LaTeX Course at ICT School

Let's add some mathematics

Alexandre Labrosse
École polytechnique, France
labrosse@kth.se

KTH *Royal Institute of Technology*

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Course overview

1. Basics and tips for your first LaTeX document
2. Let's add some mathematics
3. Illuminate your work with color and illustrations

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1. Basics and tips for your first LaTeX document
2. Let's add some mathematics
3. Illuminate your work with color and illustrations

What's next?

Bibliography

Mathematics basis

Arrays

Section 1

Bibliography

BibTeX? What's new?

- A database with entries `@TYPE` containing fields

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- A source file with `\cite` and `\bibliography{filename}`

BibTeX? What's new?

- A database with entries `@TYPE` containing fields
- A new tool `bibtex`
- A source file with `\cite` and `\bibliography{filename}`
- A longer compilation process `latex`, `bibtex`, `latex`, `latex`

An example

```
@book{knuthtex,
  author    = {Knuth, Donald E.},
  title     = {The \TeX{}book : a complete
    user's guide to computer typesetting
    with \TeX{}},
  publisher = {Addison-Wesley},
  year      = {1984},
  month     = jan,
  day       = {11},
}
```

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Citation command

```
\cite[text]{key1, key2, …}    \nocite{key1, key2, …}
```

```
\bibliographystyle{plain}

The \TeX{} language is totally described and
discussed in \cite{knuthtex}, boxes are
described in \cite[chap.~11]{knuthtex}.
```

The TEX language is totally described and discussed in [1], boxes are described in [1, chap. 11].

Allowed entry types

An article from a journal or magazine.

```
@ARTICLE{key
  author = …,
  title = …,
  journal = …,
  year = …,
  volume = …,
  number = …,
  pages = …,
  month = …,
  note = …
}
```

Allowed entry types

A book with an explicit publisher.

```
@BOOK{key
  author or editor = …,
  title = …,
  publisher = …,
  year = …,
  volume or number = …,
  series = …,
  address = …,
  edition = …,
  month = …,
  note = …
}
```

Allowed entry types

A work that is printed and bound, but without a named publisher or sponsoring institution.

```
@BOOKLET{key
  title = …,
  year = …,
  author = …,
  howpublished = …,
  address = …,
  month = …,
  year = …,
  note = …
}
```

Allowed entry types

A part of a book, may be a chapter or range of pages.

```
@INBOOK{key
  author or editor = …,
  title = …,
  chapter or pages = …,
  publisher = …,
  year = …,
  volume or number = …,
  series = …,
  type = …,
  address = …,
  edition = …,
  month = …,
  note = …
}
```

Allowed entry types

A part of a book, may be a chapter or range of pages.

```
@INBOOK{key
  author or editor = …,
  title = …,
  pages = {25, 38--43}
  publisher = …,
  year = …,
  volume or number = …,
  series = …,
  type = …,
  address = …,
  edition = …,
  month = …,
  note = …
}
```

Allowed entry types

A part of a book, may be a chapter or range of pages.

```
@INBOOK{key
  author or editor = …,
  title = …,
  chapter = 1.2,
  publisher = …,
  year = …,
  volume or number = …,
  series = …,
  type = …,
  address = …,
  edition = …,
  month = …,
  note = …
}
```

Allowed entry types

A part of a book, may be a chapter or range of pages.

```
@INBOOK{key
  author or editor = …,
  title = …,
  chapter = 1.2,
  publisher = …,
  year = …,
  volume or number = …,
  series = …,
  type = {Section},
  address = …,
  edition = …,
  month = …,
  note = …
}
```

Allowed entry types

incollection A part of a book having its own title.

Allowed entry types

incollection	A part of a book having its own title.
proceedings	The proceedings of a conference.
inproceedings	An article in a conference proceedings.

Allowed entry types

incollection	A part of a book having its own title.
proceedings	The proceedings of a conference.
inproceedings	An article in a conference proceedings.
manual	A technical documentation.
techreport	A report published by a school or other institution, usually numbered within a series.

Allowed entry types

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masterthesis	A Master's thesis.
phdthesis	A PhD thesis.

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masterthesis	A Master's thesis.
phdthesis	A PhD thesis.
unpublished	A document having an author and title, but not formally published.

Allowed entry types

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manual	A technical documentation.
techreport	A report published by a school or other institution, usually numbered within a series.
masterthesis	A Master's thesis.
phdthesis	A PhD thesis.
unpublished	A document having an author and title, but not formally published.
misc	Anything else.

What about the Internet and URLs?

First solution

```
@MISC{LaTeX2e,
  author = {\LaTeX3 Project Team},
  title = {\LaTeX{} documentation},
  howpublished = {http://www.latex-project.org/guides/}
}
```

[1] LaTeX3 Project Team. LaTeX documentation. http://www.latex-project.org/guides/.

Second solution

```
@MISC{LaTeX2e,
  author = {\LaTeX3 Project Team},
  title = {\LaTeX{} documentation},
  howpublished = {\url{http://www.latex-project.org/guides/
}
```

[1] LaTeX3 Project Team. LaTeX documentation. http://www.latex-project.org/guides/.

\url comes from the url or hyperref package

Consider using BibLaTeX...

What's more?

- An `@ONLINE` type, with `url` field

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- An `@ONLINE` type, with `url` field
- A lot of new type, all supporting the `url` field

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- An `@ONLINE` type, with `url` field
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- Lots of different citation styles

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- An `@ONLINE` type, with `url` field
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- Lots of different citation styles
- Lots of sorting and bibliography styles

Consider using BibLaTeX...

What's more?

- An `@ONLINE` type, with `url` field
- A lot of new type, all supporting the `url` field
- Lots of different citation styles
- Lots of sorting and bibliography styles
- Support for Unicode

Consider using BibLaTeX...

