Latex 1: Latex Basics

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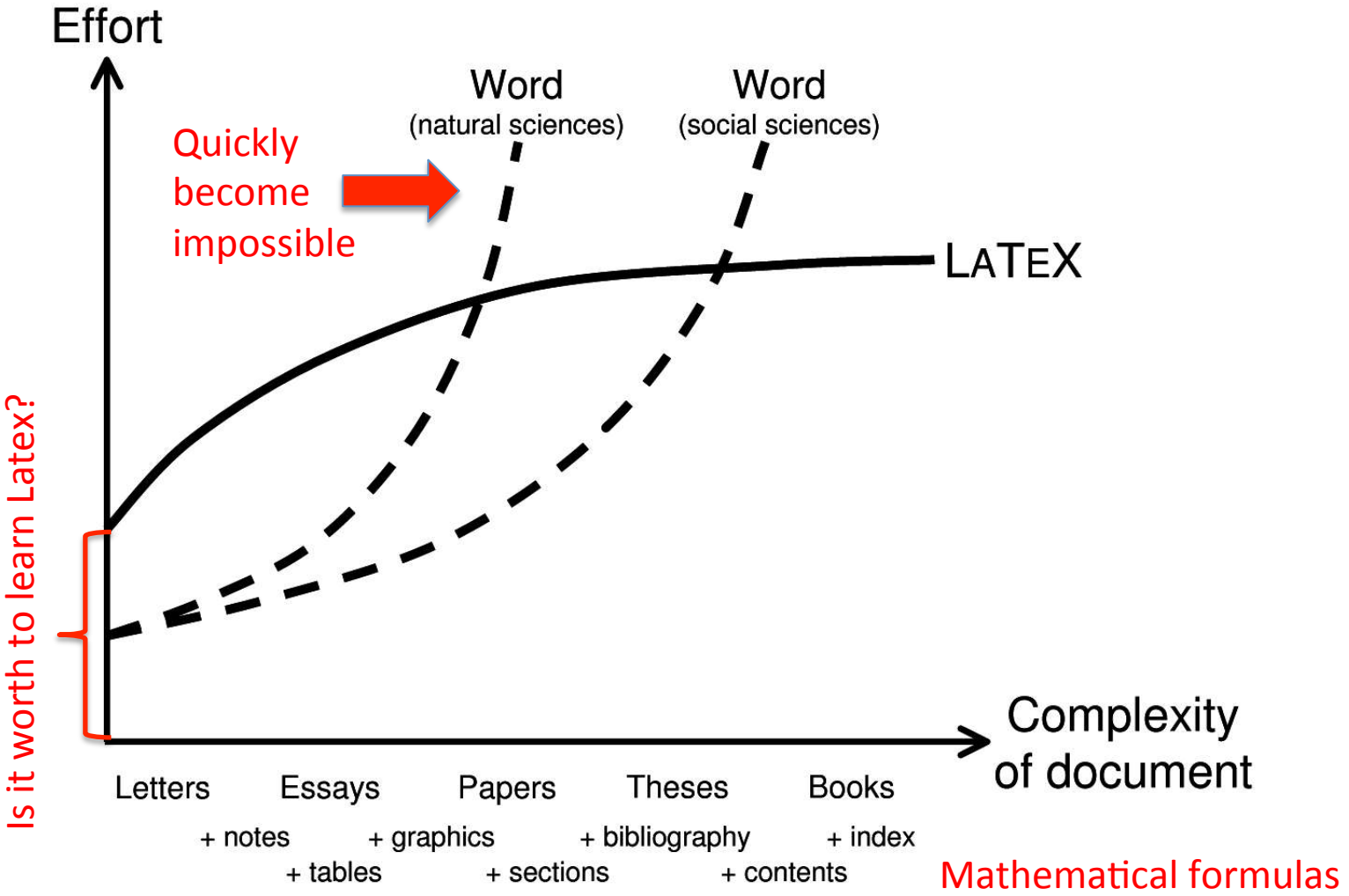
What is Latex

