

Introduction to \LaTeX

Lecture 3: Maths in \LaTeX

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- 1 Use Maths in \LaTeX
 - Equation
 - Align
 - Inline
 - Basic Maths Commands
 - Matrix and other multiline equations

The equation environment

An `equation` environment contains a set of maths equations

Command

```
\begin{equation(*)}
...
\end{equation(*)}
```

Example

$$\operatorname{rot} F = \left(\frac{\partial F_z}{\partial y} - \frac{\partial F_y}{\partial z} \right) \hat{n}_x + \left(\frac{\partial F_x}{\partial z} - \frac{\partial F_z}{\partial x} \right) \hat{n}_y + \left(\frac{\partial F_y}{\partial x} - \frac{\partial F_x}{\partial y} \right) \hat{n}_z \quad (1)$$

If a star(*) is added, the sequence number of the equation won't be displayed. Note that the environment name in the `\begin` and `\end` statements must be the same(both or neither have a * here).

The L^AT_EX script of the equation above is quite long, but not so difficult as you think so. All of the useless spaces are omitted, so please pay attention to the necessary spaces (marked in `␣`).

```

1  \begin{equation}
2      {\rm\rot}\_F=\left(\frac{\partial\_F\_z}{\partial\_y}
3      -\frac{\partial\_F\_y}{\partial\_z}\right)\hat{n}_x
4      +\left(\frac{\partial\_F\_x}{\partial\_z}
5      -\frac{\partial\_F\_z}{\partial\_x}\right)\hat{n}_y
6      +\left(\frac{\partial\_F\_y}{\partial\_x}
7      -\frac{\partial\_F\_x}{\partial\_y}\right)\hat{n}_z
8  \end{equation}

```

In equation environment, unlike in plain text, normal spaces will not lead to visible spaces in output. Only `_` or `\quad`, `\qquad` etc. will create spaces between words.

`\partial` prints the symbol ∂ , `\frac {...}{...}` makes a fraction.

`\left (` and `\right (` make brackets that fit the equation's height.

Brackets can be nested and must be in couple, and you can use two kinds of brackets on the both side, i.e., `\left [` and `\right \rbrace`.

Note that you should use `\rbrace` or `\}` to print a right brace $)()$

In order to deal with extremely long equations or equation with multiple lines, we can use `split` environment.

Example

```
1 \begin{equation*}
2   \begin{split}
3     F&=1+2+3+4+5\\
4     &=15
5   \end{split}
6 \end{equation*}
```

$$\begin{aligned} F &= 1 + 2 + 3 + 4 + 5 \\ &= 15 \end{aligned}$$

`&` is used to align the equal marks

`\\` is used to split the equation into two lines.

For equation sets, the `aligned` environment can be used, which is similar to the `split` environment above.

Example

```

1 \begin{equation*}
2   \left\lbrace
3   \begin{aligned}
4     x+y&=1\\
5     x-y&=1
6   \end{aligned}
7   \right.

```

```

1 \Longrightarrow
2 \left\lbrace
3 \begin{aligned}
4   x&=1\\
5   y&=0
6 \end{aligned}
7 \right.
8 \end{equation*}

```

$$\begin{cases} x + y = 1 \\ x - y = 1 \end{cases} \implies \begin{cases} x = 1 \\ y = 0 \end{cases}$$

We can use a dot(.) when we want to insert nothing in one of the brackets. Note that the row number of the code above is wrong...

Something more about equation environment

What if the space between equation and the main body paragraph is considered larger than expectation? Is there any way to modify the line spacing?

In default style of equation is like

Example

your body paragraph is supposed to be typed here

`\begin{equation}`a `\times` b = c `\end{equation}`

your body paragraph is supposed to be typed here

your body paragraph is supposed to be typed here

$$a \times b = c \tag{2}$$

your body paragraph is supposed to be typed here

But if we add

`\setlength\abovedisplayskip{length}` or
`\setlength\belowdisplayskip{length}`, we have

Example

your body paragraph is supposed to be typed here

```
\setlength\abovedisplayskip{0em}
\setlength\belowdisplayskip{0em}
\begin{equation}a \times b = c \end{equation}
```

your body paragraph is supposed to be typed here

your body paragraph is supposed to be typed here

$$a \times b = c \tag{3}$$

your body paragraph is supposed to be typed here

The margin between the body paragraphs and the equation will be lessened as is shown in the example.

