Introduction to LaTeX

Week 02: Structure, References, Errors

2026-10-22

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Preamble and Body

notes.tex

```
\documentclass{article}
\usepackage{amsmath}
\usepackage{zref-clever}
\title{Notes on Integrals}

\begin{document}
\maketitle
\section{Introduction}
Integrals measure areas.
\end{document}
```

- documentclass: usually the first line, exactly once, determines the kind of document
- preamble: up to \begin{document}, loads packages with \usepackage, makes settings, prints nothing
- body: up to \end{document}, the document's content

Text in the preamble is an error:

```
! LaTeX Error: Missing \begin{document}.
```

Keep your preamble neat

Put all \usepackage commands, settings etc. into a single file (e. g., mysettings.sty) and make \usepackage{mysettings} the single line in your preamble.

Commands: Backslash, Braces, Brackets

Example command	Comment
`\LaTeX`	a command without arguments
`\emph{important}`	a mandatory argument, in braces
`\setcounter{tocdepth}{1}`	two mandatory arguments, each in its own braces
`\section[Results]{Results and Proofs}`	an optional argument, in brackets, before the mandatory one
`\parbox[t][3cm][c]{5cm}{text}`	three optional and two mandatory arguments
`\section*{Preface}`	a starred variant of a command

- A command takes at most nine arguments, optional and mandatory together.
- Order can vary: `\newtheorem{lemma}[theorem]{Lemma}`

Environments

Input

```
\begin{itemize}
  \item First point
  \item Second point:
  \begin{enumerate}
    \item a nested list
  \end{enumerate}
\end{itemize}
```

Output

- First point
- Second point:
  1. a nested list

- `\begin{name} ... \end{name}` marks a region with its own rules.
- `document` is an environment, too. `\begin{document} ... \end{document}`
- Environments nest: the last one opened is the first one closed.

When they do not match:

```
! LaTeX Error: \begin{itemize} on input line 3 ended by \end{enumerate}.
```

Title, Author, Date

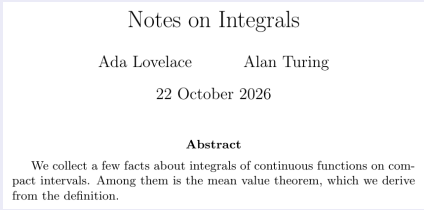
demo: title

Input

```
\documentclass{article}
% More preamble material
\title{Notes on Integrals}
\author{Ada Lovelace \and Alan Turing}
\date{22 October 2026}
\begin{document}
\maketitle
\begin{abstract}
We collect a few facts ...
\end{abstract}

% Article content
\end{document}
```

Output



Notes on Integrals

Ada Lovelace Alan Turing

22 October 2026

Abstract

We collect a few facts about integrals of continuous functions on compact intervals. Among them is the mean value theorem, which we derive from the definition.

- `\title`, `\author`, `\date` only store their argument; `\maketitle` prints them.
- `\date{\today}` gives the day of compiling, `\date{}` no date at all.

This works in almost every class. How the title looks, and which other fields exist, is up to the class: `amsart` adds `\address`, `beamer` adds `\subtitle`, `book` has no abstract, ...

Sectioning Commands

Input

```
\section{Introduction}
\subsection{Motivation}
\subsubsection{A First Example}
\paragraph{Remark}
Text continues on the same line.
```

Output

1 Introduction

1.1 Motivation

1.1.1 A First Example

Remark Text continues on the same line.

- Numbering is automatic: insert a section, and all later numbers follow.
- The argument is the title only: no number, no final period.
- In `article.cls`, the `\paragraph`-level command uses a run-in heading.
- `\section*{Acknowledgements}`: not numbered, not in the table of contents.

The Class Decides the Levels

	`article`	`report`	`book`	`beamer`
`\part`	✓	✓	✓	✓
`\chapter`	—	✓	✓	—
`\section` to `\subsubsection`	✓	✓	✓	✓
`\frontmatter`, `\mainmatter`, ...	—	—	✓	—
left and right pages differ	no	no	yes	—
a chapter starts on	—	a new page	a right page	—

- `\chapter` in an `article`: `! Undefined control sequence.`
- The class is a set of decisions about structure and form. The content stays the same.
- In this course, all examples, exercises and documents use `article.cls`, unless stated otherwise.

Many More Document Classes

Mathematics and journals

- `amsart`, `amsbook`: American Mathematical Society
- `elsarticle`: Elsevier
- `llncs`: Springer's Lecture Notes in Computer Science
- `IEEEtran`: IEEE
- `revtex4-2`: American Physical Society

Other kinds of documents

- `beamer`: slides, like these
- `tikzposter`: posters
- `moderncv`: CVs
- thesis templates of universities and research groups

Often the class is chosen for you: journals usually prescribe it.
A document marked up by its structure moves to another class with few changes.

