Documentation For Package xjtlumath

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Part I
General Information

1 What is this package?

This LaTeX package was originally intended to be used for the materials dept. of XJTLU math club. Yet I found that my university lack LaTeX templates for students, therefore I decided to extend it into a template for all users.

The package contains several useful commands and environments for mathematical documents, and redefines some existing styles so that they suit the university's style.

2 History

At the year 2020, I joined the materials dept. of XJTLU math club. This department makes materials about math and distribute them to students to help them. At that time, the materials were being prepared with Microsoft Word and MathType. I saw that it was a good opportunity to enhance the materials with the power of LaTeX, so I proposed to prepare the documents using LaTeX.

The proposition was passed and our team started to transfer our working environment. During this process, I wrote a tiny package, a predecessor of this package, which was used in our works. Many people in our department knew nearly nothing about LaTeX, and as I promised that the new preparation process would not be very hard, I managed to define the overall procedure, shared some necessary knowledge about LaTeX, and taught them how to use the package.

I admit that I was a bit irresponsible at that time. Truly I described how the working procedure was and how should my package be used, but I shared few about LaTeX. My package and workflow simplified some concepts so that the team didn't need to care about some parts of LaTeX such as the documentclass and preamble, though LaTeX itself is still a lot different from Word. I underestimated the difficulty for my colleagues to learn basic LaTeX typing skills so it was a torment for some of them. I some kind of realized this problem in the later stages, but I was occupied by my own businesses, and didn't pay enough attention to it.

The final results were generally successful and mostly good enough. Yet I feel sorry for my colleagues because this thing was in fact not that easy for them. In addition, I recently took part in the 15^{th} anniversary of XJTLU math club and this somehow strengthened my sense of belonging to the math club. For these reasons, I decided to leave something for XJTLU's students in the future. I rewrote the whole package and added a series of tutorials that covers the basics of LaTeX as well as making materials, so that people in the material dept. will do much less to make a material in LaTeX. The tutorials are in the form of a stories, since I think this method adds more fun to the studying.

Apart from that, the general students of XJTLU or even other LaTeX users may find this package and documentation useful. So its final form was decided to be a template with documentation that is published as a GitHub repository under my personal account. This is because the math club it self doesn't have a GitHub account currently. I will transfer this repository to its official account once it has established one.

Part II
Tutorials

3 Tutorial 1: Ashley's First Material

Ashley joined the material department recently. Now he is assigned to write a part of the material that covers basic calculus. He is very excited because this will be his first material as well as his first try on LaTeX. First, he needs to know how to use LaTeX and the package on his PC. In this tutorial, we will follow Ashley and see what he learns in the material preparation.

3.1 Installation and Configuration

To use LaTeX, Ashley needs a TeX distribution (and probably an editor) installed on his computer. There are several popular distributions listed on the LaTeX official website: https://www.latex-project.org/get/. The installation and configuration of these distributions are quite easy and Ashley completed them in a few minutes.

Then, Ashley wants to have an editor for writing LaTeX documents. He learns that TeXstudio is a good one, so he downloads and installs it.

What Ashley needs to do now is to obtain a copy of this package and install it. (TBD)

3.2 Basic Writings

Ashley, waiting breathlessly to begin his first work, clicks open the Templates folder and navigates into the material-book folder. He opens encapsulation.tex and notices that it is like this:

```
... Some code ...

\input{chapters.tex}

... Some code ...
```

As the file name suggests, this is for making a material that -is to be published as a book. A book contains some chapters, and in the material writing, each chapter is a specific part of the material topic. For example, Ashley's work is part of the calculus material, so he needs to start a chapter for his work. He opens chapter.tex and finds a blank document. He then adds the following command to start his first chapter and runs LaTeX on encapsulation.tex to check the output (On the left is the result of his command(s), appearing in a different font family, and on the right is his commands, with a gray background):

1 Key points in calculus

```
\chapter{Key points in calculus}
```

`\chapter{...}` is a LaTeX *command*, which starts with a `\`. The words being wrapped with the curly brackets `{}` form an *argument* for the command. At this place, they are the caption of the chapter. Ashley notices that LaTeX automatically enlarges the font and makes them bold. Being different with many other typesetting software, LaTeX only needs the logical idea of what to do (e.g. there will be a chapter named xxx at some place), and it will control the appearance for the author.

Ashley is satisfied with that result. He then types some of paragraphs. In LaTeX, paragraphs are separated by one blank line.

```
\chapter{Key points in calculus}
What does Ashley write in these
paragraphs? Well, in fact, I don't
know. You may find him and ask him
yourself.

But, wait a minute, how do I find
Ashley when he doesn't really exist?
Well, this is a good question.
```

1 Key points in calculus

What does Ashley write in these paragraphs? Well, in fact, I don't know. You may find him and ask him yourself.