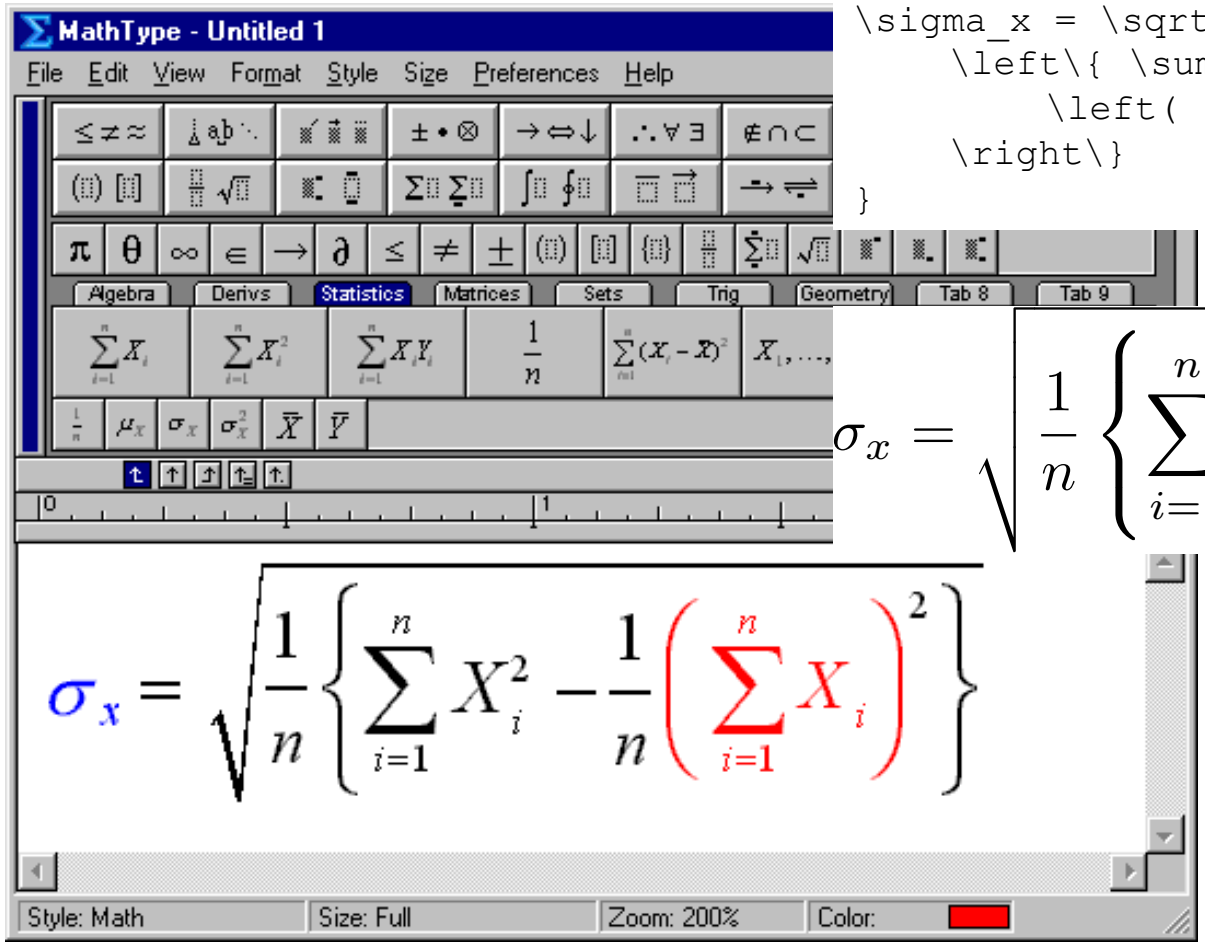
- Latex is a typesetting markup language
- Latex produces high-quality documents
  - Especially mathematical formulas, figures, tables
- Latex was created by scientists for scientists ← you…
- (As we will see soon) Latex is modularized and expandable

Why Latex?



Source: http://programmers.stackexchange.com/questions/47402/what-is-the-best-toolkit-for-writing-long-technical-texts