What's more?

- An `@ONLINE` type, with `url` field
- A lot of new type, all supporting the `url` field
- Lots of different citation styles
- Lots of sorting and bibliography styles
- Support for Unicode
- Compatible with BibTeX

Sum up about bibliography

```
\documentclass{article}

\begin{document}

  … \cite[text]{key}…

  \bibliographystyle{plain}
  \bibliography{file}

\end{document}
```

```
\documentclass{article}

\usepackage[…]{biblatex}
\bibliography{file}

\begin{document}

  … \cite[text]{key}…

  \printbibliography[…]

\end{document}
```

Documentation for BibTeX and BibLaTeX

Oren Patashnik. *BibTeXing*. Feb. 8, 1988. URL: http://bibtexml.sourceforge.net/btxdoc.pdf.

Nicolas Markey. *Tame the BeaST. The B to X of BibTeX*. Oct. 11, 2009. URL: ftp://ftp.dante.de/tex-archive/info/bibtex/tamethebeast/ttb_en.pdf.

Philipp Lehman. *The biblatex Package. Programmable Bibliographies and Citations*. Nov. 13, 2011. URL: ftp://www.ctan.org/ctan/macros/latex/exptl/biblatex/doc/biblatex.pdf.

Section 3

Mathematics basis

A syntax inherited from TEX...

```
The elastic potential energy $ U_e $ of an ideal
spring is: \[ U_e = \frac{1}{2} kx^2 \]
```

The elastic potential energy U_e of an ideal spring is:

$$U_e = \frac{1}{2}kx^2$$

A syntax inherited from TEX...

```
The elastic potential energy $ U_e $ of an ideal
spring is: \[ U_e = \frac{1}{2} kx^2 \]
```

The elastic potential energy U_e of an ideal spring is:

$$U_e = \frac{1}{2}kx^2$$

A syntax inherited from TEX...

```
The elastic potential energy $ U_e $ of an ideal
spring is: \[ U_e = \frac{1}{2} kx^2 \]
```

The elastic potential energy U_e of an ideal spring is:

$$U_e = \frac{1}{2} kx^2$$

A syntax inherited from TEX...

```
The elastic potential energy \(U_e\) of an ideal
spring is: $$ U_e = \frac{1}{2} kx^2 $$
```

The elastic potential energy U_e of an ideal spring is:

$$U_e = \frac{1}{2}kx^2$$

...extended by the American Mathematical Society

American Mathematical Society, ed. *User's guide for the* amsmath *Package*. Feb. 25, 2002. URL: http://mirror.ctan.org/macros/latex/required/amslatex/math/amsldoc.pdf.

Morten Høgholm et al. *The* mathtools *package*. Apr. 6, 2011. URL: http://mirror.ctan.org/macros/latex/contrib/mh/mathtools.pdf.

Objectives

$$\lim_{x \to p} f(x) = \ell \Leftrightarrow f(x) \xrightarrow[x \to p]{} \ell$$

$$\Leftrightarrow \forall \varepsilon > 0,\ \exists \delta > 0,\ \forall x \in I, \tag{1}$$
$$(|x - p| < \delta \Rightarrow |f(x) - \ell| < \varepsilon)$$

$$\sum_{\substack{1 \leq i \leq m \\ 1 \leq j \leq n}} x_i y_j = \sum_{i=1}^{m} \sum_{j=1}^{n} x_i y_j \tag{2}$$
$$= \left(\sum_{i=1}^{m} x_i \right) \cdot \left(\sum_{j=1}^{n} y_j \right)$$

$$\int_{-\infty}^{+\infty} \cos x^2 \, \mathrm{d}x = \sqrt{\frac{\pi}{2}} \tag{3}$$

Let's start with the first one

```
\[
  f(x)
\]
```

$$f(x)$$

Let's start with the first one

```
\[
  f(x) \rightarrow l
\]
```

$$f(x) \rightarrow l$$

Let's start with the first one

```
\[
  f(x) \underset{x\rightarrow p}{\rightarrow} l
\]
```

$$f(x) \underset{x\rightarrow p}{\rightarrow} l$$

Let's start with the first one

```
\[
  f(x) \xrightarrow[x \rightarrow p]{} l
\]
```

$$f(x) \xrightarrow[x \rightarrow p]{} l$$

Extensible arrows, harpoons and hooks

`\xleftarrow[down]{up}`	$\xleftarrow[down]{up}$
`\xrightarrow[down]{up}`	$\xrightarrow[down]{up}$
`\xleftrightarrow[down]{up}`	$\xleftrightarrow[down]{up}$
`\xLeftarrow[down]{up}`	$\xLeftarrow[down]{up}$
`\xRightarrow[down]{up}`	$\xRightarrow[down]{up}$
`\xLeftrightarrow[down]{up}`	$\xLeftrightarrow[down]{up}$

Extensible arrows, harpoons and hooks

`\xhookleftarrow[down]{up}` $\xhookleftarrow[down]{up}$

`\xhookrightarrow[down]{up}` $\xhookrightarrow[down]{up}$

`\xmapsto[down]{up}` $\xmapsto[down]{up}$

Extensible arrows, harpoons and hooks

```
\xrightharpoondown[down]{up}
```

$\xrightharpoondown[down]{up}$

```
\xrightharpoonup[down]{up}
```

$\xrightharpoonup[down]{up}$

```
\xleftharpoondown[down]{up}
```

$\xleftharpoondown[down]{up}$

```
\xleftharpoonup[down]{up}
```

$\xleftharpoonup[down]{up}$

```
\xleftrightharpoons[down]{up}
```

$\xleftrightharpoons[down]{up}$

```
\xrightleftharpoons[down]{up}
```

$\xrightleftharpoons[down]{up}$

Adding the limit

```
\[

  f(x) \xrightarrow[x \rightarrow p]{} l
\]
```

$$f(x) \xrightarrow[x \rightarrow p]{} l$$

Adding the limit

```
\[
  lim f(x) = l \Leftrightarrow
  f(x) \xrightarrow[x \rightarrow p]{} l
\]
```