But, wait a minute, how do I find Ashley when he doesn't really exist? Well, this is a good question.

Ashley notices that paragraphs are automatically indented by LaTeX. Yet he also notices that the paragraph directly under the chapter is not indented.

Apart from chapter, LaTeX also provides these sectioning commands:

- section
- subsection
- subsubsection
- paragraph
- subparagraph

You may notice that paragraph is included here. In fact, the sectioning command `\paragraph` generates a title for the paragraphs like other sectioning commands.

When Ashley turns to the whole output, he sees that his chapter appears in the table of contents:

Contents


```
\chapter{Key points in
calculus}
```

LaTeX generates the table of contents for all sectioning commands[1]. For this reason, Ashley has to run LaTeX twice on encapsulation.tex for a correct table of contents.

[1] whose depth are below the table of contents (toc) depth. The actual process of how toc is generated is a bit complex, so I will not cover it here

When Ashley once writes a very long caption for a section, the table of contents become quite ugly. To solve this, Ashley can specify a short form of the section that is used in the table of contents, as shown below:

Contents

1 **A Short Name** 1

```
\chapter[A Short Name]{A very very long Caption}
```

3.3 Adjust fonts

So far, Ashley knows how to instruct LaTeX to do some basic things. Although he feels full of energy and is writing at full speed, he soon encounters some problems. Ashley wants to emphasize some keywords such as "limit". He later learns that the command `\emph` instructs LaTeX to emphasize the text passed to it, as shown below.

Calculus is the study of *limits*.

```
Calculus is the study of \emph{limits}.
```

This thing is quite LaTeX, as Ashley only tells LaTeX to emphasize it, and has no control of how LaTeX does it. Although most of times it is enough, Ashley wants more. He wonder how can one explicitly control the appearance of the texts, since LaTeX cannot cover all needs in every situations. LaTeX does provide certain default operations on fonts, and Ashley can use them to control the size, family, and style of his texts.

Ashley can tell LaTeX to adjust the font size like: very very small the size of scripts the size of foot notes small font just being normal a bit bigger large text very big huge damn huge

```
Ashley can tell \LaTeX{} to adjust the font size like:
{\tiny very very small} {\scriptsize the size of scripts} {\footnotesize the size of foot notes} {\small small font} {\normalsize just being normal} {\large a bit bigger} {\Large large text} {\LARGE very big} {\huge huge} {\HUGE damn huge}
```

This time Ashley sees something different from the command `\emph{}`. The texts here are inside curly brackets, and the commands are just given inside the brackets along with the texts. Something enclosed by a pair of curly brackets is said to be inside a *group*. Commands called inside the group influence the whole group.

Apart from the sizes, Ashley is also able to control the style and family of fonts. As shown in Table 1, LaTeX provides these commands to control font style and family:

Many of these commands provide both an used-in-group version and a normal version. Ashley can choose which version to use depend on his needs.

Ashley also wants to learn how to change the color of fonts. He is surprised that this package documentation does not provide such a description. After

Command	Used in a group	Action
`\textrm{...}`	`{\rmfamily...}`	Text in Roman family
`\textsf{...}`	`{\sffamily...}`	Text in sans serif family
`\texttt{...}`	`{\ttfamily...}`	Text in `typewriter` family
`\textmd{...}`	`{\mdseries...}`	Text in medium series
`\textbf{...}`	`{\bfseries...}`	Text in **bold** series
`\textup{...}`	`{\upshape...}`	Text in upright shape
`\textit{...}`	`{\itshape...}`	Text in *italic* shape
`\textsl{...}`	`{\slshape...}`	Text in *slanted* shape
`\textsc{...}`	`{\scshape...}`	Text in SMALL CAPS shape
`\emph{...}`	`{\em...}`	Text *emphasized*
`\textnormal{...}`	`{\normalfont...}`	Text in default font

Table 1: Standard font-changing commands and declarations

contacting with the package author, he learns that this topic is not covered because the materials are printed in black and white, so it would be nearly useless to change colors.

3.4 Typing Mathematical Formulae

It comes the most exciting part of Ashley's work — typing formulae! Even though he had little experience in LaTeX before, he already learned that LaTeX produces high-quality math formulae, as he previously saw at some sites like Math Stack Exchange (https://math.stackexchange.com/) and ZhiHu (https://www.zhihu.com/).

Because of his previous experience on these sites, he knows a little bit about how to write formulae in LaTeX.

Generally, formulae in LaTeX are classified into two types: *inline* and *displayed*. Formulae of the former type are enclosed in a pair of dollar sign: `$...$`, while formulae of the latter type are enclosed in a pair of double dollar sign: `$$...$$`. These delimiters are the original TeX ones. LaTeX provides additionally two pairs of delimiters for inline and displayed math, respectively: `\(...\)` and `\[...\]`. In fact, the TeX shorthand `$$...$$` for displayed math should be avoided, as it may lead to strange problems in LaTeX.

