LaTeX-course
2e session: mathematics in LaTeX

TeXniCie

A–Eskwadraat

November 17, 2014

Last week

Last week you learned:

- to handle *.tex and *.pdf documents.
- to show a title.
- to divide a document in sections and paragraphs.
- to make a table of contents.
- to produce symbols.

You have also learned to handle environments
You already know two environments
In the `document` environment typed text is displayed in the document.
In the `itemize` or `enumerate` environment you can make nice listings.

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This week

1 Mathematical notation

2 Advanced constructions

3 Tables and Matrices

Mathmode

- Mathmode is the environment in which you can make mathematical formulas and signs. In 'normal' text, LaTeX will not recognise the commands.

Formulas within the lines or individual

Inline math mode:

Example

In the lines ("inline") it looks like $\oint_C B \cdot d\ell = \mu_0 \sum_{i=\text{encl}} I_i$, just like words in text.

Display math mode:

Example

Important formulas can be displayed with more space:

$$\oint_C B \cdot d\ell = \mu_0 \sum_{i=\text{encl}} I_i$$

Formulas in the lines or individually

Math mode start and close:

Inline math mode

- `\( ... \)`
- `\begin{math} ... \end{math}`
- `$... $`

Individual equations

- `\[ ... \]`
- `\begin{displaymath} ... \end{displaymath}`
- `$$... $$`

Greek

Example

$$\frac{\hbar^2 \nabla^2}{2m} \psi(r) + \frac{1}{4\pi\epsilon_0 r}\psi(r) = E\psi(r)$$

`$$\frac{\hbar^2 \nabla^2}{2m} \psi(r) + \frac{1}{4 \pi \epsilon_0 r} \psi(r) = E \psi(r) $$`

Greek characters: `\theta` (θ).

Greek capitals: `\Phi` (Φ).

Nicer Greek characters: `\varepsilon` (ε).

N.B. Not all characters can be made nicer.

Different version of a character: letter: `\hbar` ($\hbar$), `\ell` (ℓ).

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> ### Example
>
> $$\frac{\hbar^2 \nabla^2}{2m}\psi(r) + \frac{1}{4\pi\epsilon_0 r}\psi(r) = E\psi(r)$$
>
> `$$\frac{\hbar^2 \nabla^2}{2m} \psi(r) +`
> `\frac{1}{4 \pi \epsilon_0 r} \psi(r) = E \psi(r) $$`

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Vertical combinations

> ### Example
>
> | | | |
> |---|---|---|
> | `\frac{`⟨*num*⟩`}{`⟨*denom*⟩`}` | $\frac{1}{137}$ | `$\frac{1}{137}$` |
> | `{`⟨*high*⟩ `\choose` ⟨*low*⟩`}` | $\binom{n}{p}$ | `${n \choose p}$` |
> | `\sqrt[`power`]{`⟨*number*⟩`}` | $\sqrt[3]{512}$ | `$\sqrt[3]{8}$` |

Subscript and superscript

Relative placing (sub- and superscript):
The hat (ˆ) and the dash (_).

- One argument, surrounded by accolades.
- No accolades →: only the next character is taken into account.

Example

x_n	`$x_n$`
e^{tA}	`$e^{tA}$`
$3^r d$	`$3^rd$`

Sommations, integrals and products

Use of sub- and superscripts in sommations etc:

Example

$$\sum_{n=0}^\infty \int_0^1 \frac{1}{n!} A^n t^n dt$$

$$\sum_{n=0}^\infty \int_0^1 \frac{1}{n!} A^n t^n dt$$

Symbols

LaTeX has many, many mathematical symbols. You can find them here:

- Complete list at CTAN:
  http://www.ctan.org/tex-archive/info/symbols/
  comprehensive/.
- Drawing a symbol yourself:
  http://detexify.kirelabs.org/.

Brackets (left and right)

Pairs of vertical symbols can be enlarged automatically using `\left` en `\right` right in front of the symbol.

Example

Ugly:
$$(\frac{1}{2})$$

`(\frac{1}{2})`

Beautiful:
$$\left(\frac{1}{2}\right)$$

`\left( \frac{1}{2} \right)`

Only a left bracket? Place after `\right` a dot.

`\left{ ... \right.` → $\left\{\frac{1}{\omega}\right.$

White space

White spacinga are neglected in math mode. You can force white spacings using:

`\!`	‖	`\pi\!\varphi`	$\pi\varphi$
	‖	`\pi \varphi`	$\pi\varphi$
`\,`	‖	`\pi\,\varphi`	$\pi\,\varphi$
`\:`	‖	`\pi\:\varphi`	$\pi\,\varphi$
`\;`	‖	`\pi\;\varphi`	$\pi\,\varphi$
`\`	‖	`\pi\ \varphi`	$\pi\,\varphi$
`\quad`	| |	`\pi\quad\varphi`	$\pi\quad\varphi$
`\qquad`	| |	`\pi\qquad\varphi`	$\pi\qquad\varphi$

Advanced *math mode* -environments

align Displays multiple vertically aligned numbered equations.

equation Displays a single numbered equation on a new line.