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\}
}
```

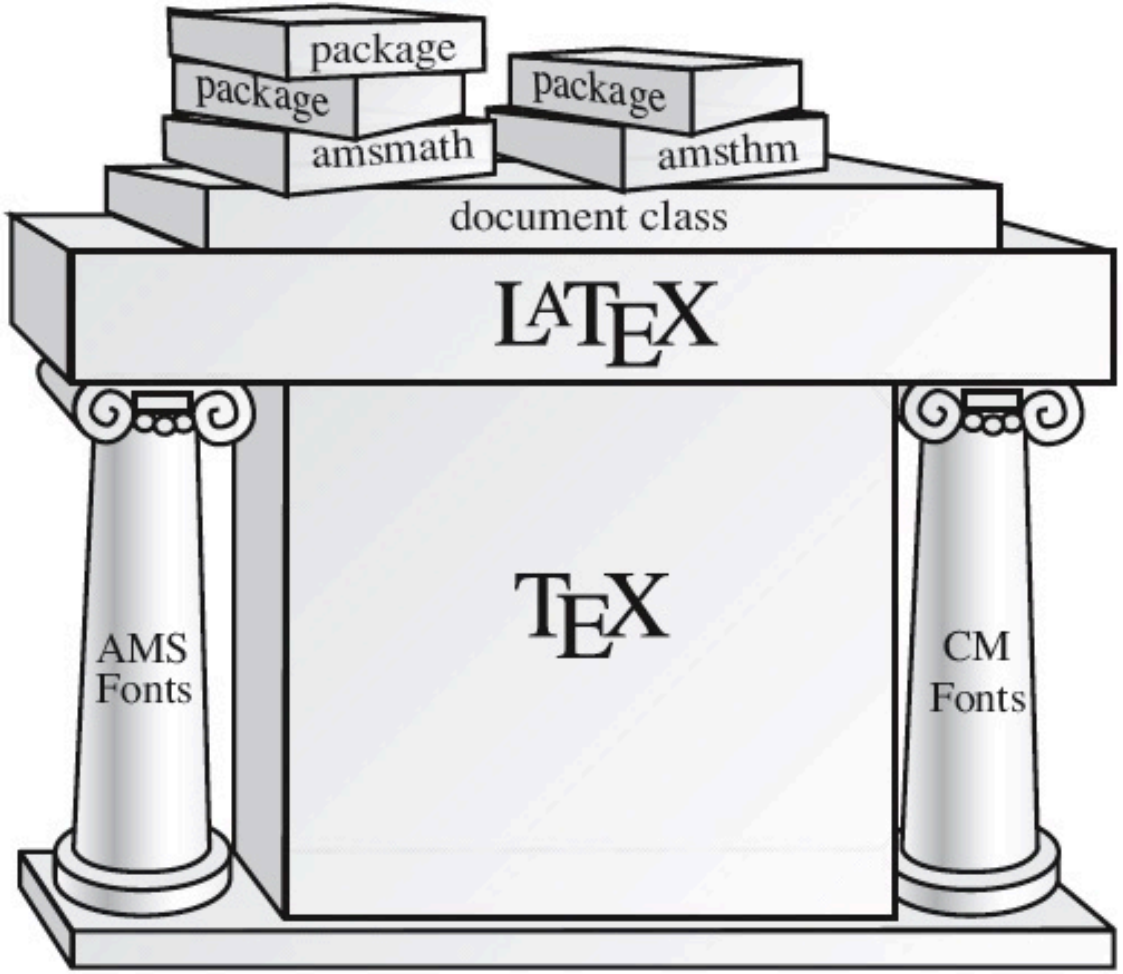
Typesetting

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

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

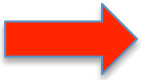
```
\begin{itemize}
\item Monkey
\item Elephant
\item Bear
\end{itemize}
```

- 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}
```