$$lim f(x) = l \Leftrightarrow f(x) \xrightarrow[x \rightarrow p]{} l$$

Adding the limit

```
\[
  \lim f(x) = l \Leftrightarrow
  f(x) \xrightarrow[x \rightarrow p]{} l
\]
```

$$\lim f(x) = l \Leftrightarrow f(x) \xrightarrow[x \rightarrow p]{} l$$

Adding the limit

```
\[
  \lim_{x \rightarrow p} f(x) = l \Leftrightarrow
  f(x) \xrightarrow[x \rightarrow p]{} l
\]
```

$$\lim_{x \to p} f(x) = l \Leftrightarrow f(x) \xrightarrow[x \to p]{} l$$

Common functions

```
\sin \cos \tan \cot
\arcsin \arccos \arctan
\sinh \cosh \tanh \coth
\ln \log \exp
\max \min \sup \inf
\ker \deg
```

$$\sin \cos \tan \cot$$
$$\arcsin \arccos \arctan$$
$$\sinh \cosh \tanh \coth$$
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Common functions

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\sin \cos \tan \cot
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$$\sin \cos \tan \cot$$
$$\arcsin \arccos \arctan$$
$$\sinh \cosh \tanh \coth$$
$$\ln \log \exp$$
$$\max \min \sup \inf$$
$$\ker \deg$$

```
\DeclareMathOperator {\argmax}{arg\,max}
\[\argmax_a f(a)\]
```

$$\arg\max_a f(a)$$

Common functions

```
\sin \cos \tan \cot
\arcsin \arccos \arctan
\sinh \cosh \tanh \coth
\ln \log \exp
\max \min \sup \inf
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$$\sin \cos \tan \cot$$
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$$\sinh \cosh \tanh \coth$$
$$\ln \log \exp$$
$$\max \min \sup \inf$$
$$\ker \deg$$

```
\DeclareMathOperator*{\argmax}{arg\,max}
\[\argmax_a f(a)\]
```

$$\arg\max_a f(a)$$

Special characters

```
\[
  \lim_{x\rightarrow p} f(x) = l \Leftrightarrow
  f(x) \xrightarrow[x \rightarrow p] l
\]
```

$$\lim_{x \to p} f(x) = l \Leftrightarrow f(x) \xrightarrow[x \to p]{} l$$

Special characters

```
\[
  \lim_{x\rightarrow p} f(x) = \ell \Leftrightarrow
  f(x) \xrightarrow[x \rightarrow p] \ell
\]
```

$$\lim_{x \to p} f(x) = \ell \Leftrightarrow f(x) \xrightarrow[x \to p]{} \ell$$

Special characters

`\alpha, \beta, …, \omega`	$\alpha, \beta, \ldots, \omega$
`A, B, …, \Omega`	$A, B, \ldots, \Omega$
`\aleph, \beth, \gimel, \daleth`	$\aleph, \beth, \gimel, \daleth$
`\forall, \exists, \bot, \top, \Im, \Re`	$\forall, \exists, \bot, \top, \Im, \Re$
`\imath, \jmath, \ell, \wp, \partial`	$\imath, \jmath, \ell, \wp, \partial$

Where to find a symbol?

Scott Pakin. *The Comprehensive LaTeX Symbol List.* Nov. 9, 2009. URL: http://mirrors.ctan.org/info/symbols/comprehensive/symbols-a4.pdf.

Daniel Kirsh. *Detexify² — LaTeX symbol classifier.* URL: http://detexify.kirelabs.org.

Writing the second equivalence

$$\begin{aligned}\lim_{x\to p} f(x) = \ell &\Leftrightarrow f(x) \xrightarrow[x\to p]{} \ell \\ &\Leftrightarrow \forall \varepsilon > 0,\ \exists \delta > 0,\ \forall x \in I, \\ &\qquad (|x-p| < \delta \Rightarrow |f(x) - \ell| < \varepsilon)\end{aligned} \tag{1}$$

Writing the second equivalence

```
\[
  \forall\epsilon > 0,\exists\delta>0,\forall x\in I,
  (|x-p|<\delta \Rightarrow |f(x) - \ell|<\epsilon)
\]
```

$$\forall\epsilon > 0, \exists\delta > 0, \forall x \in I, (|x - p| < \delta \Rightarrow |f(x) - \ell| < \epsilon)$$

Writing the second equivalence

```
\[
  \forall\varepsilon > 0,\exists\delta>0,\forall x\in I,
  (|x-p|<\delta \Rightarrow |f(x) - \ell|<\varepsilon)
\]
```

$$\forall\varepsilon > 0, \exists\delta > 0, \forall x \in I, (|x - p| < \delta \Rightarrow |f(x) - \ell| < \varepsilon)$$

Putting it alltogether

```
\begin{align}
  \lim_{x\rightarrow p} f(x) = \ell
    &\Leftrightarrow
     f(x) \xrightarrow[x\rightarrow p]{} \ell \\
    &\Leftrightarrow
     \forall\varepsilon>0,\exists\delta>0,\forall x\in I,
     (|x-p|<\delta \Rightarrow |f(x) - \ell|<\varepsilon)
\end{align}
```

$$\lim_{x\to p} f(x) = \ell \Leftrightarrow f(x) \xrightarrow[x\to p]{} \ell \tag{2}$$

$$\Leftrightarrow \forall\varepsilon > 0, \exists\delta > 0, \forall x \in I, (|x-p| < \delta \Rightarrow |f(x) - \ell| < \varepsilon) \tag{3}$$

Putting it alltogether

