

Latex 1: Latex Basics



Cheng-Hsin Hsu

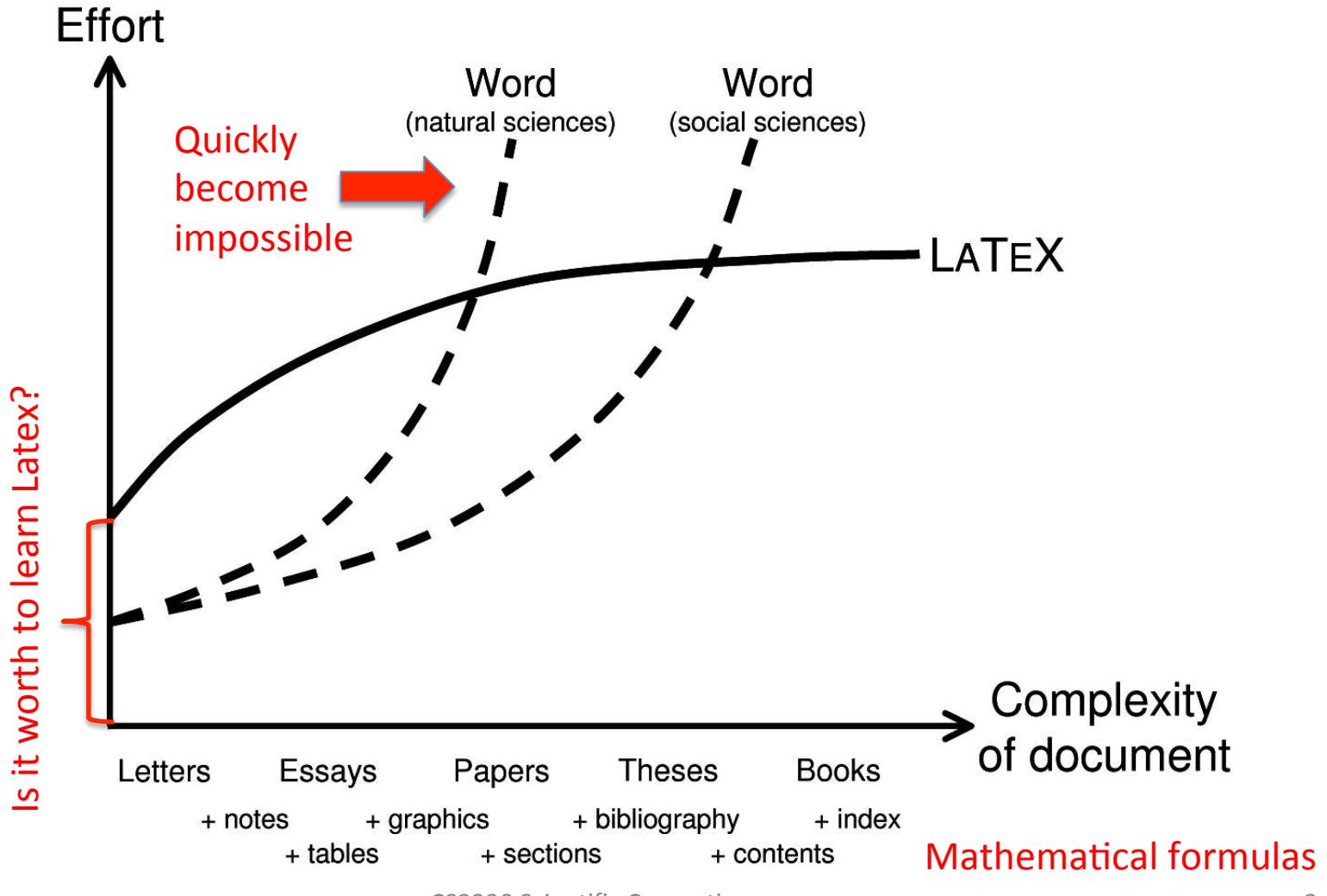
National Tsing Hua University
Department of Computer Science

What is Latex

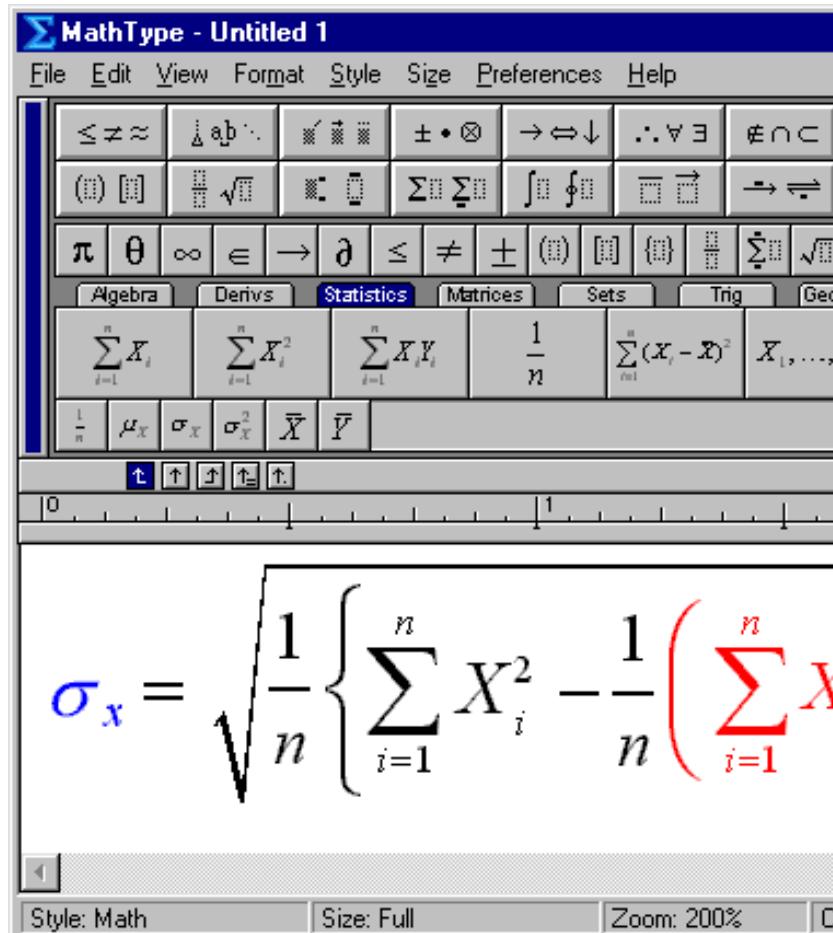
- Latex is a **typesetting markup language**
- Latex produces high-quality documents
 - Especially mathematical formulas, figures, tables
- Latex was created by scientists for scientists
← you...
- (As we will see soon) Latex is modularized and expandable

LATEX

Why Latex?



