

# Latex 1: Latex Basics



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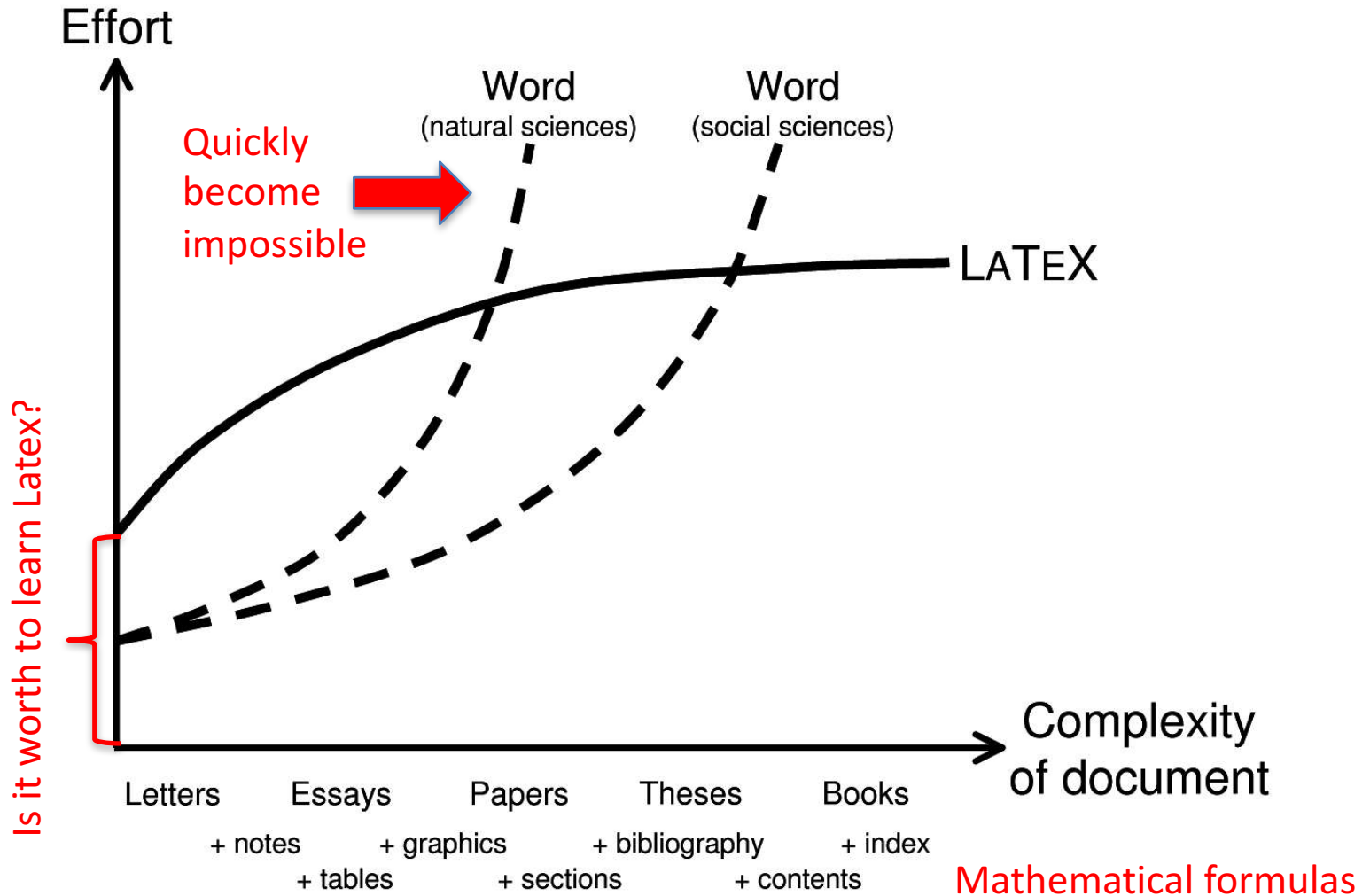
# What is Latex

---

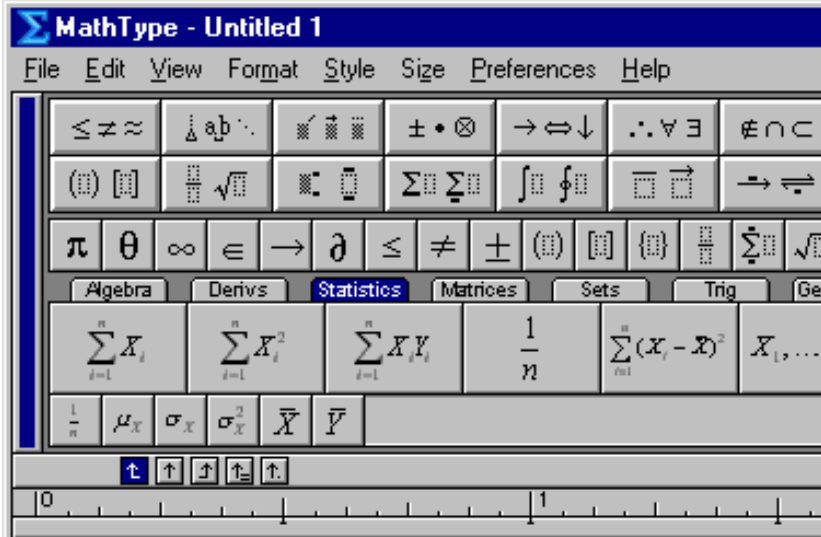
- Latex is a **typesetting markup language**
- Latex produces high-quality documents
  - Especially mathematical formulas, figures, tables
- Latex was created by scientists for scientists ← you...
- (As we will see soon) Latex is modularized and expandable