```
\begin{align}
  \lim_{x\rightarrow p} f(x) = \ell
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    &\Leftrightarrow
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\end{align}
```

$$\lim_{x\to p} f(x) = \ell \Leftrightarrow f(x) \xrightarrow[x\to p]{} \ell \tag{2}$$

$$\Leftrightarrow \forall\varepsilon > 0, \exists\delta > 0, \forall x \in I, (|x-p| < \delta \Rightarrow |f(x) - \ell| < \varepsilon) \tag{3}$$

Putting it alltogether

```
\begin{align*}
  \lim_{x\rightarrow p} f(x) = \ell
    &\Leftrightarrow
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    &\Leftrightarrow
     \forall\varepsilon>0,\exists\delta>0,\forall x\in I,
     (|x-p|<\delta \Rightarrow |f(x) - \ell|<\varepsilon)
\end{align*}
```

$$\begin{aligned}
\lim_{x\to p} f(x) = \ell &\Leftrightarrow f(x) \xrightarrow[x\to p]{} \ell \\
&\Leftrightarrow \forall\varepsilon > 0, \exists\delta > 0, \forall x \in I, (|x-p| < \delta \Rightarrow |f(x) - \ell| < \varepsilon)
\end{aligned}$$

Putting it alltogether

```
\begin{align*}
  \lim_{x\rightarrow p} f(x) = \ell
    &\Leftrightarrow
     f(x) \xrightarrow[x\rightarrow p]{} \ell \\
    &\Leftrightarrow
     \forall\varepsilon>0,\exists\delta>0,\forall x\in I,\\
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Putting it alltogether

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\begin{align*}
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    &\Leftrightarrow
 \forall\varepsilon>0,\exists\delta>0,\forall x\in I,\\
    &\phantom{\Leftrightarrow}
     (|x-p|<\delta \Rightarrow |f(x) - \ell|<\varepsilon)
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Putting it alltogether

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\begin{align*}
  \lim_{x\rightarrow p} f(x) = \ell
    &\Leftrightarrow
     f(x) \xrightarrow[x\rightarrow p]{} \ell \\
    &\Leftrightarrow
 \forall\varepsilon>0,\exists\delta>0,\forall x\in I,\\
    &\phantom{{} \Leftrightarrow {}}
     (|x-p|<\delta \Rightarrow |f(x) - \ell|<\varepsilon)
\end{align*}
```

$$\begin{aligned}
\lim_{x\to p} f(x) = \ell &\Leftrightarrow f(x) \xrightarrow[x\to p]{} \ell \\
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\end{aligned}$$

Putting it alltogether

```
\begin{align*}
  \lim_{x\rightarrow p} f(x) = \ell
    &\Leftrightarrow
     f(x) \xrightarrow[x\rightarrow p]{} \ell \\
    &\Leftrightarrow
 \forall\varepsilon>0,\;\exists\delta>0,\;\forall x\in I,\\
    &\phantom{{} \Leftrightarrow {}}\qquad
     (|x-p|<\delta \Rightarrow |f(x) - \ell|<\varepsilon)
\end{align*}
```

$$\begin{aligned}
\lim_{x\to p} f(x) = \ell &\Leftrightarrow f(x) \xrightarrow[x\to p]{} \ell \\
&\Leftrightarrow \forall\varepsilon > 0,\ \exists\delta > 0,\ \forall x \in I, \\
&\qquad (|x-p| < \delta \Rightarrow |f(x) - \ell| < \varepsilon)
\end{aligned}$$

Mathematic spaces

`\phantom`	
`\quad`	⊢⊣
`\qquad`	⊢——⊣
`\␣`	H
`\,`	H
`\:`	H
`\;`	H
`\!`	‖

Adding the equation number

```
\begin{align}
\lim_{x\rightarrow p} f(x) = \ell
  &\Leftrightarrow
f(x) \xrightarrow[x\rightarrow p]{} \ell \\
  &\Leftrightarrow
\forall\varepsilon>0,\;\exists\delta>0,\;\forall x\in I,\\
  &\phantom{{} \Leftrightarrow {}}\qquad
  (|x-p|<\delta \Rightarrow |f(x) - \ell|<\varepsilon)
\end{align}
```

$$\lim_{x\to p} f(x) = \ell \Leftrightarrow f(x) \xrightarrow[x\to p]{} \ell \tag{1}$$

$$\Leftrightarrow \forall\varepsilon > 0,\ \exists\delta > 0,\ \forall x \in I, \tag{2}$$

$$(|x - p| < \delta \Rightarrow |f(x) - \ell| < \varepsilon) \tag{3}$$

Adding the equation number

```
\begin{align}
\lim_{x\rightarrow p} f(x) = \ell
  &\Leftrightarrow\notag
f(x) \xrightarrow[x\rightarrow p]{} \ell \\
  &\Leftrightarrow\notag
\forall\varepsilon>0,\;\exists\delta>0,\;\forall x\in I,\\
  &\phantom{{} \Leftrightarrow {}}\qquad
  (|x-p|<\delta \Rightarrow |f(x) - \ell|<\varepsilon)
\end{align}
```

$$\begin{aligned}
\lim_{x\to p} f(x) = \ell &\Leftrightarrow f(x) \xrightarrow[x\to p]{} \ell \\
&\Leftrightarrow \forall\varepsilon > 0,\ \exists\delta > 0,\ \forall x \in I, \\
&\qquad (|x-p| < \delta \Rightarrow |f(x) - \ell| < \varepsilon) \qquad (1)
\end{aligned}$$

Adding the equation number