The align/aligned environment

An **align** environment is used outside a maths environment like **equation**

Command

```
\begin{align(*)}  
...  
\end{align(*)}
```

An **aligned** environment is used inside a maths environment like **equation**, it is known as an **inline** environment.

Command

```
\begin{equation(*)}  
  \begin{aligned}  
    ...  
  \end{aligned}  
\end{equation(*)}
```

The `align/aligned` environment is a basic align and multiline environment.

Example

```
1 \begin{align*}
2   a+b & \Leftrightarrow b+a \\
3   (a+b)+c & \Leftrightarrow a+(b+c)
4 \end{align*}
```

$$a + b \Leftrightarrow b + a$$

$$(a + b) + c \Leftrightarrow a + (b + c)$$

This is similar to `split` environment.

Moreover, you can use multiple `&`s and the `&`s on every line will be aligned respectively.

A simple method of entering math environment

Usually, we can use `$$...$$` to display a maths equation instead of `\begin{equation*}... \end{equation*}`, which almost have same effect.

However, there is another style of math environment, inline style, which will display the maths equation on the same line of the text before it. It is used like `$...$`

Example

- 1 This is a simple equation `$$x^2+y^2=1$$`
- 2 This is a simple inline equation `$x^2+y^2=1$ \\\`
- 3 The concentration of `[H$_3$O$^+$]` (`[H_3O^+]`) is `\dots`

This is a simple equation

$$x^2 + y^2 = 1$$

This is a simple inline equation $x^2 + y^2 = 1$

The concentration of $[H_3O^+]$ ($[H_3O^+]$) is ...

The difference between inline and normal

Actually, the display style of inline and normal equations have some differences.

Example

Expression

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

inline

$$\left(\frac{1}{\frac{1}{2}}\right)^{\frac{1}{2}}$$

normal

$$\left(\frac{1}{\frac{1}{2}}\right)^{\frac{1}{2}}$$

`\lim_{n\rightarrow\infty} a_n = +\infty`

$$\lim_{n\rightarrow\infty} a_n = +\infty$$

$$\lim_{n\rightarrow\infty} a_n = +\infty$$

`\sum_{k=1}^{10} k = 55`

$$\sum_{k=1}^{10} k = 55$$

$$\sum_{k=1}^{10} k = 55$$

However, most of the differences can be fixed by some other commands

Example

Expression

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

inline

$$\left(\frac{1}{\frac{1}{2}}\right)^{\frac{1}{2}}$$

normal

$$\left(\frac{1}{\frac{1}{2}}\right)^{\frac{1}{2}}$$

`\lim\limits_{n\rightarrow\infty} a_n = +\infty`

$$\lim_{n \rightarrow \infty} a_n = +\infty$$

$$\lim_{n \rightarrow \infty} a_n = +\infty$$

`\sum\limits_{k=1}^{10} k = 55`

$$\sum_{k=1}^{10} k = 55$$

$$\sum_{k=1}^{10} k = 55$$

Here the command `\limits` can be used in much more situations to fix the position of the bounds. The command `\dfrac` is used to print a fraction in normal size.

Basic Maths Commands

Here some basic commands commonly used in L^AT_EX are introduced. You may need `amsmath` and `amssymb` packages.

- `x^abc`, `x_abc`, `x^abc_abc` - x^abc , x_abc , x^abc_abc
- `x^{abc}`, `x_{abc}`, `x^{abc}_{abc}` - x^{abc} , x_{abc} , x^{abc}_{abc}
- `\sqrt{a}`, `\sqrt[b]{a}` - \sqrt{a} , $\sqrt[b]{a}$
- `\overline{a+b}`, `\underline{a+b}` - $\overline{a+b}$, $\underline{a+b}$
- `\overbrace{1+2+\cdots+n}^n` - $\overbrace{1+2+\cdots+n}^n$
- `\underbrace{1+2+\cdots+n}_n` - $\underbrace{1+2+\cdots+n}_n$
- `\overrightarrow{a+b}`, `\vec{a+b}` - $\overrightarrow{a+b}$, $\vec{a+b}$
- `\dots`, `\cdot`, `\cdots`, `\vdots`, `\ddots` - \dots , \cdot , \cdots , \vdots , \ddots