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

# Why Latex?



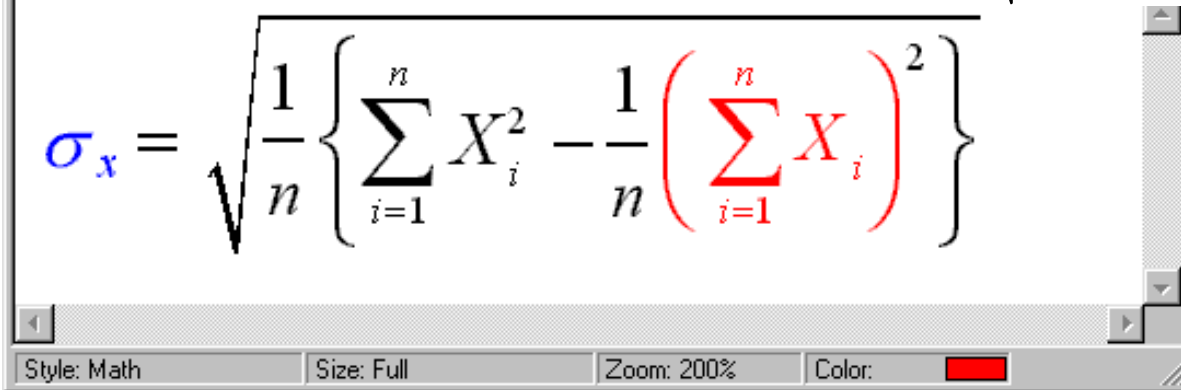
# Beautiful and Easy-to-Type Formulas



```
\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

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

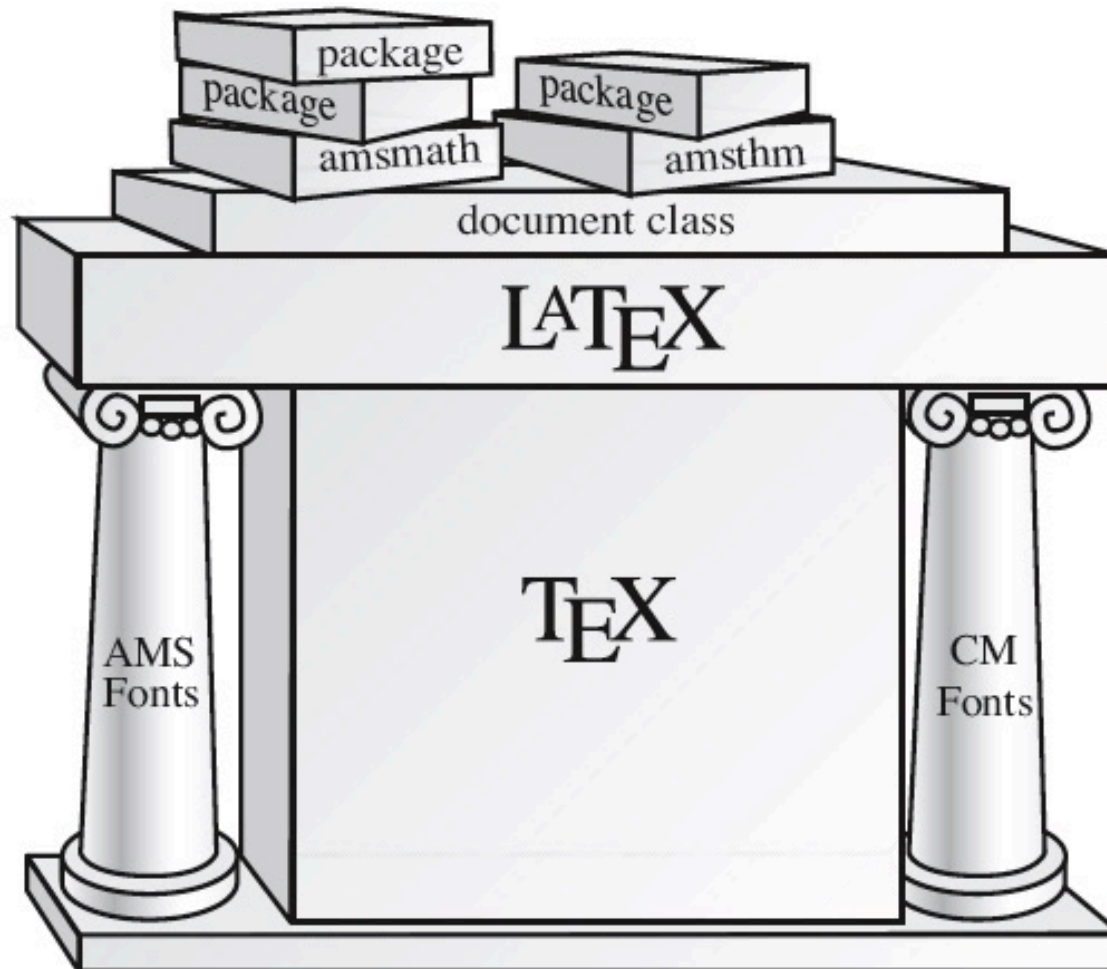


# History of LaTeX

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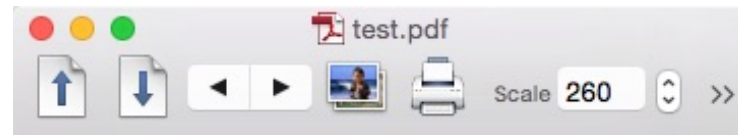
- **Foundation:** Donald Knuth started developing the typesetting language TeX in 1978 ← requires too much typesetting knowledge
- **Platform:** AMS-TeX by Michael Spivak and Latex by Leslie Lamport in early 1980's
  - AMS stands for American Mathematical Society
- **AMS Package:** In 1990's, several 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

