AMS Bootcamp: LaTeX Tutorial

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Outline

What is latex?

- Latex is a stable dispersion of polymer microparticles in an aqueous medium.
- It is found in nature, but synthetic latexes can be made by polymerizing a monomer such as styrene that has been emulsified with surfactants.
- Latex as found in nature is a milky fluid found in 10% of all flowering plants.
- It is a complex emulsion consisting of
  - proteins
  - alkaloids
  - starches
  - sugars
  - oils...

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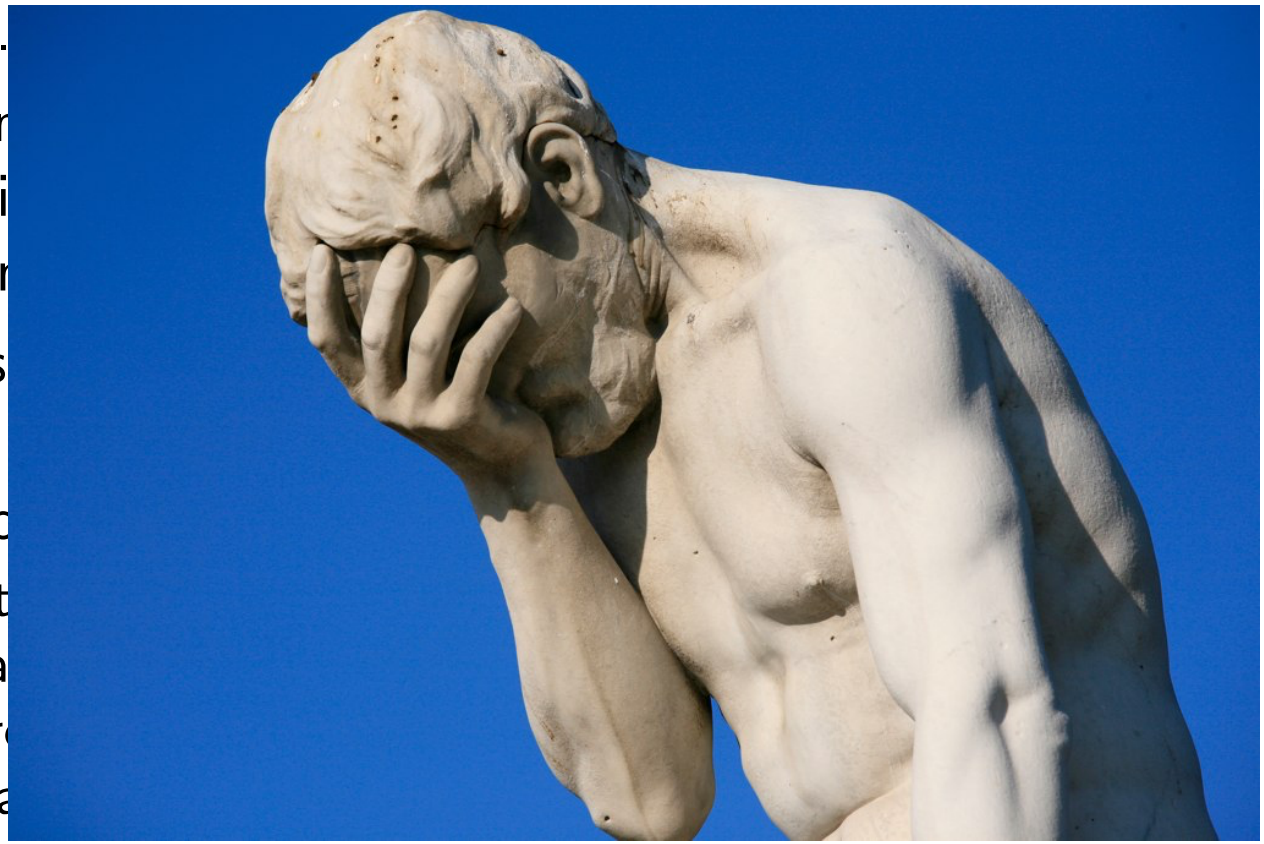
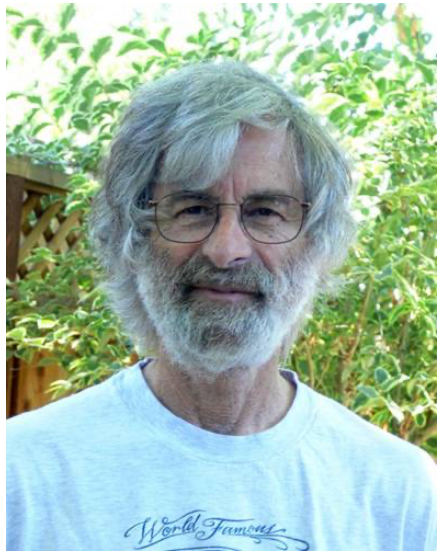
  - oils...



