Mathematics

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Overview

Packages for mathematics

Some packages very useful for mathematics are listed here below:

- "mathtools" which is mainly an upgrade of the very well-known "amsmath" package (the backbone for mathematics with LaTeX),
- "cases" which provides the `numcases` command to number all lines of a system of equations.

Equations

The main LaTeX environment to write an equation is... `equation`. As an example:

$$\vec{\nabla} \cdot \vec{B} = 0 \tag{1}$$

The starred version disables numbering:

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

There are also shorter forms thanks to:

- the \[...\] wrapper surrounding the equation,
- the double $$ symbol surrounding the equation (plain TEX, deprecated, should not be used).

However, I recommend the use of the `equation` environment because it highlights the mathematics in the LATEX code and for its versatility between the numbered and the unnumbered version.

Inline equations

It is sometimes useful to write mathematics inside a text, for instance to describe the variable $\vec{B}$ appearing in eq. (1). To do so, the mathematical formula must be wrapped by single $ signs.
Recommendation: try to not abuse of inline equations because they

- can be difficult to read in the text,
- could "ruin" the line space,
- cannot be numbered so it is not possible to refer to them.

Grouping equations

No alignment inside the group

Tool: `gather` environment, double backslash (\\) before starting a new equation.
Example with the local equation from Ampere theorem:

$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{j} + \varepsilon_0 \mu_0 \frac{\partial \vec{E}}{\partial t}, \tag{2}$$

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

$$\oint_C \vec{B} \cdot \mathrm{d}\vec{l} = \mu_0 \iint_S \vec{j} \cdot \mathrm{d}\vec{S} + \varepsilon_0 \mu_0 \iint_S \frac{\partial \vec{E}}{\partial t} \cdot \mathrm{d}\vec{S}. \tag{3}$$

Text can be written between equations thanks to the `intertext` and `shortintertext` commands.

Grouping equations

Alignment inside the group

Tool: `align` environment, double backslash (\\) before starting a new equation, ampersand (&) to indicate where the alignment is performed. Examples with the vector potential:

$$\vec{B} = \vec{\nabla} \times \vec{A} \tag{4}$$

$$\vec{E} = -\vec{\nabla} V - \frac{\partial \vec{A}}{\partial t} \tag{5}$$

The `intertext` and `shortintertext` commands are also available. The alignment is generally performed on the equal sign.

Systems of equations

Defined-by-domain functions

Tool: `cases` environment, which displays an opening bracket surrounding all equations included in the environment. It must be included inside another mathematical equation environment. As in `align`, `\\` before starting a new line. One and only one & per line can be used to create a column, typically used to specify the domain on which the equation is valid. A starred version makes the right column *text-mode* instead of *math-mode*. A `dcases` variant makes the environment *displaystyle*.
For examples:

$$a = \begin{cases} x^2 + 2 & \text{if } x < 2 \\ \int x - 3 \, \mathrm{d}x & \text{otherwise} \end{cases} \tag{6}$$

$$a = \begin{cases} x^2 + 2 & \text{if } x < 2 \\ \displaystyle\int x - 3 \, \mathrm{d}x & \text{otherwise} \end{cases} \tag{7}$$

Systems of equations

Systems using cases: not very efficient

The cases environment to write systems:

$$\begin{cases} x + 2y - z = 1 \\ x - 3y + 2z = 4 \\ -x + y + z = 0 \end{cases} \tag{8}$$

Issues:

1. the whole system is numbered but it would be useful to number each line of the system $\rightarrow$ see the "cases" package,
2. there is no alignment between the variables like it is sometimes done in algebra.

Systems of equations

Numbering all lines of the system

Tool: `numcases` environment from the "cases" packages:

$$\begin{cases} x + 2y - z = 1 & (9) \\ x - 3y + 2z = 4 & (10) \\ -x + y + z = 0 & (11) \end{cases}$$

Can also be used for defined-by-domain functions:

$$a = \begin{cases} x^2 + 2 & \text{if } x < 2 \quad (12) \\ \displaystyle\int x - 3 \, \mathrm{d}x & \text{otherwise} \quad (13) \end{cases}$$

In addition to the numbering of all lines, it correspond to `dcases*`, which means that:

- it is directly in *displaystyle*,
- the right column is in *text-mode*.

Systems of equations

Alignment on variables

Tool: `systeme` command from the "systeme" packages. Works outside any math environment and inside `equation`. Commas (,) used to separate equations.
Example:

$$\begin{cases} x + 2y - \ \ z = 1 \\ x - 3y + 2z = 4 \\ -x + \ \ y + \ \ z = 0 \end{cases} \tag{14}$$

Issue: the numbering counter used by the `systeme` command is independent from the LaTeX's equation internal counter.

Matrices

Types of matrices

Matrices can be written by using a `matrix`-like environment inside a mathematical equation environment such as the ones presented here above. Several types of matrices exist. They differ with the type of delimiters surrounding the matrix:

`matrix`

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

`pmatrix`

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

`bmatrix`

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

`Bmatrix`

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

`vmatrix`

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

`Vmatrix`

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

Matrices

Alignment

By default, numbers are centred in each column of a matrix:

$$\begin{pmatrix} 2 & -3 \\ 42 & 0 \end{pmatrix}$$

A starred version of each `matrix` environment offers an optional argument where the alignment can be provided through a letter: `c` for center, `r` for right and `l` for left. Example with right alignment:

$$\begin{pmatrix} 2 & -3 \\ 42 & 0 \end{pmatrix}$$

Package options for layout modification

It is possible to change the layout of equations thanks to package options:

- position of equation numbers
  - on the right (default) with the `reqno` option,
  - on the left with the `leqno` option.