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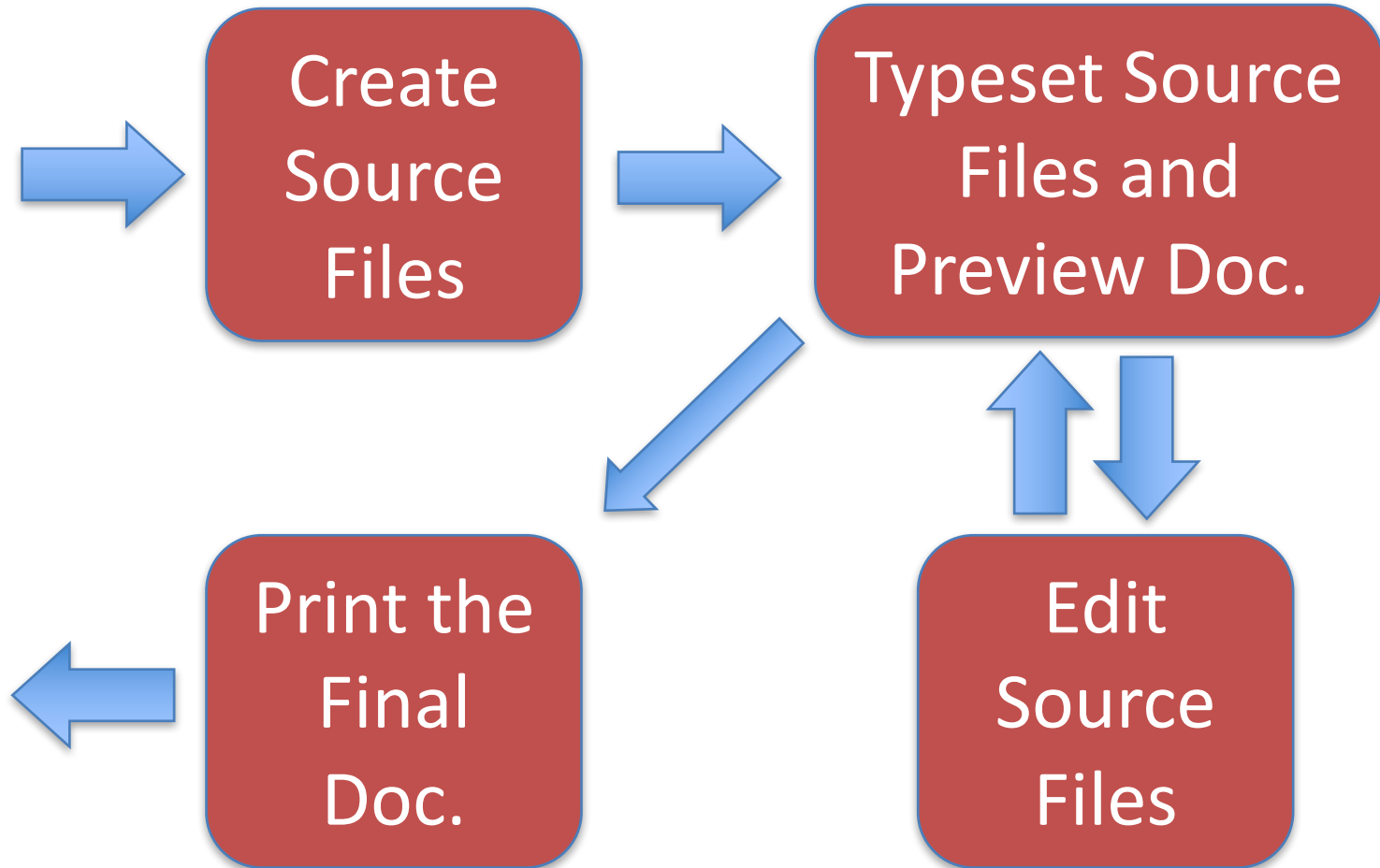
- In Latex, we describe “what is it”, not “how it looks like”
- Focus on your content (not layout) while writing
- Let Latex and its friends to do their jobs

We 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



# Compilers & Integrated Environments

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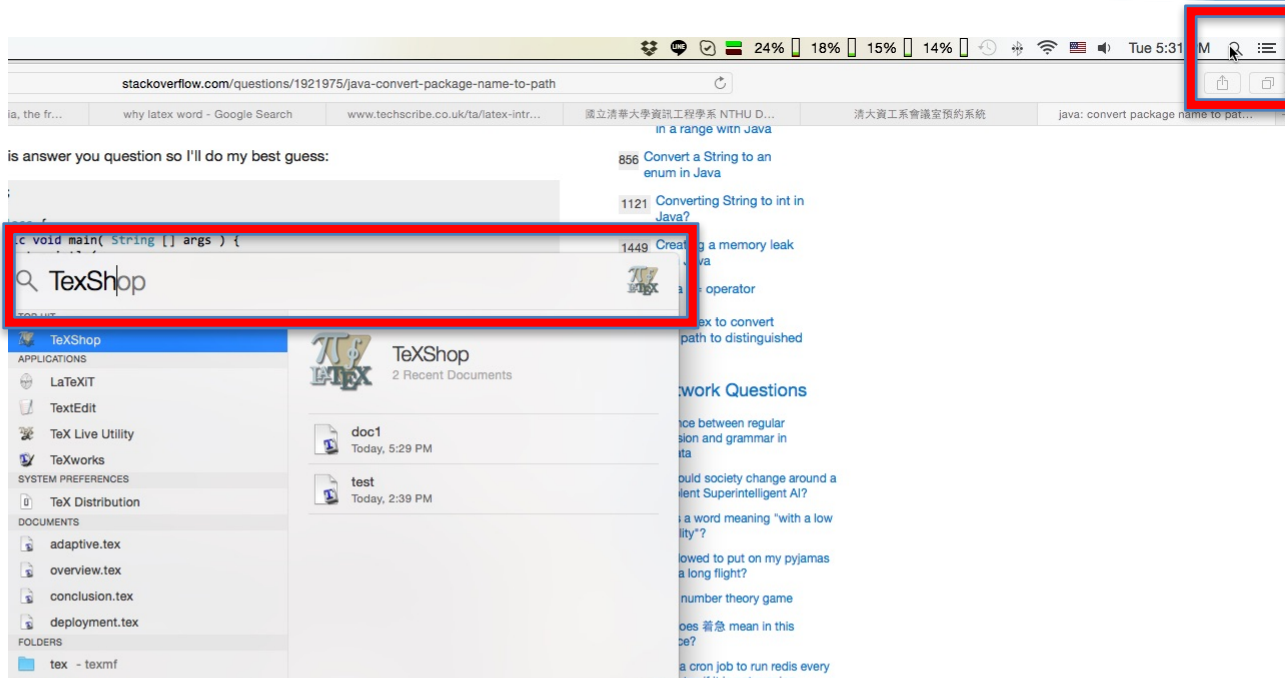
- Compilers
  - MikTeX: <http://miktex.org>
  - MacTeX: <https://tug.org/mactex/>
  - TeXLive: <https://www.tug.org/texlive/>
- IDEs
  - TexShop: <http://pages.uoregon.edu/koch/texshop/>
  - TexMaker: <http://www.xm1math.net/texmaker/>
  - Vim + Makefile: <http://www.vim.org> ← well, not really an integrated environment....

# Other Handy Tools

---

