

SM-2302 Software for Mathematicians

L^AT_EX1: The basics

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<https://github.com/SM-2302-Aug25>

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Why L^AT_EX?

AV Wa
No kerning

AV Wa
Kerning applied

- It makes beautiful documents (kerning, ligatures, hyphenation).
- Open source and active community. Lots of packages available.
- Extensible document types (articles, presentation slides, books, theses, exam papers, etc.).

Reminder

Sign up for Overleaf if you haven't done so!

How does it work?

- You write your document in plain text with commands that describe its structure and meaning.
- The L^AT_EX program then processes your text and commands to produce a beautifully formatted document.

The rain in Spain falls `\emph{mainly}` on the plain.



The rain in Spain falls *mainly* on the plain.

More examples of commands and output...

```
\begin{itemize}
  \item Tea
  \item Milk
  \item Biscuits
\end{itemize}
```

- Tea
- Milk
- Biscuits

```
\begin{figure}
  \includegraphics{gerbil}
\end{figure}
```

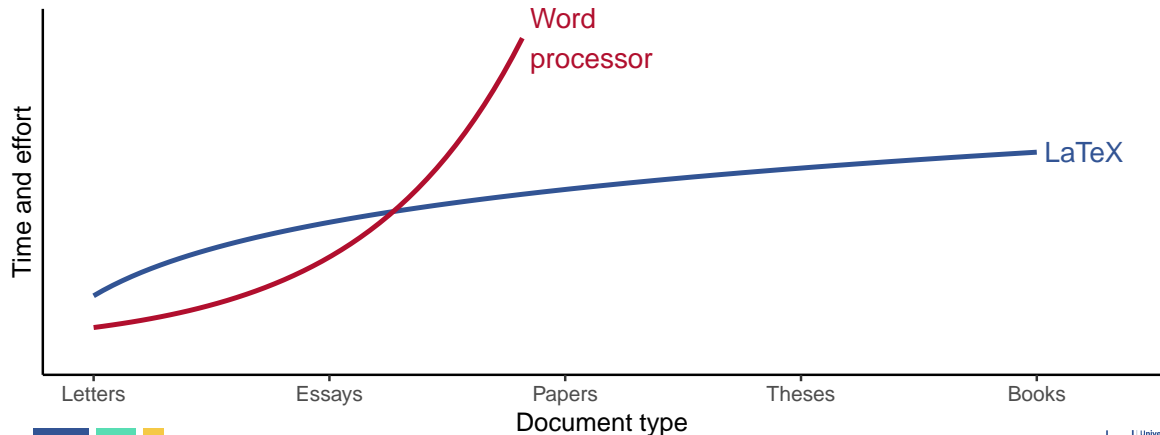


```
\begin{equation}
y = \alpha + \beta x
\end{equation}
```

$$y = \alpha + \beta x \quad (1)$$

Attitude adjustment

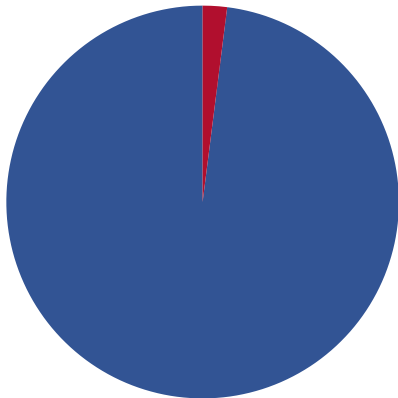
- Use commands to describe 'what it is' and not 'how it looks'.
- Focus on your content.
- Let $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}$ do its job.





Float placements

L^AT_EX takes care of figure placements (“floats”) automatically.

