

Comprehensive Introduction to **L^AT_EX** for Scientists and Engineers

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Chapter 1

Introduction

This manual was originally written several years ago because of my friends' request. The contents are arranged, so everyone can get started scientific theses or manuscripts without "studying" \LaTeX . It is not easy to read off the essence from some of \LaTeX books since the books usually contain every single detail. It could be a bit overwhelming if you do not know anything about \LaTeX . Some people seem to need a short introduction so they can explore by themselves later on. Therefore, this manual shows only the basics to get into \LaTeX by yourself. I am not explaining the philosophical or historical aspects on \LaTeX in this book. I tried to arrange this for physicists, mathematicians, chemists, and engineers so they can easily start writing a thesis or a manuscript. However, it is always a good idea to purchase a complete reference. There are so called bibles of \TeX written by initial developers. [1, 2] These books might be a little old and you may want to buy some of newer ones which explain more commands and updated techniques.

Here is the outline. In chapter 2, it teaches how to set up a basic \LaTeX environment. \LaTeX is the free software and you can use it on most of the operating systems. In chapter 3, you will learn how to express mathematical equations. In chapter 4, this will introduce the basic techniques of how to format the text. In chapter 5, this will explain how to manage pictures and figures. Chapter 6 will illustrate how to make a bibliography. Chapter 7 collects frequently-used symbols and commands so you can refer to them anytime.

Chapter 2

Starting Up L^AT_EX

2.1 How to Download, Install, and Use L^AT_EX

If you are using Linux, you can go to the software center to find the related packages to install. You can also type `latex` in the command prompt called “terminal.” Especially for Ubuntu Linux,¹ if you type that command in the terminal, the instruction will be given to install such as `$ sudo apt-get install texlive`.² You need a network connection for this. After that, all you have to do is type “yes” in the terminal. Once you installed, there is no further setting up. On Linux, you can use any editor provided to write a document, such as `gedit`, `emacs`, etc. Some of them are associated with the software. You can find icons in the tool-bar to compile the file. No need to worry even if you don’t find it. You can always compile from the terminal by typing `latex mydoc.tex`. The extension of the file name must be `tex`.

If you are using Windows, there is so called MikT_EX as one of the free types. [3] After installing the Windows-adapted T_EX, you may have to setup the editor, but most likely the package includes the editor and compiler after the installation completed. In order to save and compile, click the related button on the tool-bar. It depends on the versions and its setting, but one button could compile it and display the `dvi` or `pdf` file without further arrangement. While it is compiling, there would appear error messages. You can keep it compiled by pressing enter key if you want to see the final result anyway. There is always a button or command to abort compiling. For Linux, press control key and ‘z’ at the same time to stop it forcibly.

¹Linux is one of the computer operating systems based on UNIX. Ubuntu is one of them and it is close to Windows operating systems.

²“texlive” is an example. Please follow the instruction displayed on the terminal.

2.2 Basic Settings for a T_EX Document

The document of T_EX file starts from `\begin{document}` and ends at `\end{document}`. The style of the document is set by typing `\documentclass[11pt]{report}` before `\begin{document}`³. The options of style can be “report”, “article”, “book”, etc. The parameter [11pt] is the font size. You can also find the following setting if you see the source file:

```
\renewcommand{\baselinestretch}{1.5}
\setlength{\topmargin}{.1in}
\setlength{\textheight}{8.5in}
\setlength{\oddsidemargin}{.1in}
\setlength{\textwidth}{6.0in}
```

The first line determines the line spacing. If the parameter is {2.0}, it makes double space. The rest of the lines set the margin of the document. After this, the several packages are listed, which make us utilize more expressions for the document. This web page shows the current available packages. [4] The commands, `\title` and `\author`, are shown in the cover page when you command `\maketitle`. This will also give the date after the title. When you put chapters and sections, you will command with `\chapter{title}`, `\section{title}`, `\subsection{title}`, etc. If you want to start a new line forcibly, you have to use double backslash, `\\`. When you put `\tableofcontents`, the contents are shown before starting the document. The table of contents must be updated by compiling the file two times usually.