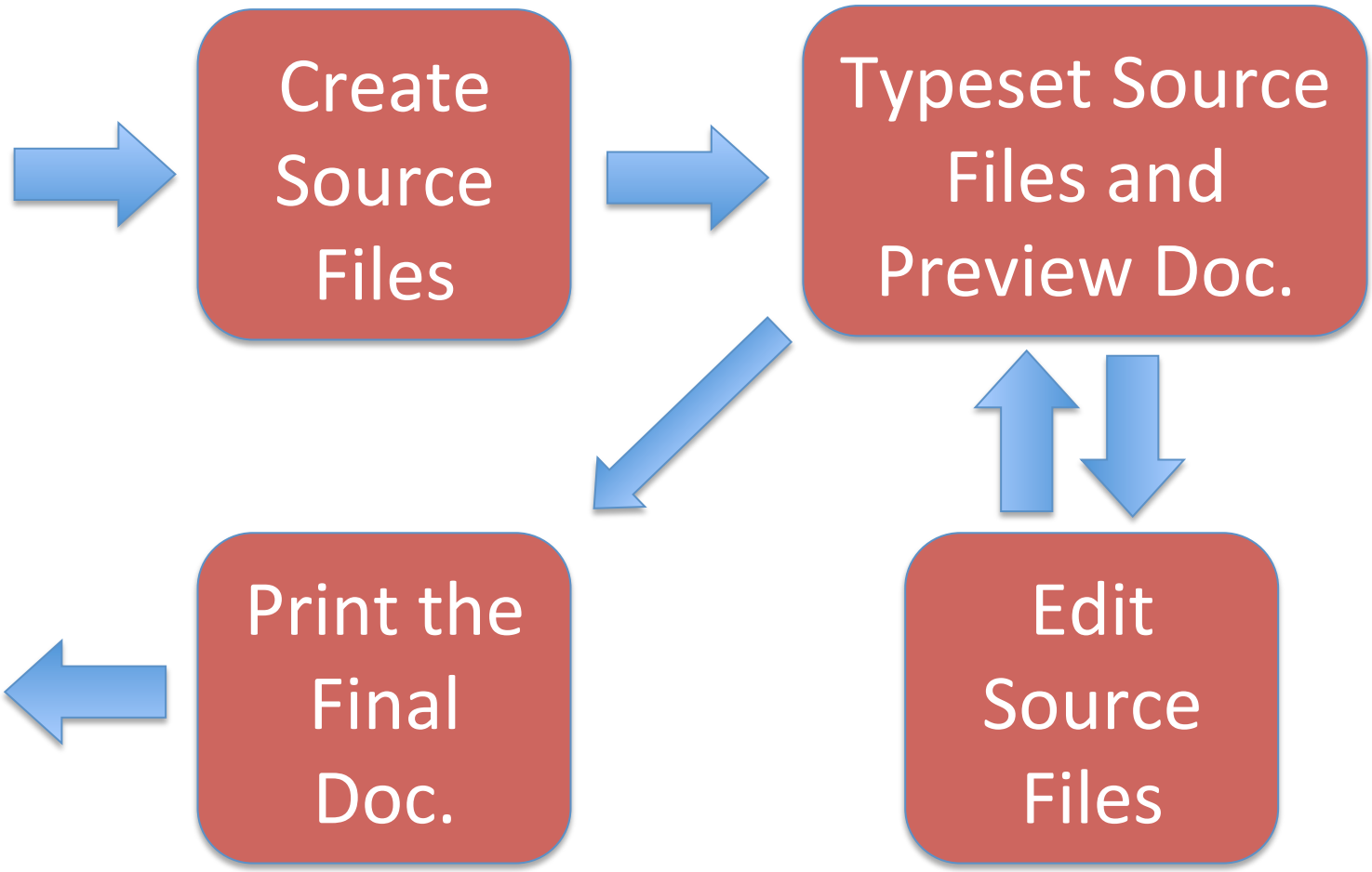
Compared to Word Processors

- 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

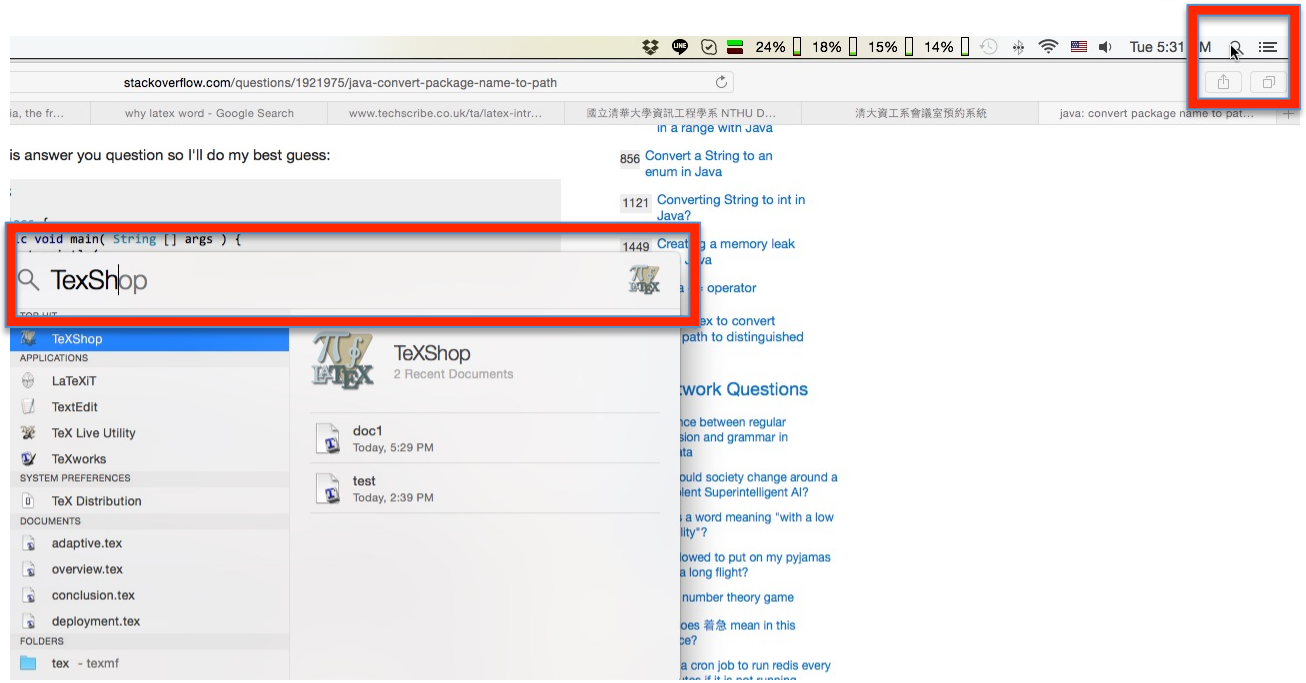
```
%% Overwrite the first paragraph and add WiFi parts
Widely adoption of heterogeneous computing devices, such as PCs, tablets,
smart TVs, and smartphones, urges diverse ways for people to share
photos, watch videos, and play games, with their family and friends.
Most people prefer to use larger or 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