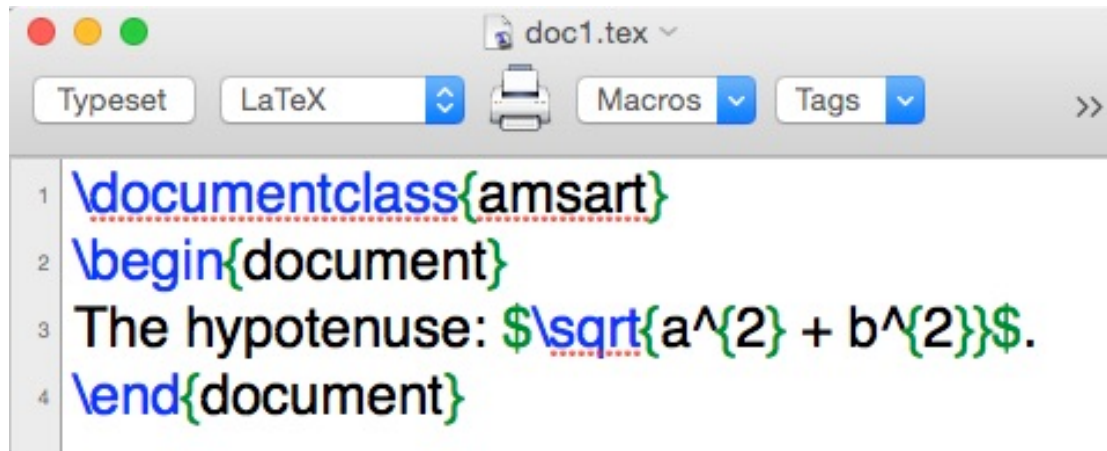
- GSView: <http://pages.cs.wisc.edu/~ghost/gsview/>
- GhostScript: <http://www.ghostscript.com>
- Acrobat: See the download page at CC
- Cygwin: <https://www.cygwin.com>

# Step 1: Creating a Source File



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

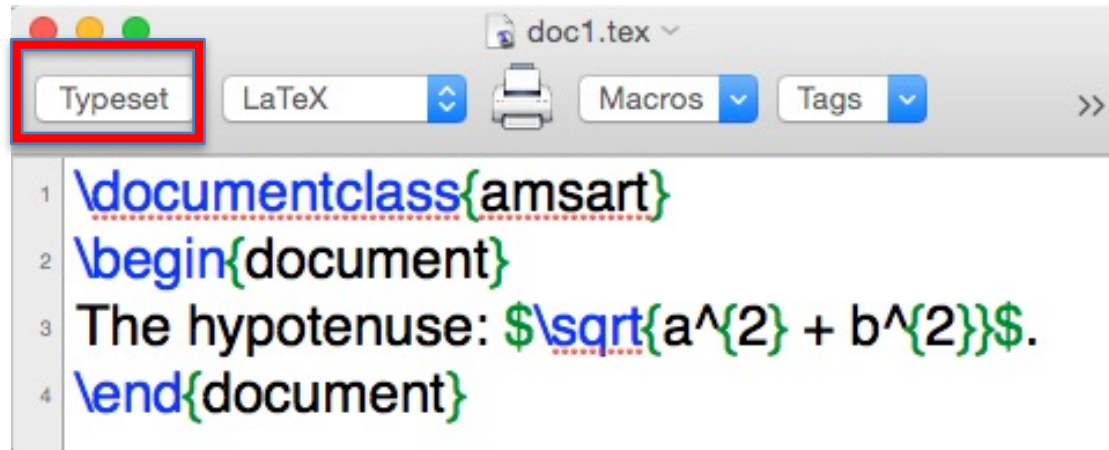
# Step 1: Creating a Source File (cont.)



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

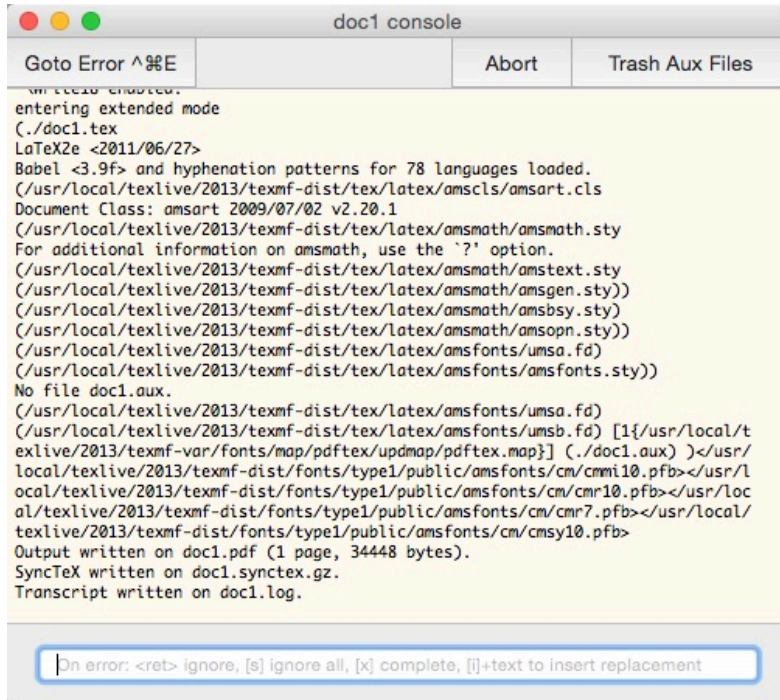
1. Type the above code snippet

# Step 2 Typeset the Source File and Preview Document



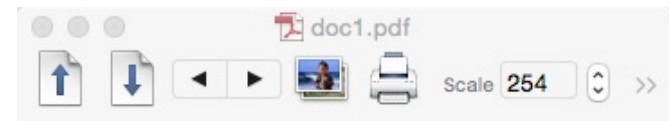
1. Click Typeset button
2. You will be prompted to save the file
3. Save it on the Desktop as doc1.tex

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