The style called REVT_EX is the one which you should know if you submit a manuscript to journals of American Physical Society. [5]

2.3 Reserved Characters for L^AT_EX

The following characters can be used for the text in addition to numbers and alphabetical letters:

. : ; , ? ! () [] ‘ ’ - / * @

However, the following characters cannot be used in the text directly since they are reserved for L^AT_EX commands:

% \$ & _ { } ^ ~ \ | < >

You can find most of the above in the math mode. The % is used to comment in L^AT_EX. When you use some of these characters in the sentences, you have to put backslash, such as

³This is called preamble.

`\#` `\$` `\&` `_` `\{` `\%`. Some of them need `\verb` command, such as `\verb|\|` to express a backslash. You can also use `\backslash` and it shows `\`. Some of them also have the commands like `\textless` is `<`, `\textgreater` is `>`, `\textbar` is `|`, `\textasciicircum` is `^`, and `\textasciitilde` is `~`. Note that `\backslash` is a math expression, so you have to use `$` to insert it in the text sentence. This will be explained in the next chapter.

Chapter 3

Designing Mathematical Expressions

L^AT_EX allows you to express a beautiful mathematical equations. Some of journals accept the original L^AT_EX file. Once you complete it, your article can be published without any further editing. Let's get started.

3.1 Examples for Displaying Equations

Especially in physics and math, there are many of the special symbols for equations. For example,

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

Alphabetical symbols are typed directly from the keyboard, but the arrows, cross product, and dell operator need some technique. This is the command you will write in the L^AT_EX file to express above:

```
\begin{displaymath}
\vec{B} = \vec{\nabla} \times \vec{A}
\end{displaymath}
```

Commands start with backslash and the argument will be described inside curly brackets. ¹ As you can see, `\vec` makes the vector notation. `\nabla` and `\times` are ∇ and \times , respectively. `\begin{displaymath}` and `\end{displaymath}` indicate the start and end places of the mathematical expression. “Displaymath” places the equation in the center without numbering. If you need to label each equation, you have to use “equation” as follows:

```
\begin{equation}
\phi' = \phi - \frac{\partial x_{0}}{\partial t}
\end{equation}
```

¹Some cases use square brackets for the second argument.

This will give the following:

$$\phi' = \phi - \frac{\partial x_0}{\partial t} \quad (3.1)$$

As you can see the commands, `\frac{a}{b}` gives $\frac{a}{b}$. You can also use `{a \over b}` to express $\frac{a}{b}$.

When you want to display more than one equation continuously with numbering, you have to use “`eqnarray`”:

```
\begin{eqnarray}
f(x) = \sqrt{\frac{\pi}{2l^2}} \sum_{n=-\infty}^{\infty} e^{in\pi x/l} F_n \ \backslash
F_n = \frac{1}{\sqrt{2\pi}} \int_{-l}^l e^{in\pi x/l} f(x) dx.
\end{eqnarray}
```

This will display as:

$$f(x) = \sqrt{\frac{\pi}{2l^2}} \sum_{n=-\infty}^{\infty} e^{in\pi x/l} F_n \quad (3.2)$$

$$F_n = \frac{1}{\sqrt{2\pi}} \int_{-l}^l e^{in\pi x/l} f(x) dx. \quad (3.3)$$

Note that there must be `\` to start the next equation. A superscript and subscript are expressed with `^{ }` and `_{ }`, respectively.