- TeX is a typesetting system for writing developed in 1978 by Donald Knuth.



Donald Knuth (left) and Leslie Lamport (right)

LaTeX and TeX

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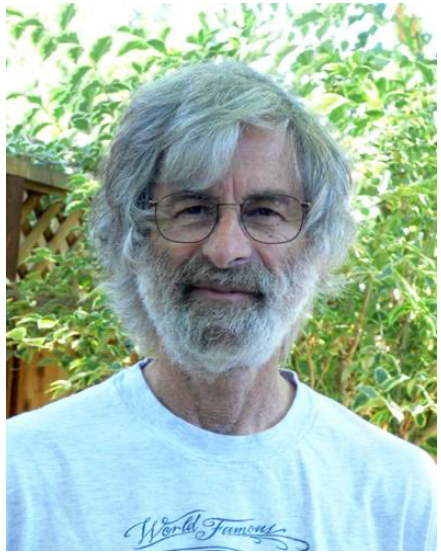
- The letters T, E, X in TeX come from the Greek letters tau, epsilon, and chi.



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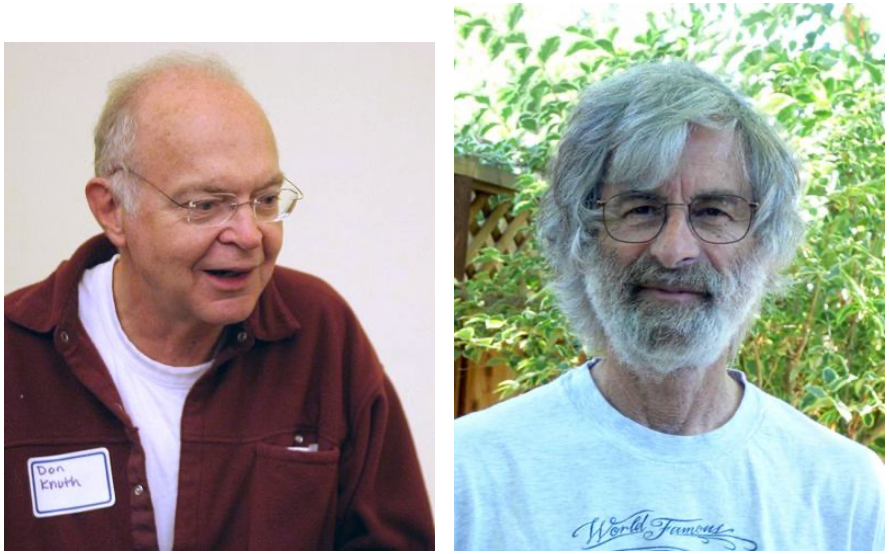
LaTeX and TeX

- TeX is a typesetting system for writing developed in 1978 by Donald Knuth.
- The letters T, E, X in TeX come from the Greek letters tau, epsilon, and chi.
- LaTeX, a document preparation system containing TeX macros for ease of access, was developed by Leslie Lamport in the 1980s (initial release 1984).



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Learning Outcomes

By the end of this tutorial, participants will be able to...

- Write a simple LaTeX article with conscious awareness of preamble and document content.
- Typeset documents containing thoughtfully formatted mathematical expressions/statements.
- Utilize common commands and environments relevant to scientific and mathematical communication.

Uses of LaTeX

- LaTeX allows users to typeset scientific and technical documents, including
  - Journal articles
  - Presentations
  - Textbooks
  - Posters
  - Course notes (Student[1] or Instructor)

[1] This typically takes some familiarity with LaTeX and planning in advance to be effective. Can discuss this afternoon!