No numbering: place a star (*) after the environment.

Example: `\begin{equation*}`

There are more environments but these are the most important ones.

Advanced *math mode*-environments *(example)*

Example

$$a = b + c \tag{1}$$
$$a + 2b = c \tag{2}$$

```
\begin{align}
a      &=   b+c\\
a+2b  &=   c
\end{align}
```

$$2x + 3 = 0$$
$$2x = -3$$
$$x = -\frac{3}{2}$$

```
\begin{align*}
2x + 3 &= 0    \\
2x     &= -3   \\
x      &= -\frac{3}{2}
\end{align*}
```

Environments in equations

Groups, alignments and numbering of equations can be influenced within the environment math mode:

split   Displays a formula with multiple (in)equalities and assigns only one number to the equation.

cases   Places a big accolade left from the split-environment.

cases (example)

Example

$$fib(n) = \begin{cases} 0 & \text{als } n \leq 0 \\ 1 & \text{als } n = 1 \\ fib(n-1) + fib(n-2) & \text{als } n \nleq 1 \end{cases} \tag{3}$$

```
\begin{equation}
fib(n) =
\begin{cases}
0 &\text{if } n\leq 0\\
1 &\text{if } n=1\\
fib(n-1) + fib(n-2) & \text{if } n\not\leq 1
\end{cases}
\end{equation}
```

$\mathcal{A}_{\mathcal{M}}\mathcal{S}$-L^AT_EX

The American Mathematical Society provides a number of packages for working with mathemcial formulae. This project includes the following packages:

amsmath   The basis of most mathematical editing, used many times in these slides.

amssymb   Additional symbols like $\therefore$, $\sqsupset$ and $\mho$.

amsfonts   Provides some additional font types. (Try also the packages eufrak and eucal).

amsthm   Support for defining definitions, theorems, exercises and so on.

Mathmode and text

Normal text in *math mode*: `\text{}`.
Standard *math mode*-text: `\mathnormal{}`.
Other text forms:

Mathematical characters:	
Roman	`\mathrm{}`
Italic	`\mathit{}`
Bold	`\mathbf{}`
Teletype	`\mathtt{}`
SansSerif	`\mathsf{}`

Normal text	
Roman	`\textrm{}`
Italic	`\textit{}`
Bold	`\textbf{}`
Teletype	`\texttt{}`
Sans Serif	`\textsf{}`

$\mathcal{A}_{\mathcal{M}}\mathcal{S}$-theorem: an example

Theorem (Non-compactness of unit sphere in ℓ^2)

Show that the unit sphere is not compact in ℓ^2.

Proof.

Take the sequence $(1, 0, \ldots)$, $(0, 1, 0, \ldots)$, etc. This is a bounded sequence in ℓ^2, but clearly has no convergent subsequence. □

This type of construction is done by

Example

```
\begin{theorem}[⟨Naam stelling⟩]
Theorem.
\end{theorem} \begin{proof}
The difficult proof.
\end{proof}
```

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```

Tips

- In the manual you can often find a way to make the exercise.
- The command \verb is used to display commands in text.

Tables

LaTeX has three standard tables:

  array A table to display formulas.

 tabular A standard table, as big as needed.

tabular* A table with given width.

A simple table

Example

Theme	Forground	Background
Albatross	white	navy
Crane	blue	orange
Fly	black	grey
Seagull	black	white

```
\begin{tabular}{lcc}
Theme & Foreground & Background \\ \hline
Albatross & white & navy \\
Crane & blue & orange\\
Fly & black & grey\\
Seagull & black & white \\
\end{tabular}
```

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\end{tabular}

Packages

For listings and tables, the following packages can be really useful:

supertabular for a table at multiple pages.

longtable for a tagble at multiple pages.

multirow for input in multiple rows.

enumitem for changing options in tables and listings.

http://www.ctan.org

Arrays

A table in *math mode*: the array-environment.

Example

$\lvert \cdot \rvert$	absolute waarde:	$\lvert x \rvert$
$\lVert \cdot \rVert$	norm:	$\lVert x \rVert$

```
\[
\begin{array}{cp{15mm}l}
|\cdot| & absolute value: & |x|\\
\|\cdot\| & norm: & \|x\|
\end{array}
\]
```

Matrices

- Matrices are special arrays.
- The matrix-environment is used like the *array*-environment.
- Matrices in textline: the smallmatrix-environment.

Example

$$\begin{bmatrix} \alpha & -\beta \\ \bar{\beta} & \bar{\alpha} \end{bmatrix}$$

```
\[
\left[\begin{matrix}
\alpha & -\beta\\
\bar\beta & \bar\alpha\\
\end{matrix}\right]
\]
```

Next week

- Figures, in all forms and formats
- References and labels

Do you like this activity?

- If you have remarks, please tell us or e-mail to texnicie@a-eskwadraat.nl
- Maybe you like other A–Eskwadraat activities as well. More information can be found at `https://www.a-eskwadraat.nl/Activiteiten/?setlanguage=en`