```
doc1 console
Goto Error ^␣E Abort Trash Aux Files
! ! !
entering extended mode
./doc1.tex
LaTeX2ε <2011/06/27>
Babel <3.9f> and hyphenation patterns for 78 languages loaded.
(/usr/local/texlive/2013/texmf-dist/tex/latex/amscls/amsart.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/amsbsy.sty)
(/usr/local/texlive/2013/texmf-dist/tex/latex/amsmath/amsopn.sty))
(/usr/local/texlive/2013/texmf-dist/tex/latex/amsfonts/umsa.fd)
(/usr/local/texlive/2013/texmf-dist/tex/latex/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/cm110.pfb></usr/l
ocal/texlive/2013/texmf-dist/fonts/type1/public/amsfonts/cm/cm10.pfb></usr/loc
al/texlive/2013/texmf-dist/fonts/type1/public/amsfonts/cm/cm7.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

[␣n error: <ret> ignore, [s] ignore all, [x] complete, [i]+text to insert replacement
```

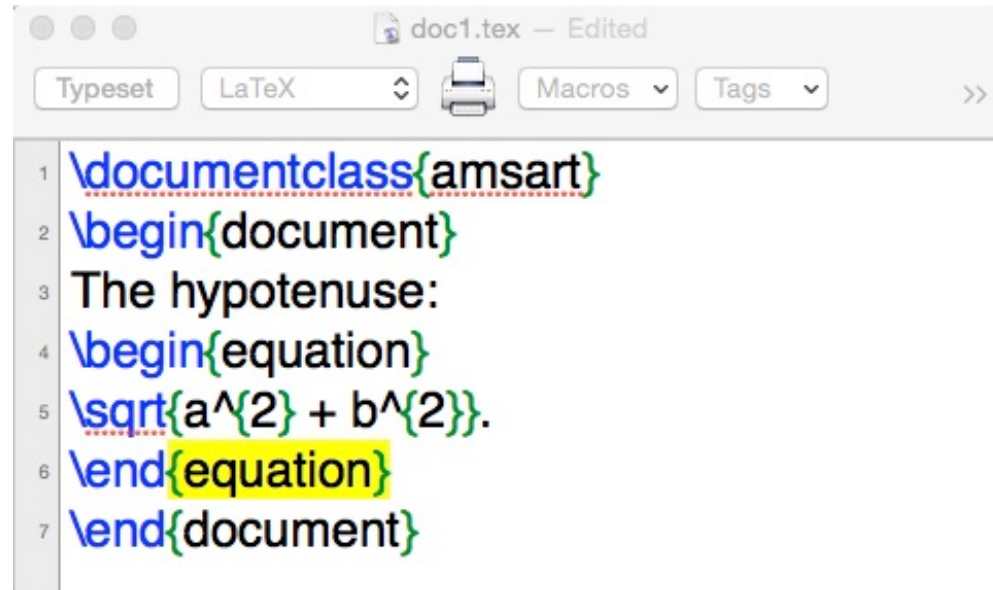


The hypotenuse:  $\sqrt{a^2 + b^2}$ .

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



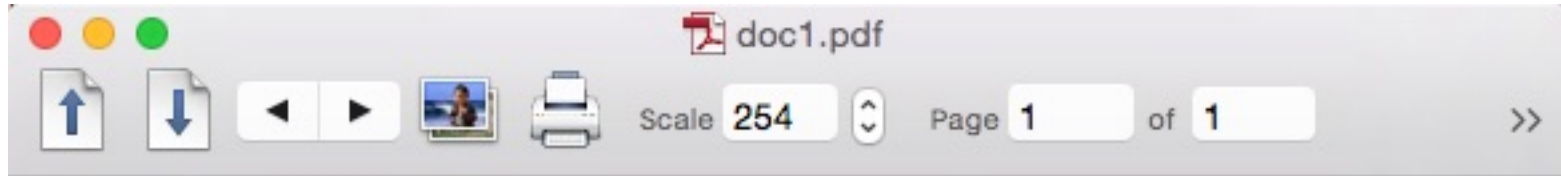
# Step 3 Edit Source File