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- LaTeX allows users to typeset scientific and technical documents, including
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  - Presentations
  - Textbooks
  - Posters
  - Course notes (Student[1] or Instructor)
- Today, LaTeX-based equation editors are integrated into several common tools utilized in academia:
  - Word processors (e.g. MS Word, Apple Pages)
  - Presentation tools (e.g. MS PowerPoint, Apple Keynote)
  - Learning management and testing tools (e.g. Canvas, GradeScope)

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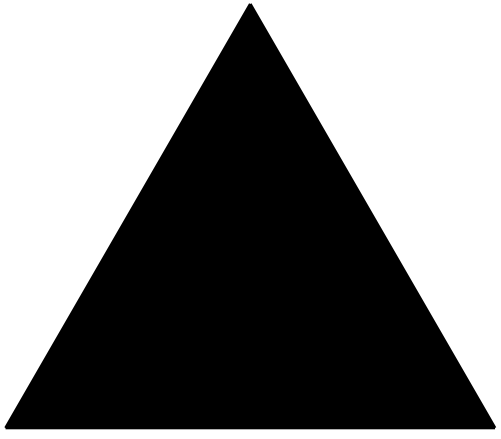
Features

- High-quality typesetting of complicated mathematical formulae
- Clean, sensible default layouts to begin writing with minimal effort
- Fine-tuned control over stylistic details available as needed or desired
- Characters from several alphabets and languages
- Dedicated functionality for organizing documents and presenting information



Drawn in TikZ

Aligned equations

$$\begin{aligned} \dot{x} &= \mu\left(x - \frac{1}{3}x^3 - y\right) \\ \dot{y} &= \dot{y}\frac{1}{\mu}x \end{aligned}$$

Local .png image

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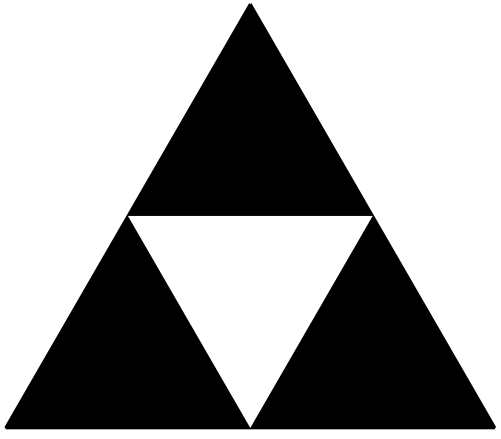

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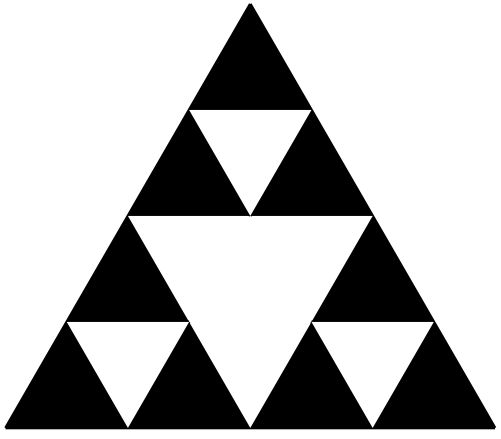

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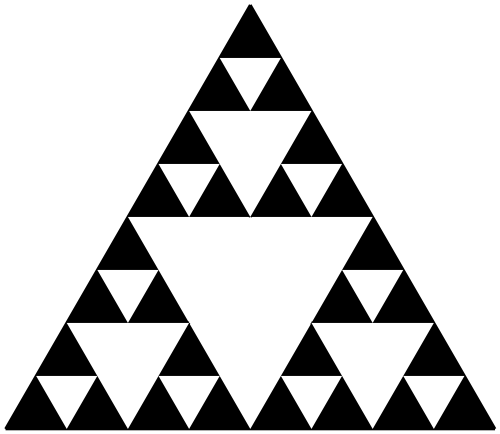

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Aligned equations

$$\dot{x} = \mu\left(x - \frac{1}{3}x^3 - y\right)$$

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Outline

LaTeX Commands

- Indicated by a backslash "\" preceding the command name
- Processed by LaTeX as a set of instructions
- General structure:

```
\commandname[<optional arguments>]{<mandatory arguments>}
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Note

Not all commands have optional arguments.

Document Class

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- The available options depend on the choice of class

Example

Journal article with A4 paper size and 12-point font

```
\documentclass[a4paper,12pt]{article}
```

Hello, World!

```
\documentclass{article}

\begin{document}

  Hello, World!

