

Intermediate LaTeX

Coding mathematics

Jean Hare

Sorbonne Université
Laboratoire Kastler Brossel
jean.hare@lkb.ens.fr

Décembre 2020

Table des matières

- 1 Basic mathematics in standard \LaTeX
 - Minimal math notations
 - Math elements by class
 - More math elements
- 2 \LaTeX -math and mathtools
 - Multi-line display
 - Miscellanea

Sommaire

- 1 Basic mathematics in standard \LaTeX
 - Minimal math notations
 - Math elements by class
 - More math elements
- 2 \LaTeX -math and mathtools
 - Multi-line display
 - Miscellanea

Dans la section

- 1 Basic mathematics in standard \LaTeX
 - Minimal math notations
 - Math elements by class
 - More math elements
- 2 \LaTeX -math and mathtools
 - Multi-line display
 - Miscellanea

Math in standard L^AT_EX

By conception, T_EX is specially efficient for typesetting math. The basic maths in L^AT_EX are described first.

- Math input defines “mathmode” in two version and four styles:
 - *In-line* mode, with \dots , $\backslash(\dots\backslash)$, environment `math`.
 - *Display* mode, with $\left[\dots\right]$ or environment `displaymath`.
 - `\displaystyle`, `\textstyle`, `\scriptstyle` and `\scriptscriptstyle`, mostly related to size of symbols.
- In mathmode, each letter is supposed to be single variable, so that $\$abc\$$ gives abc and not abc
- Typed spaces are ignored. T_EX introduces the required spacing on the basis of the class of symbols, variables, operators, delimiter, binary relations, etc. Tweaking this spacing is sometimes required, with the commands (unit $\mu=1/18\text{em}$):

<code>\quad</code>	<code>\qqquad</code>	<code>\l</code>	<code>\;</code>	<code>\;</code>	<code>\,</code>	<code>\!</code>
18 μ	36 μ	9 μ	5 μ	4 μ	3 μ	-3 μ

Math in standard L^AT_EX(II)

Basic math constructions

- Indices and exponents:

$\$2^3=8\$$ → $2^3 = 8$	$\$\delta_{ij}=\pm 1\$$ → $\delta_{ij} = \pm 1$
$\$a^3^2\$$ → Error	$\$a^{3^2}=a^9\$$ → $a^{3^2} = a^9$
$\$C_2^4=6\$$ → $C_2^4 = 6$	$\$\mathrm{H}_3\text{O}^+\$$ → H_3O^+

- Primes :

$\$x'=1\$$ → $x' = 1$	$\$(x^2)'=2x\$$ → $(x^2)' = 2x$
$\$x''=0\$$ → $x'' = 0$	$\$\{(x^3)'\}=3x\$$ → $(x^3)' = 3x$

- Fractions and roots :

$\$\frac{a}{b}\$$ → $\frac{a}{b}$	$\$\sqrt{4}=2\$$ → $\sqrt{4} = 2$
$\left[\frac{a}{b}\right]$ → $\frac{a}{b}$	$\$\sqrt[3]{27}=3\$$ → $\sqrt[3]{27} = 3$

Dans la section

1 Basic mathematics in standard L^AT_EX

- Minimal math notations
- Math elements by class
- More math elements

2 $\mathcal{A}\mathcal{M}\mathcal{S}$ -math and mathtools

- Multi-line display
- Miscellanea

Binary operators

L^AT_EX distinguishes “Binary operators”, “relations” and “(unary) operators”.

Binary operators are automatically surrounded by medium space (4 μ).

<code>\pm</code>	\pm	<code>\cap</code>	\cap	<code>\diamond</code>	\diamond	<code>\oplus</code>	\oplus
<code>\mp</code>	\mp	<code>\cup</code>	\cup	<code>\bigtriangleup</code>	\triangle	<code>\ominus</code>	\ominus
<code>\times</code>	\times	<code>\uplus</code>	\uplus	<code>\bigtriangledown</code>	∇	<code>\otimes</code>	\otimes
<code>\div</code>	\div	<code>\sqcap</code>	\sqcap	<code>\triangleleft</code>	\triangleleft	<code>\oslash</code>	\oslash
<code>\ast</code>	$*$	<code>\sqcup</code>	\sqcup	<code>\triangleright</code>	\triangleright	<code>\odot</code>	\odot
<code>\star</code>	\star	<code>\vee</code>	\vee	<code>\bigcirc</code>	\bigcirc	<code>\wr</code>	\wr
<code>\circ</code>	\circ	<code>\wedge</code>	\wedge	<code>\dagger</code>	\dagger	<code>\ddagger</code>	\ddagger
<code>\bullet</code>	\bullet	<code>\cdot</code>	\cdot	<code>\setminus</code>	\setminus	<code>\amalg</code>	\amalg

This can be emulated with `\mathbin{<text>}`,

Declare a new one with `\newcommand{\<name>}{\mathbin{<name>}}`.