```
doc1.tex — Edited
Typeset LaTeX Macros Tags >>
1 \documentclass{amsart}
2 \begin{document}
3 The hypotenuse:
4 \begin{equation}
5 \sqrt{a^2 + b^2}.
6 \end{equation}
7 \end{document}
```

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

# Alternative: Do This on Windows

The image shows a Windows 10 desktop environment. In the background, a LaTeX editor window titled "Document : C:/Users/bear/assignment1.tex" is open. The editor's menu bar includes "File", "Edit", "Tools", "LaTeX", "Math", "Wizard", "Bibliography", "User", "View", "Options", and "Help". The main editing area shows the following LaTeX code:

```
1 \documentclass{article}
2 \usepackage{amsthm}
3 \begin{document}
4 The hypotenuse:
5 \begin{equation}
6 \sqrt{a^2 + b^2}.
7 \end{equation}
8 \end{document}
9
```

In the foreground, an Adobe Acrobat Pro window titled "assignment1.pdf" is open, displaying the rendered PDF. The PDF content is:

The hypotenuse:  $\sqrt{a^2 + b^2}.$

The taskbar at the bottom of the screen shows the Windows Start button, search icon, and several application icons including File Explorer, Edge, and the LaTeX editor. The system tray in the bottom right corner displays the date and time as "12:58 PM 9/12/16" and the language as "ENG".

# Documentclass and Comments

The screenshot shows a LaTeX editor window titled 'doc1.tex -- Edited' with a toolbar containing 'Typeset', 'LaTeX', 'Macros', and 'Tags'. The source code is as follows:

```
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}
```

A red arrow points from the source code to the rendered PDF output window titled 'doc1.pdf'. The PDF shows the text 'The hypotenuse:' followed by the equation  $\sqrt{a^2 + b^2}$  and the label '(1)'. The PDF window also shows a toolbar with navigation and printing icons, and a status bar indicating 'Scale 164', 'Page 1 of 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`.



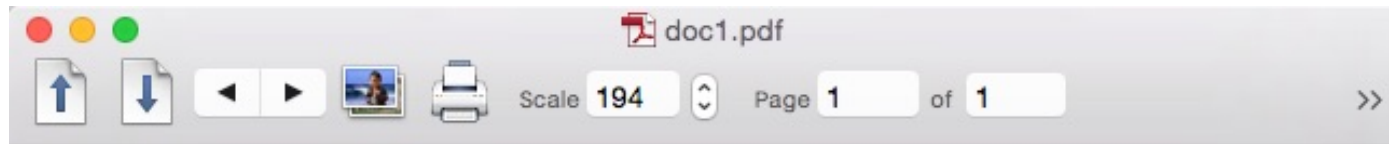
Text



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

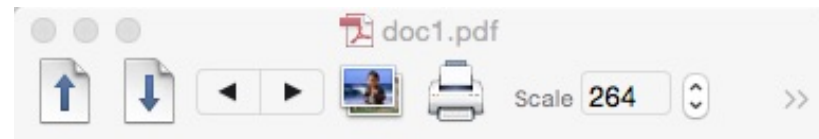
---

- 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}
```



```
1
123
12345
```

