The LaTeX mini-guide

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Chapter 1

Mathematics – Basics with the “mathtools” package

Mathematics writing is one of the most advantage of LaTeX compared to common text editors. On a first approach, it looks like a programming language but it is in fact quite intuitive.

The first package which was extremely useful in mathematics writing was `amsmath`. Since then, it has been upgraded by the `mathtools` package that I recommend to use.

1.1 Writing an equation

Writing an equation is simply done thanks to the `equation` environment. Maxwell’s equations will be used as examples. So, the

```
\begin{equation}
    \vec{\nabla}\cdot\vec{B}=0.
    \label{eq::Maxwell:no_magnetic_monopole}
\end{equation}
```

LaTeX code generates

$$\vec{\nabla} \cdot \vec{B} = 0. \tag{1.1}$$

1.1.1 Unnumbered equations

Automatic numbering can be avoided by using the starred version: `equation*`. For instance,

```
\begin{equation*}
    \vec{\nabla}\times\vec{E}
        =-\frac{\partial\vec{B}}{\partial t}.
\end{equation*}
```

produces

$$\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}.$$

Nevertheless, it is generally recommended to number all equations in scientific documents for easier reference.

Shorter forms of the unnumbered version are offered by the package: the \[...\] wrapper or the double $$ symbol. Please note that the latter is plain TEX, which means that it should not be used with LaTeX because it is not robust.

Here follow the corresponding examples:

```
$$\iint_{\Sigma_f} \vec{B} \cdot \mathrm{d}\vec{S},$$
```

is the code corresponding to

$$\iint_{\Sigma_f} \vec{B} \cdot \mathrm{d}\vec{S},$$

while

```
\[ \oint_{C} \vec{E} \cdot \mathrm{d}\vec{l}
    = - \iint_{S} \frac{\partial\vec{B}}{\partial t}
      \cdot \mathrm{d}\vec{S}. \]
```

creates

$$\oint_{C} \vec{E} \cdot \mathrm{d}\vec{l} = - \iint_{S} \frac{\partial\vec{B}}{\partial t} \cdot \mathrm{d}\vec{S}.$$

However, I do not recommend to use them. On the one hand, the `equation*` environment highlights the mathematics when looking in the LATEX code. On the other hand, if the author changes his mind and wants to number the equation, he must simply remove the `*` character.

1.1.2 Inline equations

Inline equations are equations written in the text. It can be useful in some circumstances, such as the description of a variable. For instance, I could specify that $\vec{B}$ in eq. (1.1) is the magnetic field. To do so, the equation is surrounded by single $ signs:

```
$\vec{B}$
```

Unfortunately, inline equations may introduce unpleasant distortion in the text, especially with “big” symbols. As an example, let us use express the acceleration as the derivative of the speed: $a = \frac{\mathrm{d}v}{\mathrm{d}t}$. It can be seen that the fraction symbol has been compacted to fit with the line space.

It is possible to prevent the fraction from being reshaped by forcing the *math*-mode. To do so, the writer must use the `displaystyle` command, which exists in shorter forms for common mathematical symbols such as fractions. Expressing again the acceleration: $a = \dfrac{\mathrm{d}v}{\mathrm{d}t}$, or, equivalently, $a = \displaystyle\frac{\mathrm{d}v}{\mathrm{d}t}$. It can be seen that the space line is increased above and below the line including the equation, creating a somewhat uncomfortable text arrangement.

The problem presented here above is related to the following LaTeX codes:

```
$a=\frac{\mathrm{d}v}{\mathrm{d}t}$
$a=\dfrac{\mathrm{d}v}{\mathrm{d}t}$
$\displaystyle a=\frac{\mathrm{d}v}{\mathrm{d}t}$
```

1.1.3 General recommendations for equations

Recommendations:

- use numbered equation only (with the `equation` environment),
- try to avoid inline equations except
  - to describe variables or operators,
  - for very small, less important formulae which do not contain “big” symbols (e.g., integral, fraction).

1.2 Writing groups of equations

Several commands and environments allow to group equations. The most-used are presented here after. For a complete presentation, please refer to the “amsmath” and “mathtools” packages documentation.

1.2.1 Group of equations

The first tool which allow to group equations is the `gather` environment. Inside the environment, a double backslash (\\) indicates the end of an equation. Consequently, a new line is produced and another equation can be written. Pay attention: no double backslash must be put after the last equation. Otherwise, an additional space is added at the end of the group.

