

# SM-2302 Software for Mathematicians

L<sup>A</sup>T<sub>E</sub>X1: The basics

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<https://github.com/sm2302-aug23>

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# Why L<sup>A</sup>T<sub>E</sub>X?

A V W a  
No kerning

A V W a  
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.).

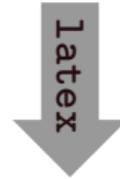
## Reminder

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  $\text{\LaTeX}$  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.

---

This workshop is inspired by the  $\text{\LaTeX}$  course by JD Miller. MIT license.

## 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}
```



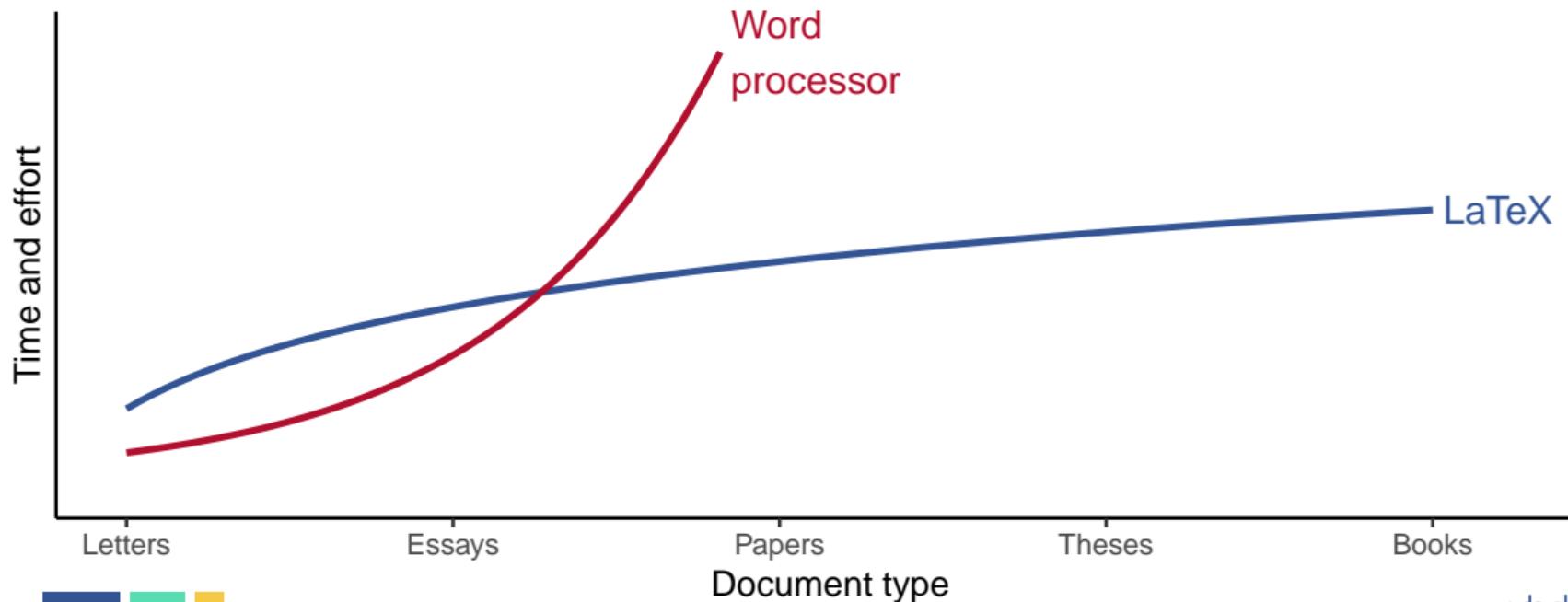
```
\begin{equation}
y = \alpha + \beta x
\end{equation}
```

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

\*Image license: CC0

# Attitude adjustment

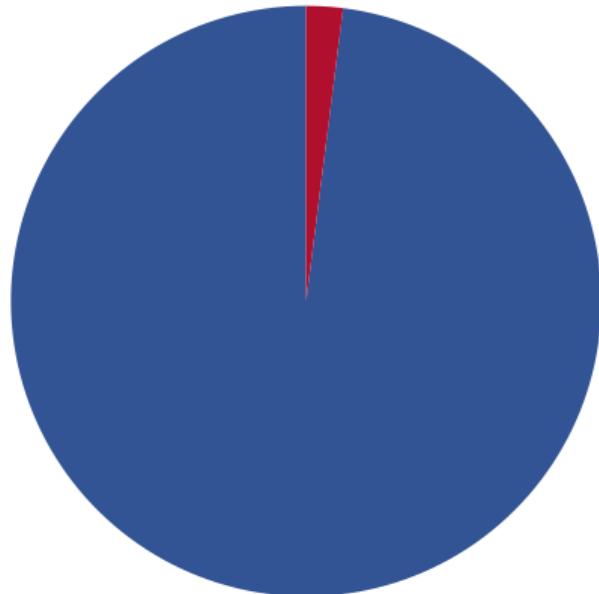
- Use commands to describe ‘what it is’ and not ‘how it looks’.
- Focus on your content.
- Let  $\text{\LaTeX}$  do its job.



# Float placements

L<sup>A</sup>T<sub>E</sub>X 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

College Student  
@CollegeStudent

using microsoft word

\*moves an image 1 mm to the left\*

all text and images shift. 4 new pages appear. in the distance, sirens.

10:12 AM · Sep 24, 2017 · Twitter Web Client

52.3K Retweets 1,694 Quote Tweets 171.8K Likes

Reply Retweet Like

This block contains a screenshot of a tweet from a user named "College Student" (@CollegeStudent) on Twitter. The tweet discusses moving an image in Microsoft Word, stating that it shifts all text and images, causing four new pages to appear in the distance. The tweet was posted at 10:12 AM on September 24, 2017, via the Twitter Web Client. It has received 52.3K retweets, 1,694 quote tweets, and 171.8K likes. Below the tweet are standard Twitter interaction icons for reply, retweet, and like.

## 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.

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  $\ell$ , the Fisher information for  $f$  is

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

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

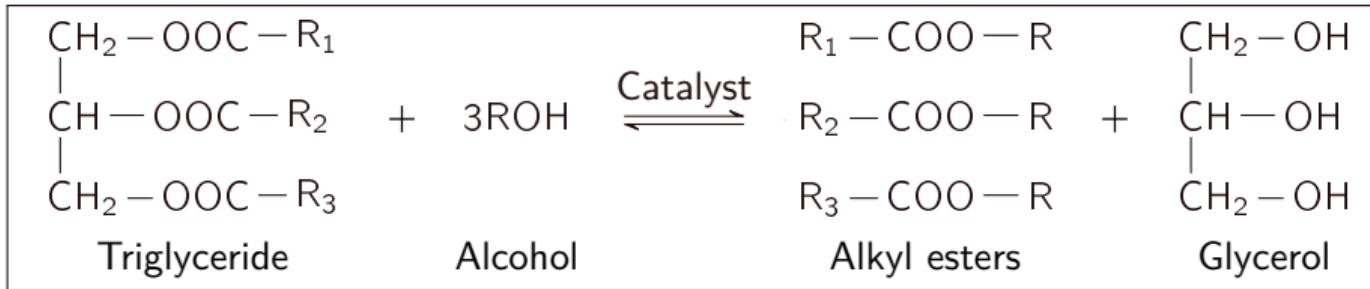


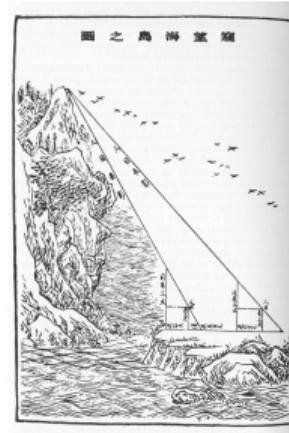
Figure 1: Transesterification of triglyceride with alcohol.

Figure 1 obtained from <https://tex.stackexchange.com/a/472486>

# Multilingual support



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



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

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# Getting started

## A minimal L<sup>A</sup>T<sub>E</sub>X 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<sup>A</sup>T<sub>E</sub>X what kind of document we are creating (in this case, an article).
- A percent sign % starts a *comment*—L<sup>A</sup>T<sub>E</sub>X will ignore the rest of the line.

