FORMULA REFERENCE

# Calculus Formulas

Find the rule that matches the expression, then read its conditions before using it.

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## Derivative rules

Differentiate basic functions, sums, products, quotients, and compositions.

### Constant rule

$$\frac{d}{dx}c = 0$$

**Text version:** The derivative with respect to x of a constant c equals zero.

**When to use:** Use this rule for a term that does not change as x changes.

**Conditions**

- c is constant with respect to x.

### Power rule

$$\frac{d}{dx}x^n = nx^{n-1}$$

**Text version:** The derivative with respect to x of x to the n equals n times x to the n minus one.

**When to use:** Use this rule to differentiate a power of the variable.

**Conditions**

- n is constant with respect to x.
- Work at points where the real-valued power is defined and differentiable.

### Sum rule

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

**Text version:** The derivative of f of x plus g of x equals f prime of x plus g prime of x.

**When to use:** Use this rule to differentiate a sum term by term.

**Conditions**

- f and g are differentiable at the point being evaluated.

## Product rule

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

**Text version:** The derivative of f of x times g of x equals f prime of x times g of x plus f of x times g prime of x.

**When to use:** Use this rule when two differentiable functions are multiplied.

**Conditions**

- f and g are differentiable at the point being evaluated.

## Quotient rule

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

**Text version:** The derivative of f of x divided by g of x equals f prime times g minus f times g prime, all divided by g squared.

**When to use:** Use this rule when one differentiable function is divided by another.

**Conditions**

- f and g are differentiable at the point being evaluated.
- g of x is not zero at that point.

## Chain rule

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

**Text version:** The derivative of f composed with g equals f prime evaluated at g of x, multiplied by g prime of x.

**When to use:** Use this rule when one differentiable function is composed inside another.

**Conditions**

- g is differentiable at x.
- f is differentiable at g of x.

## Natural exponential derivative

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

**Text version:** The derivative with respect to x of e to the x equals e to the x.

**When to use:** Use this rule for the natural exponential function; combine it with the chain rule when the exponent is not x.

**Conditions**

- x is real for the real-valued form shown.

### Natural logarithm derivative

$$\frac{d}{dx}\ln x = \frac{1}{x}$$

**Text version:** The derivative with respect to x of the natural logarithm of x equals one divided by x.

**When to use:** Use this rule to differentiate the natural logarithm on its real domain.

**Conditions**

- x is greater than zero.

### Sine derivative

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

**Text version:** The derivative with respect to x of sine x equals cosine x.

**When to use:** Use this rule to differentiate sine; combine it with the chain rule for sine of another function.

**Conditions**

- Angles are measured in radians.

## Integral rules

Recognize common antiderivatives and evaluate definite integrals.

### Power antiderivative

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

**Text version:** The indefinite integral of x to the n with respect to x equals x to the n plus one divided by n plus one, plus a constant C.

**When to use:** Use this rule to integrate a power of x other than x to the negative one.

**Conditions**

- n is constant with respect to x.
- n is not negative one.
- Use an interval where the real-valued power is defined.

### Natural exponential antiderivative

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

**Text version:** The indefinite integral of e to the x with respect to x equals e to the x plus a constant C.

**When to use:** Use this rule to integrate the natural exponential function.

**Conditions**

- C is an arbitrary constant of integration.

## Reciprocal antiderivative

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

**Text version:** The indefinite integral of one divided by x with respect to x equals the natural logarithm of the absolute value of x plus a constant C.

**When to use:** Use this rule for the reciprocal function on an interval that does not cross zero.

**Conditions**

- x is not zero.
- Choose an interval entirely on one side of zero.
- C is an arbitrary constant of integration.

## Integration by parts

$$\int u\,dv = uv - \int v\,du$$

**Text version:** The integral of u times d v equals u times v minus the integral of v times d u.

**When to use:** Use this identity when differentiating one factor simplifies it and the other factor can be integrated.

**Conditions**

- u and v are differentiable on the interval of interest.
- The displayed integrals exist on that interval.

## Definite integral evaluation

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

**Text version:** The definite integral from a to b of f of x equals F of b minus F of a, where F prime equals f.

**When to use:** Use this result to evaluate a definite integral from a verified antiderivative.

**Conditions**

- f is continuous on the closed interval from a to b.
- F is an antiderivative of f on that interval.

# Limit rules

Combine known limits and use the standard sine limit with the correct conditions.

## Limit sum law

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

**Text version:** The limit as x approaches a of f of x plus g of x equals L plus M.

**When to use:** Use this law to split the limit of a sum when both component limits exist.

**Conditions**

- The limit of f of x as x approaches a equals L.
- The limit of g of x as x approaches a equals M.
- L and M are finite real numbers for the form shown.

## Limit product law

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

**Text version:** The limit as x approaches a of f of x times g of x equals L times M.

**When to use:** Use this law to multiply two component limits that both exist.

**Conditions**

- The limit of f of x as x approaches a equals L.
- The limit of g of x as x approaches a equals M.
- L and M are finite real numbers for the form shown.

## Limit quotient law

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

**Text version:** The limit as x approaches a of f of x divided by g of x equals L divided by M.

**When to use:** Use this law to divide two component limits when the denominator limit is nonzero.

**Conditions**

- The limit of f of x as x approaches a equals L.
- The limit of g of x as x approaches a equals M.
- M is not zero.

## Standard sine limit

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

**Text version:** The limit as x approaches zero of sine x divided by x equals one.

**When to use:** Use this standard limit when a trigonometric expression reduces to sine of a small angle divided by that angle.

**Conditions**

- Angles are measured in radians.
- The limit is two-sided over the real numbers.