As their name suggest, an inline formula is in a line of texts, while a displayed formula is displayed outside of the main texts.

The derivative of a function f can be written as f', or as

$$\frac{\mathrm{d}f}{\mathrm{d}x}$$

```
The derivative of a function $f$
can be written as $f'$, or as
\[
\frdt{x}
\]
```

Here, Ashley uses a command provided by xjtlumath: `\frdt`. This command takes two argument, where the first one is optional with the default value f. They represent the function and the variable, respectively. When Ashley wants to typeset the derivative of g to x, he will write `\frdt[g]{x}`, which gives $\frac{\mathrm{d}g}{\mathrm{d}x}$. The optional argument is passed to the command in the embrace of a pair of two square brackets. As careful as Ashley, you may notice that in inline mode, a formula is shrunk to some extent so that it can fit in one line.

Ashley is quite satisfied with the rendering effect. He then writes some equations and texts. But when he wants to reference a equation, a problem arises. How does he address the equation he wants to reference? Here Ashley is introduced with another way of giving a displayed math: the equation environment.

The fundamental theorem of calculus can be expressed in the form of Equation 1

$$\int_a^b f(x)\,\mathrm{d}x = F(b) - F(a) \tag{1}$$

```
The fundamental theorem of calculus
can be expressed in the form of
Equation \ref{eq:fundthmcal}
\begin{equation}
\int_a^b f(x) \dx = F(b) - F(a) \label
{eq:fundthmcal}
\end{equation}
```

Ashley understands the equation by his previous knowledge: the underscore (`_`) introduces the subscript (a) to the integral symbol $\int$ (`\int`), while the caret (`^`) introduces the superscript (b) to it. The command `\dx` is provided by xjtlumath. If Ashley types dx directly, the result will be like this $\int f(x)dx$, which is ugly. `\dx` refines the result. Note that `\dx` can only be used to represent the integral variable, because it adds a little space before it. If Ashley needs to use other variables, he needs to use the command `\dd`. xjtlumath also provides the same facility for multiple integrals.

$$\int f(t)\,\mathrm{d}t, \quad \iint f(x,y)\,\mathrm{d}x\,\mathrm{d}y, \quad \iiint f(x,y,z)\,\mathrm{d}x\,\mathrm{d}y\,\mathrm{d}z$$

$$\iint f\,\mathrm{d}r\,\mathrm{d}\theta, \quad \iiint f\,\mathrm{d}z\,\mathrm{d}r\,\mathrm{d}\theta, \quad \iiint f\,\mathrm{d}\rho\,\mathrm{d}\theta\,\mathrm{d}\phi$$

```
\[
\int f(t) \dd t,\quad
\iint f(x,y) \dxdy,\quad
\iiint f(x,y,z) \dxdydz
\]
\[
\iint f \drdt,\quad
\iiint f \dzdrdt,\quad
\iiint f \drdtdp
\]
```

However, Ashley knows nothing about cross-referencing in LaTeX as well as the equation environment. Let's explain them to Ashley. In LaTeX, an environment is started by the `\begin` command and ends at the `\end` command. The name of the environment is passed to the pair of commands. The equation environment gives a displayed math equation that is *counted*. The `\label` command at the end of the equation catches the counter as well as some other

information like its location and store it in the label represented by the name given to `\label`. To use the label, Ashley needs the `\ref` command, which prints the counter[2].

The equation environment gives a numbered counted, while `\[\]` doesn't. Using a label inside this causes the label to be directed to another counter, so use a label only when that thing is counted.

3.5 Space Management

The space management in LaTeX is a bit more complex than just typing white spaces. Ashley is a careful person, he soon finds that the space after a sentence is a little bit larger than the space between words (you may zoom in the .pdf file to see this). LaTeX decides a space as a space at the end of a sentence if

1. A full stop (.) or right quotation mark (') is immediately followed by the space, and
2. if it is a full stop being followed, the letter immediately before the full stop is in lowercase.

Most sentences end according to the above rules, though there are some exceptions. For example, LaTeX may take a Mr. as the sign of a sentence ending, and thus produces wrong spacing. Under such circumstances, Ashley needs to configure LaTeX manually by `~` and `\@`.

In another world, Mr. Ashley was once loved by Miss Scarlett. In this world, Mr. Ashley has a PC. He loves programming on his PC.

```
In another world, Mr.~Ashley was once
loved by Miss Scarlett. In this world,
 Mr.~Ashley has a PC\@. He loves
programming on his PC.
```

Ashley is happy as he learned how to manage the spaces. Yet soon he finds another problem.

Some commands like LaTeXseems to eat the space after it.

```
Some commands like \LaTeX seems to eat
 the space after it.
```

To solve this problem, Ashley needs to add an empty group (`{}`) at the end of the command.