Unless the starred version (`gather*`) is used, all equations are numbered. To prevent one line from being numbered, the `\notag` or the `\nonumber` command can be used.

It is also possible to write text between equations while still being in the `gather` environment. This is done with the `\intertext` command, or `\shortintertext` which removes extra vertical space. It is specifically useful for a mathematical development.

As an example, the

```
\begin{gather}
    \vec{\nabla} \times \vec{B}
        = \mu_0 \vec{\jmath}
        + \varepsilon_0 \mu_0 \frac{\partial \vec{E}}{\partial t},
        \\
```

```
    \intertext{which can be written in the integral form by
        applying the Green theorem}
    \oint_{C} \vec{B} \cdot \mathrm{d} \vec{l}
        = \mu_0 \iint_S \vec{\jmath} \cdot \mathrm{d} \vec{S}
        + \varepsilon_0 \mu_0 \iint_S \frac{\partial \vec{E}}{
            \partial t} \cdot \mathrm{d} \vec{S}
\end{gather}
```

code will generate

$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{\jmath} + \varepsilon_0 \mu_0 \frac{\partial \vec{E}}{\partial t}, \tag{1.2}$$

which can be written in the integral form by applying the Green theorem

$$\oint_{C} \vec{B} \cdot \mathrm{d} \vec{l} = \mu_0 \iint_S \vec{\jmath} \cdot \mathrm{d} \vec{S} + \varepsilon_0 \mu_0 \iint_S \frac{\partial \vec{E}}{\partial t} \cdot \mathrm{d} \vec{S} \tag{1.3}$$

(see the use of `\intertext`).

1.2.2 Group of aligned equations

The second tool allowing to group equations is the `align` environment. It does the same as the `gather` environment but also allows to align the equations. The alignment is performed thanks to the & symbol. All other commands and symbol performs the same as in the texttttgather environment.

For instance,

```
\begin{align}
    \vec{B} &= \vec{\nabla} \times \vec{A} \\
    \vec{E} &= -\vec{\nabla} V - \frac{\partial \vec{A}}{\partial t}.
\end{align}
```

creates

$$\vec{B} = \vec{\nabla} \times \vec{A} \tag{1.4}$$

$$\vec{E} = -\vec{\nabla} V - \frac{\partial \vec{A}}{\partial t}. \tag{1.5}$$

1.3 Writing matrices

Matrices can be generated thanks to the `matrix` environment which must be used inside a mathematical equation environment. The simplest LaTeX code which generates a matrix is

```
\begin{equation*}
    \begin{matrix}
        x_{11} & x_{12} \\
        x_{21} & x_{22} \\
    \end{matrix}
\end{equation*}
```

and results in

$$\begin{matrix} x_{11} & x_{12} \\ x_{21} & x_{22} \end{matrix}$$

There are several variants of `matrix` which produce different delimiters surrounding the matrix. They are presented here below, with the corresponding name on top of each matrix:

`matrix`	`pmatrix`	`bmatrix`	`Bmatrix`
$\begin{matrix} x_{11} & x_{12} \\ x_{21} & x_{22} \end{matrix}$	$\begin{pmatrix} x_{11} & x_{12} \\ x_{21} & x_{22} \end{pmatrix}$	$\begin{bmatrix} x_{11} & x_{12} \\ x_{21} & x_{22} \end{bmatrix}$	$\begin{Bmatrix} x_{11} & x_{12} \\ x_{21} & x_{22} \end{Bmatrix}$
	`vmatrix`	`Vmatrix`	
	$\begin{vmatrix} x_{11} & x_{12} \\ x_{21} & x_{22} \end{vmatrix}$	$\begin{Vmatrix} x_{11} & x_{12} \\ x_{21} & x_{22} \end{Vmatrix}$	

The "mathtools" package offers starred versions of the `matrix` environments which allow to pass an optional argument to specify the alignment inside the matrix's columns. A LaTeX example is shown here below:

```latex
\begin{align*}
    \begin{pmatrix}
        2  & -3 \\
        42 & 0
    \end{pmatrix}
    &&
    \text{VS}
    &&
    \begin{pmatrix*}[r]
        2  & -3 \\
        42 & 0
    \end{pmatrix*}
\end{align*}.
```

Observe the difference in alignment between `pmatrix` and `pmatrix*`:

$$\begin{pmatrix} 2 & -3 \\ 42 & 0 \end{pmatrix} \qquad \text{VS} \qquad \begin{pmatrix*}[r] 2 & -3 \\ 42 & 0 \end{pmatrix*}.$$

Part III

LaTeX for advanced users