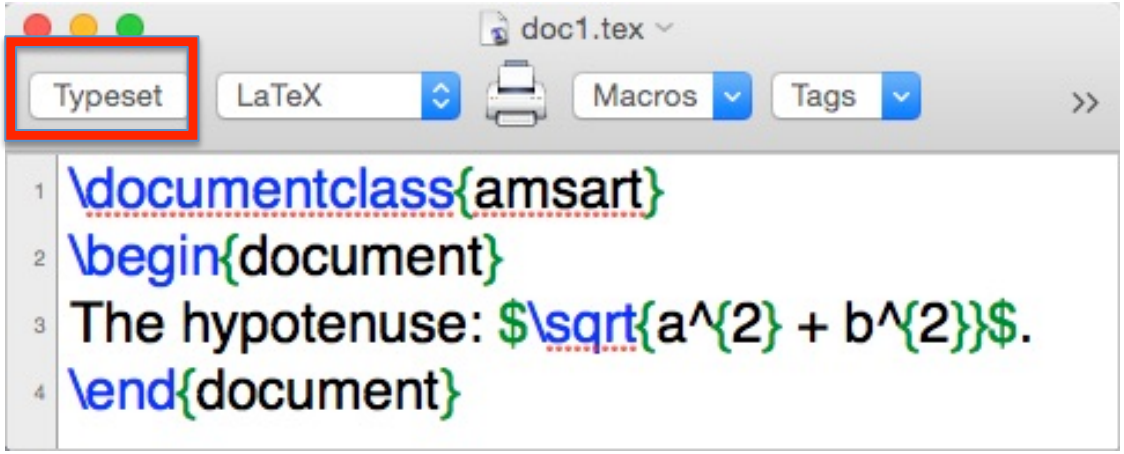


1. Use Spotlight to launch TexShop
2. Choose File -> New to create a new tex file

Step 1: Creating a Source File (cont.)

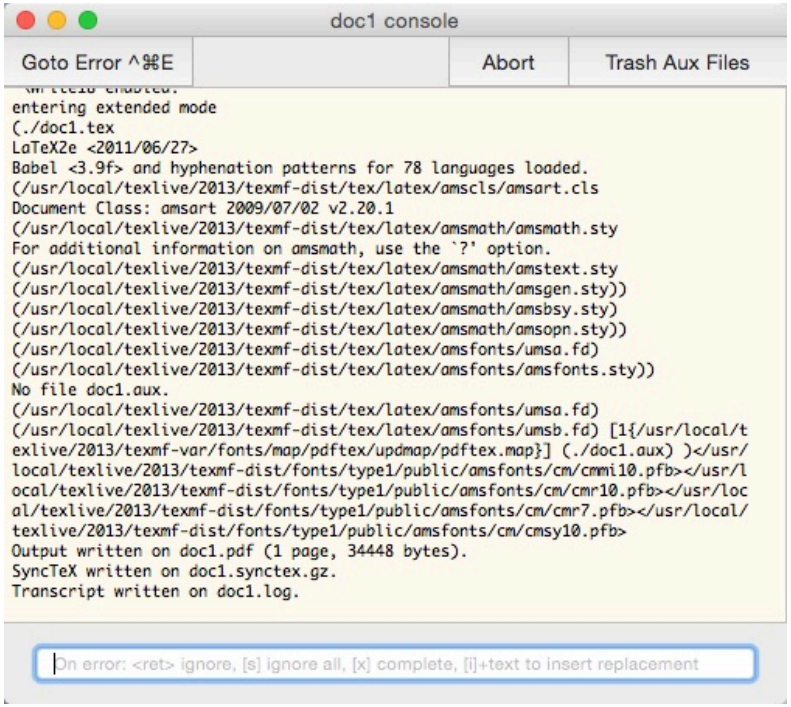
1. Type the above code snippet

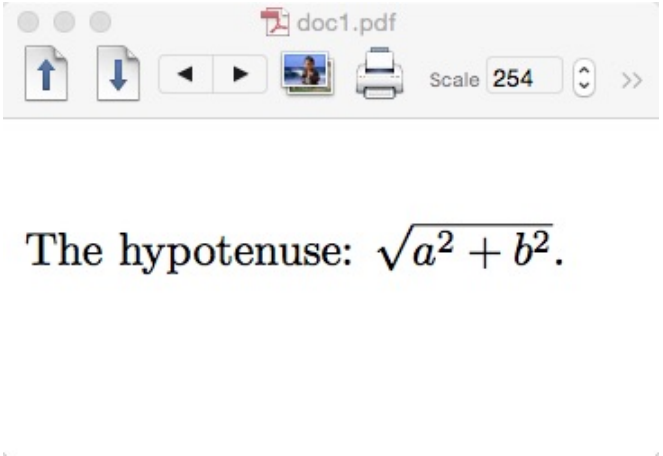
Step 2 Typeset the Source File and Preview Document



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

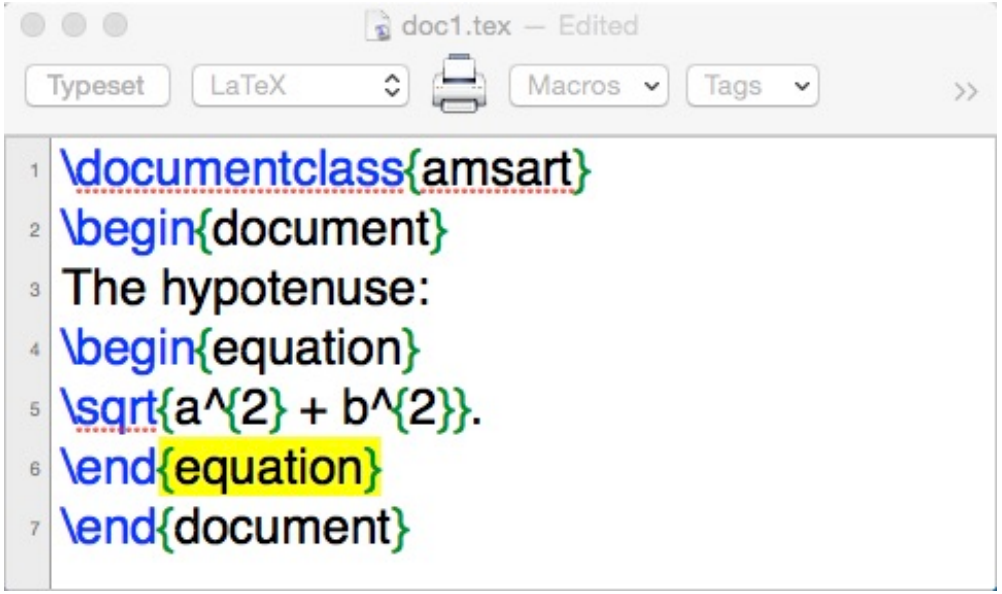