As for mathematical formulae, things become different. LaTeX ignores all white spaces in math mode, whether it is inline or displayed. To add extra spaces, Ashley has to use the commands shown in Table 2.

3.6 Lists and Other Environments

Now Ashley has learned about dealing with texts, he continues his writing. Soon he has to break again as he is working on a list. At first, he hard-codes the list

[2] and in addition generates a clickable hyperlink, which on click navigates to the location of the equation, and which is the effect of the hyperref package loaded by the template.

Command	Effect (approximately)
`\,`	$\frac{3}{18}$ quad (␣)
`\:`	$\frac{4}{18}$ quad (␣)
`\;`	$\frac{5}{18}$ quad (␣)
`\` (\ followed by a space)	a space
`\quad`	Width of 'M' in current font (␣)
`\qquad`	2 quad (␣␣)

Table 2: Spacing in Math Mode

like this:

1. Something
2. Something
3. Something

```
1. Something

2. Something

3. Something
```

Yet this solution looks rather silly. In addition, if Ashley wants to change the number, he needs to do it manually. He wonders if LaTeX has some more convenient way to do it.

Fortunately there is. LaTeX provides several environment to deal with lists. One example is shown below.

1. Something
2. Something
3. Something

```
\begin{enumerate}
\item Something
\item Something
\item Something
\end{enumerate}
```

Now Ashley has nearly everything he needs to know. He is content with what he has written and feels happy. The only thing that matters for him is that he wants to show theorems, definitions, and other things in a more fancy fashion so that his readers can focus on these.

xjtlumath provides some fancy environments just for this purpose.

Definition 3.1: Absolute Convergence

An infinite series $\sum_{n=0}^{\infty} a_n$ is said to be absolutely convergent iff

$$\sum_{n=0}^{\infty} |a_n|$$

converges

```
\begin{definition}[Absolute Convergence]
An infinite series $\infseries{n}{0}$ is said to be absolutely convergent iff
\[
\sum_{n=0}^\infty |a_n|
\]
converges
\end{definition}
```

xjtlumath loads amsthm, which gives the proof environment. When Ashley uses this environment to write proofs, he finds that a q.e.d. sign appears at the end of the environment.

Now we prove the mean value theorem for definite integrals. That is, for a continuous function f that is bounded on $[a,b]$, the definite integral $\int_a^b f(x)\,\mathrm{d}x = f(c)(b-a)$, where $c \in [a,b]$.

Proof. Let m, M be the infimum and supermum of $f([a,b])$, respectively. Therefore, $m \le f \le M$, and

$$\int_a^b m\,\mathrm{d}x \le \int_a^b f(x)\,\mathrm{d}x \le \int_a^b M\,\mathrm{d}x$$

, which gives

$$m(b-a) \le \int_a^b f(x)\,\mathrm{d}x \le M(b-a)$$

$$m \le \frac{\int_a^b f(x)\,\mathrm{d}x}{b-a} \le M \tag{2}$$

Since that f is continuous, it can reach every value between the infimum and supermum of its range. That is, $\exists c \in [a,b], f(c) = \int_a^b f(x)\,\mathrm{d}x$. Substitute $f(c)$ back to equation 2 gives what the theorem states. □

```
Now we prove the mean value theorem for definite integrals. That is, for a continuous function $f$ that is bounded on $[a,b]$, the definite integral $\int_a^b f(x) \dx = f(c)(b-a)$, where $c \in [a,b]$.
\begin{proof}
Let $m,M$ be the infimum and supermum of $f([a,b])$, respectively.
Therefore, $m\le f \le M$, and
\[
\int_a^b m \dx \le \int_a^b f(x) \dx \le \int_a^b M \dx
\]
, which gives
\begin{align}
m(b-a) \le &\int_a^b f(x) \dx \le M(b-a) \nonumber\\
m \le &\frac{\int_a^b f(x) \dx}{b-a} \le M \label{eq:meanvalint}
\end{align}

Since that $f$ is continuous, it can reach every value between the infimum and supermum of its range. That is, $\exists c \in [a,b], f(c) = \int_a^b f(x) \dx$.
Substitute $f(c)$ back to equation \ref{eq:meanvalint} gives what the theorem states.
\end{proof}
```

Ashley is able to control where the q.e.d. sign appears by using the `\qedhere` command provided by proof. If this command is given before, then it will not appear at the end.

Proof. Some words...

$$a+b=c \qquad \square$$

Som words...

```
\begin{proof}
Some words...
\[
a+b=c \qedhere
\]
Som words...
\end{proof}
```

Besides of definition and proof, Ashley is also able to use theorem, proposition, corollary, lemma, axiom, and example. Except for proof, these environments own their individual counters, and Ashley can simply use label to reference them.