Beautiful and Easy-to-Type Formulas



```
\sigma_x = \sqrt{\frac{1}{n} \left\{ \sum_{i=1}^n X_i^2 - \frac{1}{n} \left( \sum_{i=1}^n X_i \right)^2 \right\}}
```

Typesetting

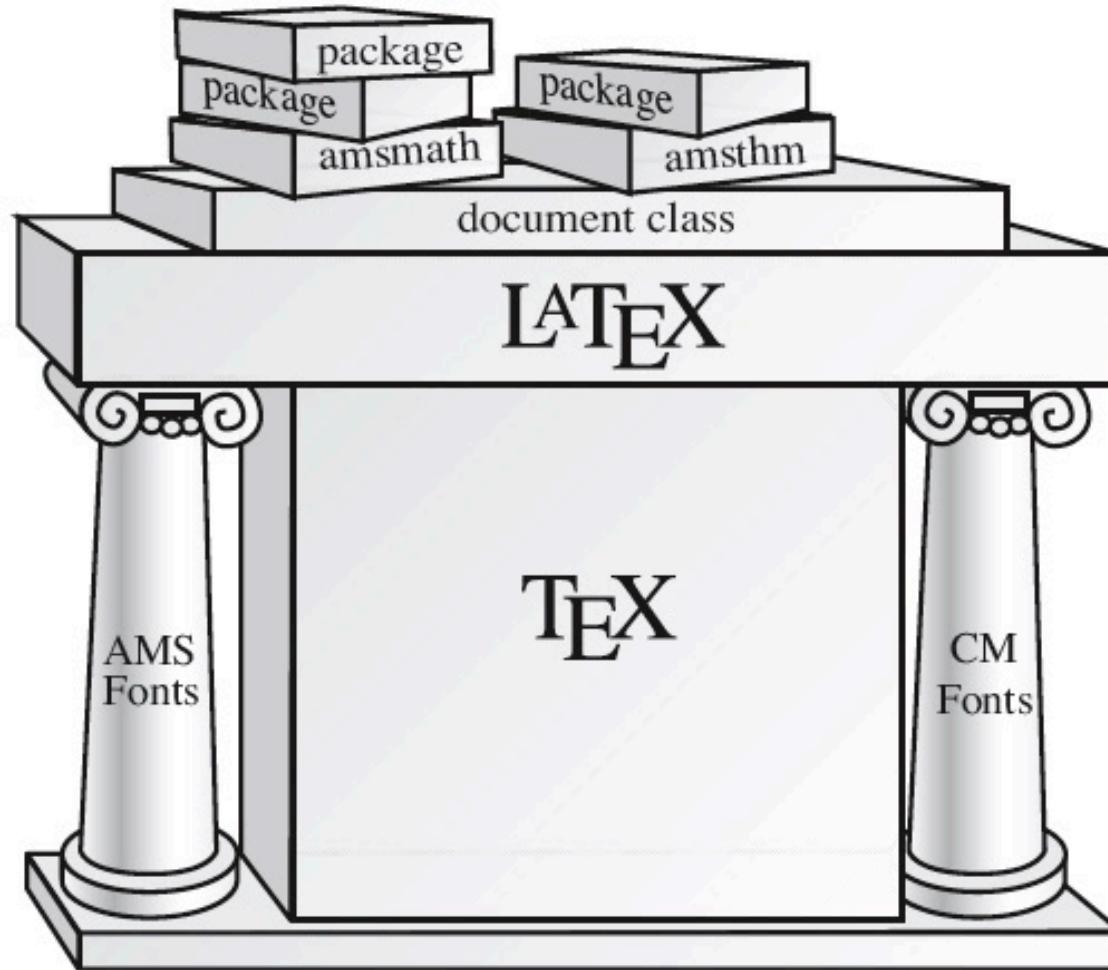
$$\sigma_x = \sqrt{\frac{1}{n} \left\{ \sum_{i=1}^n X_i^2 - \frac{1}{n} \left(\sum_{i=1}^n X_i \right)^2 \right\}}$$

$$\sigma_x = \sqrt{\frac{1}{n} \left\{ \sum_{i=1}^n X_i^2 - \frac{1}{n} \left(\sum_{i=1}^n X_i \right)^2 \right\}}$$

History of LaTeX

- **Foundation:** Donald Knuth started developing the typesetting language TeX in 1978 ← requires too much typesetting knowledge
- **Platform:** AMS-TeX by Michael Spivak and Latex by Leslie Lamport in early 1980's
 - AMS stands for American Mathematical Society
- **AMS Packages:** In 1990's, several AMS-TeX features are released as LaTeX packages
- **When we say Latex, we refer to TeX + LaTeX + AMS packages**

The Three Layers



Let's Start with Simple Examples

- We write documents in **plain-text** and with commands describing the structure ← **markup language**
 - E.g., $\sqrt{a^2 + b^2}$. I can type math!
- Latex program and its friends **typeset** your plain-text file into formatted, say PDF documents



$\sqrt{a^2 + b^2}$. I can type math!