Table of Contents and Numbering Depth

demo : toc

Input

```
\begin{document}
\tableofcontents
\section{Introduction}
\subsection{Motivation}
\section{Results}
\subsection{Existence}
\subsection{Uniqueness}
\section*{Acknowledgements}
```

Output

Contents

1 Introduction 1
1.1 Motivation . . . 1
2 Results 1
2.1 Existence . . . 1
2.2 Uniqueness . . . 1

1 Introduction

1.1 Motivation

2 Results

2.1 Existence

2.2 Uniqueness

Acknowledgements

- The table of contents needs two runs, like references: the first writes it to the `.toc` file.
- How deep, counting `\section` as 1: `\setcounter{tocdepth}{1}` lists sections only, `\setcounter{secnumdepth}{2}` numbers down to subsections.

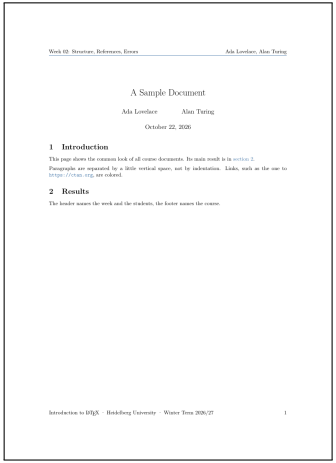
A Custom Package for the LaTeX Course

demo: course-package

The top of every stub

```
\documentclass{article}
% Your packages go here.
\usepackage{latex-course}
\courseweek{02}{Structure, References, Errors}
\coursestudents{Ada Lovelace, Alan Turing}
\begin{document}
```

- gives all course documents the same look: layout, header, footer, links
- is the last package: add your own `\usepackage` lines above it
- Set your names with `\coursestudents`; leave the rest.



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Paragraphs, Not Line Breaks

Input

```
This is one sentence.
This is another,     longer one,
spread over two lines.

A blank line separates paragraphs. % note
```

Output

This is one sentence. This is another, longer one, spread over two lines.

A blank line separates paragraphs.

- Line breaks and runs of spaces in the input count as a single space.
- A blank line separates paragraphs; more blank lines add nothing.
- % starts a comment: the rest of the line is ignored.
- \\ breaks a line inside a paragraph: use rarely.
  (\\ has other uses outside of plain text.)

Suggested rule

Use one sentence per line, so that changes are easy to compare (and git conflicts are manageable).

Emphasis

Input

```
This is \emph{important}.

\emph{One \emph{word} set off.}

We call $f$ \textbf{continuous} if ...
```

Output

This is *important*.

One word *set off.*

We call f **continuous** if ...

- `\emph` says *why*: this matters. The document decides *how*: italic in upright text, upright in italic text.
- These say *how*, where a convention asks for it, such as a term being defined:

`\textbf`	`\textit`	`\textsl`	`\textsc`	`\textsf`	`\texttt`
bold	*italic*	*slanted*	SMALL CAPS	sans serif	`typewriter`

- Underlining for emphasis is rarely used.

Quotation Marks

Input

```
"Straight" and ``curly'' quotes.

\enquote{She said \enquote{yes}.}
```

Output

"Straight" and “curly” quotes.

“She said ‘yes’.”

The keyboard has only the straight ". Typeset text uses curly quotes:

- `` (two backticks) opens
- '' (two apostrophes) closes

Use `csquotes.sty`

Load `\usepackage{csquotes}` and write `\enquote{...}`.

- It alternates outer and inner quotation marks.
- It follows the language of the document.

Dashes, Ellipses, Non-Breaking Spaces

Input	Output	Use
`-`	-	hyphen: well-known, non-zero
`--`	–	en dash: ranges and joint names, pages 10–20, Euler–Lagrange
`---`	—	em dash: a break in a sentence—like this
`$-1$`	-1	minus sign: in mathematics only
`\dots`	...	ellipsis: and so on...
`~`		non-breaking space: Section 2, D. E. Knuth
`e.g.\ this`	e.g. this	after an abbreviation: an ordinary space, not the wider one after a sentence

Special Characters

Character	Meaning	To print it
#	parameter of a definition	`\#`
$	starts and ends mathematics	`\$`
%	comment	`\%`
&	table column separator	`\&`
_	subscript, in mathematics	`\_`
^	superscript, in mathematics	`\textasciicircum`
{ }	arguments and groups	`\{ \}`
~	non-breaking space	`\textasciitilde`
\	starts a command	`\textbackslash`

These ten characters are instructions to LaTeX, not text.
`\\` is a line break, not a backslash.