\end{document}
```

General Layout

The `Hello, World!` program illustrates the two primary components of a LaTeX document:

- Preamble
  - Document properties (including required `\documentclass` *command*)
  - Packages and libraries
  - Style and format settings (whole document)
  - Title-page information
  - Custom commands

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The `Hello, World!` program illustrates the two primary components of a LaTeX document:

- Preamble
  - Document properties (including required `\documentclass` *command*)
  - Packages and libraries
  - Style and format settings (whole document)
  - Title-page information
  - Custom commands
- Document
  - All writing and displayed content contained within `document` *environment*
  - Many settings may be changed within the document part (e.g. for local formatting)
  - Can be organized into sections, subsections, paragraphs, etc.

Outline

Preamble

`\usepackage[<options>]{<packages>}`

- Additional commands, options, and environments available
- Multiple packages can be listed within the same pair of braces (with same/no options declared)
- Packages can inherit options from the `\documentclass` command

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Example

Loads packages for mathematics typesetting, enumeration and multiple-column formatting, and graphical tools:

```
\usepackage{amsmath, amsthm, amssymb, mathtools, enumitem,
multicols, tikz, pgfplots}
```

Preamble

```
\title{<Document Title>}
\author{<Name>}
\date{<Date>}
```

Document

```
\maketitle
```

Document

```
\section{<Section Title>}
\subsection{<Subsection Title>}
\subsubsection{<Subsubsection Title>}
```

- Sections are numbered in the order that they appear within the `document` environment by default.
- An asterisk "*" between the command name and braces suppresses the numbering for that section.

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Example

```
\section*{Cheesy Maths Jokes}
\subsection*{Infinitely Many Mathematicians\dots}
```

Document

```
\begin{<environment>}
<Content>
\end{<environment>}
```

Document

```
\begin{<environment>}
<Content>
\end{<environment>}
```

- Environments alter the typesetting rules
- Can be nested when multiple environments are in play
- The `document` environment is necessary at the outermost level of each LaTeX file

More to come...

Common Commands

Miscellany

- `\textbf{}`, `\textit{}`, `\underline{}`

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- \centering, \raggedright, \raggedleft

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- \centering, \raggedright, \raggedleft
- \dots, \cdots, \vdots, \hdots, \ddots

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- \centering, \raggedright, \raggedleft
- \dots, \cdots, \vdots, \hdots, \ddots
- \newline, \newpage, \vspace{}, \hspace{}, \rule{}{}

Common Environments

Listing

- "Listing environments" provide various formats for listed content

[2] With package `enumitem`, the list appearance may be easily customized, e.g. (a), (b), (c) instead of 1., 2., 3.

Common Environments

Listing

- "Listing environments" provide various formats for listed content
- Items in the list are distinguished by the `\item` command.
  - `itemize` – bulleted list
  - `enumerate` – ordered list[2]
  - `description` – Description list; requires command `\item[<description>]`, with `<description>` used instead of a bullet or number.

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Example

```
\begin{description}
\item[First] The first thing
\item[Second] A second thing
\end{description}
```

[2] With package `enumitem`, the list appearance may be easily customized, e.g. (a), (b), (c) instead of 1., 2., 3.

Common Environments

Floating Bodies

A **float** is a container for content in a document that cannot be broken over a page (as opposed to, say, freely typed text).

```
\begin{<float>}[placement]
<Content>
\end{<float>}
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Common Environments

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- Common floats:
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  - `figure`

Common Environments

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\end{<float>}
```

- Common floats:
  - `table`
  - `figure`
- Placement options
  - t – "top"
  - h – "here"
  - b – "bottom"
  - p – "separate page"
  - ! – "override LaTeX parameters"

Common Environments

Float Example

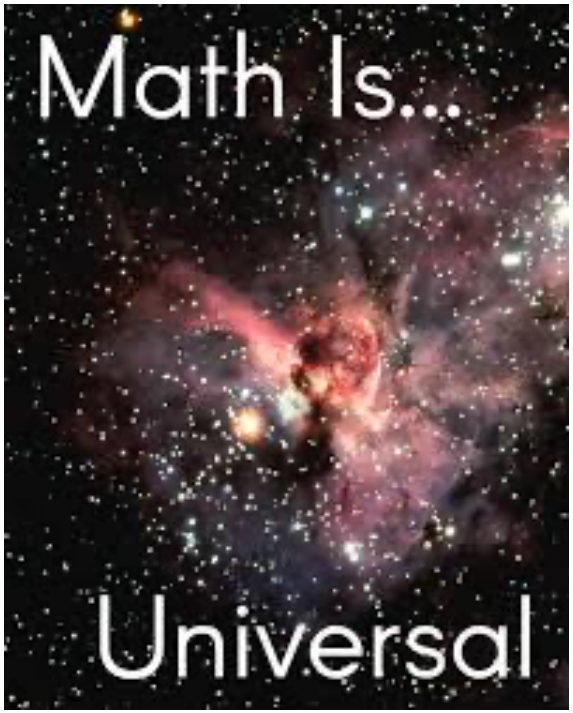

Figure: Re-creation of South Park's iconic "Math is universal" poster. https://andyborne.com/math/freestuff.html

Common Environments

Float Example

Math is universal