More Examples

```
\begin{itemize}  
\item Monkey  
\item Elephant  
\item Bear  
\end{itemize}
```

- Monkey
- Elephant
- Bear



```
\begin{equation}  
\alpha = \frac{2}{\beta} + 0.95  
\end{equation}
```

$$\alpha = \frac{2}{\beta} + 0.95$$



```
\begin{figure}  
\includegraphics{./bob.eps}  
\end{figure}
```



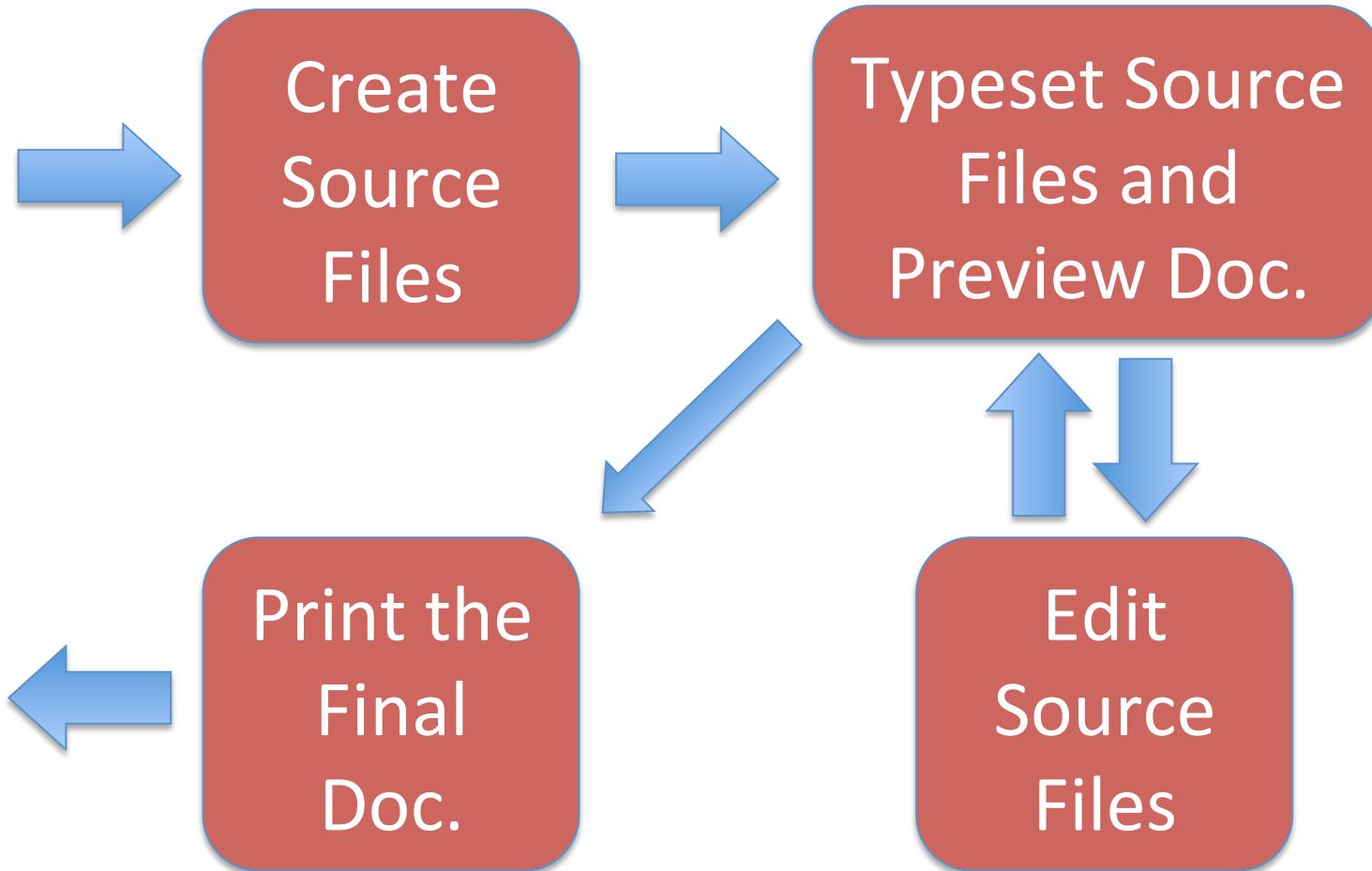
Compared to Word Processors

- In Latex, we describe “what is it”, not “how it looks like”
- Focus on your **content** (not layout) while writing
- Let Latex and its friends to do their jobs