However, one colleague of Ashley, Chao, complains that the English caption of these environments conflicts with the Chinese material he is writing. For this purpose, xjtlumath additionally provides Chinese version environments in replace of them in Chinese materials. Appending a 'c' to the environments' names gives the names of the Chinese version environments.

These facilities greatly help Ashley in his material preparation, and he will finish his work soon...

4 Tutorial 2: Delilah and Complex Math Formulae

Delilah is working on a part of a material about linear algebra. As her work proceeds, she will obtain the ability to deal with complex mathematical formulae in LaTeX, especially those methods provided by the ams packages loaded in xjtlumath.

4.1 Multiple Lined Formulae

A system of linear equations is a fundamental part of linear algebra. When Delilah tries to type a group of equations, she encounters a problem. In the predefined `\[\]` and environment equation, she finds no option to start a new line. Even the line-break options of LaTeX like `\\` and `\newline` do not work there. Of course the equations should not be put in one line, so what should she do now? Later she learns that the environment *aligned* is designed to allow a system of equations to be aligned in multiple lines:

$$\begin{aligned} x+y &= 1\\ x-y &= 2 \end{aligned}$$

```
\[
\begin{aligned}
x+y &= 1\\
x-y &= 2
\end{aligned}
\]
```

Here, the ampersand sign `&` is used before the symbols according to which the equations are to be aligned. The line break sign `\\` starts a new line of equation. Note that other line-break operations cannot be used here.

Delilah likes the result, but she feels that the equations are too lonely. She thinks that adding a large curly bracket for them will comfort them. LaTeX supports a syntax to put things before and after a group of things.

$$\left\{\begin{aligned} x+y &= 1\\ x-y &= 2 \end{aligned}\right.$$

```
\[
\left\{
\begin{aligned}
x+y &= 1\\
x-y &= 2
\end{aligned}
\right.
\]
```

The `\left` command defines what is to be put on the left, and the `\right` command defines what is to be put on the right. Delilah does not want to put anything on the right, so she writes `.` for nothing.

For a group of equations that requires no alignment, or for a single equation that is too long to fit in one line, the environment *gathered* that does no alignment is a better choice:

$$\cos z = 1 - \frac{z^2}{2!} + \frac{z^4}{4!} - \frac{z^6}{6!} + \cdots = \sum_{n=0}^{\infty} \frac{(-1)^n z^{2n}}{(2n!)}$$

```
\[
\begin{gathered}
\cos {z} = 1 - \frac{z^2}{2!} + \frac{z^4}{4!} - \cdots \\
= \sum_{n=0}^\infty {\frac{(-1)^n z^{2n}}{(2n!)}}
\end{gathered}
\]
```

After writing several groups of equations, Delilah wants to reference one of them. She uses the equation environment instead of `\[\]`, but finds out that the equations are numbered as a whole.

$$x + y = 1 \qquad (3)$$
$$x - y = 2$$

```
\begin{equation}
\begin{aligned}
x+y &= 1\\
x-y &= 2
\end{aligned}
\end{equation}
```

So it is difficult for her to reference a single equation in a group. amsmath provides the environment align for this purpose:

$$x + y = 1 \qquad (4)$$
$$x - y = 2 \qquad (5)$$

```
\begin{align}
x+y &= 1\\
x-y &= 2
\end{align}
```

If she doesn't want to number a single equation, she needs to append `\nonumber` at the end of that line.

$$x + y = 1 \qquad (6)$$
$$z = 10$$
$$x - y = 2 \qquad (7)$$

```
\begin{align}
x+y &= 1\\
z &= 10 \nonumber\\
x-y &= 2
\end{align}
```

Without the "ed" suffix, *gather* is also a standalone environment that does what gathered do. But there is a major difference between the normal version and "ed"ed version. Delilah finds it impossible to put the bracket again before a align or gather, because they don't need to be surrounded by mathematical environments. Also, their width are fixed to be the width of texts, while their "ed"ed versions can be of any width.

As the same as the equation environment, their starred versions give no number by default.

$$x + y = 1$$
$$x - y = 2$$

```
\begin{align*}
x+y &= 1\\
x-y &= 2
\end{align*}
```

Delilah is able to put multiple groups of equations in one align, just by adding ampersands between the groups.

$$x + y = 1 \qquad a + b = 3$$
$$x - y = 2 \qquad a - b = 4$$

```
\begin{align*}
x+y &= 1  & a+b &= 3\\
x-y &= 2  & a-b &= 4
\end{align*}
```

The space between the groups is adjusted automatically by align.