A few less used binary operators are available with the packages `latexsym`/`amssymb`.

Greek letters

<code>\alpha</code>	α	<code>\imath</code>	\imath	<code>\rho</code>	ρ	<code>\varepsilon</code>	ε
<code>\beta</code>	β	<code>\kappa</code>	κ	<code>\sigma</code>	σ	<code>\vartheta</code>	ϑ
<code>\gamma</code>	γ	<code>\lambda</code>	λ	<code>\tau</code>	τ	<code>\varkappa</code>	\varkappa
<code>\delta</code>	δ	<code>\mu</code>	μ	<code>\upsilon</code>	υ	<code>\varpi</code>	ϖ
<code>\epsilon</code>	ϵ	<code>\nu</code>	ν	<code>\phi</code>	ϕ	<code>\varsigma</code>	ς
<code>\zeta</code>	ζ	<code>\xi</code>	ξ	<code>\chi</code>	χ	<code>\varrho</code>	ϱ
<code>\eta</code>	η	<code>\omicron</code>	\omicron	<code>\psi</code>	ψ	<code>\varphi</code>	φ
<code>\theta</code>	θ	<code>\pi</code>	π	<code>\omega</code>	ω		
<code>\Gamma</code>	Γ	<code>\Lambda</code>	Λ	<code>\Sigma</code>	Σ	<code>\Psi</code>	Ψ
<code>\Delta</code>	Δ	<code>\Xi</code>	Ξ	<code>\Upsilon</code>	Υ	<code>\Omega</code>	Ω
<code>\Theta</code>	Θ	<code>\Pi</code>	Π	<code>\Phi</code>	Φ		
<code>\varGamma</code>	\varGamma	<code>\varLambda</code>	\varLambda	<code>\varSigma</code>	\varSigma	<code>\varPsi</code>	\varPsi
<code>\varDelta</code>	\varDelta	<code>\varXi</code>	\varXi	<code>\varUpsilon</code>	\varUpsilon	<code>\varOmega</code>	\varOmega
<code>\varTheta</code>	\varTheta	<code>\varPi</code>	\varPi	<code>\varPhi</code>	\varPhi		

Slanted capital are also obtained with `\mathnormal{\Gamma}` → Γ

More math symbols

<code>\ldots</code>	\dots	<code>\cdots</code>	\cdots	<code>\vdots</code>	\vdots	<code>\ddots</code>	\ddots
<code>\aleph</code>	\aleph	<code>\prime</code>	\prime	<code>\forall</code>	\forall	<code>\infty</code>	∞
<code>\hbar</code>	\hbar	<code>\emptyset</code>	\emptyset	<code>\exists</code>	\exists	<code>\Box</code>	\square
<code>\imath</code>	\imath	<code>\nabla</code>	∇	<code>\neg</code>	\neg	<code>\Diamond</code>	\diamond
<code>\jmath</code>	\jmath	<code>\surd</code>	\surd	<code>\flat</code>	\flat	<code>\triangle</code>	\triangle
<code>\ell</code>	ℓ	<code>\top</code>	\top	<code>\natural</code>	\natural	<code>\clubsuit</code>	\clubsuit
<code>\wp</code>	\wp	<code>\bot</code>	\bot	<code>\sharp</code>	\sharp	<code>\diamondsuit</code>	\diamondsuit
<code>\Re</code>	\Re	<code>\ </code>	$\ $	<code>\backslash</code>	\backslash	<code>\heartsuit</code>	\heartsuit
<code>\Im</code>	\Im	<code>\angle</code>	\angle	<code>\partial</code>	∂	<code>\spadesuit</code>	\spadesuit
<code>\mho</code>	\mho	<code>.</code>	\cdot	<code> </code>	$ $		

For a more extended list of symbols look at
[The Comprehensive L^AT_EX Symbol List](#)