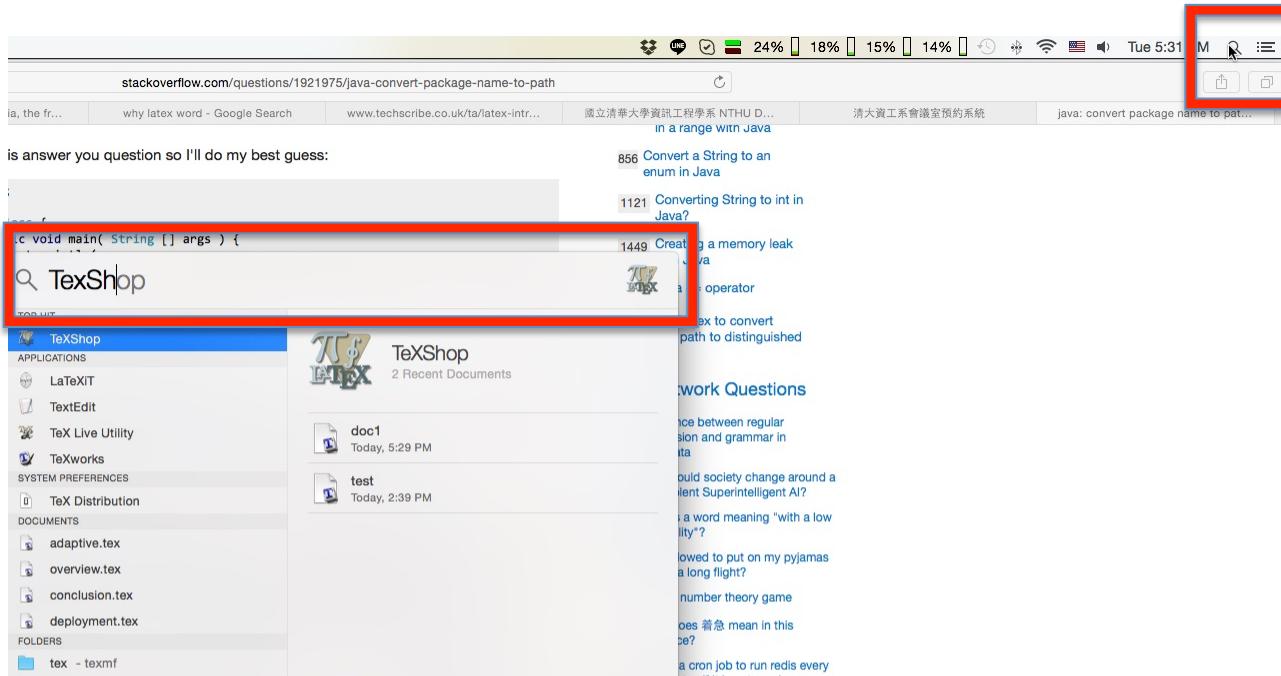
```
## Overwrite the first paragraph and add new parts
Widely adoption of heterogeneous computing devices, such as PCs, tablets,
smart TVs, and smartphones, urges diverse ways for people to share
photos, watch videos, and play games, with their family and friends.
Most people prefer to use larger or even multiple screens
to share contents instead of limiting to a single screen.
Ubiquitous displays are therefore gradually deployed in homes, schools,
offices, shops, and
even outdoor squares for experience sharing, educations, presentations,
advertisements. According to market research reports,
the global flexible display market is expected to worth \$3.89 billion by
2020, growing with high Compound Annual Growth Rate (CAGR) from 2014 to
2020~\cite{mar}. Moreover,
wireless networks have surged in popularity. Featuring
displaying screen contents without cable connections to computing devices,
wireless displays are expected to grow at a CAGR of 28.03% from
2012 to 2017~\cite{wirelessdisplay}.
These reports show that the {\em binding} between computing devices and displays
becomes more dynamic, leading to flexible and diverse displaying experience.
```

← For example, where
to break the lines
Is not important
at all, unless
there is a blank
line ← new paragraph

Editing Cycle

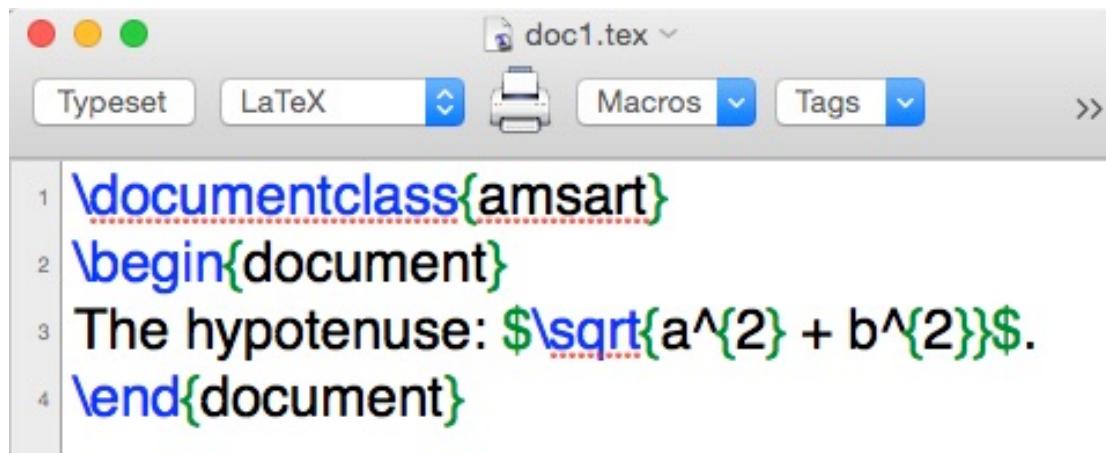


Step 1: Creating a Source File



1. Use Spotlight to launch TexShop
2. Choose File -> New to create a new tex file

Step 1: Creating a Source File (cont.)

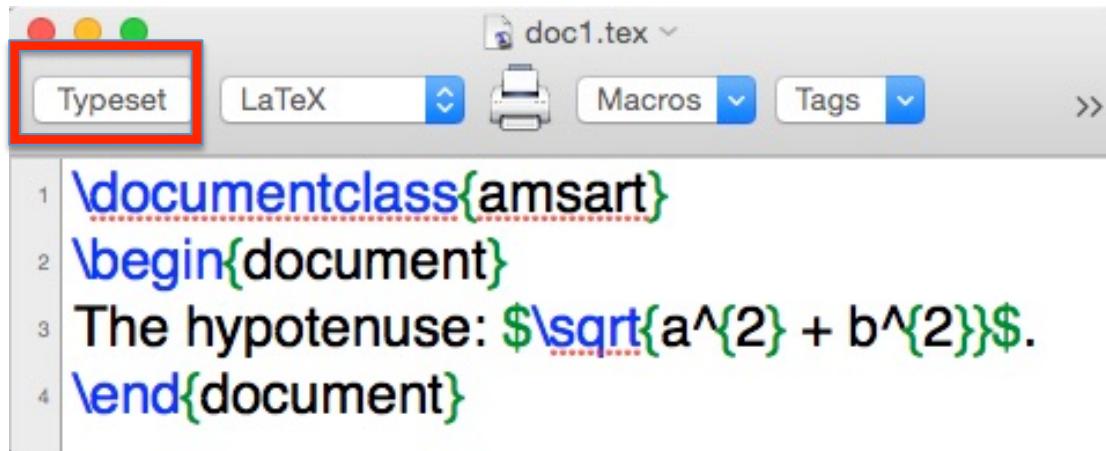


The screenshot shows a LaTeX editor window titled "doc1.tex". The interface includes a toolbar with "Typeset", "LaTeX", "Macros", and "Tags" buttons. The code area contains the following LaTeX code:

```
1 \documentclass{amsart}
2 \begin{document}
3 The hypotenuse: $ \sqrt{a^2 + b^2} .
4 \end{document}
```

