Introduction to LaTeX

Week 01: Getting Started

2026-10-15

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1. What LaTeX Is
2. A Short History of LaTeX
3. Getting a LaTeX System
4. Your First Document
5. Engines, Formats, Distributions

What Is LaTeX?

LaTeX is a document preparation system.
You write plain text with markup, and a program typesets it.

What you write: paper.tex

```
\section{Results}
Let $f$ be continuous on $[0,1]$.
Then
\begin{equation}
  \int_0^1 f(x) \, \textup{d}x
  =
  f(\xi)
\end{equation}
for some $\xi \in [0,1]$.
```

pdflatex →

What you get: paper.pdf

1 Results

Let f be continuous on $[0,1]$. Then

$$\int_0^1 f(x)\,\mathrm{d}x = f(\xi) \tag{1}$$

for some $\xi \in [0,1]$.

Visual Design vs. Logical Design

WYSIWYG: Word, LibreOffice, Google Docs

- you format what you see, piece by piece
- quick to start, fine for short, one-off documents with little structure
- WYSIAYG: "What you see is all you've got." (attributed to Brian Reid and/or Brian Kernighan)

Markup: LaTeX, Markdown, HTML

- you say what each piece is: a section, an emphasis, a citation, an equation
- the document class decides how it looks
- one change restyles the whole document

Lamport's example, adapted: an inner product

```
\newcommand{\ip}[2]{\langle #1, #2 \rangle}  % or: (#1 \mid #2)
... where \ip{A}{B} ... and therefore \ip{x}{y} ...
```

Change the one definition, and every inner product in the paper follows.

Lamport, *LaTeX: A Document Preparation System*, 1994, pp. 7–8

Why LaTeX, and When Not

Pros of Using LaTeX

- the lingua franca of mathematics, CS, physics and other disciplines: journals, arXiv, theses, presentations
- long, structured documents: numbering, cross-references, bibliography, table of contents, all automatic
- line breaking that optimizes entire paragraphs at once (Knuth–Plass)
- plain text source, favorable for git, diffs, any editor, still readable in decades
- free, runs everywhere

Knuth, Plass, "Breaking Paragraphs into Lines", 1981

When Other Tools May Fit Better

- short, one-off documents with little structure
- documents whose layout is the content: flyers, forms
- content meant primarily for the web
- when an accessible (tagged) PDF is required, e. g., for text-to-speech or Braille output: support is still being built

Alternatives to LaTeX worth knowing:

- Markdown
- Typst

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Donald Knuth and TEX



Donald Knuth, 2005

Photo: Jacob Appelbaum, CC BY-SA 2.5, via Wikimedia Commons

- Born 1938; Stanford professor of computer science since 1968; Turing Award 1974.
- 1977: he finds the phototypeset proofs of *The Art of Computer Programming*, Vol. 2 (Knuth, 1981) unacceptable.
- He writes a typesetting system, TEX /tɛx/, first in SAIL (1978), and METAFONT for its fonts (Computer Modern).
- TEX is a Turing-complete programming language: there is even a BASIC interpreter written in it (Greene, 1990).
- Rewritten as TEX82 in WEB (Pascal with documentation); published in full in *Computers & Typesetting* (Knuth, 1986).
- Frozen since 1990: bug fixes only, the version number converges to π (today 3.141592653).
- The name: Greek $\tau\acute{\epsilon}\chi\nu\eta$ /'texni/ (art, craft); the X is a χ.

Leslie Lamport and LaTeX



Leslie Lamport (right), Heidelberg Laureate Forum, September 2026

Photo: Roland Herzog

- Early 1980s: Lamport writes macros on top of TeX, released as LaTeX 2.09 in 1985 with his book (Lamport, 1985).
- In Lamport's image, TeX provides the lumber and nails, and LaTeX is a house built with them.
- "LaTeX is your typographic designer, and TeX is its typesetter."
  This is why you write `\section`, not `\Large\bfseries`.
- Turing Award 2013 for distributed systems.