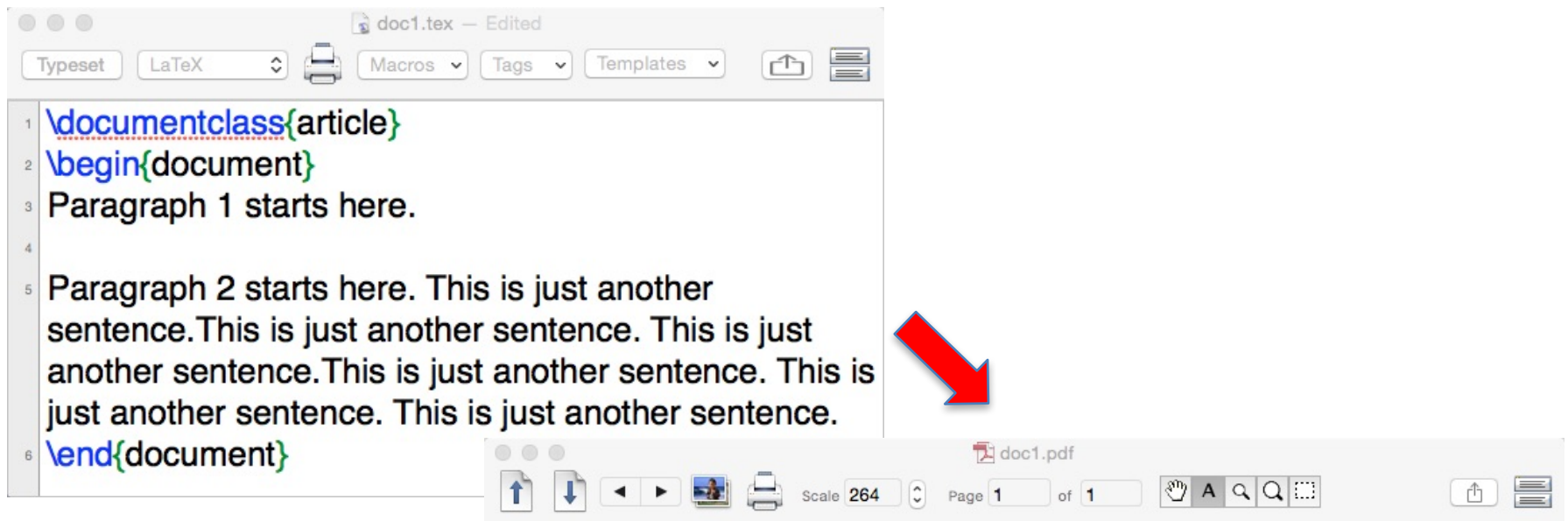
# Special Characters

- #, \$, %, &, ~, \_, ^, \, {, }, “, | 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



Paragraph 1 starts here.

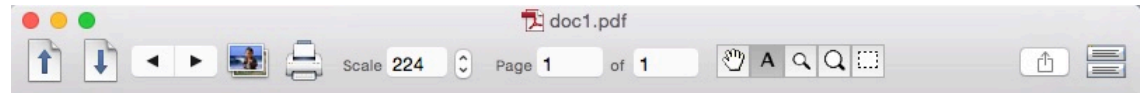
Paragraph 2 starts here. This is just another sentence. This is just another sentence. This is just another sentence. This is just another sentence. This is just another sentence.

# 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**

*Please use my email address*

**george@example.com**

```
\documentclass{article}
```

```
\begin{document}
```

```
\begin{flushright}
```

```
\today
```

```
\end{flushright}
```

```
\textbf{From the desk of George} \\\[24pt]
```

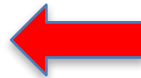
```
\emph{Please use my email address}
```

```
\begin{center}
```

```
\texttt{george@example.com}
```

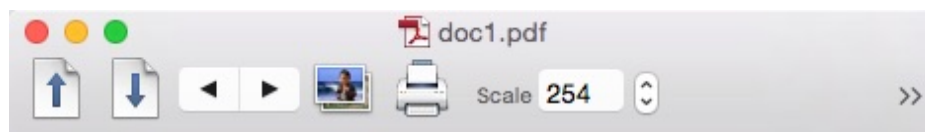
```
\end{center}
```

```
\end{document}
```



# Inline Math

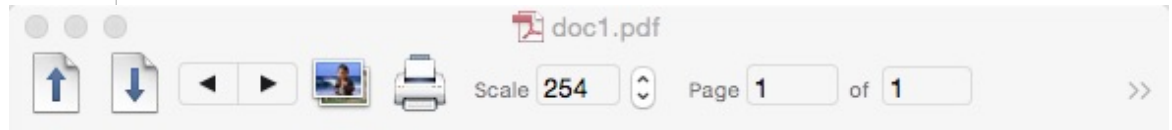
```
doc1.tex -- Edited
Typeset LaTeX Macros Tags >>
1 \documentclass{article}
2 \begin{document}
3 This is an inline formula:  $2 < |x| > y$ .
4
5 This is another one:  $2 > |z| < y$ .
6 \end{document}
```



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

# Displayed Math

```
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}
```



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  $\infty a$

–  $\$\infty a\$$  gives

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

# 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

---

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

# 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 ,
  - $\dot{\phantom{x}}$
  - $1, 2, \dots, 100$
  
- 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]

\]

$$\begin{bmatrix} a + b + c & uv & 28 \\ a + b & u + v & 132 \end{bmatrix}$$

# When Running out of Symbols

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

$\alpha, \delta$

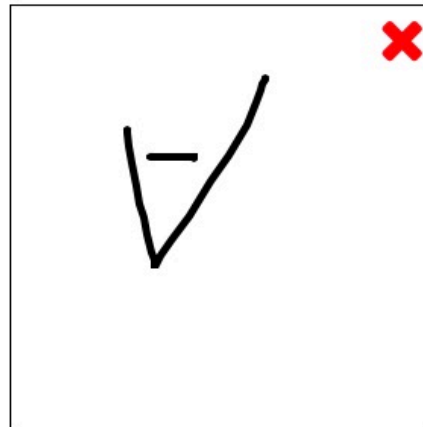
# Unknown Symbols?