Dans la section

1 Basic mathematics in standard L^AT_EX

- Minimal math notations
- Math elements by class
- More math elements

2 $\mathcal{A}\mathcal{M}\mathcal{S}$ -math and mathtools

- Multi-line display
- Miscellanea

Decorations

Math mode accents

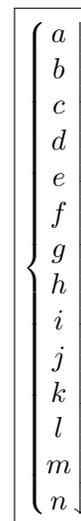
<code>\hat{a}</code>	\hat{a}	<code>\acute{a}</code>	\acute{a}	<code>\bar{a}</code>	\bar{a}	<code>\dot{a}</code>	\dot{a}
<code>\breve{a}</code>	\breve{a}	<code>\check{a}</code>	\check{a}	<code>\grave{a}</code>	\grave{a}	<code>\vec{a}</code>	\vec{a}
<code>\ddot{a}</code>	\ddot{a}	<code>\tilde{a}</code>	\tilde{a}				

Other constructions

<code>\widetilde{abc}</code>	\widetilde{abc}	<code>\widehat{abc}</code>	\widehat{abc}
<code>\overleftarrow{abc}</code>	\overleftarrow{abc}	<code>\overrightarrow{abc}</code>	\overrightarrow{abc}
<code>\overline{abc}</code>	\overline{abc}	<code>\underline{abc}</code>	\underline{abc}
<code>\overbrace{abc}^d</code>	\overbrace{abc}^d	<code>\underbrace{efg}_h</code>	\underbrace{efg}_h

Extensible delimiters The `\Bigg\bigg\Big\big` delimiters are sometimes too small. Get larger delimiters as shown here with:

`\left<delim1> content \right<delim2>`
`\left` and `\right` must be paired `<delim1>` and `<delim2>` can differ. Use `.` for no printed delimiter.



Integrals, sums and limits

The Euler-Mascheroni constant γ

• In `textstyle` (in-line math) $\gamma = \lim_{n \rightarrow \infty} (\sum_{k=1}^n \frac{1}{k} - \int_1^n \frac{dx}{x})$

is produced by the command :

`\lim_{n\to\infty}(\sum_{k=1}^n \frac{1}{k} - \int_1^n \frac{dx}{x})`

• Better result obtained in `displaystyle` : $\lim_{n \rightarrow \infty} (\sum_{k=1}^n \frac{1}{k} - \int_1^n \frac{dx}{x})$

– With the `displaymath` environment `\[...]`

– By adding the command `\displaystyle` in front of the formula:

`\displaystyle\lim_{n\to\infty}(\sum_{k=1}^n \frac{1}{k} \dots`

• The limits position is controlled by `\limits` or `\nolimits`:

– in `textstyle` `\lim\limits_{n\to\infty}(\sum_{k=1}^n \dots)`

gives

$$\lim_{n \rightarrow \infty} (\sum_{k=1}^n \frac{1}{k} \dots)$$

– in `displaystyle` `\[\lim_{n\to\infty}(\sum\nolimits_{k=1}^n \dots)`

gives

$$\lim_{n \rightarrow \infty} (\sum_{k=1}^n \frac{1}{k} \dots)$$

Math Fonts

Regular math is in “*mathematical italic*” (`lmmi` for `latinmodern`)

Styles and families work like in text, but with `\math<style>`:

`mathrm`, `mathtt`, `mathsf`, `mathbf`, `mathit`

Symbols are not embolden by `\mathbf`:

`\mathbf{\sum\int\beta}` $\rightarrow \sum \int \beta \leftarrow \mathbf{\sum\int\beta}$

Use instead `\bm{\sum\int\beta}` $\rightarrow \sum \int \beta$ of package `bm`

Other styles (with packages)

• `\mathcal{ABCDEFGH}` $\rightarrow \mathcal{ACDEFGH}$ (uppercase only, `latex`)

• `\mathbbm{ABCNR12abc}` $\rightarrow \mathbb{ABCNR12abc}$ (`bbm`)

• `\upalpha\upbeta\upmu` $\dots \rightarrow \alpha\beta\mu \dots$ (`upgreek`)

• `\mathfrak{ABCNR12abc}` $\rightarrow \mathfrak{ABCNR12abc}$ (`amssymb`)

• `\mathscr{ABCD}` $\rightarrow \mathscr{ABCD}$ (uppercase only, `mathrsfs`)

• etc.