```
\begin{figure}[h]
\includegraphics[width=0.3\textwidth]{math_universal.png}
\label{fig:math_universal}
\caption{Re-creation of South Park's iconic ``Math is
universal'' poster. https://andyborne.com/math/freestuff.html}
\end{figure}
```

Notes

- The commands `\includegraphics`, `\caption`, and `\label` belong *inside* the `figure` (or other `<float>`) environment
- The marker used for `\label{<marker>}` is the same one used to reference this figure elsewhere in the document with `\ref{<marker>}`

Common Environments

Tables

```
\begin{tabular}[<position>]{<columns>}
<Content>
\end{tabular}
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Tables

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<Content>
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- Position does not need to be specified by default, and can also be inherited if the `tabular` environment is nested within a `table` (float) environment.
- The `<columns>` option conveys how many columns the table contains and the justification (alignment) of each:
  - l – left-justified
  - c – center-justified
  - r – right-justified

Table of Greek letters

```
\begin{table}[t]
\caption{Some Greek Letters}
\begin{tabular}{| c | c | c |}\hline
Letter & Lowercase & Uppercase \\ \hline
alpha & $\alpha$ & $\mathrm A$ \\ \hline
beta & $\beta$ & $\mathrm B$ \\ \hline
gamma & $\gamma$ & $\Gamma$ \\ \hline
\end{tabular}
\label{tbl:greek}
\end{table}
```

Some Greek Letters

Letter	Lowercase	Uppercase
alpha	α	A
beta	β	B
gamma	γ	Γ

Some Greek Letters

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Notes

- Vertical bars within the `<columns>` option add vertical lines at corresponding boarders to columns
- The command `\\` moves to the next row of the table
- The command `\hline` adds a horizontal line at the boarder above the following row

Text environments create a block of text with modified typesetting rules for various circumstances:

- `quote` – Indented quote block
- `quotation` – Like quote, but with indented paragraphs
- `verse` – Like quotation, but indentation inverted
- `verbatim` – Monospaced text with literal characters (good for replicating computer code in LaTeX)
- `verbatim*` – Like verbatim, but with spaces as ␣

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- References are formatted automatically based on the `\bibliographystyle{<style>}` (preamble) command.
- The command `\bibliography{<filename>}` places the bibliography in the document.
- Each source in BibTeX has an associated reference key (user-determined) for use in citations.
  - The command `\cite{<key>}` will place an in-line citation to the corresponding reference.
  - Only sources that are cited in line will be added to the displayed reference list.

The following would be placed in the `.bib` file corresponding to the LaTeX document:

```
@article{Man2002, % cite key
title={The oral glucose minimal model: Estimation of insulin se
author={C. D. Man and A. Caumo and C. Cobelli},
journal={IEEE Transactions on Biomedical Engineering},
year={2002},
volume={49},
pages={419-429}
}
```

Outline

Math Mode

In order for text within a paragraph to be typeset as mathematics, a special environment is used: `$...$` or `\(...\)`.

Example

Euler's Identity: `$e^{i\pi}+1=0$`

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- **Math mode** refers to the designation of special typesetting rules in effect within certain environments.
- Normal text is not processed as such within math mode (words are processed like strings of successive variables, and spaces are skipped, for instance).
- Math mode offers access to a wide assortment of commands relevant to mathematics, and to scientific and technical writing involving specialized notation

Mathematical Commands and Operators

A very small sample

Command	Example	Command	Example
\rightarrow	$\rightarrow$	\Rightarrow	$\Rightarrow$
\rightharpoonup	$\rightharpoonup$	\frac{a}{b}	$\frac{a}{b}$
\in	$\in$	\ni	$\ni$
\sum_{j=1}^n	$\sum_{j=1}^{n}$	\prod_{j=1}^n	$\prod_{j=1}^{n}$
\partial	∂	\int_a^b	$\int_a^b$
\iint_a^b	$\iint_a^b$	\oint_a^b	$\oint_a^b$

