?

Yes, there are several online resources such as educational websites, forums, and document-sharing platforms where you can find pre-made calculus integrals cheat sheets. Additionally, tools like LaTeX can help you create your own customized cheat sheet.

What common mistakes should I avoid when using a calculus integrals cheat sheet?

Common mistakes include misapplying integral formulas, neglecting to check the limits of integration, and overlooking the need for substitution in more complex integrals. Always verify the conditions under which each formula applies.

Can a calculus integrals cheat sheet help with understanding integral concepts?

While a cheat sheet is primarily a reference tool, it can aid in understanding integral concepts by providing clear examples and summaries of the fundamental theorems and techniques. However, it's important to complement it with in-depth study and practice.

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