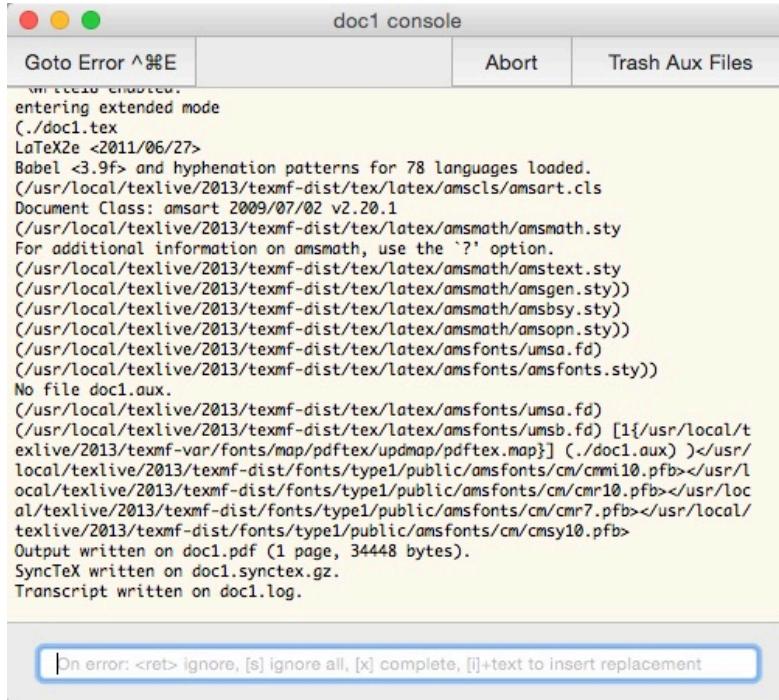
1. Type the above code snippet

Step 2 Typeset the Source File and Preview Document



1. Click Typeset button
2. You will be prompted to save the file
3. Save it on the Desktop as doc1.tex

Step 2 Typeset the Source File and Preview Document (cont.)



The screenshot shows a LaTeX console window titled "doc1 console". The window has three tabs at the top: "Goto Error ⌘%E", "Abort", and "Trash Aux Files". The main area displays the LaTeX log output:

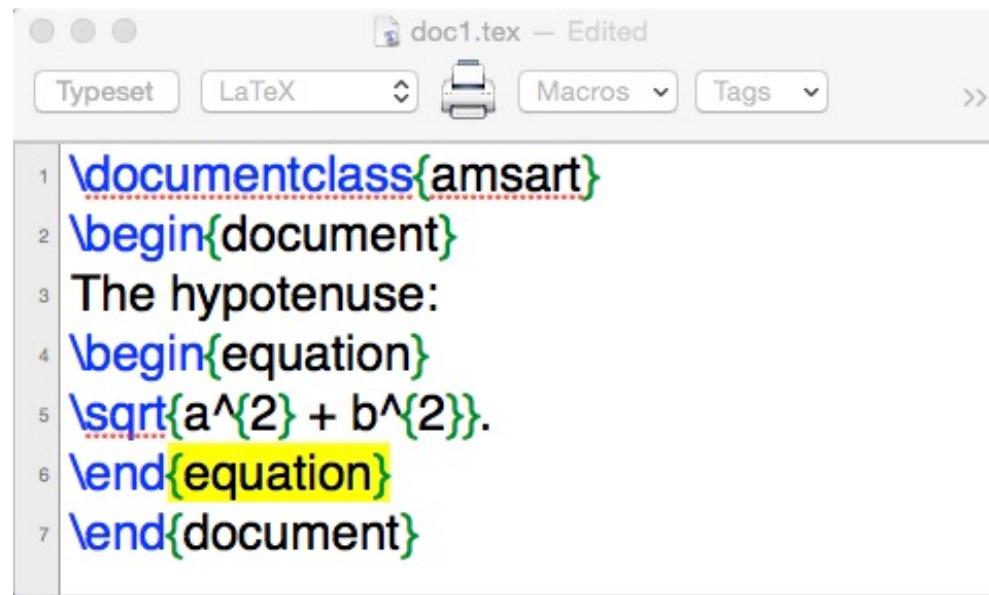
```
! LaTeX2e <2011/06/27>
entering extended mode
./doc1.tex
LaTeX2e <2011/06/27>
Babel <3.9f> and hyphenation patterns for 78 languages loaded.
(/usr/local/texlive/2013/texmf-dist/tex/latex/amslatex/amslatex.cls
Document Class: amsart 2009/07/02 v2.20.1
(/usr/local/texlive/2013/texmf-dist/tex/latex/amsmath/amsmath.sty
For additional information on amsmath, use the '?' option.
(/usr/local/texlive/2013/texmf-dist/tex/latex/amsmath/amstext.sty
(/usr/local/texlive/2013/texmf-dist/tex/latex/amsmath/amsgen.sty))
(/usr/local/texlive/2013/texmf-dist/tex/latex/amsmath/ambsy.sty)
(/usr/local/texlive/2013/texmf-dist/tex/latex/amsmath/amsoopn.sty)
(/usr/local/texlive/2013/texmf-dist/tex/latex/amsmath/amsfonts/umsa.fd)
(/usr/local/texlive/2013/texmf-dist/tex/latex/amsmath/amsfonts/amsfonts.sty))
No file doc1.aux.
(/usr/local/texlive/2013/texmf-dist/tex/latex/amsfonts/umsa.fd)
(/usr/local/texlive/2013/texmf-dist/tex/latex/amsfonts/umsb.fd) [1{/usr/local/texlive/2013/texmf-var/fonts/map/pdftex/updmap/pdftex.map}] (./.doc1.aux) )</usr/local/texlive/2013/texmf-dist/fonts/type1/public/amsfonts/cm/cmmi10.pfb></usr/local/texlive/2013/texmf-dist/fonts/type1/public/amsfonts/cm/cmr10.pfb></usr/local/texlive/2013/texmf-dist/fonts/type1/public/amsfonts/cm/cmr7.pfb></usr/local/texlive/2013/texmf-dist/fonts/type1/public/amsfonts/cm/cmsy10.pfb>
Output written on doc1.pdf (1 page, 34448 bytes).
SyncTeX written on doc1.synctex.gz.
Transcript written on doc1.log.
```

At the bottom of the window is a status bar with the message: "On error: <ret> ignore, [s] ignore all, [x] complete, [i]+text to insert replacement".