4.2 Matrices

Matrices are vital to linear algebra, as they represent linear mappings from a vector space to another in specific bases. Also, the coefficient matrix and the augmented matrix are convenient in operating linear equations.

amsmath provides several environments for typing matrices.

$$\begin{bmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 9 & 10 & 11 & 12 \\ 13 & 14 & 15 & 16 \end{bmatrix}$$

```
\[
\begin{bmatrix}
1&2&3&4\\
5&6&7&8\\
9&10&11&12\\
13&14&15&16
\end{bmatrix}
\]
```

The environments pmatrix, Bmatrix, vmatrix, and Vmatrix produce delimiters of `()`, `{}`, `||`, and `|| ||`, respectively.

To use matrices in inline mode, Delilah uses the environment smallmatrix, which has no p,b,B,v,V versions in amsmath, as it is the author's responsibility to decide the delimiters.

The matrix $\left(\begin{smallmatrix} a & b \\ c & d \end{smallmatrix}\right)$ is so small and cute!

```
The matrix $\left(\begin{smallmatrix} a&b\\c&d \end{smallmatrix}\right)$ is so small and cute!
```

When Delilah tries to put fractions inside a matrix, she finds something annoying.

$$\begin{bmatrix} 1 & \frac{1}{2} & \frac{1}{3} \\ 1 & \frac{1}{4} & \frac{1}{5} \end{bmatrix}$$

```
\[
\begin{bmatrix}
1&\frac{1}{2}&\frac{1}{3}\\
1&\frac{1}{4}&\frac{1}{5}\\
\end{bmatrix}
\]
```

The fractions above and below are so close that they touch each other! This is not what Delilah wants and she is surprised that LaTeX doesn't detect this and do something. Fortunately, in amsmath environments, an optional argument is allowed to be passed to \\ to define the actual vertical space between lines. For fractions, 2ex is a good option. Also, the fractions are in inline mode. The `\dfrac` command gives displayed fractions.

$$\begin{bmatrix} 1 & \dfrac{1}{2} & \dfrac{1}{3} \\[2ex] 1 & \dfrac{1}{4} & \dfrac{1}{5} \end{bmatrix}$$

```
\[
\begin{bmatrix}
1&\dfrac{1}{2}&\dfrac{1}{3}\\[2ex]
1&\dfrac{1}{4}&\dfrac{1}{5}
\end{bmatrix}
\]
```

Sometimes a matrix is too large to be displayed fully. At these times, the use of ellipses (plural of ellipsis, not ellipse) is important. When Delilah writes the inverse of a matrix, she uses ellipses.

$$A^{-1} = \frac{1}{\det A} \begin{bmatrix} C_{11} & C_{21} & \cdots & C_{n1} \\ C_{12} & C_{22} & \cdots & C_{n2} \\ \vdots & \vdots & \ddots & \vdots \\ C_{n2} & C_{n2} & \cdots & C_{nn} \end{bmatrix}$$

```
\[
A^{-1} = \frac{1}{\det A}
\begin{bmatrix}
C_{11} & C_{21} & \cdots & C_{n1} \\
C_{12} & C_{22} & \cdots & C_{n2} \\
\vdots & \vdots & \ddots & \vdots \\
C_{n2} & C_{n2} & \cdots & C_{nn}
\end{bmatrix}
\]
```

4.3 Texts and Operator Names

To put text inside math environments, Delilah uses the `\text` command provided by amsmath.

Definition 4.1: Null Space

The null space of an $m \times n$ matrix A, written as $\operatorname{Nul} A$, is the set of all solutions of the homogeneous equation $A\mathbf{x} = \mathbf{0}$. In set notation,

$$\operatorname{Nul} A = \{\mathbf{x} : \mathbf{x} \text{ is in } \mathbb{R}^n \text{ and } A\mathbf{x} = \mathbf{0}\}$$

```
\begin{definition}[Null Space]
The null space of an $m \times n$ matrix $A$, written as $\Nul A$, is the set of all solutions of the homogeneous equation $A\vec{x} = \vec{0}$. In set notation,
\[
\Nul A = \{\vec{x}:\vec{x} \text{ is in } \mathbb{R}^n \text{ and } A\vec{x} = \vec{0} \}
\]
\end{definition}
```

The commands like `\Nul`, `\sin`, ... are math operators. Part of predefined math operators in LaTeX are shown in Table 3.

Result	Command	Result	Command	Result	Command
arccos	`\arccos`	arcsin	`\arcsin`	arctan	`\arctan`
cos	`\cos`	sin	`\sin`	tan	`\tan`
cot	`\cot`	sec	`\sec`	csc	`\csc`
cosh	`\cosh`	sinh	`\sinh`	tanh	`\tanh`
lim	`\lim`	lim inf	`\liminf`	lim sup	`\limsup`
ln	`\ln`	log	`\log`	lg	`\lg`
max	`\max`	min	`\min`	sup	`\sup`
inf	`\inf`				
ker	`\ker`	det	`\det`	exp	`\exp`

Table 3: Some Predefined Math Operators

In fact, operator `\Nul` and `\Span` are defined by xjtlumath as in the forms in the year 1 linear algebra textbook of XJTLU. Also, xjtlumath changes the default `\vec` command in LaTeX so that vectors appear in bold form rather than with a arrow above them.

