LaTeX Tutorial

A beginner's guide

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Focus: Creating Perfect Mathematical Notation

Outline

The Problem with Word Processors

Microsoft Word:

- Click-heavy equation editors
- Inconsistent formatting
- Poor spacing in complex formulas
- Difficult alignment
- Version control nightmares

LaTeX Solution:

- Write once, render perfectly
- Professional spacing automatically
- Perfect alignment control
- Industry standard for research
- Version control friendly

Quick Overleaf Setup

Let's get started in 3 steps:

1. **Go to:** `www.overleaf.com`
2. **Register** with university email or your gmail
3. **Create Project** $\rightarrow$ "Math Practice"

Two Types of Math Mode

1. Inline Math: $...$

For formulas within sentences: $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$.

```
$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$.
```

2. Display Math:

For important, centered equations:

```
\begin{equation}
    x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}
\end{equation}
```

Output:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Hands-On Practice 1: Basic Operations

Type these in your Overleaf project:

Code

```
$E = mc^2$              % Superscripts

$a_{n+1} = a_n + d$     % Subscripts

$\frac{a}{b}$           % Fractions

$\sqrt{x + y}$          % Square roots

$\sum_{i=1}^{n} i^2$ % Summation
```

Output

$E = mc^2$

$a_{n+1} = a_n + d$

$\frac{a}{b}$

$\sqrt{x + y}$

$\sum_{i=1}^{n} i^2$

Remember: Curly braces {} group elements together!

Greek Letters and Common Symbols

Lowercase Greek	Uppercase Greek	Mathematical Symbols
`\alpha, \beta, \gamma` α, β, γ	`\Gamma, \Delta, \Theta` Γ, Δ, Θ	`\times, \div, \pm` $\times, \div, \pm$
`\delta, \epsilon, \zeta` δ, ϵ, ζ	`\Pi, \Sigma, \Omega` Π, Σ, Ω	`\leq, \geq, \neq` $\leq, \geq, \neq$
`\pi, \sigma, \omega` π, σ, ω	`\Lambda, \Xi, \Phi` Λ, Ξ, Φ	`\infty, \partial, \nabla` ∞, ∂, ∇

Example

`$\alpha \times \beta \leq \Gamma \pm \infty$`
Output: $\alpha \times \beta \leq \Gamma \pm \infty$

Aligned Equations with `align` Environment

Code

```
\begin{align}
  (a + b)^2 &= a^2 + 2ab + b^2 \\
  (a - b)^2 &= a^2 - 2ab + b^2 \\
  (a + b)(a - b) &= a^2 - b^2
\end{align}
```

Output

$$(a+b)^2 = a^2 + 2ab + b^2 \tag{1}$$
$$(a-b)^2 = a^2 - 2ab + b^2 \tag{2}$$
$$(a+b)(a-b) = a^2 - b^2 \tag{3}$$

The & aligns at the equals sign! Each line is automatically numbered.

Matrices

Different Matrix Types

```
\begin{matrix} a & b \\ c & d
\end{matrix}
\quad
\begin{pmatrix} a & b \\ c & d
\end{pmatrix}
\quad
\begin{bmatrix} a & b \\ c & d
\end{bmatrix}
\quad
\begin{vmatrix} a & b \\ c & d
\end{vmatrix}
```

& separates columns, \\ starts new row.

Output

$$\begin{matrix} a & b \\ c & d \end{matrix} \quad \begin{pmatrix} a & b \\ c & d \end{pmatrix} \quad \begin{bmatrix} a & b \\ c & d \end{bmatrix} \quad \begin{vmatrix} a & b \\ c & d \end{vmatrix}$$

Piecewise Functions

Using cases Environment

```
\begin{block}{Output}
    \[
    f(x) =
    \begin{cases}
      x^2 & \text{if } x \geq 0 \\
      -x & \text{if } x < 0
    \end{cases}
    \]
\end{block}
```

Output

$$f(x) = \begin{cases} x^2 & \text{if } x \geq 0 \\ -x & \text{if } x < 0 \end{cases}$$