1. Console shows the typesetting messages including warnings and errors
2. Preview window shows the resulting document

Step 3 Edit Source File



The screenshot shows a LaTeX editor window titled "doc1.tex – Edited". The interface includes tabs for "Typeset", "LaTeX", "Macros", and "Tags", along with standard window controls. The code area contains the following LaTeX source code:

```
1 \documentclass{amsart}
2 \begin{document}
3 The hypotenuse:
4 \begin{equation}
5 \sqrt{a^2 + b^2}.
6 \end{equation}
7 \end{document}
```

The line "\documentclass{amsart}" is underlined in red, indicating it is selected or has an error. The line "\sqrt{a^2 + b^2}." is highlighted in yellow.

1. Say if we prefer to have standalone math equation
2. Edit the source file as shown above

Step 2 + Step 4 Print the Final Doc.



The hypotenuse:

(1)

$$\sqrt{a^2 + b^2}.$$

1. Typeset again
2. We are happy with the pdf, let's call it a day

Documentclass and Comments

The screenshot shows a LaTeX editor interface. On the left, the code editor displays a file named 'doc1.tex' with the following content:

```
%\documentclass{amsarticle}
\documentclass{article}
\begin{document}
The hypotenuse:
\begin{equation}
\sqrt{a^2 + b^2}.
\end{equation}
\end{document}
```

A red arrow points from the code editor to the right panel, which shows the generated PDF output:

The hypotenuse:

$$\sqrt{a^2 + b^2}.$$

(1)

- Add % to a line would comment everything after % out
 - In this example, the **whole** line
- Documentclass points latex to templates, such as `IEEEtran.cls` and `acmsmall.cls`
 - Allow us to focus on **content** not layout!

Typing Texts

A source file is made up of text, math (e.g., $\sqrt{5}$), and *instructions* to *LaTeX*.



A source file is made up of text, math (e.g., $\sqrt{5}$), and *instructions to *LaTeX**.

- Each source file is composed of: text, math (formulas), and instructions (commands)

Commands



- Commands are one kind of instructions
- Commands starts with a backslash (\), and may come with zero (\LaTeX), one (\em{to}), or more arguments
 - The texts between {...} are mandatory arguments
 - The texts between [...] are optional arguments

Environments

- Environments are another kind of instructions
- Always come in pairs, such as `\begin{document}` and `\end{document}`
- Try this:

```
\documentclass{article}
\begin{document}
\begin{flushright}
1 \\
123 \\
12345
\end{flushright}
\end{document}
```



Special Characters

- #, \$, %, &, ~, _, ^, \, {, }, “, | are special characters
 - For example, \$ is used to start/end the math mode, _ indicates subscript (in math mode)
 - To type special characters, prepend a \

This_is_a_test. This_is_a_test.
 - Exceptions: \textbackslash, \\$\backslash, \\$\texttildelow (need textcomp package), and \\$\sim\\$

Paragraphs

- A blank line indicates a new paragraph

The screenshot shows a LaTeX editor window titled "doc1.tex – Edited". The code area contains:

```
1 \documentclass{article}
2 \begin{document}
3 Paragraph 1 starts here.
4
5 Paragraph 2 starts here. This is just another
sentence. This is just another sentence. This is just
another sentence. This is just another sentence. This is
just another sentence. This is just another sentence.
6 \end{document}
```

A red arrow points from the blank line between "Paragraph 1" and "Paragraph 2" in the code to the rendered output below.

The rendered output window is titled "doc1.pdf" and shows:

Paragraph 1 starts here.
Paragraph 2 starts here. This is just another sentence. This is just another sentence.

Paragraph 1 starts here.
Paragraph 2 starts here. This is just another sentence. This is just another sentence.

Extra Space

- Popular units
 - pt: point (1 in = 72.27 pt)
 - in: inch (1 in = 25.4 mm)
 - cm: centimeter (1 cm = 10 mm)
 - mm: millimeter
- Adding horizontal space
 - \<space> ← large space
 - \; ← smaller space
 - ~ (tilde) ← nonbreakable space
 - Others, such as \quad and \qquad
- Exercise: try the space and see the different effects produced by them

More Text Features



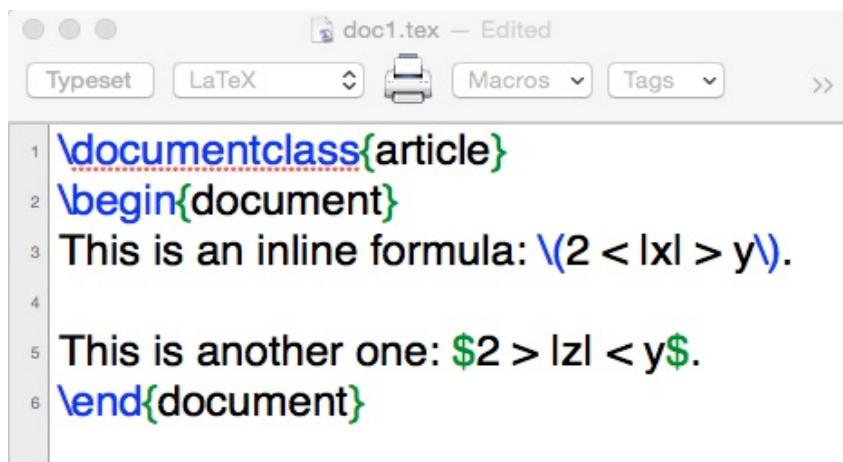
September 2, 2015

From the desk of George

```
\documentclass{article}
\begin{document}
\begin{flushright}
\today
\end{flushright}
\textbf{From the desk of George} \\[24pt]
\emph{Please use my email address}
\begin{center}
\tt{george@example.com}
\end{center}
\end{document}
```

Red arrows point from the right margin to the following elements: the date, the bolded text, the italicized text, and the text within the center environment.