Lists

demo : lists

Input

```
\begin{itemize}
  \item Bring your own device.
  \item Work in pairs:
  \begin{enumerate}
    \item compile the stub,
    \item solve the exercises.
  \end{enumerate}
\end{itemize}
\begin{description}
  \item[Preamble] Everything before
    \verb|\begin{document}|.
  \item[Body] The content.
\end{description}
```

Output

- Bring your own device.
- Work in pairs:
  1. compile the stub,
  2. solve the exercises.

Preamble Everything before `\begin{document}`.

Body The content.

- `itemize`: bullets
  `enumerate`: numbers
  `description`: labels
- Lists nest up to four levels.

Footnotes

Input

```
The claim holds.\footnote{See below.}
The next sentence continues.
```

Output

The claim holds.[1] The next sentence continues.

[1] See below.

- Footnotes are numbered automatically and set at the bottom of the page.
- In English, the mark goes after the punctuation.
- No space before `\footnote`: it would end up before the mark.

Longer footnotes

```
The claim holds.\footnote{%
The first known proof of this result dates back to 1908.
We will study it in the exercise.
}
```

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Labels and References

Input

```
\section{Results}
\label{sec:results}
...
See Section~\ref{sec:results}
on page~\pageref{sec:results}.
```

What the .aux file records

```
\newlabel{sec:results}{{2}{1}{Results}{section.2}{}}
```

number, page, title, link target

- `\label` goes right after the command that creates the number.
- `\ref` prints the number, `\pageref` the page.
- Run 1 writes the `.aux` file, run 2 reads it.
- A reference to a label that does not exist prints ?? and warns:
  `LaTeX Warning: Reference `sec:resutls' on page 1 undefined on input line 3.`

Clickable Links

Input

```
\usepackage{hyperref}
\hypersetup{colorlinks}
...
\url{https://ctan.org}
\href{https://ctan.org}{CTAN}
```

- Every reference, every entry of the table of contents, every footnote mark becomes a link.
- The headings become PDF bookmarks.
- `\url` and `\href` produce hyperlinks.

- Load `hyperref.sty` after other packages, since it changes many of their commands. Its manual names the few exceptions to this loading order.
- In this course, `latex-course` loads it for you, at the end of the preamble.

References That Name Themselves

demo: links

```
\usepackage{zref-clever}
```

Input	Output
`see \zcref{sec:results}`	see section 3
`\zcref[S]{sec:results} shows`	Section 3 shows
`see \zcref{sec:intro, sec:methods, sec:results}`	see sections 1 to 3
`see \zcref{sec:results, eq:mean-value}`	see section 3 and equation (1)
`on \zcpageref{sec:results}`	on page 2

- The name comes with the number, joined by a non-breaking space, and it is never the wrong one.
- It works with the ordinary `\label`.
- `\zcsetup{cap}` gives "Section 3" (capitalized) everywhere.

Choosing Label Names

- Start with the kind of object: `sec:`, `eq:`, `fig:`, `tab:`, `thm:`
- Or even `section:`, `equation:`, `figure:`, `table:`, `theorem:`
- Then describe the content: `sec:results`, `eq:mean-value`, not `eq:3`.
  Numbers change when you insert something; labels do not.
- Labels are case-sensitive.
- Although umlauts, Greek letters and even emojis work, as in `sec:größe`, `sec:`$\alpha\beta\gamma$ or `sec:`😀, stick to ASCII letters (`a-z`, `A-Z`), digits (`0-9`), hyphens (`-`) and the colon (`:`), preferably in lower case.
- Every label exists once:
  `LaTeX Warning: Label `sec:a' multiply defined.`

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Anatomy of an Error Message

demo : dollar

dollar.tex

```
1 \documentclass{article}
2 \usepackage{latex-course}
3 \courseweek{02}{Structure, References, Errors}
4 \coursestudents{Roland Herzog}
5 \begin{document}
6 Let x_1 be positive.
7 \end{document}
```

dollar.log

```
! Missing $ inserted.
<inserted text>
                $
l.6 Let x_
          1 be positive.
```

- `!`: what TEX noticed, in its own terms. Here: `_` (underscore) only works in mathematics mode.
- `<inserted text>`: what TEX did to carry on. It is not a fix.
- `l.6` and the line break: where TEX stopped reading.
- Fix the first error first. The second one in this log, at `\end{document}`, is a consequence of the first.

