

# Complex Equations Showcase for TeXSync Website

Developed with L<sup>A</sup>T<sub>E</sub>X by TeXSync

April 30, 2025

## Contents

# 1 Introduction

Welcome to **TeXSync**, the online L<sup>A</sup>T<sub>E</sub>X editor. Here we showcase the capability to render highly complex mathematical structures.

## 2 Calculus

### 2.1 Complex Differentiation

Let  $f(z) = u(x, y) + iv(x, y)$ , then the complex derivative is:

$$f'(z) = \lim_{\Delta z \rightarrow 0} \frac{f(z + \Delta z) - f(z)}{\Delta z}$$

The Cauchy-Riemann equations are:

$$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}, \quad \frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x}$$

### 2.2 Multivariable Integration

The volume under a surface  $z = f(x, y)$  is:

$$V = \iint_D f(x, y) \, dx \, dy$$

Where  $D$  is the domain of integration.

### 2.3 Line Integrals

For a vector field  $\vec{F}$ , the line integral along curve  $C$  is:

$$\oint_C \vec{F} \cdot d\vec{r} = \oint_C (F_x \, dx + F_y \, dy + F_z \, dz)$$

## 3 Series and Summations

The infinite geometric series:

$$\sum_{n=0}^{\infty} ar^n = \frac{a}{1-r}, \quad \text{for } |r| < 1$$

The Taylor series expansion for  $e^x$  is:

$$e^x = \sum_{n=0}^{\infty} \frac{x^n}{n!}$$

## 4 Linear Algebra and Matrices

A system of linear equations:

$$\begin{aligned} 2x + 3y - z &= 7 \\ 4x - y + 5z &= 3 \\ -6x + 2y + 3z &= 8 \end{aligned}$$

In matrix form:

$$\begin{bmatrix} 2 & 3 & -1 \\ 4 & -1 & 5 \\ -6 & 2 & 3 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 7 \\ 3 \\ 8 \end{bmatrix}$$

## 5 Tensor Calculus (Advanced)

The Riemann curvature tensor:

$$R^\rho_{\sigma\mu\nu} = \partial_\mu \Gamma^\rho_{\nu\sigma} - \partial_\nu \Gamma^\rho_{\mu\sigma} + \Gamma^\rho_{\mu\lambda} \Gamma^\lambda_{\nu\sigma} - \Gamma^\rho_{\nu\lambda} \Gamma^\lambda_{\mu\sigma}$$

Einstein field equations:

$$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

## 6 Physics: Quantum Mechanics

The time-dependent Schrödinger equation:

$$i\hbar \frac{\partial}{\partial t} \Psi(\mathbf{r}, t) = \left( -\frac{\hbar^2}{2m} \nabla^2 + V(\mathbf{r}, t) \right) \Psi(\mathbf{r}, t)$$

numerator<sub>denominator</sub>

## 7 Graphics: TikZ Example