Lamport, *LaTeX: A Document Preparation System*, 1994, pp. 5–6

How to Say It

	Intended	Often heard in English	Often heard in German
TEX	/tɛx/ (Knuth), with "ch" as in Scottish "loch"	/tɛk/	/tɛɕ/, with "ch" as in "ich"
LATEX	Lamport declines to rule	/ˈleɪtɛk/, /ˈlaːtɛk/	/ˈlaːtɛɕ/
LATEX	The LATEX Project says /ˈlaːtɛx/ or /ˈleɪtɛx/		

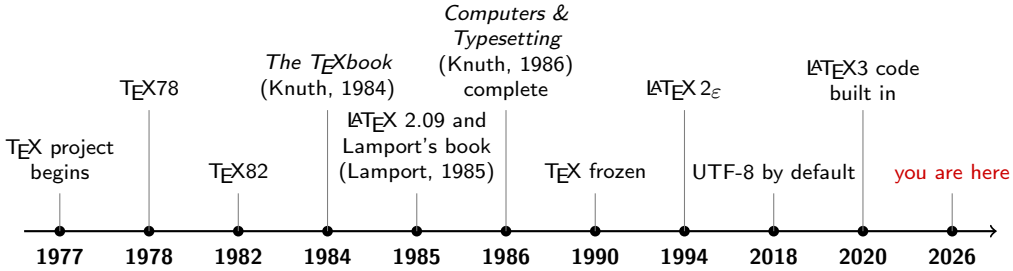
Knuth, *The TEXbook*, 1984, p. 1; Lamport, 1994, p. 5; The LATEX Project, 2026b

LaTeX 2ε and Today

- By the early 1990s, incompatible local extensions of LaTeX 2.09 threatened "a Tower of Babel".
- 1994: LaTeX 2ε, by the LaTeX Project team led by Frank Mittelbach. It brings `\documentclass`, `\usepackage`, graphics and color: the structure you will use from today on.
- "2ε" was meant as a stopgap until LaTeX3, a planned complete rewrite. The LaTeX Project later dropped the idea of a separate LaTeX3 and instead modernizes LaTeX 2ε step by step.
- Since 2020, LaTeX includes the LaTeX3 programming language (`expl3`), in which more and more packages are written, and more flexible ways to define your own commands.
- LaTeX 2ε is actively maintained: new releases about twice a year, UTF-8 input by default since 2018, and work in progress on tagged, accessible PDF.

Lamport, *LaTeX: A Document Preparation System*, 1994, pp. xv, 2; The LaTeX Project, 2026a

Timeline


TEX project begins
1977
TEX78
1978
TEX82
1982
The TEXbook (Knuth, 1984)
1984
LATEX 2.09 and Lamport's book (Lamport, 1985)
1985
Computers & Typesetting (Knuth, 1986) complete
1986
TEX frozen
1990
LATEX 2ε
1994
UTF-8 by default
2018
LATEX3 code built in
2020
you are here
2026

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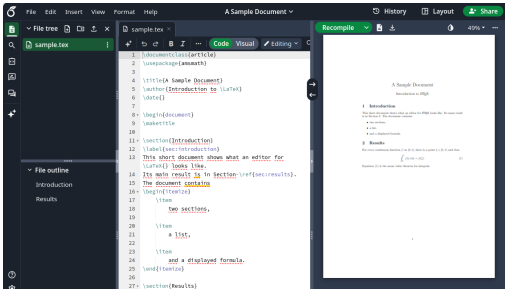
Overleaf: LaTeX in the Browser



Runs on: any operating system with a current web browser, including tablets.

Pros

- nothing to install or update
- provides multiple LaTeX versions
- forward and reverse search
- completion for commands, citations, labels
- invite a collaborator to edit with you

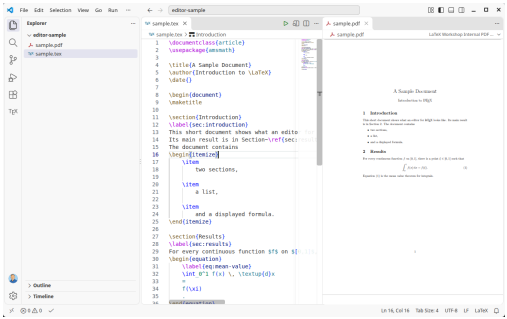
Cons

- needs an internet connection throughout
- free plan: one collaborator per project, short compile timeout, 24 h of history, no git or track changes

Overleaf: Getting Started

1. Create a free account at `https://www.overleaf.com`.
2. Start a new project, e. g., blank, from a template, or a `.zip` file.
3. Click Recompile.
4. To work in pairs: Share the project with your partner by e-mail.

VS Code with LaTeX Workshop



Runs on: Linux, Windows, macOS.