Making larger or smaller symbols

- Some symbols sometimes need to be enlarged.
- But the fonts `cmex` or `lmex` are defined as non-scalable !
Fix this by loading package `exscale` (sample in `\Huge`):

$$\langle X \rangle = \frac{\sum_i \sum_j p_{ij} x_i}{\sum_j n_j} \rightarrow \langle X \rangle = \frac{\sum_i \sum_j p_{ij} x_i}{\sum_j n_j} = \frac{\sum_j n_j x_j}{\sum_j n_j}$$

- For a finer control use the package `relsize` and do for example:

```
1 \def\Sum{\mathop{\mathlarger{\sum}}}
2 \def\sums{\mathop{\mathsmaller{\sum}}}
```

To get :

$$\langle X \rangle = \frac{\sum_i \sum_j p_{ij} x_i}{\sum_j n_j} = \frac{\sum_j n_j x_j}{\sum_j n_j}$$

Sommaire

1 Basic mathematics in standard L^AT_EX

- Minimal math notations
- Math elements by class
- More math elements

2 A_MS-math and mathtools

- Multi-line display
- Miscellanea

AMS-math & mathtools

- **Never** use the awful `\eqalign` to align equations.
- For this purpose you should load the package `amsmath`, with its companion `mathtools`.
- **Warning:** `amsmath` package and not `ams(la)tex` class, and its documentation is named `amslldoc.pdf`.
- `amsmath` & `mathtools` define (namely) :
 - Many multi-line displayed equation environments.
 - Better `matrices`, `root`, `fractions`, `limits` and `integrals`.
 - `\boxed{ }` formulas, and `\text{...}` in math mode.
 - Stacking of subscript (`\substack`) or relations (`\stackrel`).
 - `\DeclareMathOperator{\xxx}{xxx}` (starred for limit position).
 - Content of null vertical space (`\smash`, `\smashoperator`) or horizontal width (`\mathllap`, `\mathclap`, `\mathrlap`).
 - Extensible arrows like `\xleftarrow[<sub>>]{<sup>>}` for $A \xleftarrow[under]{over} B$
 - Left indices and exponents, etc.

Dans la section

- 1 Basic mathematics in standard L^AT_EX
 - Minimal math notations
 - Math elements by class
 - More math elements
- 2 AMS-math and mathtools
 - Multi-line display
 - Miscellanea

Aligned equations : align and aligned

By default, all lines are numbered. Use `*` to suppress all numbers, or `\nonumber` on specific lines.

```

1 \begin{align*}
2 aa &= bbbbbb \\
3 ccccc &= dd \\
4 \end{align*}

```

$$\begin{array}{l}
 aa = bbbbbb \\
 ccccc = dd
 \end{array}$$

```

1 \begin{align*}
2 aa &= bbbbbb & ee &= ff \\
3 cccc &= dd & hhhh &= gg \\
4 \end{align*}

```

$$\begin{array}{ll}
 aa = bbbbbb & ee = ff \\
 ccccc = dd & hhhh = gg
 \end{array}$$

```

1 \begin{equation}
2 \left\{
3 \begin{aligned}
4 aaa &= bbb \\
5 w &= u \text{ ou } v
6 \end{aligned}
7 \right.
8 \end{equation}

```

$$\left\{ \begin{array}{l} aaa = bbb \\ w = u \text{ ou } v \end{array} \right. \quad (1)$$

More aligned equations

- `alignat` reduces the inter equations space (use number of columns)

```

1 \begin{align*}
2 aa &= bbbbbb & eee &= vvvv \\
3 cccc &= dd & fff &= zzz \\
4 \end{align*}
5 \smallskip
6 \begin{alignat*}{2}
7 aa &= bbbbbb & eee &= vvvv \\
8 cccc &= dd & fff &= zzz \\
9 \end{alignat*}

```

$$\begin{array}{ll|ll}
 aa = bbbbbb & & eee = vvvv & \\
 cccc = dd & & fff = zzz & \\
 \hline
 aa = bbbbbb & & eee = vvvv & \\
 cccc = dd & & fff = zzz &
 \end{array}$$

- `split` is used to display a single equation with multiline aligned terms

```

1 \begin{equation}
2 \begin{split}
3 a &= b + c - d \\
4 &\quad + e - f \\
5 &= g + h
6 \end{split}
7 \end{equation}

```

$$\begin{array}{r}
 a = b + c - d \\
 \quad + e - f \\
 = g + h
 \end{array} \quad (2)$$