Moving a picture in MS Word



 You mess up the whole document

 It actually does what you want



Citations

Sometimes, however, what others tell us is important as *corroboration* of what we have already found out (or think we have found out) for ourselves. The Scottish philosopher Thomas Reid makes this point in connection with mathematical research in the belief that, if it applies to the science ‘in which, of all sciences, authority is acknowledged to have least weight’ [2], it will be even more significant in other areas of thought and practice...Russell, as we shall see in a later chapter, considered this aspect of our reliance upon testimony essential to the understanding of what it is to be a physical thing and he criticized logical positivism for its failure to appreciate the implications of this point [4]. In the *Analysis of Matter* he says explicitly, ‘I mean here by “objective” not anything metaphysical but merely “agreeing with the testimony of others” ’ [3].

Excerpt from *Testimony: A Philosophical Study* by C. A. J. Coady (1992)

Bibliography

- [1] Cecil Anthony John Coady. *Testimony: A philosophical study*. Clarendon Press, 1992.
- [2] Thomas Reid, Derek Brookes, and Knud Haakonssen. "Thomas Reid: Essays on the Intellectual Powers of Man." In: *Thomas Reid-Essays on the Intellectual Powers of Man*. Edinburgh University Press, 2002.
- [3] Bertrand Russell. "Analysis of Matter (1927)." In: *Consciousness in the Physical World: Perspectives on Russellian Monism* (2015), p. 29.
- [4] Bertrand Russell. *Logic and knowledge: Essays 1901-1950*. Spokesman Books, 2007.

Mathematics

For $i = 1, \dots, n$, let

$$\begin{aligned} y_i &= f(x_i) + \epsilon_i \\ (\epsilon_1, \dots, \epsilon_n)^\top &\sim N_n(0, \Psi^{-1}), \end{aligned} \tag{2}$$

where $y_i \in \mathbb{R}$, $x_i \in \mathcal{X}$, and $f \in \mathcal{F}$ a reproducing kernel Hilbert space (RKHS) of functions with kernel $h : \mathcal{X} \times \mathcal{X} \rightarrow \mathbb{R}$.

Lemma 1 (Fisher information for regression function)

For the normal model (2) with log-likelihood ℓ , the Fisher information for f is

$$\mathcal{I}_f = -\mathbb{E} \nabla^2 \ell(f|y) = \sum_{i=1}^n \sum_{j=1}^n \psi_{ij} h(\cdot, x_i) \otimes h(\cdot, x_j) \tag{3}$$

where ' \otimes ' is the tensor product of two vectors in \mathcal{F} .

The bilinear form (3) in Lemma 1 is a consequence of variational calculus.

Chemical equations

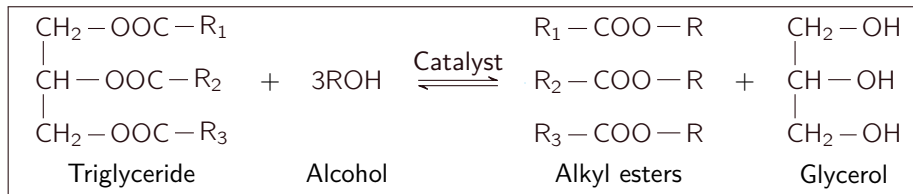
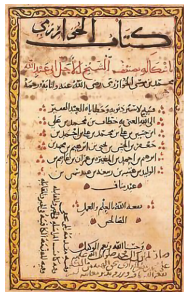
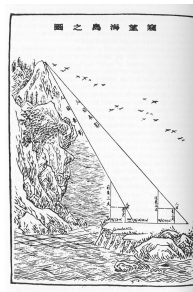


Figure 1: Transesterification of triglyceride with alcohol.

Multilingual support



الكِتَابُ الْمُخْتَصَرُ فِي حِسَابِ الْجَبْرِ وَالْمُقَابَلَةِ (The Compendious Book on Calculation by Completion and Balancing), also known as الجبر (Al-Jabr), written by محمد بن موسى الخوارزمي (Muḥammad ibn Mūsā al-Khwārizmī) around 820 CE.



(Hǎidǎo suàn jīng–The Sea Island Mathematical Manual) was written by (Liú Huī) ca. 200 CE. The Chinese were aware of a good approximation of $\pi \approx 355/113 = 3.1415929204$ very early on (Zǔ Chōng Zhī, 500 CE).