## Getting started



<https://www.overleaf.com/>

- Overleaf is a website for writing documents in  $\text{\LaTeX}$ .
- It ‘compiles’ your  $\text{\LaTeX}$  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.

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.

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

- $\text{\LaTeX}$  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`,  $\text{\LaTeX}$  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 paragraph<sup>1</sup> in LATEX:

*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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<sup>1</sup>[http://en.wikipedia.org/wiki/Economy\\_of\\_the\\_United\\_States](http://en.wikipedia.org/wiki/Economy_of_the_United_States)

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  Inline equations

  Displayed equations

  Interlude: Environments

  Interlude: Packages

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# Inline equations

- Dollar signs `$` 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  $c = a - b + 1$ .

- Always use dollar signs in pairs—one to **begin** and one to **end**.
- $\text{\LaTeX}$  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

The screenshot shows a web browser window for the Detexify LaTeX handwritten symbol recognition service. The URL in the address bar is `detexify.kirelabs.org`. The main interface features the word "Detexify" in large bold letters, followed by two buttons: "classify" (highlighted in yellow) and "symbols". On the left, there is a large input field containing a handwritten symbol that looks like a Greek letter beta (β). A red "X" icon is positioned in the top right corner of this input field. To the right of the input field, three suggested matches are listed, each with a score and a LaTeX command:

- Score: 0.10291823112281329  
 $\beta$   
\beta  
mathmode
- Score: 0.11024688463388  
 $\beta$   
\ss  
textmode
- Score: 0.1218880372150471  
 $\beta$   
\usepackage{ marvosym }  
\Shilling  
textmode

At the bottom of the list, another score is shown: 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

$\text{\LaTeX}$  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}
```

```
\begin{enumerate} % for numbers
```

```
\item Biscuits  
\item Tea  
\end{enumerate}
```

- Biscuits
- Tea

1. Biscuits
2. Tea

## Interlude: Packages

- All of the commands and environments we've used so far are built into  $\text{\LaTeX}$ .
- *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` command 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 L<sup>A</sup>T<sub>E</sub>X:

*Let  $X_1, X_2, \dots, X_n$  be a sequence of independent and identically distributed random variables with mean  $\mu$  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  $\text{\LaTeX}$
- 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  $\text{\LaTeX}$  to write structured documents with sections, cross references, figures, tables and bibliographies.