```
\begin{align}
\lim_{x\rightarrow p} f(x) = \ell
  &\Leftrightarrow
f(x) \xrightarrow[x\rightarrow p]{} \ell \\
  &\Leftrightarrow\begin{multlined}
\forall\varepsilon>0,\;\exists\delta>0,\;\forall x\in I,\\
  (|x-p|<\delta \Rightarrow |f(x) - \ell|<\varepsilon)
  \end{multlined}
\end{align}
```

$$\begin{aligned}
\lim_{x\to p} f(x) = \ell &\Leftrightarrow f(x) \xrightarrow[x\to p]{} \ell \\
&\Leftrightarrow \begin{array}{l} \forall \varepsilon > 0,\ \exists \delta > 0,\ \forall x \in I, \\ \quad (|x-p| < \delta \Rightarrow |f(x) - \ell| < \varepsilon) \end{array}
\end{aligned} \tag{1}$$

Adding the equation number

```
\begin{align}
\lim_{x\rightarrow p} f(x) = \ell
  &\Leftrightarrow
f(x) \xrightarrow[x\rightarrow p]{} \ell \\
  &\Leftrightarrow\begin{multlined}[t]
\forall\varepsilon>0,\;\exists\delta>0,\;\forall x\in I,\\
  (|x-p|<\delta \Rightarrow |f(x) - \ell|<\varepsilon)
  \end{multlined}
\end{align}
```

$$\begin{aligned}
\lim_{x\to p} f(x) = \ell &\Leftrightarrow f(x) \xrightarrow[x\to p]{} \ell \\
&\Leftrightarrow \forall\varepsilon > 0,\ \exists\delta > 0,\ \forall x \in I, \\
&\qquad (|x-p| < \delta \Rightarrow |f(x) - \ell| < \varepsilon)
\end{aligned} \tag{1}$$

Adding the equation number

```
\begin{align}
\lim_{x\rightarrow p} f(x) = \ell
  &\Leftrightarrow
f(x) \xrightarrow[x\rightarrow p]{} \ell \\
  &\Leftrightarrow
\forall\varepsilon>0,\;\exists\delta>0,\;\forall x\in I,\\
  &\phantom{{} \Leftrightarrow {}}\qquad
  (|x-p|<\delta \Rightarrow |f(x) - \ell|<\varepsilon)
\end{align}
```

$$\lim_{x\to p} f(x) = \ell \Leftrightarrow f(x) \xrightarrow[x\to p]{} \ell \tag{1}$$

$$\Leftrightarrow \forall\varepsilon > 0,\ \exists\delta > 0,\ \forall x \in I, \tag{2}$$

$$(|x - p| < \delta \Rightarrow |f(x) - \ell| < \varepsilon) \tag{3}$$

Adding the equation number

```
\begin{equation}
\begin{aligned}
\lim_{x\rightarrow p} f(x) = \ell
  &\Leftrightarrow
f(x) \xrightarrow[x\rightarrow p]{} \ell \\
  &\Leftrightarrow
\forall\varepsilon>0,\;\exists\delta>0,\;\forall x\in I,\\
  &\phantom{{} \Leftrightarrow {}}\qquad
  (|x-p|<\delta \Rightarrow |f(x) - \ell|<\varepsilon)
\end{aligned}
\end{equation}
```

$$\begin{aligned}\lim_{x\rightarrow p} f(x) = \ell &\Leftrightarrow f(x) \xrightarrow[x\rightarrow p]{} \ell \\ &\Leftrightarrow \forall\varepsilon>0,\;\exists\delta>0,\;\forall x\in I, \\ &\qquad (|x-p|<\delta \Rightarrow |f(x) - \ell|<\varepsilon)\end{aligned} \tag{1}$$

Equation environments

Outer environment	Mostly inner environment	Exclusively inner environment
`equation*`	`multline[b|t]*`	`aligned[b|t]`
`align*`	`split`	`gathered[b|t]`
`xxalignat*`		`alignedat[b|t]`
`gather*`		

Equation environments

Outer environment	Mostly inner environment	Exclusively inner environment
`equation*`	`multline[b|t]*`	`aligned[b|t]`
`align*`	`split`	`gathered[b|t]`
`xxalignat*`		`alignedat[b|t]`
`gather*`		

And many more within the `mathtools` package...

Let's continue with the second equation

$$\begin{aligned}\sum_{\substack{1\leq i\leq m\\1\leq j\leq n}} x_i y_j &= \sum_{i=1}^{m}\sum_{j=1}^{n} x_i y_j \\ &= \left(\sum_{i=1}^{m} x_i\right)\cdot\left(\sum_{j=1}^{n} y_j\right)\end{aligned} \tag{2}$$

Let's continue with the second equation

```
\begin{equation}
  \sum_i=1^m\sum_j=1^n x_i y_j
\end{equation}
```

$$\sum_{i} = 1^{m} \sum_{j} = 1^{n} x_i y_j \tag{2}$$

Let's continue with the second equation

```
\begin{equation}
  \sum_{i=1}^m\sum_{j=1}^n x_i y_j
\end{equation}
```

$$\sum_{i=1}^{m}\sum_{j=1}^{n} x_i y_j \tag{2}$$

Big operators

`\sum`	$\sum$	`\prod`	$\prod$	`\coprod`	$\coprod$
`\bigoplus`	$\bigoplus$	`\bigotimes`	$\bigotimes$	`\bigodot`	$\bigodot$
`\bigcup`	$\bigcup$	`\bigcap`	$\bigcap$	`\biguplus`	$\biguplus$
`\bigsqcup`	$\bigsqcup$	`\bigvee`	$\bigvee$	`\bigwedge`	$\bigwedge$
`\int`	$\int$	`\oint`	$\oint$	`\iint`	$\iint$
`\iiint`	$\iiint$	`\iiiint`	$\iiiint$	`\idotsint`	$\int\cdots\int$

Let's continue with the second equation