Inline Math



A screenshot of a LaTeX editor window titled "doc1.tex – Edited". The window shows the following code:

```
1 \documentclass{article}
2 \begin{document}
3 This is an inline formula: \((2 < |x| > y)\).
4
5 This is another one: \$2 > |z| < y\$.
6 \end{document}
```



This is an inline formula: $2 < |x| > y$.
This is another one: $2 > |z| < y$.

Displayed Math

The screenshot shows a LaTeX editor window titled "doc1.tex – Edited". The code in the editor is:

```
1 \documentclass{article}
2 \begin{document}
3 This is a displayed formula:
4 \[
5 2 < \frac{x_1}{x_2} > y.
6 \]
7
8 This is another one:
9 \begin{equation}
10 2 > |z| < y.
11 \end{equation}
12 \end{document}
```

A red arrow points from the editor window to a PDF viewer window titled "doc1.pdf". The PDF viewer shows the rendered output:

This is a displayed formula:

$$2 < \frac{x_1}{x_2} > y.$$

This is a displayed formula:

$$2 < \frac{x_1}{x_2} > y.$$

This is another one:

$$2 > |z| < y.$$

Blank Spaces in Text and Math

- Many spaces equal **one** space in text, whereas spacing is **ignored** in math, unless the space **terminates** a command
 - $\$ab\$$, $\$a b\$$, and $\$a \quad b\$$ all typeset into *ab*
 - $\$\\infty a\$$ gives ∞a
 - $\$\\infty a\$$ gives

```
./doc1.tex:3: Undefined control sequence.  
<recently read> \inftya  
1.3 $\\inftya  
         $  
     ?
```

Arithmetic

- $\$a + b\$$
- $\$ a / b\$$
- $\$a b\$$
- $\$a \cdot b\$$ $a \cdot b$
- $\$a \times b\$$ $a \times b$
- $\$\\frac{1+2x}{x+y+xy}\$$ $\frac{1+2x}{x+y+xy}$

Superscripts and Subscripts

- \$a_1\$
- \$b^3\$
- \$c_1^3\$
- \$c_1^{x^2}\$
- \$a_{n'}^2\$

Binomial Coefficient

- $\binom{a}{b+c}$
- $\binom{\frac{n^2-1}{2}}{n+1}$

Delimiters

- $\$(\backslashfrac{1+x}{2+y^2})^2\$ \quad \left(\frac{1+x}{2+y^2}\right)^2$
 - The height of (...) is not enough
- $\$\\left(\\frac{1+x}{2+y^2} \\right)^2\$ \quad \left(\frac{1+x}{2+y^2}\right)^2$
- The same rule can be applied to {}, [], and |

Ellipses



- With ,
 - \cdot
 - $1, 2, \dots, 100$
- Without ,
 - \cdots
 - $x \rightarrow \cdots \rightarrow 100$

Integrals and Partial Derivatives

- $\int_0^\pi \sin x \, dx = 2$

$$\int_0^\pi \sin x \, dx = 2$$

- $\frac{\partial u}{\partial t}$

- $\lim_{x \rightarrow +\infty} x^2$

$$\lim_{x \rightarrow +\infty} x^2$$

Matrices

```
\[
\left[
\begin{matrix}
a+b+c & uv & 28 \\
a+b & u+v & 132
\end{matrix}
\right]
```

$$\left[\begin{matrix} a + b + c & uv & 28 \\ a + b & u + v & 132 \end{matrix} \right]$$

When Running out of Symbols

- \bar{a}
- \hat{a}
- \tilde{a}
- \vec{a}
- Greek symbols: α , δ , and so on

α, δ

Unknown Symbols?

<http://detexify.kirelabs.org/classify.html>

Detexify [classify](#) [symbols](#)

\forall	Score: 0.09108357568367145 \forall mathmode
\veebar	Score: 0.10546324372757358 \usepackage{ amssymb } \veebar mathmode
\textbar	Score: 0.120752749897953 \usepackage{ tipa } \textbar textmode
\textwedge	Score: 0.13342109520034448 \usepackage{ textcomp } \textwedge textmode
\coprod	Score: 0.19223369535559443 \coprod mathmode

Want a desktop app?

Please fill out this mini-survey!
<http://goo.gl/forms/K0zoCpfhVq>

What is this?

Anyone who works with LaTeX knows how time-consuming it can be to find a symbol in [symbols-a4.pdf](#) that you just can't memorize