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

Detexify

classify

symbols



Score: 0.09108357568367145

`\forall`  
mathmode



Score: 0.10546324372757358

`\usepackage{ amssymb }`  
`\veebar`  
mathmode



Score: 0.120752749897953

`\usepackage{ tipa }`  
`\textbaru`  
textmode



Score: 0.13342109520034448

`\usepackage{ textcomp }`  
`\textwon`  
textmode



Score: 0.19223369535559443

`\coprod`  
mathmode

## Want a desktop app?

Please fill out this mini-survey!  
<http://goo.gl/forms/K0zoCpfnVq>

## What is this?

Anyone who works with LaTeX knows how time-consuming it can be to find a symbol in `symbols-a4.nsf` that you just can't memorize

# Operators

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



# Embed Text in Formulas

---

\[

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

\]

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

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

Typeset it once, what do you get?

doc1.pdf

Scale 254 Page 1 of 1

(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 L<sup>A</sup>T<sub>E</sub>X's standard document classes* [7] and in Chapter 9 of *The L<sup>A</sup>T<sub>E</sub>X 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}
```

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

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

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

# 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

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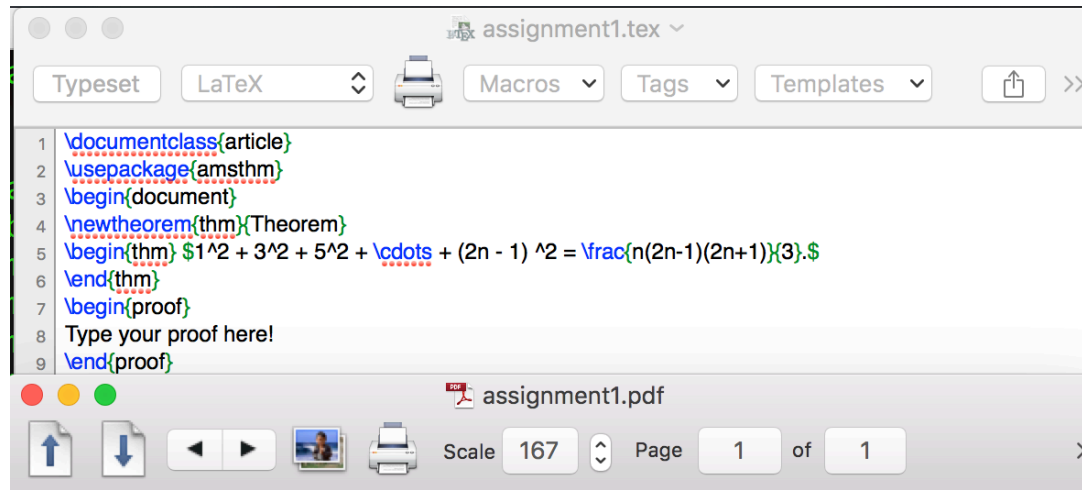
- We introduced the latex basics and its history
- We presented both text and math modes
- We demonstrated the typical workflow of writing with Latex and its friends
- References:
  - <http://www.latex-project.org> ← Official Web and resources
  - <http://link.springer.com/book/10.1007%2F978-0-387-68852-7> ← 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{article}
\usepackage{amsthm}
\begin{document}
\newtheorem{thm}{Theorem}
\begin{thm}  $1^2 + 3^2 + 5^2 + \cdots + (2n - 1)^2$ 
 $= \frac{n(2n-1)(2n+1)}{3}.$ 
\end{thm}
\begin{proof}
Type your proof here!
\end{proof}
\end{document}
```

# Latex #1 Homework (L1) (cont.)



```
assignment1.tex
Typeset LaTeX Macros Tags Templates
1 \documentclass{article}
2 \usepackage{amsthm}
3 \begin{document}
4 \newtheorem{thm}{Theorem}
5 \begin{thm}  $1^2 + 3^2 + 5^2 + \dots + (2n - 1)^2 = \frac{n(2n-1)(2n+1)}{3}.$ 
6 \end{thm}
7 \begin{proof}
8 Type your proof here!
9 \end{proof}
assignment1.pdf
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```

**Theorem 1.**  $1^2 + 3^2 + 5^2 + \dots + (2n - 1)^2 = \frac{n(2n-1)(2n+1)}{3}.$

*Proof.* Type your proof here! □

```
ntcs/cm/cmrm10.pfb></usr/local/texlive/2015/texmf-dist/fonts/type1/
public/amsfont
s/cm/cmrm10.pfb></usr/local/texlive/2015/texmf-dist/fonts/type1/public
amsfonts/
```