Pros

- familiar if you already program in VS Code
- builds on save, PDF preview in a tab
- forward and reverse search
- completion for commands, citations, labels

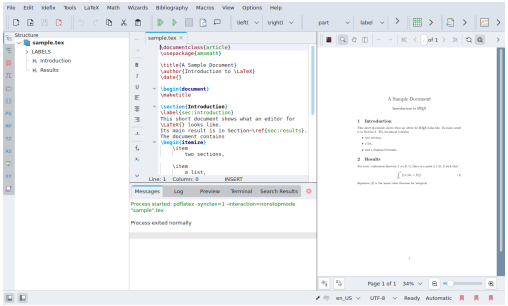
Cons

- LaTeX only via an extension
- heavier than a dedicated LaTeX IDE

VS Code with LaTeX Workshop: Installation

1. Install a TeX distribution first (TeX Live recommended).
2. Install VS Code from `https://code.visualstudio.com`.
3. Open the Extensions view (Ctrl+Shift+X), search for LaTeX Workshop, click Install.
4. Open a `.tex` file: saving builds the PDF; Ctrl+Alt+V shows it.

TeXstudio



Runs on: Linux, Windows, macOS.

Pros

- made for LaTeX; everything in menus
- built-in PDF viewer, forward and reverse search
- spell check, outline, symbol tables, completion
- free (GPL v2), actively developed

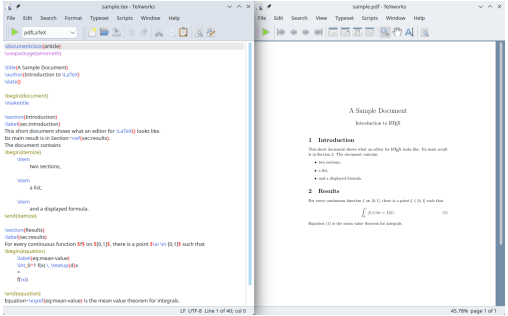
Cons

- crowded interface
- of little use beyond LaTeX

TeXstudio: Installation

1. Install a TeX distribution first (TeX Live recommended).
2. Install TeXstudio:
   - Linux: from your distribution, e. g. `sudo apt install texstudio`
   - Windows, macOS: download from `https://www.texstudio.org`
3. Open a `.tex` file and press F5 (Build & View).

TeXworks



Runs on: Windows (comes with the TeX Live and MiKTeX installers), Linux (separate package), macOS.

Pros

- deliberately minimal: a source window, a PDF window, a typeset button
- already there on Windows once TeX Live or MiKTeX is installed
- forward and reverse search

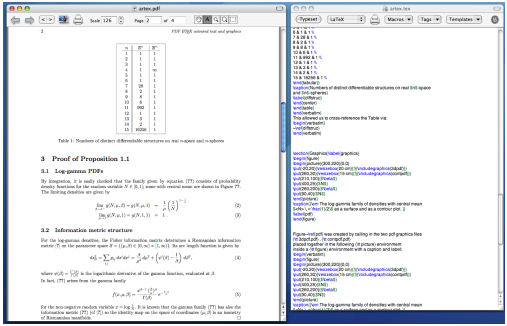
Cons

- few helpers beyond that
- slow development

TeXworks: Installation

1. Windows: nothing to do; it comes with TeX Live and MiKTeX.
2. Linux: `sudo apt install texworks` (not part of TeX Live there).
3. macOS: download from `https://tug.org/texworks`.
4. Open a `.tex` file, choose pdfLaTeX next to the typeset button, press Ctrl+T.

TeXShop



TeXShop 2.09b (2009). Screenshot: Eliashc, GPL, via Wikimedia Commons

Runs on: macOS only.

Pros

- installed together with MacTeX
- a native macOS application
- forward and reverse search
- free (GPL v2)

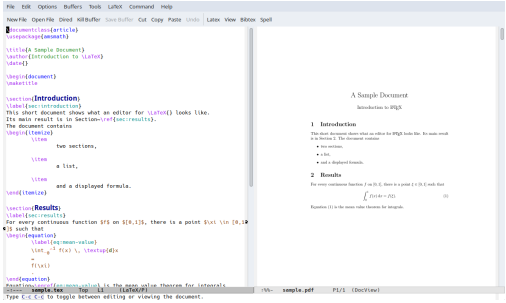
Cons

- macOS only
- fewer helpers than TeXstudio or VS Code

TeXShop: Installation

1. Install MacTeX from `https://tug.org/mactex`; this includes TeXShop.
2. Start it from `/Applications/TeX`.
3. Open a `.tex` file and click Typeset.

GNU Emacs with AUCTEX



Runs on: Linux, Windows, macOS.