Step 2 Typeset the Source File and Preview Document (cont.)





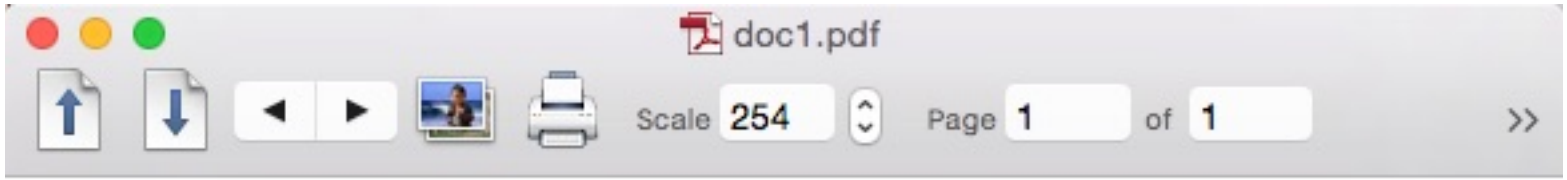
1. Console shows the typesetting messages including warnings and errors
2. Preview window shows the resulting document

Step 3 Edit Source File



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

doc1.tex — Edited

Typeset | LaTeX | Macros | Tags

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

doc1.pdf

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The hypotenuse:

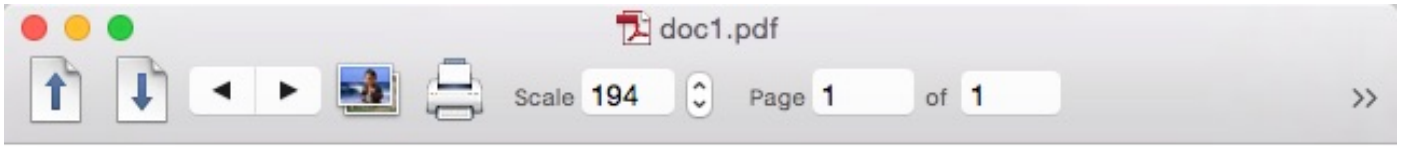