Line Numbers Aren't Always Helpful

demo: enclosed, runaway

A missing \end{itemize}

```
1  \documentclass{article}
2  \usepackage{latex-course}
3  \courseweek{02}{Structure, References, Errors}
4  \coursestudents{Roland Herzog}
5  \begin{document}
6  \section{Results}
7  \begin{itemize}
8    \item One
9    \item Two
10
11 Some more text.
12 \end{document}
```

```
! LaTeX Error: \begin{itemize} on input line 7
↪  ended by \end{document}.
l.12 \end{document}
```

A missing }

```
1  \documentclass{article}
2  \usepackage{latex-course}
3  \courseweek{02}{Structure, References, Errors}
4  \coursestudents{Roland Herzog}
5  \begin{document}
6  This is \textbf{important.
7
8  Next paragraph.
9  \end{document}
```

```
Runaway argument?
{important. \par Next paragraph. \end
↪  {document}
! File ended while scanning use of \textbf .
```

TEX reports where it noticed the problem, not where you made it. Read the whole message: it names the line of the `\begin`, and shows what was swallowed.

Errors You Will Meet Frequently

Message	Usual cause
`! Undefined control sequence.`	misspelled command, or the package defining it not loaded
`! Missing $ inserted.`	_ (underscore), ^ (caret) or a math command like \sin outside mathematics
`! LaTeX Error: Environment itemise undefined.`	misspelled environment
`! LaTeX Error: \begin{...} ... ended by \end{...}.`	missing or mismatched \end
`! File ended while scanning use of ...`	missing }
`! LaTeX Error: File `hyperef.sty' not found.`	misspelled or missing package
`! LaTeX Error: Missing \begin{document}.`	text or typesetting commands in the preamble
`! LaTeX Error: Option clash for package hyperref.`	package loaded twice, with different options

Loading a package twice is harmless: the second \usepackage is ignored. The option clash arises only when the second one asks for an option the first did not.

Warnings Worth Reading

Warning	What to do
`Reference `sec:resutls' on page 1 undefined`	fix the label, or run again
`Label(s) may have changed. Rerun ...`	run again (automatic with `latexmk`)
`Label `sec:a' multiply defined.`	rename one of the labels
`Overfull \hbox (144.49638pt too wide)`	a line sticks out into the margin: fix it if you can see it
`Underfull \hbox (badness 10000)`	a line is too loose, often after a stray `\\`

- Warnings do not stop the run, so they are easy to miss. Overleaf lists them next to the errors.
- `\documentclass[draft]{article}` marks every overfull line with a black bar.

The Question Mark Prompt

- In a terminal, `pdflatex` stops at an error and waits at a ? prompt:
  - Enter: carry on, and hope for the best
  - `h`: more help on this error
  - `x`: quit
- Overleaf and most editors do not stop: they run with
  `pdflatex -interaction=nonstopmode hello.tex`
  The errors land in the log, and a PDF may appear anyway (with). Check the log.

Following the Chain of an Error: \errorcontextlines

chain.tex

```
1 \documentclass{article}
2 \usepackage{amsmath}
3 \errorcontextlines=10
4 \newcommand{\R}{\mathbb{R}}
5 \newcommand{\Rn}{\R^n}
6 \newcommand{\Lp}{L^p(\Omega;\Rn)}
7 \begin{document}
8 Let $u \in \Lp$.
9 \end{document}
```

- Read from the bottom up: line 8 uses \Lp, which uses \Rn, which uses \R.
- Each definition is split where TEX had got to.
- The cause: amsmath is not enough, \mathbb needs amssymb.

Line 3 commented out (the default)

```
! Undefined control sequence.
\R ->\mathbb
                {R}
l.8 Let $u \in \Lp
```

With line 3

```
! Undefined control sequence.
\R ->\mathbb
                {R}
\Rn ->\R
           ^n
\Lp ->L^p(\Omega ;\Rn
                     )
l.8 Let $u \in \Lp
```

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CTAN

- `https://ctan.org`: the Comprehensive TEX Archive Network, home of almost every package
- Each package has a page, such as `https://ctan.org/pkg/zref-clever`:
  - description and documentation
  - version and date, maintainer, repository and bug tracker
  - license, and whether TEX Live and MiKTEX contain it
- Browse by topic: `https://ctan.org/topic`
- TEX Live (and with it MacTEX) and MiKTEX take their packages from CTAN. You get new versions through updates, rarely by downloading them yourself.

texdoc

In a terminal

```
texdoc zref-clever        # the manual of zref-clever
texdoc -l hyperref        # list all documents about hyperref
texdoc l2tabu-english     # not only package manuals
```

- `texdoc` comes with TEX Live and opens the documentation of the version you have installed.
- Without a local installation, as on Overleaf: `https://texdoc.org` serves the same documents. The CTAN page of a package links them, too.
- Look up the manual before you copy options from somewhere else.