```
\begin{equation}
\sum_{1\leq i\leq m,\;1\leq j\leq n}
  = \sum_{i=1}^m\sum_{j=1}^n x_i y_j
\end{equation}
```

$$\sum_{1\leq i\leq m,\ 1\leq j\leq n} = \sum_{i=1}^{m}\sum_{j=1}^{n} x_i y_j \tag{2}$$

Let's continue with the second equation

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\begin{equation}
\sum_{1\leq i\leq m,\;1\leq j\leq n}
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\end{equation}
```

$$\sum_{1\leq i\leq m,\ 1\leq j\leq n} = \sum_{i=1}^{m}\sum_{j=1}^{n} x_i y_j \tag{2}$$

Inequalities

		\neq	$\neq$		
\geq	$\geq$	\gg	$\gg$	\ngeq	$\ngeq$
\leq	$\leq$	\ll	$\ll$	\nleq	$\nleq$
\lesssim	$\lesssim$	\lll	$\lll$	\nless	$\nless$
\gtrsim	$\gtrsim$	\ggg	$\ggg$	\ngtr	$\ngtr$

Let's continue with the second equation

```
\begin{equation}
  \sum_{1\leq i\leq m,\;1\leq j\leq n}
  = \sum_{i=1}^m\sum_{j=1}^n x_i y_j
\end{equation}
```

$$\sum_{1\leq i\leq m,\ 1\leq j\leq n} = \sum_{i=1}^{m}\sum_{j=1}^{n} x_i y_j \tag{2}$$

Let's continue with the second equation

```
\begin{equation}
  \sum_{\substack{1\leq i\leq m\\1\leq j\leq n}}
  = \sum_{i=1}^m\sum_{j=1}^n x_i y_j
\end{equation}
```

$$\sum_{\substack{1\leq i\leq m\\1\leq j\leq n}} = \sum_{i=1}^{m}\sum_{j=1}^{n} x_i y_j \tag{2}$$

Let's continue with the second equation

```
\begin{equation}
  \begin{aligned}
    \sum_{\substack{1\leq i\leq m\\1\leq j\leq n}}
    & = \sum_{i=1}^m\sum_{j=1}^n x_i y_j \\
    & = (\sum_{i=1}^m x_i)(\sum_{j=1}^n y_j)
  \end{aligned}
\end{equation}
```

$$\begin{aligned}\sum_{\substack{1\leq i\leq m\\1\leq j\leq n}} &= \sum_{i=1}^{m}\sum_{j=1}^{n} x_i y_j \\ &= (\sum_{i=1}^{m} x_i)(\sum_{j=1}^{n} y_j)\end{aligned} \tag{2}$$

Let's continue with the second equation

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\begin{equation}
  \begin{aligned}
    \sum_{\substack{1\leq i\leq m\\1\leq j\leq n}}
    & = \sum_{i=1}^m\sum_{j=1}^n x_i y_j \\
    & = (\sum_{i=1}^m x_i)(\sum_{j=1}^n y_j)
  \end{aligned}
\end{equation}
```

$$\begin{aligned}\sum_{\substack{1\leq i\leq m\\1\leq j\leq n}} &= \sum_{i=1}^{m}\sum_{j=1}^{n} x_i y_j \\ &= (\sum_{i=1}^{m} x_i)(\sum_{j=1}^{n} y_j)\end{aligned} \tag{2}$$

Delimiters size

(	)	( )
\big(	\big)	$\big(\big)$
\Big(	\Big)	$\Big(\Big)$
\bigg(	\bigg)	$\bigg(\bigg)$
\Bigg(	\Bigg)	$\Bigg(\Bigg)$
\left(	\right)	*variable size*

Delimiters

`(`	`)`	$( )$
`[`	`]`	$[ ]$
`\{`	`\}`	$\{ \}$
`|`	`|`	$\| \|$
`\\|`	`\\|`	$\| \|$
`\langle`	`\rangle`	$\langle \rangle$
`\lfloor`	`\rfloor`	$\lfloor \rfloor$
`\lceil`	`\rceil`	$\lceil \rceil$
`\left.`	`\right.`	*balancing*

Let's continue with the second equation

```
\begin{equation}
  \begin{aligned}
    \sum_{\substack{1\leq i\leq m\\1\leq j\leq n}}
    & = \sum_{i=1}^m\sum_{j=1}^n x_i y_j \\
& = \left(\sum_{i=1}^m x_i\right)
        \left(\sum_{j=1}^n y_j\right)
  \end{aligned}
\end{equation}
```

$$\begin{aligned}\sum_{\substack{1\leq i\leq m\\1\leq j\leq n}} &= \sum_{i=1}^{m}\sum_{j=1}^{n} x_i y_j \\ &= \left(\sum_{i=1}^{m} x_i\right)\left(\sum_{j=1}^{n} y_j\right)\end{aligned} \tag{2}$$

Let's continue with the second equation

```
\begin{equation}
  \begin{aligned}
    \sum_{\substack{1\leq i\leq m\\1\leq j\leq n}}
    & = \sum_{i=1}^m\sum_{j=1}^n x_i y_j \\
& = \left(\sum_{i=1}^m x_i\right)\cdot
      \left(\sum_{j=1}^n y_j\right)
  \end{aligned}
\end{equation}
```

$$\begin{aligned}\sum_{\substack{1\leq i\leq m\\1\leq j\leq n}} &= \sum_{i=1}^{m}\sum_{j=1}^{n} x_i y_j \\ &= \left(\sum_{i=1}^{m} x_i\right) \cdot \left(\sum_{j=1}^{n} y_j\right)\end{aligned} \tag{2}$$

How to get the parentheses to be the same size?

- By using a static size, with `\Big`, `\bigg`, etc.

How to get the parentheses to be the same size?

- By using a static size, with `\Big`, `\bigg`, etc.
- With `\vphantom{...}`.