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`\in`	$\in$	`\ni`	$\ni$
`\sum_{j=1}^n`	$\sum_{j=1}^{n}$	`\prod_{j=1}^n`	$\prod_{j=1}^{n}$
`\partial`	∂	`\int_a^b`	$\int_{a}^{b}$
`\iint_a^b`	$\iint_{a}^{b}$	`\oint_a^b`	$\oint_{a}^{b}$

Operator	Example	Operator	Example
`\lim_{x\to\infty}`	$\lim_{x\to\infty}$	`\max_{n\le c}`	$\max_{n\le c}$
`\arcsin`	$\arcsin$	`\cos^2`	$\cos^2$
`\exp`	$\exp$	`\ln`	$\ln$

Outline

Display Mode

Math Environments

- Several environments exist that typeset mathematical symbols in a larger format than their inline counterparts.
  - `\begin{equation}...\end{equation}` – numbered equation (single label for environment, regardless of number of equations)
  - `\[...\]` – equation with numbering suppressed (can use `equation*` environment, too)
  - `\begin{align}...\end{align}` – multiple equations (or columns of equations) with vertical alignment specified by "&" (one label per equation)

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  - `\begin{align}...\end{align}` – multiple equations (or columns of equations) with vertical alignment specified by "&" (one label per equation)
- Within the environments above, math is set in "display style" (as opposed to the "text style" of inline math)

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Math Environments

- Several environments exist that typeset mathematical symbols in a larger format than their inline counterparts.
  - `\begin{equation}...\end{equation}` – numbered equation (single label for environment, regardless of number of equations)
  - `\[...\]` – equation with numbering suppressed (can use `equation*` environment, too)
  - `\begin{align}...\end{align}` – multiple equations (or columns of equations) with vertical alignment specified by "&" (one label per equation)
- Within the environments above, math is set in "display style" (as opposed to the "text style" of inline math)
- Typically used for the mathematical statements within important results, esp. to be referenced elsewhere

Display Mode

Single-Equation Example

Code

```
\begin{equation}
\forall\varepsilon>0,\,\exists\delta>0 such that \left\lvert
x-c\right\rvert>\delta\Rightarrow\left\lvert
f(x)-L\right\rvert>\varepsilon.
\end{equation}
```

$$\forall\varepsilon > 0,\, \exists\delta > 0 \text{ such that } |x - c| < \delta \Rightarrow |f(x) - L| < \varepsilon. \tag{1}$$

Display Mode

Multiple-Equation Example

Code

```
\ begin{align}
\dot G(t)&=-\left[p_1+X(t)\right]G(t)+p_1\cdot G_b&
    G(0)&=G_b,\\
\dot X(t)&=-p_2X+p_3\left[I(t)-I_b\right],&
    X(0)&=0.
\ end{align}
```

$$\dot{G}(t) = -\left[p_1 + X(t)\right] G(t) + p_1 \cdot G_b, \qquad G(0) = G_b, \tag{2}$$

$$\dot{X}(t) = -p_2 X + p_3 \left[I(t) - I_b\right], \qquad X(0) = 0. \tag{3}$$

Numbering may be suppressed by using environment `align*`.

Delimiters

- Delimiters act logically like parentheses
- Can only be used in math mode (though the related symbols may be used in text mode)
- Delimiters should "fit" around the expressions they encompass: precede with `\left` and `\right` for auto-sizing.

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LaTeX Delimiters

Delimiter	Text
Parentheses	`( )`
Brackets	`[ ]`
Braces	`\{ \}`
Angle Brackets	`\langle \rangle`
Vertical Lines	`\lvert \rvert`
Double Vertical Lines	`\lVert \rVert`

Math Fonts

Font	Command	Examples	Required Packages
Blackboard	`\mathbb{}`	$\mathbb{N}, \mathbb{Z}, \mathbb{R}, \mathbb{C}$	`amssymb`
Calligraphic	`\mathcal{}`	$\mathcal{R}, \mathcal{B}, \mathcal{P}$	None
Roman	`\mathrm{}`	$\mathrm{A}, \mathrm{B}, \mathrm{K}$	None
Italic	`\mathit{}`	$\mathit{123}, \mathit{abc}, \mathit{ABC}$	None
Script	`\mathscr{}`	$\mathscr{C}, \mathscr{L}, \mathscr{B}$	`mathrsfs`

Additional Resources

- https://www.overleaf.com/learn
- https://www.latex-tutorial.com
- https://tex.stackexchange.com
- https://detexify.kirelabs.org/classify.html
- http://ctan.math.washington.edu/tex-archive/macros/latex/required/amsmath/amsldoc.pdf
- Workshop today, 1-3 pm (yay!)