Operators

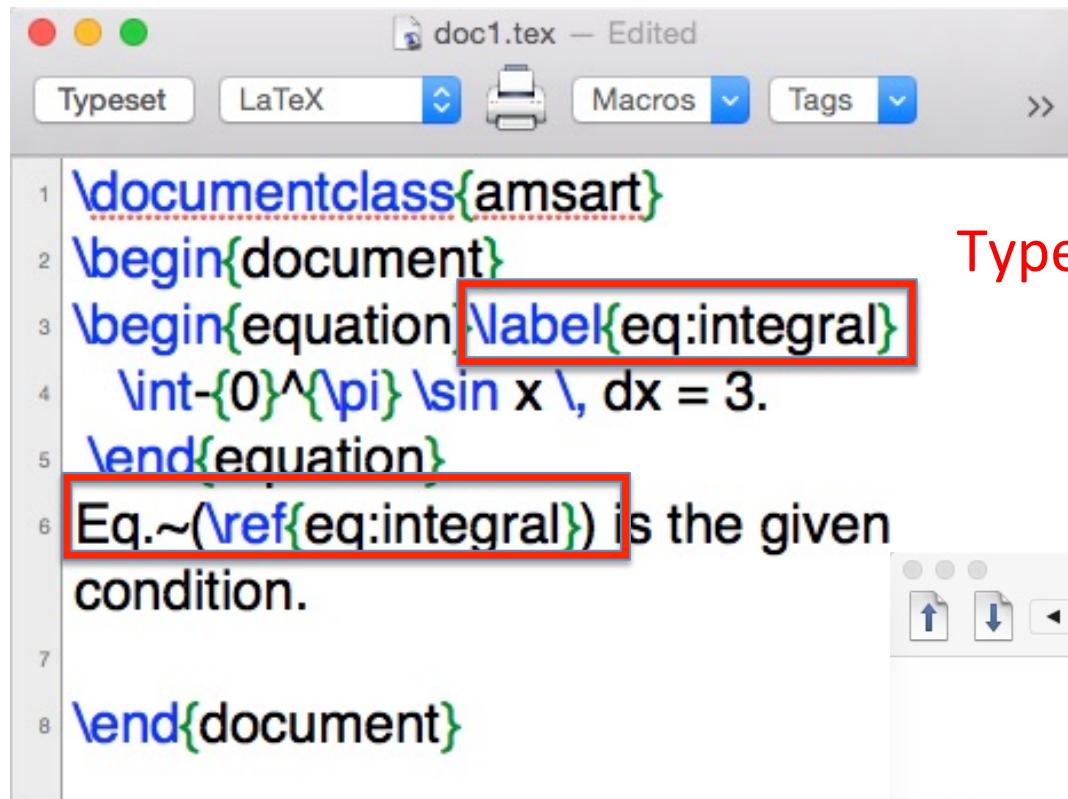
- $\lim_{x \rightarrow 1} f(x) = 0$ $\lim_{x \rightarrow 1} f(x) = 0$
- $\displaystyle \lim_{x \rightarrow 1} f(x) = 0$ $\lim_{x \rightarrow 1} f(x) = 0$
- $\displaystyle \sum_{i=1}^n x_i^2$ $\sum_{i=1}^n x_i^2$
- $\prod_{i=1}^n x^2_i$ $\prod_{i=1}^n x_i^2$

Embed Text in Formulas

```
\[  
    a = b, \text{ by assumption}  
\]
```

$$a = b, \text{ by assumption}$$

Labeled Equations



A screenshot of a LaTeX editor window titled "doc1.tex – Edited". The code is as follows:

```
1 \documentclass{amsart}
2 \begin{document}
3 \begin{equation} \label{eq:integral}
4 \int_0^\pi \sin x \, dx = 3.
5 \end{equation}
6 Eq.~\ref{eq:integral} is the given
7 condition.
8 \end{document}
```

The line "\label{eq:integral}" is highlighted with a red box. The line "Eq.~\ref{eq:integral} is the given condition." is also highlighted with a red box.

Typeset it once, what do you get?



Eq. (1) is the given condition.

Other References

- `Eq.\eqref{eq:integral}` ← handles (...) for us
- `Page\pageref{eq:integral}`
- `\ref` is also used for referring to
 - sections (`\label{sec:introduction}`)
 - figures (`\label{fig:result}`)
 - tables (`\label{fig:symbols}`)
- Exception: `\cite{KL05}` for citations

The `babel` package is described in detail in Johannes Braams, *Babel, a multilingual package for use with L^AT_EX's standard document classes* [7] and in Chapter 9 of *The L^AT_EX Companion*, 2nd edition [46].

Aligned Formulas

```
\begin{align}
r^2 &= s_2 + t^2 \label{eq:pyth} \\
2u+1 &= v+w^\alpha \label{eq:alpha} \\
x &= \frac{y+z}{2} \label{eq:frac}
\end{align}
```

$$r^2 = s_2 + t^2 \tag{1}$$

$$2u + 1 = v + w^\alpha \tag{2}$$

$$x = \frac{y+z}{2} \tag{3}$$

Aligned Formulas Without Numbers

- `\begin{align}`
- `r^2 &= s_2 + t^2 \label{eq:pyth} \\`
- `2u+1 &= v+w^{\alpha} \label{eq:alpha}\\`
- `x &= \frac{y+z}{2} \nonumber`
- `\end{align}`

$$r^2 = s_2 + t^2 \tag{1}$$

$$2u + 1 = v + w^\alpha \tag{2}$$

$$x = \frac{y + z}{2}$$

Guidelines for Aligned Formulas

- Use `environment`
- Separate lines with `\\"`
- Use `&` to indicate alignment point. Put it **before** `=`, `+`, or other operators
- Use `\nonumber` to mark the un-numbered lines
- Place `\label` for each numbered line to be used for `\ref` later

Annotated Alignment

```
\begin{align}
r^2 &= s_2 + t^2 \boxed{\&& \text{(line 1)}} \label{eq:pyth} \\
2u+1 &= v+w^{\alpha} \label{eq:alpha} \\
x &= \frac{y+z}{2} \&& \text{(line 3)} \nonumber \\
\end{align}
```

$$r^2 = s_2 + t^2 \quad \boxed{\text{(line1)}} \quad (1)$$

$$2u + 1 = v + w^\alpha \quad (2)$$

$$x = \frac{y+z}{2} \quad \text{(line3)}$$

Cases

```
\[  
f(x) =
```

```
\begin{cases}
```

```
x^2, & \text{if } $x < 0$ \\
```

```
x^{-2} & \text{otherwise.}
```

```
\end{cases}
```

```
\]
```

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

Summary



- We introduced the latex basics and its history
- We presented both text and math modes
- We demonstrated the typical workflow of writing with Latex and its friends
- References:
 - <http://www.latex-project.org> ← Official Web and resources
 - <http://link.springer.com/book/10.1007%2F978-0-387-68852-7> ← Our textbook

Latex #1 Homework (L1)

1. (3%) Finish the following proof using Mathematical Induction in Latex. Turn in your source .tex and .pdf files.

```
\documentclass{amsart}
\begin{document}
\newtheorem{thm}{Theorem}
\begin{thm}

$$\sum_{i=1}^n = \frac{n(n+1)}{2},$$

\forall n \in \mathbf{Z}^+.
\end{thm}
\begin{proof}
Type your proof here!
\end{proof}
\end{document}
```

Theorem 1.
$$\sum_{i=1}^n = \frac{n(n+1)}{2}, \forall n \in \mathbf{Z}^+$$
.

Proof. Type your proof here!