```
\left(\vphantom{\sum_j^n}\sum_{i=1}^m x_i\right)\cdot
\left(\sum_{j=1}^n y_j\right)
```

$$\left(\sum_{i=1}^{m} x_i\right) \cdot \left(\sum_{j=1}^{n} y_j\right)$$

How to get the parentheses to be the same size?

- By using a static size, with `\Big`, `\bigg`, etc.
- With `\vphantom{...}`.
- By defining new delimiters.

```
\DeclarePairedDelimiterX\parprod[2]
  {(} {)}
  {#1\delimsize){}\cdot{}\delimsize(#2}

\parprod* {\sum_{i=1}^m x_i} {\sum_{j=1}^n y_j}
```

$$\left(\sum_{i=1}^{m} x_i\right) \cdot \left(\sum_{j=1}^{n} y_j\right)$$

How to get the parentheses to be the same size?

- By using a static size, with \Big, \bigg, etc.
- With \vphantom{...}.
- By defining new delimiters.

```
\DeclarePairedDelimiterX\parprod[2]
  {(} {)}
  {#1\delimsize){}\cdot{}\delimsize(#2}

\parprod* {\sum_{i=1}^m x_i\!} {\sum_{j=1}^n y_j\!}
```

$$\left(\sum_{i=1}^{m} x_i\right) \cdot \left(\sum_{j=1}^{n} y_j\right)$$

Other use of this solution

```
\DeclarePairedDelimiterX\brakket[3]{\langle}{\rangle}
  {#1\,\delimsize|\,#2\,\delimsize|\,#3}

\[ \brakket[\Big]{B}{\sum_k \varphi_k}{C} \]
```

$$\Big\langle B \Big| \sum_k \varphi_k \Big| C \Big\rangle$$

Other use of this solution

```
\DeclarePairedDelimiter\abs{|}{|}

\[ \abs*{\frac12} \]
```

$$\left|\frac{1}{2}\right|$$

I think we're over with equation 2

```
\DeclarePairedDelimiterX\parprod[2]
  {(} {)}
  {#1\delimsize){}\cdot{}\delimsize(#2}
\begin{equation}
  \begin{aligned}
    \sum_{\substack{1\leq i\leq m\\1\leq j\leq n}}
    & = \sum_{i=1}^m\sum_{j=1}^n x_i y_j \\
    & = \parprod*{\sum_{i=1}^m x_i\!}{\sum_{j=1}^n y_j\!}
  \end{aligned}
\end{equation}
```

$$\begin{aligned}\sum_{\substack{1\leq i\leq m\\1\leq j\leq n}} &= \sum_{i=1}^{m}\sum_{j=1}^{n} x_i y_j \\ &= \left(\sum_{i=1}^{m} x_i\right) \cdot \left(\sum_{j=1}^{n} y_j\right)\end{aligned} \tag{2}$$

The last one is a piece of cake

```
\int_{-\infty}^{+\infty} cos x^2 dx
```

$$\int_{-\infty}^{+\infty} cosx^2 dx$$

The last one is a piece of cake

```
\int_{-\infty}^{+\infty} \cos x^2 \mathrm{d}x
```

$$\int_{-\infty}^{+\infty} \cos x^2 \mathrm{d}x$$

Math fonts

	$ABCabc123$	
`\mathrm`	$\mathrm{ABCabc123}$	
`\mathit`	$\mathit{ABCabc123}$	
`\mathbf`	$\mathbf{ABCabc123}$	
`\mathsf`	$\mathsf{ABCabc123}$	
`\mathtt`	$\mathtt{ABCabc123}$	
`\mathcal`	$\mathcal{ABC}$	
`\mathbb`	$\mathbb{ABC}$	
`\mathfrak`	$\mathfrak{ABCabc123}$	
`\mathscr`	$\mathscr{ABC}$	`\usepackage[mathscr]{euscript}`
`\mathscr`	$\mathscr{ABC}$	`\usepackage{mathrsfs}`

The last one is a piece of cake

```
\int_{-\infty}^{+\infty} \cos x^2 \mathrm{d}x
```

$$\int_{-\infty}^{+\infty} \cos x^2 \mathrm{d}x$$

The last one is a piece of cake

```
\int_{-\infty}^{+\infty} \cos x^2 \,\mathrm{d}x
```

$$\int_{-\infty}^{+\infty} \cos x^2 \,\mathrm{d}x$$

The last one is a piece of cake

```
\newcommand\ud{\,\mathrm{d}}
\int_{-\infty}^{+\infty} \cos x^2 \ud x
```

$$\int_{-\infty}^{+\infty} \cos x^2 \,\mathrm{d}x$$

The last one is a piece of cake

```
\newcommand\ud{\,\mathrm{d}}
\int_{\mathrlap{-\infty}}^{\mathrlap{+\infty}}
\cos x^2 \ud x
```

$$\int_{-\infty}^{+\infty} \cos x^2 \,\mathrm{d}x$$

The last one is a piece of cake

```
\newcommand\ud{\,\mathrm{d}}
\int_{\mathrlap{-\infty}}^{\mathrlap{+\infty}}
\cos x^2 \ud x
= \sqrt{\frac{\pi}{2}}
```

$$\int_{\mathrlap{-\infty}}^{\mathrlap{+\infty}} \cos x^2 \,\mathrm{d}x = \sqrt{\frac{\pi}{2}}$$

The last one is a piece of cake