Additional: table

Code

```
\begin{table}[]
    \centering
    \begin{tabular}{c|c|c}
John & Alice & Wells \\
67   & 82    & 78    \\
80   & 83    & 52    \\
\end{tabular}
\end{table}
```

Output

John	Alice	Wells
67	82	78
80	83	52

Additional: figures

Code

```
\begin{figure}
    \centering
    \includegraphics[width=0.5\linewidth]{Screenshot 2025-10-28 at 10.25.49 AM.png}
    \caption{Robot}
    \label{fig:placeholder}
\end{figure}
```

Output

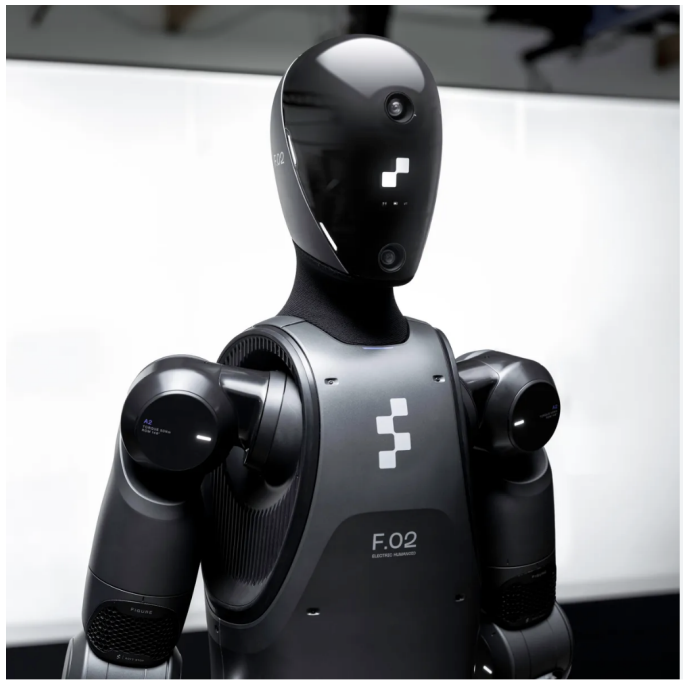

Figure: Robot

Hands-on Lab 1: create an optimization model in LaTeX

Problem Data

Item	Weight (kg)	Value ($)
1	2	10
2	5	15
3	8	25
4	3	12
5	6	20

Capacity: 15 kg

Objective

Select items to maximize total value without exceeding weight capacity

Hands-on Lab 1: create an optimization model in LaTeX

Decision Variable

$$x_i = \begin{cases} 1 & \text{if item } i \text{ is selected} \\ 0 & \text{otherwise} \end{cases} \qquad \forall i = \{1, \ldots, 5\}$$

Optimization Model

$$\begin{aligned} \max \quad & 10x_1 + 15x_2 + 25x_3 + 12x_4 + 20x_5 \\ s.t. \quad & 2x_1 + 5x_2 + 8x_3 + 3x_4 + 6x_5 \leq 15 \\ & x_i \in \{0, 1\} \quad \forall i \in \{1, ..., 5\} \end{aligned}$$

Hands-on Lab 2: COPT code for a simple Knapsack Problem

Parameter? w = [w1,w2,w3,w4]

Decision Variables? - model.addVars(n,vtype="",name="")

Constraints? - model.addConstrs()

Objective? - model.setObjective(obj, COPT.MAXIMIZE)

Result visualization? - model.status - model.ObjVal -Var.x

Essential Resources

Top Tools for LaTeX Math

1. **All mathematic symbols**
   `https://www.cmor-faculty.rice.edu/~heinken/latex/symbols.pdf`
   Get whatever symbols you want!
2. **Overleaf Math Guide**
   `https://overleaf.com/learn/latex/Mathematics`
3. **Comprehensive Symbol List**
   `https://artofproblemsolving.com/wiki/index.php/LaTeX:Symbols`
4. **LaTeX for slides generations**
   `https://legaled.ai/use-ai-to-generate-beautiful-pdf-presenta`
5. **Beautiful LaTeX tables**
   `https://tex.stackexchange.com/questions/112343/beautiful-tab`

Thank You!

Congratulations!
You can now create your own professional mathematical documents.

Slides created with LaTeX Beamer