Pros

- a power tool: everything by keyboard, fully programmable
- formula previews inside the source, folding, RefTeX for labels and citations
- decades of development

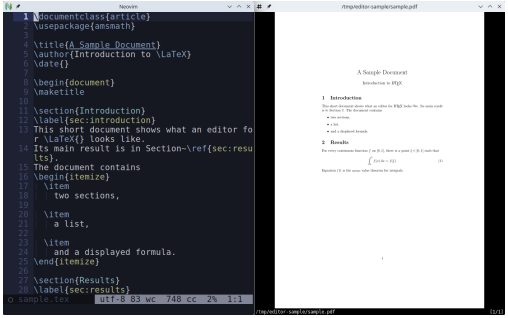
Cons

- steep learning curve, unusual key bindings
- configured in Emacs Lisp

GNU Emacs with AUCTEX: Installation

1. Install a TEX distribution first (TEX LIVE recommended).
2. Install GNU Emacs from your distribution or `https://www.gnu.org/software/emacs`.
3. In Emacs: `ALT-x package-install RET auctex RET`.
4. Open a `.tex` file: `CTRL-c CTRL-c` compiles, `CTRL-c CTRL-v` shows the PDF.

Neovim with VimTeX



Runs on: Linux, Windows, macOS.

Pros

- a power tool for Vim users
- text objects for environments, commands
- continuous compilation with `latexmk`
- forward and reverse search with Zathura, Okular, Skim, SumatraPDF
- actively developed; free (MIT)

Cons

- requires fluency in Vim
- assembled from parts: plugin manager, PDF viewer, configuration

Neovim with VimTeX: Installation

1. Install a TeX distribution first (TeX Live recommended).
2. Install Neovim (or Vim) and a PDF viewer with reverse search, e. g. Zathura.
3. Add `lervag/vimtex` to your Neovim plugin manager.
4. Open a `.tex` file: `\ll` starts continuous compilation, `\lv` shows the PDF.

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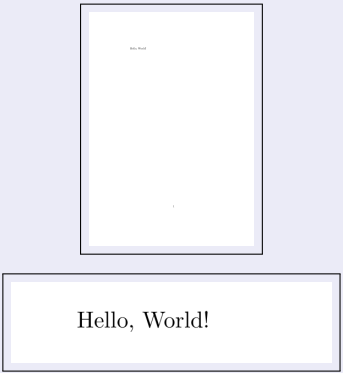
Hello, World!

What you write: hello.tex

```
1 \documentclass{article}
2 % Preamble would go here
3 \begin{document}
4 Hello, World!
5 \end{document}
6 Anything here will be ignored.
```

- `\documentclass{article}`: the kind of document, defined in `article.cls`
- between `\begin{document}` and `\end{document}`: the content
- before `\begin{document}`: the preamble, for settings (empty here)

What you get: hello.pdf



Page size, margins, font, page number: LaTeX chose according to defaults.

Try It Yourself

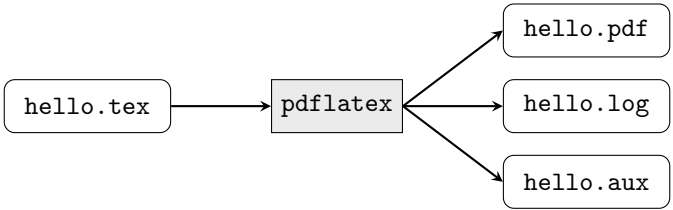
On Overleaf

1. New project → Blank project
2. Replace the contents of `main.tex` by the five lines.
3. Optionally: rename `main.tex` to `hello.tex`.
4. Click Recompile.

On your computer

1. Save the five lines as `hello.tex`.
2. Compile with your editor's build button, or in a terminal:
   `pdflatex hello.tex`
3. Open `hello.pdf`.

What the Run Produces



- `.pdf`: the typeset document
- `.log`: a record of the run, with every warning and error
- `.aux`: notes for the next run, such as section numbers and page numbers

On Overleaf, these files are under Logs and output files, next to Recompile.

Why Multiple Passes are Often Needed

twice.tex

```
1 \documentclass{article}
2 \begin{document}
3 \section{Introduction}
4 See Section~\ref{section:results}.
5
6 \section{Results}
7 \label{section:results}
8 Here they are.
9 \end{document}
```

After Run 1

See Section ??.

```
LaTeX Warning: Label(s) may have changed.
Rerun to get cross-references right.
```

After Run 2

See Section 2.

Run 1 writes the label into `twice.aux`.
Run 2 reads it.

`latexmk`: Runs as Often as Needed

- `latexmk -pdf twice.tex`
  runs `pdflatex` until nothing changes any more (here: twice), and any other programs a document needs
- Overleaf, VS Code's LaTeX Workshop and VimTeX use `latexmk` behind the scenes; TeXstudio offers it as an option.