Reading a Package Manual

- Do not read it from cover to cover.
  1. introduction: what the package is for
  2. loading the package, and its options
  3. the commands you need, with their examples
- Syntax lines, as in the manual of `zref-clever`:
  `\zcref⟨*⟩[⟨options⟩]{⟨labels⟩}`
  - `⟨labels⟩`: a placeholder for what you write
  - brackets: optional, braces: mandatory, `⟨*⟩`: an optional star
- Look for a section on compatibility, known problems or load order.

Is This Package Still Maintained?

	`cleveref`	`zref-clever`
latest version	0.21.4, 2018-03-27	0.5.1, 2024-11-28
works with tagged PDF	partially	yes

- Good signs: recent versions, a repository with a bug tracker, questions that get answers.
- Bad signs: "obsolete" or "superseded by" on its CTAN page.
- Old is not always bad: a finished package may need no changes. `nag` is from 2011 and still works.

Load Order and Conflicts

- Packages are loaded in order, and a later one may change what an earlier one did.
- `hyperref`, in the words of its manual:
  "Make sure it comes *last* of your loaded packages, to give it a fighting chance of not being over-written."
- A package is loaded only once. A second `\usepackage` with new options fails:

```
\usepackage[hidelinks]{hyperref}
\usepackage[colorlinks]{hyperref}
! LaTeX Error: Option clash for package hyperref.
```

- Give all options in one place, or set them later with a setup command, where the package has one: `\hypersetup` (`hyperref.sty`), `\ExecuteBibliographyOptions` (`biblatex.sty`), `\captionsetup` (`caption.sty`), `\sisetup` (`siunitx.sty`)
- If another package loads the package you want first, pass your additional options ahead of that load: `\PassOptionsToPackage{colorlinks}{hyperref}`

Asking for Help

A minimal working example

```
\documentclass{article}
\usepackage{zref-clever}
\begin{document}
\section{Results}
\label{sec:results}
See \zcref{sec:results}.
\end{document}
```

- Ask an AI assistant first: give it the error message and a minimal working example (MWE). Check its answer against the manual; it may suggest obsolete commands.
- Or search `https://tex.stackexchange.com`, which has answered most questions you will come across. Beware of outdated answers.
- A minimal working example is complete, compiles by itself, and shows the problem and nothing else.
- Build the MWE by deleting. Often you find the cause on the way.

Dummy Text and Images

Input

```
\usepackage{graphicx}
\usepackage{lipsum}
...
\lipsum[1][1-2]
\begin{center}
  \includegraphics[width = 3cm]{example-image-a}
\end{center}
\lipsum[2][1]
```

Output

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis.



Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi.

- `lipsum`: 150 paragraphs of Lorem ipsum, as in `\lipsum[1-3]` or `\lipsum[2][1-2]` (sentences 1–2).
- `example-image`, `-a`, `-b`, `-c`, `-golden`, ...: image files in TeX Live and MiKTeX, found by `graphicx`.
- Anyone can compile an MWE built this way.

Old Advice Is Everywhere

- Templates, forum answers and AI assistants are full of commands that still work, but may be outdated.
- The classic list: `texdoc l2tabu-english`
- The nag package warns while you compile:

```
\RequirePackage[l2tabu, orthodox]{nag}
\documentclass{article}
```

```
Package nag Warning: Command \bf is an old LaTeX 2.09 command.
(nag)                Use \bfseries or \textbf instead on input line 7.
```

Trettin, *An Essential Guide to LaTeX 2ε Usage*, 2007

Some Obsolete Practices

Obsolete	Use instead	Why
`\bf`, `\it`, `\sc`, ...	`\textbf`, `\textit`, ...	from LaTeX 2.09; they cannot be combined
`{\em ...}`	`\emph{...}`	
`\centerline{...}`	`\centering`	
`\\` at the end of a paragraph	a blank line	`\\` breaks a line, not a paragraph
`\vspace` for layout	structure and settings	spacing belongs to the class and packages
`\usepackage{color}`	`\usepackage{xcolor}`	
`a4wide`, `fullpage`, `anysize`	`geometry`	
`latexsym`	`amssymb`	

References



Trettin, M. (2007). *An Essential Guide to LaTeX 2ε Usage. Obsolete Commands and Packages*. Version 1.8.5.7. URL: https://ctan.org/pkg/l2tabu-english.