Introduction to LaTeX

Lecture 3: Maths in LaTeX

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The equation environment

An equation environment contains a set of maths equations

Command

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

Example

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

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 LaTeX 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 ␣).

```
\begin{equation}
    curl␣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}
\end{equation}
```

In the script, only a space after `\` will be printed as a space.
`\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)(}).

How about equations with multiple lines?
The aligned environment can be used.

Example

```
\begin{equation}
    \left\lbrace\begin{aligned}
        x+y&=1\\x-y&=1
    \end{aligned}\right.\Longrightarrow
    \left\lbrace\begin{aligned}
        x&=1\\y&=0
    \end{aligned}\right.
\end{equation}
```

$$\begin{cases} x+y=1 \\ x-y=1 \end{cases} \Longrightarrow \begin{cases} x=1 \\ y=0 \end{cases} \tag{2}$$

We can use a dot(.) when we want to insert nothing in one of the brackets.

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

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

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

$$a \times b = c \tag{4}$$

your body paragraph is supposed to be typed here

The margin between the body paragraphs and the equation will be lessened as is 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

```
\begin{align}
    a+b & \Leftrightarrow b+a \\
    (a+b)+c & \Leftrightarrow a+(b+c)
\end{align}
```

$$a + b \Leftrightarrow b + a \tag{5}$$

$$(a + b) + c \Leftrightarrow a + (b + c) \tag{6}$$

In order to make a new line, you can easily use \\ where you'd like (but not in certain maths environments such as equation). & is used to align the equations, 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

This is a simple equation

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

This is a simple inline equation $x^2 + y^2 = 1$
The concentration of $[H_3O^+]$

```
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$_3$O$^+$]
```

The difference between inline and normal

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

Example

Expression	inline	normal
`\left(\frac{1}{\frac{1}{2}}\right)^{\frac{1}{2}}`	$\left(\frac{1}{\frac{1}{2}}\right)^{\frac{1}{2}}$	$\left(\frac{1}{\frac{1}{2}}\right)^{\frac{1}{2}}$
`\lim_{n\to\infty}a_n=+\infty`	$\lim_{n\to\infty} a_n = +\infty$	$\lim_{n\to\infty} a_n = +\infty$
`\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	inline	normal
`\left(\dfrac{1}{\frac{1}{2}}\right)^{\frac{1}{2}}`	$\left(\frac{1}{\frac{1}{2}}\right)^{\frac{1}{2}}$	$\left(\frac{1}{\frac{1}{2}}\right)^{\frac{1}{2}}$
`\lim\limits_{n\to\infty}a_n=+\infty`	$\lim\limits_{n\to\infty} a_n = +\infty$	$\lim\limits_{n\to\infty} a_n = +\infty$
`\sum\limits_{k=1}^{10}k=55`	$\sum\limits_{k=1}^{10} k = 55$	$\sum\limits_{k=1}^{10} k = 55$

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 LaTeX 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^bx^2dx, \oint ,\iint\limits_A^{\quad B} -

$$\int_a^b x^2 dx \qquad \oint \qquad \iint\limits_A^B$$

- \lim_{n\to\infty}\sup a_n - $\lim_{n\to\infty} \sup a_n$
- \cos, \sin, \tan, \arccos, \arcsin, \arctan, \log, \ln - cos, sin, tan, arccos, arcsin, arctan, log, ln
- \rightarrow, \leftarrow, \leftrightarrow, \Rightarrow, \longleftarrow, \Longleftrightarrow - $\rightarrow$, $\leftarrow$, $\leftrightarrow$, $\Rightarrow$, $\longleftarrow$, $\Longleftrightarrow$

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}
    ... & ... & ... \\
    ⋮ & ⋱ & ⋮ \\
    ... & ... & ... \\
\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

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

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}
```

$$a + b = 1 \tag{7}$$

$$aaa + c = 2222 \tag{8}$$

The flalign and multline environment

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

Example

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

$$a + b = 1 = b + a \quad (9)$$

$$b = 2 = c \quad (10)$$

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

Example

```
\begin{multline}
    a+b+c=1\\b+c=2\\c=3
\end{multline}
```

$$a + b + c = 1$$

$$b + c = 2$$

$$c = 3 \quad (11)$$

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