When Things Go Wrong

typo.tex

```
1 \documentclass{article}
2 \begin{document}
3 \sectoin{Results}
4 Hello, World!
5 \end{document}
```

typo.log

```
! Undefined control sequence.
l.3 \sectoin
                {Results}
```

- `!` starts an error message: LaTeX does not know `\sectoin`.
- `l.3` is the line number; the line break shows where TeX stopped reading.
- In a terminal, `pdflatex` waits at a `?` prompt: type `x` and Enter to quit.
- A PDF may appear anyway, but it will be incorrect or contain unexpected results. Do not ignore compilation errors.

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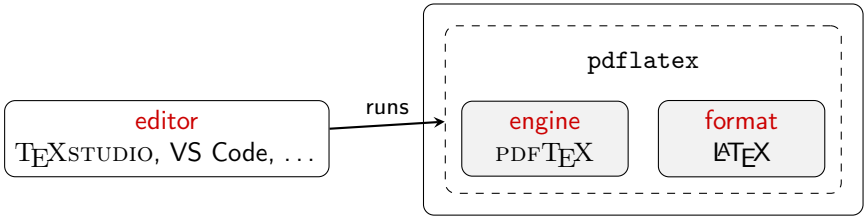
Some Vocabulary



- Editor: where you type; its build button runs a command for you.
- Engine: the program that does the typesetting.
- Format: a collection of macros preloaded into the engine.
- Distribution: engines, formats, packages, fonts and tools, installed together.

On Overleaf, the "Compiler" setting chooses the engine plus format.

Engines

Engine	Output	Input and fonts
TEX (Knuth)	DVI, to be converted to PDF afterwards	8-bit, TEX fonts
PDFTEX	PDF directly	8-bit, TEX fonts; micro-typography
XETEX	PDF	Unicode, system fonts
LUATEX	PDF	Unicode, system fonts; built-in Lua

All of them extend Knuth's TEX: the same typesetting core, with additions.

Formats and Commands

- A format is a large collection of macros: plain TeX (Knuth), LaTeX, ConTeXt.
- It is preloaded as a binary file, so it need not be read anew on every run: `pdflatex.fmt` is 3.6 MB, `tex.fmt` 0.3 MB.
- Each command is an engine with a format.

Command	Engine	Format
`tex`	TeX	plain TeX
`pdftex`	pdfTeX	plain TeX
`pdflatex`	pdfTeX	LaTeX
`xelatex`	XeTeX	LaTeX
`lualatex`	LuaHBTeX	LaTeX
`context`	LuaMetaTeX	ConTeXt

```
pdflatex --version
```

```
pdfTeX 3.141592653-2.6-1.40.28 (TeX Live 2025/Debian)
```

TeX 3.141592653, e-TeX 2.6, pdfTeX 1.40.28, from TeX Live 2025, repackaged by Debian

Distributions

- TeX Live: all platforms, a new release every year, package manager `tlmgr`
- MacTeX: TeX Live plus macOS programs such as TeXShop
- MiKTeX: primarily Windows, also macOS and Linux; installs missing packages on demand
- Linux distributions repackage TeX Live (e. g. `texlive-*` on Debian and Ubuntu); updates then come from the distribution's package manager, not `tlmgr`.

This course is built on `pdflatex` from TeX Live 2025 (the current default on arXiv) but other recent distributions will work as well.
(Overleaf's default is TeX Live 2026.)

TeX Live in a Docker Container

- Docker images with a complete TeX Live, built by the Island of TeX: `texlive/texlive` on Docker Hub, updated weekly.
- The same TeX Live year on every machine, independent of the operating system and its packages.
- `TL2025-historic`: TeX Live 2025, frozen (about 2.6 GB to download); `latest`: the current TeX Live; smaller variants such as `latest-small`.
- Windows and macOS need Docker Desktop. VS Code's LaTeX Workshop can build inside such a container (setting `latex-workshop.docker.enabled`).

Compile from inside the container

```
docker pull texlive/texlive:TL2025-historic
docker run -it --rm -v "$PWD":/workdir -w /workdir \
  texlive/texlive:TL2025-historic bash
latexmk -pdf hello.tex     # now inside the container
```

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- Greene, A. M. (1990). "BASIX: An Interpreter Written in TEX". *TUGboat* 11.3, pp. 381–392. URL: https://tug.org/TUGboat/tb11-3/tb29greene.pdf.
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