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A minimal L^AT_EX document

```
\documentclass{article}  
\begin{document}  
Hello, World!  % your content goes here...  
\end{document}
```

- Commands start with a backslash `\`.
- Every document starts with a `\documentclass` command.
- The *argument* in curly braces `{ }` tells L^AT_EX what kind of document we are creating (in this case, an *article*).
- A percent sign `%` starts a *comment*—L^AT_EX will ignore the rest of the line.

Getting started



`https://www.overleaf.com/`

- Overleaf is a website for writing documents in \LaTeX .
- It 'compiles' your \LaTeX document online to show you the results.
- As we go through the following slides, try out the examples by typing them into the example document on Overleaf!

Exercise 0 (Hello world)

Click [Hello World](#) to open the “Hello world” document in **Overleaf** (you’ll need to sign in first).
Let’s get started!

Typesetting text

- Type your text between `\begin{document}` and `\end{document}`.
- For the most part, you can just type your text normally.

Words are separated by one or more spaces.

Paragraphs are separated by one or more blank lines.

- Blank space in the source file is collapsed in the output.

The rain in Spain
falls mainly on the plain.

Words are separated by one or more spaces.

Paragraphs are separated by one or more blank lines.

The rain in Spain falls mainly on the plain.

Typesetting text (Caveats)

- Quotation marks are a bit tricky: Use a backtick ``` on the left and an apostrophe `'` on the right.

Single quotes: ``text'`.

Single quotes: `'text'`.

Double quotes: ``text''`.

Double quotes: `"text"`.

- Some common characters have special meanings in \LaTeX :
 - `%` is used to comment text
 - `#` is used for macros definitions
 - `&` is used for alignment
 - `$` is used for maths
- If you just type these, you'll get an error. If you want one to appear in the output, you have to *escape* it by preceding it with a backslash `\`.

`\$ \% \& \#`

`$ % & #`

Handling errors

- \LaTeX can get confused when it is trying to compile your document. If it does, it stops with an error, which you must fix before it will produce any output.
- For example, if you misspell `\emph` as `\meph`, \LaTeX will stop with an `undefined control sequence error`, because `\meph` is not one of the commands it knows.

Advice on errors

1. Don't panic! Errors happen. The error messages can give a clue as to what's wrong.
2. Fix them as soon as they arise—if what you just typed caused an error, you can start your debugging there.
3. If there are multiple errors, start with the first one—the cause may even be above it.

Exercise

Exercise 1 (Typesetting Text)

Typeset the following paragraph¹ in L^AT_EX:

In March 2006, Congress raised that ceiling an additional \$0.79 trillion to \$8.97 trillion, which is approximately 68% of GDP. As of October 4, 2008, the “Emergency Economic Stabilization Act of 2008” raised the current debt ceiling to \$11.3 trillion.

Click [Exercise 1](#) to open this exercise in **Overleaf**.

Watch out for

- characters with special meanings `%` `#` `&` `$`
- typesetting quotation marks correctly.

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- Inline equations

- Displayed equations

- Interlude: Environments

- Interlude: Packages

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Inline equations

- Dollar signs $\boxed{\$}$ are used to mark mathematics in text.

% not so good:

Let a and b be distinct positive integers, and let $c = a - b + 1$.

% much better:

Let a and b be distinct positive integers, and let $c = a - b + 1$.

Let a and b be distinct positive integers, and let $c = a - b + 1$.

Let a and b be distinct positive integers, and let $c = a - b + 1$.

- Always use dollar signs in pairs—one to **begin** and one to **end**.
- \LaTeX handles spacing automatically; it ignores your spaces.

Let $y=mx+c$ be \ldots

Let $y = mx + c$ be ...

Let $y = m x + c$ be \ldots

Let $y = mx + c$ be ...