$$\sqrt{a^2 + b^2}. \quad (1)$$

- 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 \em{instructions} to \LaTeX.

Text Math Instruction



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)

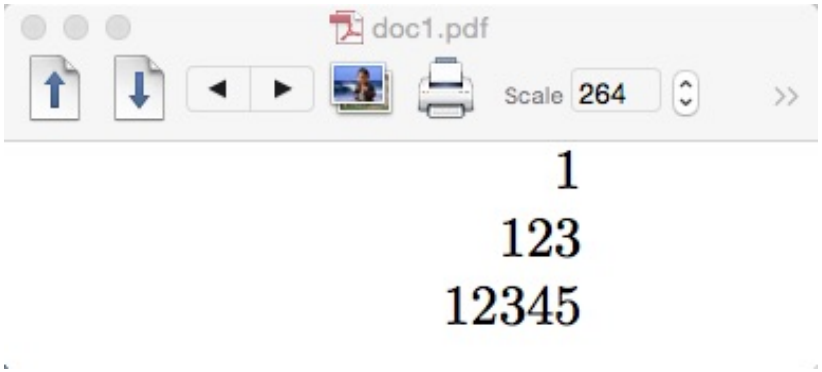
Commands

- 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 $\sim$

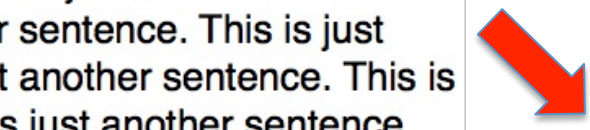
Paragraphs

- A blank line indicates a new paragraph

doc1.tex — Edited

Typeset | LaTeX | Macros | Tags | Templates