Some operators, like `\lim`, are designed to support taking limits. That is, in displayed mode, when one tries to give one of such operators a subscript using `_`, the subscript will appear at the bottom of the operator.

$$\lim_{x \to 0} f(x)$$

```
\[
\lim_{x\to 0} f(x)
\]
```

Delilah is able to explicitly control the limit style by using `\limits` and `\nolimits`. Note that these two commands can only be used after a operation that supports taking limits.

$\lim_{x\to 0} f(x)$ $\lim_{x\to 0} f(x)$

```
$\lim\limits_{x \to 0}f(x)$
\[
\lim\nolimits_{x\to 0} f(x)
\]
```

4.4 Symbols

The standard LaTeX font in math environments is neat and clean. Yet in some special occasions Delilah would like to change the font of some symbols. For example, to represent some conventional sets, she uses the blackboard font.

$\mathbb{R}\quad \mathbb{N}\quad \mathbb{Q}\quad \mathbb{Z}$

```
\[
\mathbb{R}\quad \mathbb{N}\quad \mathbb{Q}\quad \mathbb{Z}
\]
```

Writing `\mathbb` every time is somehow irritating. For this purpose, xjtlumath defines shorthands for them.

$\mathbb{R}\quad \mathbb{Q}\quad \mathbb{Z}\quad \mathbb{N}\quad \mathbb{N}^+$

```
\[
\setr \quad \setq \quad \setz \quad \setn \quad \setnp
\]
```

Other font controlling methods are like what we have talked about in subsection 3.3. For example, `\mathrm` gives font in Roman family, and `\mathbf` gives font in **bold** series.

$\mathrm{Like normal text}\quad \mathbf{bold}$

```
\[
\mathrm{Like normal text} \quad \mathbf{bold}
\]
```

5 Tutorial 3: Yue Handling Floats

Yue is preparing her material for the monthly of math club. She wants to make her material interesting and easy to understand, so she utilizes many figures and tables.

Figures, tables and many other things that occupy an (often large) area of random width and height are treated as *floats* in LaTeX. Floats are common in today's documents, yet they cause great troubles in typesetting. In this section, we will work along with Yue to see how floats are handled in LaTeX.

5.1 Inserting Images

To insert images in LaTeX, package graphicx (loaded by the template files) is a good option. It provides the `\includegraphics` that accepts the input image filename and some optional specifiers.


```
\includegraphics[width=\textwidth]{assets/
examplelogo.jpg}
```

Yue soon finds out that simply using this command is not a good option, because if there is not enough vertical space for the image, it will be placed on the next page, leaving a large vacant area, which is quite ugly. Also, she is unable to provide the image with a caption or to reference it.

So, Yue wraps the image with the figure environment that makes the image a *figure*.

Figure 1: Example Logo

Figure 1 shows the figure Yue uses.

```
\begin{figure}
\includegraphics[width=\textwidth]{assets
/examplelogo.jpg}
\caption{Example Logo}
\label{fig:example}
\end{figure}
Figure \ref{fig:example} shows the figure
 Yue uses.
```

LaTeX automatically gives a number to it so that Yue is able to reference it. Note that due to implementation reasons, `\label` should only be placed immediately after a `\caption` lest the reference be wrong.

5.2 Tables

Even if using figures does require an extra environment, it is still quite simple and Yue soon becomes familiar with it. Dealing with tables, however, is more complex in LaTeX.

To generate a table-like content in LaTeX, Yue has to use special environments. tabular and array are two specific examples of them. In fact, the two

environments are alike in most of the aspects, with one major difference being that array is often used in math mode.

The syntax of array and tabular resembles the one of matrix environments used by Delilah, though here Yue has to explicitly specify the column behavior.

Entry 1	Entry 2
a	b

```
\begin{tabular}{|c|c|}
\hline
Entry 1 & Entry 2\\
\hline
a & b\\
\hline
\end{tabular}
```

Yue doesn't quite understand what `|c|c|` means, so she searches on the Internet for this. It tells her that this argument passed to tabular specifies each column. The letter c tells tabular that the contents in this column should be centered. And two other alignment specifier l and r are available for "left" and "right", respectively. The vertical bar indicates that at this place a vertical line should be inserted (c.f. The `\hline` command that instructs a horizontal line to be inserted at the top of the current row)

The width of a column is determined by the contents of the contents when either c,l, and r is given. Yue is able to control the width of a column by using another specifier "p", in which the content is left-aligned.