- `\sum_{k=1}^{10} a_k` - $\sum_{k=1}^{10} a_k$
- `\prod_{k=1}^{10} a_k` - $\prod_{k=1}^{10} a_k$
- `\int_a^b x^2 dx`, `\oint`, `\iint\limits_A \{ \quad B \}` -

$$\int_a^b x^2 dx \quad \oint \quad \iint_A$$

- `\lim_{n \rightarrow \infty} \sup a_n` - $\lim_{n \rightarrow \infty} \sup a_n$
- `\cos`, `\sin`, `\tan`, `\arccos`, `\arcsin`, `\arctan`, `\log`, `\ln` - cos, sin, tan, arccos, arcsin, arctan, log, ln
- `\rightarrow`, `\leftarrow`, `\leftrightarrow`, `\Rightarrow`, `\Longleftarrow`, `\Leftrightarrow` - \rightarrow , \leftarrow , \leftrightarrow , \Rightarrow , \Longleftarrow , \Leftrightarrow

Matrix environment

Matrix is commonly used in Maths. There are various kinds of matrix environments defined in `amsmath` package, they are `matrix`, `pmatrix`, `bmatrix`, `Bmatrix`, `vmatrix`, `Vmatrix`.

Command

```
\begin{[p/b/B/v/V]matrix}
    ... & ... & ... \\
    \vdots & \ddots & \vdots \\
    ... & ... & ... \\
\end{[p/b/B/v/V]matrix}
```


Here is some examples of the style of these matrix.

Example

matrix

$$\begin{matrix} a & b \\ c & d \end{matrix}$$

bmatrix

$$\begin{bmatrix} a & b \\ c & d \end{bmatrix}$$

vmatrix

$$\begin{vmatrix} a & b \\ c & d \end{vmatrix}$$

pmatrix

$$\begin{pmatrix} a & b \\ c & d \end{pmatrix}$$

Bmatrix

$$\begin{Bmatrix} a & b \\ c & d \end{Bmatrix}$$

Vmatrix

$$\begin{Vmatrix} a & b \\ c & d \end{Vmatrix}$$

If you take Vv285 and want to use L^AT_EX to finish your homework, you may use `gmatrix`.

Example

```

1  \usepackage{gauss}
2  \begin{equation*}
3      \begin{array}{ccc|}
4          4 & 2 & -2 & \\
5          -3 & 1 & 0 & \\
6          1 & 4 & 2 & 
7      \end{array}
8      \begin{gmatrix}
9          -2 & \\ 6 & \\ -9 & 
10         \rowops
11         \swap{0}{2}
12         \add[*{3}]{0}{1}
13     \end{gmatrix}
14 \end{equation*}

```

$$\begin{array}{ccc|c}
 4 & 2 & -2 & -2 \\
 -3 & 1 & 0 & 6 \\
 1 & 4 & 2 & -9
 \end{array}
 \begin{array}{l}
 \leftarrow \\
 \leftarrow + \\
 \leftarrow
 \end{array}
 \begin{array}{l}
 * (3) \\
 \\

 \end{array}$$

The gather/gathered environment

The `gather/gathered` environment is used to print multiline equations, similar to the `align/aligned` environment but all of the lines align in center. Each line of the equation will be ordered.

Command

```
\begin{gather(*)}
...
\end{gather(*)}
\begin{equation(*)}
  \begin{gathered}
    ...
  \end{gathered}
\end{equation(*)}
```

Example

```
\begin{gather}
a+b=1 \\
aaa+c=2222
\end{gather}
```

$$a + b = 1 \quad (4)$$

$$aaa + c = 2222 \quad (5)$$

The flalign and multiline environment

There another two maths environment called `flalign` and `multiline`, useful in some special situations.

Example

```
1 \begin{flalign}
2   a+b&=1=&b+a\\
3   b&=2=&c
4 \end{flalign}
```

$$a + b = 1 = \qquad b + a \quad (6)$$

$$b = 2 = \qquad c \quad (7)$$

You may notice that the left column is aligned left and the right column is aligned right, different from the `align` environment.

Example

```
1 \begin{multiline}
2   a+b+c=1\\b+c=2\\
3   c+d=1\\d=3
4 \end{multiline}
```

$$a + b + c = 1$$

$$b + c = 2$$

$$c + d = 1$$

$$d = 3 \quad (8)$$

Here, the first column aligns left, the last aligns right and others align center. Note that it is only one equation in order.