More notation

- Use caret/hat $\hat{}$ for superscripts and underscore $\underline{}$ for subscripts.

```
$y = c_2 x^2 + c_1 x + c_0$
```

$$y = c_2 x^2 + c_1 x + c_0$$

- Use curly braces $\{ \}$ to group supers/sub scripts.

```
% oops!
```

```
$F_n = F_{n-1} + F_{n-2}$
```

$$F_n = F_{n-1} + F_{n-2}$$

```
% ok!
```

```
$F_n = F_{\{n-1\}} + F_{\{n-2\}}$
```

$$F_n = F_{n-1} + F_{n-2}$$

- There are commands for Greek letters and common notation.

```
$\mu = A e^{\{Q/RT\}}$
```

$$\mu = A e^{Q/RT}$$

```
$\Omega = \sum_{\{k=1\}}^{\{n\}} \omega_k$
```

$$\Omega = \sum_{k=1}^n \omega_k$$

detexify.kirelabs.org

Detexify LaTeX handwritten symbol recognition

Detexify

classify symbols



Score: 0.10291823112281329
 β
`\beta`
mathmode

Score: 0.11024688463388
 $\text{\textcircled{B}}$
`\ss`
textmode

Score: 0.1218880372150471
 $\text{\textcircled{B}}$
`\usepackage{ marvosym }`
`\Shilling`
textmode

Score: 0.13370433935413875

Displayed equations

- If the mathematics is big and scary, *display* it on its own line using `\begin{equation}` and `\end{equation}`

The roots of a quadratic equation are given by

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

where a , b and c are \ldots

The roots of a quadratic equation are given by

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

where a , b and c are ...

Caution

L^AT_EX mostly ignores your spaces in mathematics, but it can't handle blank lines in equations—don't put blank lines in your mathematics.

Interlude: Environments

- equation is an *environment* (a context).
- The `\begin` and `\end` commands are used to create many different environments. E.g., `itemize` and `enumerate` for lists:

```
\begin{itemize} % for bullet points
\item Biscuits
\item Tea
\end{itemize}
```

- Biscuits
- Tea

```
\begin{enumerate} % for numbers
\item Biscuits
\item Tea
\end{enumerate}
```

1. Biscuits
2. Tea

Interlude: Packages

- All of the commands and environments we've used so far are built into \LaTeX .
- *Packages* are libraries of extra commands and environments. There are thousands of freely available packages.
- We have to load each package we want to use with a `\usepackage` commands in the *preamble*.
- Example: `amsmath` from the American Mathematical Society.

```
\documentclass{article}
\usepackage{amsmath} % preamble
\begin{document}
% now we can use commands from amsmath here...
\end{document}
```

An example with amsmath

- Align a sequence of equations at the equals sign

$$\begin{aligned}(x+1)^3 &= (x+1)(x+1)(x+1) \\ &= (x+1)(x^2 + 2x + 1) \\ &= x^3 + 3x^2 + 3x + 1\end{aligned}$$

with the `align*` environment.

```
\begin{align*}
(x+1)^3 &= (x+1)(x+1)(x+1) \\
&= (x+1)(x^2 + 2x + 1) \\
&= x^3 + 3x^2 + 3x + 1
\end{align*}
```

- An ampersand `&` separates the left column (before the '=') from the right column (after the '=').
- A double backslash `\\` starts a new line.

Exercise

Exercise 2 (Maths)

Typeset the following paragraph in \LaTeX :

Let X_1, X_2, \dots, X_n be a sequence of independent and identically distributed random variables with mean μ and variance $\sigma^2 < \infty$, and let

$$S_n = \frac{1}{n} \sum_{i=1}^n X_i \tag{5}$$

denote their mean. Then as n approaches infinity, the random variables $\sqrt{n}(S_n - \mu)$ converge in distribution to a normal $N(0, \sigma^2)$.

Click [Exercise 2](#) to open this exercise in **Overleaf**.

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Wrap-up



You have now learned how to...

- Typeset text in \LaTeX
- Use lots of different commands
- Typeset some beautiful mathematics
- Use several different environments (figures, tables, lists).
- Load packages

Next time, we'll see how to use \LaTeX to write structured documents with sections, cross references, figures, tables and bibliographies.