LaTeX Tutorial

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What is LaTeX?

- Professional typesetting system for academic documents
- Superior math typesetting capabilities
- Code-based workflow with PDF output
- Used in arXiv submissions, academic papers, and textbooks
- Pronunciation: /ltk/ (LAH-tek) or /letk/ (LAY-tek)

Word vs. LaTeX Comparison

Microsoft Word	LaTeX
WYSIWYG interface	Code-based workflow
Real-time collaboration	Requires Overleaf for collaboration
Basic math support	Professional math typesetting
Limited customization	Extensive package ecosystem
Automatic figure placement	Precise float control

Key advantages of LaTeX:

- Required for complex mathematics
- Standard in academic publishing
- Produces publication-quality output

New Challenger: Typst

Now we get a new challenger typst. It has easier syntax and "understandable error messages" compared with LaTeX. While its community is still at the beginning stage and it hasn't been generally accepted. You might could pay attention to it.

Online Setup with Overleaf

1. Visit `https://www.overleaf.com`
2. Create new project $\rightarrow$ Example Project
3. Core components:
   - `.tex` file: Main document
   - `.bib` file: Bibliography
   - Packages: `amsmath`, `graphicx`, etc.

Recommended Local Workflow(for advanced users)

VS Code (IDE) + LaTeX Workshop (Plugin)+ MikTeX (core LaTeX distribute)

Basic Document Structure

```
\documentclass{article}
\usepackage{amsmath}
\begin{document}
\section{Introduction}
Hello LaTeX! Euler's formula:
\begin{equation}
    e^{i\pi} + 1 = 0
\end{equation}
\end{document}
```

Tables and Figures

Table example:

```
\begin{tabular}{|c|c|}
\hline                        1
A & B \\ \hline
1 & 2 \\ \hline              2
\end{tabular}
```

Figure example:

```
\includegraphics[width=0.8\
    textwidth]
{figures/diagram.pdf}
```

Tip

Use `tablesgenerator.com` for table creation

Reference

Create a .bib file in the folder. Add the bibtex infromation into the file

```
1  \bibliographystyle{
       plain}
2  \bibliography{
       references}
```

Tip

To generate the pdf file correctly, we technically need some to compile multiple times with different compilers. This is done by Overleaf

Essential Math Commands

- Fractions: `\frac{a}{b}`
- Summation:
  `\sum_{n=1}^{\infty}` *Matrices* :
  `\begin{bmatrix}`
- Operators: `\int, \partial`

Example equation:

$$\nabla \times \mathbf{B} = \mu_0 \left(\mathbf{J} + \epsilon_0 \frac{\partial \mathbf{E}}{\partial t} \right)$$

Basic Math Environments

```
Inline math: $E=mc^2$

Numbered equation:
\begin{equation}
\hat{H}\psi = E\psi
\end{equation}

Aligned equations:
\begin{align}
\nabla \cdot \mathbf{E} &=
    \frac{\rho}{\epsilon_0}
    \\
\nabla \times \mathbf{E} &=
    -\frac{\partial \
    mathbf{B}}{\partial t}
\end{align}
```

Inline math: $E = mc^2$
Numbered equation:

$$\hat{H}\psi = E\psi \qquad (1)$$

Aligned equations:

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\epsilon_0} \qquad (2)$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \qquad (3)$$

Matrices and Brackets

```
\[
\begin{pmatrix}
a & b \\
c & d
\end{pmatrix}
\]

\[
\left\langle \psi \
   middle| \phi \
   right\rangle
\]

\[
\left\{\frac{x^2}{2}\
   right\}
\]
```

$$\begin{pmatrix} a & b \\ c & d \end{pmatrix}$$

$$\langle \psi | \phi \rangle$$

$$\left\{ \frac{x^2}{2} \right\}$$

- pmatrix: Parentheses
- bmatrix: Square brackets
- vmatrix: Vertical bars

Common Mathematical Symbols

Symbol	LaTeX	Example	Output
Integral	\int	\int_a^b	$\int_a^b$
Partial	\partial	\partial t	∂t
Nabla	\nabla	\nabla f	∇f
Product	\prod	\prod_{n=1}^5	$\prod_{n=1}^5$
Union	\cup	A \cup B	$A \cup B$
Approx	\approx	x \approx y	$x \approx y$

```
% Greek letters
\alpha , \beta , \Gamma , \Delta        $\alpha , \beta , \
    Gamma , \Delta $

% Quantum notation
\langle \psi | \phi \rangle       $\langle \psi | \phi \
    rangle $
```

Mathematical Accents

$\dot{x}, \ddot{x} \quad \hat{p}, \tilde{\psi}$

$$\vec{F} = m\vec{a}$$

$$\bar{z} = x + iy$$

$$\underline{\text{Important}}$$

$$\overbrace{a + b + c}^{\text{total}}$$

```
$\dot{x}$, $\ddot{x}$
$\hat{p}$, $\tilde{\psi}$
$\vec{F}$, $\overline{z}$
$\underline{\text{Important
   }}$
$\overbrace{a+b+c}^{\text{
   total}}$
```

Tip

Use \left and \right for automatic sizing:

```
\left( \frac{1}{x} \right)^2          $\left( \frac{1}{x} \
   right)^2$
```

Physics Examples

```
% Schr dinger equation
i\hbar\frac{\partial}{\
    partial t}
\psi = \hat{H}\psi

% Maxwell's equations
\nabla \cdot \mathbf{E} =
\frac{\rho}{\epsilon_0}

% Commutator
[\hat{x}, \hat{p}] = i\hbar
```

Schrödinger equation:
$$i\hbar\frac{\partial}{\partial t}\psi = \hat{H}\psi$$

Maxwell's equations:
$$\nabla \cdot \mathbf{E} = \frac{\rho}{\epsilon_0}$$

Commutator:
$$[\hat{x}, \hat{p}] = i\hbar$$

Physics Package

Use `physics` package for:

```
\dv{x}{t}, \pdv[2]{U}{x}, \bra{\psi}, \ket{\phi}
```

Advanced Formatting

- Formatting: `geometry`, `graphicx`, `xcolor`
- Mathematics: `amsmath`, `amssymb`
- Citations and hyperlinks: `biblatex`, `hyperref`
- Advanced use cases: Beamer, etc.

Alignment Example

$$F = ma$$

$$KE = \frac{1}{2}mv^2$$

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\epsilon_0}$$

Physics Package Examples

\dv{x}{t}, \vb{p}, \braket{\phi|\psi}

Learning Materials

- Official documentation: `https://ctan.org`
- Community support: `https://tex.stackexchange.com`
- Chinese resources: zhihu LaTeX
- Templates: Overleaf Template Gallery
- Books: "The LaTeX Companion"

Happy LaTeX-ing!