```
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}
```



doc1.pdf

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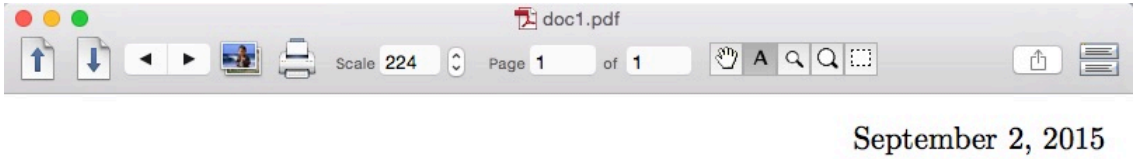
Paragraph 1 starts here.

Paragraph 2 starts here. This is just another sentence.This is jus sentence. This is just another sentence.This is just another sentence 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 Feasures




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

Inline Math

doc1.tex — Edited

Typeset | LaTeX | Macros | Tags

```
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}
```

doc1.pdf

Scale 254

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

Displayed Math

doc1.tex — Edited

Typeset | LaTeX | Macros | Tags

```
\documentclass{article}
\begin{document}
This is a displayed formula:
\[
2 < \frac{x_1}{x_2} > y.
\]

This is another one:
\begin{equation}
2 > |z| < y.
\end{equation}
\end{document}
```

doc1.pdf

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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 $a b$ all typeset into ab
  - ∞a gives ∞a
  - $\inftya$ gives

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

l.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
- $c_1^{x^2}$ $c_1^{x^2}$
- $a_{n'}^{2}$ $a_{n'}^{2}$

Binomial Coefficient

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

Delimiters

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

Ellipses

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

Integrals and Partial Derivatives

- $\int_{0}^{\pi} \sin x \, dx = 2$

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

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

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

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

Matrices

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

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

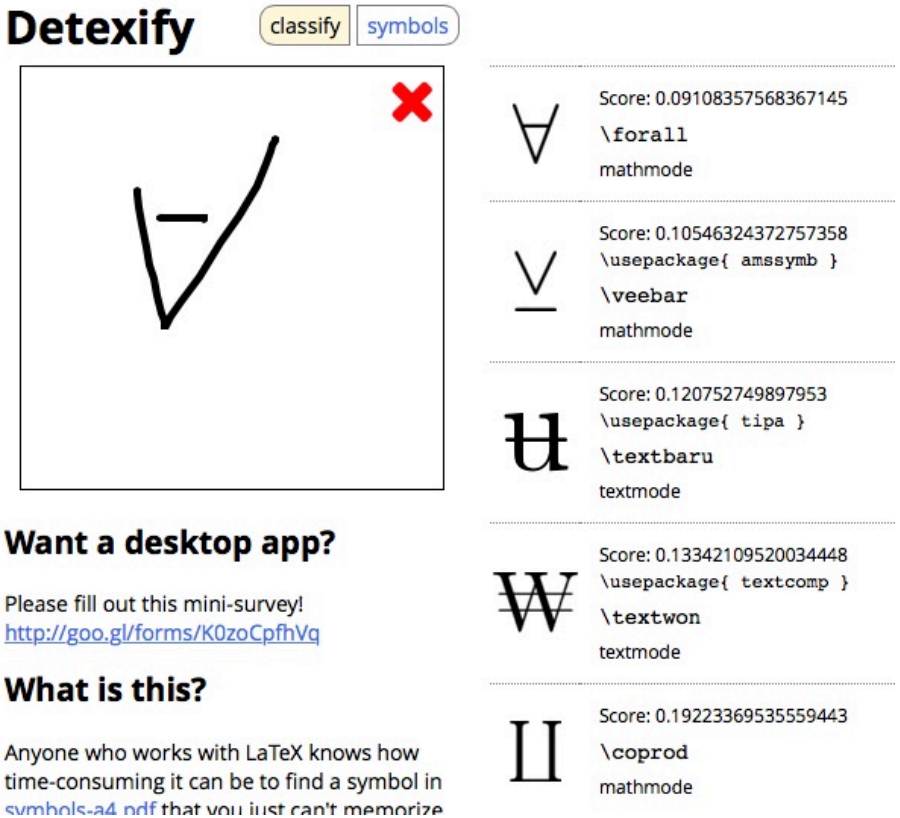
When Running out of Symbols

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

$$\alpha,\ \delta$$

Unknown Symbols?

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



Operators

- $\lim_{x \to 1} f(x) = 0$ $\lim_{x \to 1} f(x) = 0$
- $\displaystyle \lim_{x \to 1} f(x) = 0$ $\displaystyle \lim_{x \to 1} f(x) = 0$

- $\displaystyle \sum_{i=1}^n x_i^2$ $\displaystyle \sum_{i=1}^{n} x_i^2$
- $\prod_{i=1}^n x^2_i$ $\prod_{i=1}^{n} x_i^2$

Embed Text in Formulas

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

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

Labeled Equations

doc1.tex — Edited

Typeset | LaTeX | Macros | Tags

```
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
  condition.
7
8 \end{document}
```

Typeset it once, what do you get?

doc1.pdf

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(1) $$\int -0^{\pi} \sin x \, dx = 3.$$

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 LaTeX's standard document classes* [7] and in Chapter 9 of *The LaTeX 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 align 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 && (line 1) \label{eq:pyth} \\
2u+1 &= v+w^{\alpha} \label{eq:alpha}\\
x       &=\frac{y+z}{2} && (line 3) \nonumber
\end{align}
```

$$r^2 = s_2 + t^2 \qquad (line1) \qquad (1)$$

$$2u + 1 = v + w^{\alpha} \qquad (2)$$

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

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}
$\displaystyle\sum_{i=1}^{n} = \frac{n(n+1)}{2}$, $
\forall n \in \mathbf{Z}^+$.
\end{thm}
\begin{proof}
Type your proof here!
\end{proof}
\end{document}
```

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

Proof. Type your proof here!