Entry 1	Entry 2
a	b

```
\begin{tabular}{|c|p{2cm}|}
\hline
Entry 1 & Entry 2\\
\hline
a & b\\
\hline
\end{tabular}
```

When there is many columns with the same specifier, Yue can use this syntax `*{num}{spe}` to repeat the specifiers, where num is the number of repetitions, and spe is the specifier.

a	a	a	a	a	a	a
a	a	a	a	a	a	a

```
\begin{tabular}{|*{7}{c|}}
\hline
a&a&a&a&a&a&a\\
\hline
a&a&a&a&a&a&a\\
\hline
\end{tabular}
```

Yue doesn't like line-separated tables because she considers them not tidy. She wants to use space to separate contents. She can use `@{\hspace{}}` between column specifiers to specify the inter-column space and use `\vspace{}`

immediately before \\ to add extra space before the next row.

a b b
a b b

c d d

```
\begin{tabular}{c@{\hspace{1cm}}cc}
a & b & b\\
a & b & b\vspace{.5cm}\\
c & d & d\vspace{.5cm}\\
\end{tabular}
```

In fact, inside `@{}` Yue can use not only spaces, but any other contents.

crime scene <POLICE, stay away> people
crime scene <POLICE, stay away> people

```
\begin{tabular}{c@{ <POLICE, stay away> }
c}
crime scene & people \\
crime scene & people \\
\end{tabular}
```

Like the environment figure, the environment table is designed to accept a table-like content.

a b
c d

Table 1: Example Table

Table 1 shows a table.

```
\begin{table}
\begin{tabular}{cc}
a & b \\
c & d \\
\end{tabular}
\caption{Example Table}
\label{tab:example}
\end{table}
Table \ref{tab:example} shows a table.
```

Now that Yue understands how to manipulate table-like contents in LaTeX, she soon resumes to her work. At some point, she has to create a super big table that contains at least 20 columns, and she finds that it sticks out of the page. When she tries to use `\small` to reduce the size of the texts, she finds that she has to copy it for every entry of the table, which means hundreds times of repetition. To control the overall style, Yue needs to give the controlling commands between the beginning of table and the beginning of tabular.

a	a	a	a	a	a	a	a	a	a	a	a	a	a
a	a	a	a	a	a	a	a	a	a	a	a	a	a

```
\begin{table}
\small
\begin{tabular}{|*{14}{c|}}
\hline
a&a&a&a&a&a&a&a&a&a&a&a&a&a\\
\hline
a&a&a&a&a&a&a&a&a&a&a&a&a&a\\
\hline
\end{tabular}
\end{table}
```

5.3 Placement of Floats

Yue used to use Microsoft Word, which places floats wherever the user wants to place it at. Everything had been fine since she had turned to LaTeXfor some time, but now Yue has a problem. A figure "disappeared" from the output. After checking her code and the output again and again, she accidentally finds that the figure appears in the next page. This really confuses her. Due to the internal algorithm of TeX, it is technically impossible to arrange every float at where the user wants to place them. According to *the LaTeX Companion*,

> "Floats are often problematic in the present version of LaTeX, because the system was developed at a time when documents contained considerably less graphical material than they do today."

Yet LaTeX does give some option to allow the Yue to control the placement of a float to some extend. For a figure or table environment, Yue is able to pass to it an optional argument that specify the desired placement. There are five placement specifiers and they can be combined together in any order.

! Ignores some LaTeX limitation[3] when trying to place the float.

h Tries to place the float exactly at where the the environment is issued. If the attempt fails and no other specifier other that ! is given, the specifier will be changed to t.

t Tries to place the float at the top of the page.

b Tries to place the float at the bottom of the page.

p Tries to place the float at a float page (a page that is generated by LaTeX to place floats)

LaTeX tries to place a float according to the specifiers in the order of the above list from the top to the bottom. Generally all floats of a document can be handled properly. But should a float proves impossible to handle, the author should adjust (probably reduce) its width and height.

5.4 Table of Floats

As mentioned at the beginning, in Yue's material, there are many floats. She wonders if there is a way to provide a quick reference to them.

Like `\tableofcontents`, LaTeX provides the following two commands to print a list of all figures and a list of all tables used in a document, respectively.

`\listoffigures and \listoftables`

The name of a float that appears on the list is defined by the caption of the float. If the captions appears to be too long, Yue can pass to caption an optional argument that will instead be shown on the list. Also, don't forget to compile the file at least twice for the lists to show properly.

[3] LaTeX has some limitations when it tries to place floats. For example, if the height of a float is larger than a degree of page height, then it cannot be placed at the bottom of a page.

5.5 A Suggestion About Images

Yue is suggested to use vector graph for images, as vector graph is lossless when the image is scaled along with the output file.

There are several packages that enables drawing images directly in LaTeX, yet they all require great efforts. It is suggested to use modern tools to generate appropriate images (e.g. Mathematica is able to export the math plots drawn.).