```
\begin{equation}
\newcommand\ud{\,\mathrm{d}}
\int_{\mathrlap{-\infty}}^{\mathrlap{+\infty}}
\cos x^2 \ud x
= \sqrt{\frac{\pi}{2}}
\end{equation}
```

$$\int_{-\infty}^{+\infty} \cos x^2 \,\mathrm{d}x = \sqrt{\frac{\pi}{2}} \tag{3}$$

What haven't we seen yet?

What haven't we seen yet?

$$A = \begin{pmatrix} 0 & -1 & -2 & \cdots & -20 \\ 1 & 0 & -1 & \cdots & -19 \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ 19 & 18 & 17 & \ddots & -1 \\ 20 & 19 & 18 & \cdots & 0 \end{pmatrix}$$

Section 6

Arrays

Typeset a matrix

```
A = \begin{matrix}
  0 & -1 & -2 \\
  1 &  0 & -1 \\
  2 &  1 &  0 \\
\end{matrix}
```

$$A = \begin{matrix} 0 & -1 & -2 \\ 1 & 0 & -1 \\ 2 & 1 & 0 \end{matrix}$$

Typeset a matrix

```
A = \left(\begin{matrix}
  0 & -1 & -2 \\
  1 &  0 & -1 \\
  2 &  1 &  0 \\
\end{matrix}\right)
```

$$A = \begin{pmatrix} 0 & -1 & -2 \\ 1 & 0 & -1 \\ 2 & 1 & 0 \end{pmatrix}$$

Typeset a matrix

```
A = \begin{pmatrix}
  0 & -1 & -2 \\
  1 &  0 & -1 \\
  2 &  1 &  0 \\
\end{pmatrix}
```

$$A = \begin{pmatrix} 0 & -1 & -2 \\ 1 & 0 & -1 \\ 2 & 1 & 0 \end{pmatrix}$$

Matrix environments

```
\begin{xmatrix}a&b\\c&d\end{xmatrix}
```

`matrix`	$\begin{matrix}a & b\\c & d\end{matrix}$
`pmatrix`	$\begin{pmatrix}a & b\\c & d\end{pmatrix}$
`bmatrix`	$\begin{bmatrix}a & b\\c & d\end{bmatrix}$
`Bmatrix`	$\begin{Bmatrix}a & b\\c & d\end{Bmatrix}$
`vmatrix`	$\begin{vmatrix}a & b\\c & d\end{vmatrix}$
`Vmatrix`	$\begin{Vmatrix}a & b\\c & d\end{Vmatrix}$

Typeset a matrix

```
A = \begin{pmatrix}
    0 & -1 & -2 & \cdots & -20 \\
    1 &  0 & -1 & \cdots & -19 \\
  \vdots & \vdots & \ddots & \ddots & \vdots \\
  19 & 18 & 17 & \ddots &  -1 \\
  20 & 19 & 18 & \cdots &   0
\end{pmatrix}
```

$$A = \begin{pmatrix} 0 & -1 & -2 & \cdots & -20 \\ 1 & 0 & -1 & \cdots & -20 \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ 19 & 18 & 17 & \ddots & -1 \\ 20 & 19 & 18 & \cdots & 0 \end{pmatrix}$$

Dots

`\ldots`	$A, B, \ldots, \Omega$
`\cdots`	$A + B + \cdots + \Omega$
`\vdots`	$\vdots$
`\ddots`	$\ddots$
`\hdotsfor{n}`	$\begin{bmatrix} A & B & \cdots & \Omega \\ A & \ldots\ldots & & \Omega \end{bmatrix}$

Semantic Dots

`\dotsc`	commas	$A, B, \ldots, \Omega$
`\dotsb`	binary operators	$A + B + \cdots + \Omega$
`\dotsm`	multiplication	$AB \cdots \Omega$
`\dotsi`	integrals	$\int_A \int_B \cdots \int_\Omega$
`\dotso`	“other”	

Semantic Dots

`\dotsc`	commas	$A, B, \ldots, \Omega$
`\dotsb`	binary operators	$A + B + \cdots + \Omega$
`\dotsm`	multiplication	$AB \cdots \Omega$
`\dotsi`	integrals	$\int_A \int_B \cdots \int_\Omega$
`\dotso`	"other"	please avoid

Better: `\let\dotsx\xdots`

Matrices, a special case of array

```
\left\{\begin{array}{rcl}
  \mathit{monday}    &=& 1    \\
                     &\vdots& \\
  \mathit{wednesday} &=& 3 \\
                     &\vdots& \\
  \mathit{sunday}    &=& 7
\end{array}\right.
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Cases

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h(x) = \left\{\begin{array}{rl}
       f(x) & when x<0 \\
       g(x) & otherwise
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$$h(x) = \left\{ \begin{array}{ll} f(x) & whenx < 0 \\ g(x) & otherwise \end{array} \right.$$

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Cases

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h(x) = \begin{dcases*}
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$$h(x) = \begin{cases} f(x) & \text{when } x < 0 \\ g(x) & \text{otherwise} \end{cases}$$

And outside math mode?

The tabular environment I

```
\usepackage{array}

\newcolumntype{L}{>{$}l<{$}}
\newcolumntype{C}{>{$}c<{$}}
\newcolumntype{R}{>{$}r<{$}}

\begin{tabular}{L|l!{$\rightarrow$}R@{,}L}
 \text{id} & fruit & \multicolumn{2}{c}{price} \\ \hline
  1   & apple     &  1 & 2  \\
  2   & banana    &  3 & 4  \\
  345 & pear      &  5 & 63 \\
  42  & pineapple & 13 & 37 \\
\end{tabular}
```

The tabular environment II

id	fruit	→	price
1	apple	→	1,2
2	banana	→	3,4
345	pear	→	5,63
42	pineapple	→	13,37

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It's over for today, and next week?

- use colors
- import pictures
- draw pictures

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