While using “`eqnarray`”, you can delete the numbers by inserting `\nonumber`:

```
\begin{eqnarray}
f(x) = \sqrt{\frac{\pi}{2l^2}} \sum_{n=-\infty}^{\infty}
e^{in\pi x/l} F_n \ \nonumber \ \backslash
F_n = \frac{1}{\sqrt{2\pi}} \int_{-l}^l e^{in\pi x/l} f(x) dx,
\end{eqnarray}
```

This will be:

$$f(x) = \sqrt{\frac{\pi}{2l^2}} \sum_{n=-\infty}^{\infty} e^{in\pi x/l} F_n$$

$$F_n = \frac{1}{\sqrt{2\pi}} \int_{-l}^l e^{in\pi x/l} f(x) dx, \quad (3.4)$$

You may have multiple equations to list without number labeling. It is not efficient to use `\nonumber` for each equation. In this case, use “`eqnarray*`”.

```
\begin{eqnarray*}
f(x) = \sqrt{\frac{\pi}{2l^2}} \sum_{n=-\infty}^{\infty} e^{in\pi x/l} F_n \ \backslash
F_n = \frac{1}{\sqrt{2\pi}} \int_{-l}^l e^{in\pi x/l} f(x) dx
\end{eqnarray*}
```


Then it shows:

$$f(x) = \sqrt{\frac{\pi}{2l^2}} \sum_{n=-\infty}^{\infty} e^{in\pi x/l} F_n$$

$$F_n = \frac{1}{\sqrt{2\pi}} \int_{-l}^l e^{in\pi x/l} f(x) dx$$

If you want to include equations or symbols in the text sentences, you will use dollar signs or `\(...\)`. For example,

The function is expressed as `\j_0(\rho)=\frac{\sin \rho}{\rho}`.

That will give:

The function is expressed as $j_0(\rho) = \frac{\sin \rho}{\rho}$.

Also, $\sqrt{2} = 1.41421356\dots$, and other special characters like \square , \diamond , \cup , \clubsuit , and \oplus have to use `$$` in the sentences. Here is a summary and extra equivalent commands:

Purpose	Command 1	Command 2	Command 3
In text sentences	<code>...\\$</code>	<code>\begin{math}...\end{math}</code>	<code>\(...\)</code>
Display without number	<code>\$\$...\$\$</code>	<code>\begin{displaymath}... \end{displaymath}</code>	<code>\[...\]</code>
Single equation with numbers		<code>\begin{equation}... \end{equation}</code>	
Multiple equations with numbers		<code>\begin{eqnarray}... \end{eqnarray}</code>	
Multiple equations without numbers		<code>\begin{eqnarray*}... \end{eqnarray*}</code>	

The equations in array may have different lengths, such as following:

$$f(x) = \sqrt{\frac{\pi}{2l^2}} \sum_{n=-\infty}^{\infty} e^{in\pi x/l} F_n \tag{3.5}$$

$$k = \frac{n\pi}{l} \tag{3.6}$$

The equations are aligned to the right. In order to realign them with = signs, use `&&` to ‘clip’ them as follows:

```
\begin{eqnarray}
f(x) && \sqrt{\frac{\pi}{2l^2}} \sum_{n=-\infty}^{\infty} e^{in \pi x/l} F_n \\
k && \frac{n \pi}{l}
\end{eqnarray}
```

Then, we can have a better look for the array of equations:

$$f(x) = \sqrt{\frac{\pi}{2l^2}} \sum_{n=-\infty}^{\infty} e^{in\pi x/l} F_n \quad (3.7)$$

$$k = \frac{n\pi}{l} \quad (3.8)$$

The above technique can be used with any part of the equation besides = signs. You can also arrange two equations in one line if they are short enough to them together:

$$\tan 2\gamma = -b \cos 2\gamma, \tan 2\gamma = -\frac{2b}{\Delta} \quad (3.9)$$

It looks alright; however, the space between two equations looks too close each other. In the math mode, simple spaces made by the space key will not be counted. One of the methods is a combination of backslash and semicolon that makes a certain space between equations:

```
\begin{equation}
\tan 2 \gamma = -b \cos 2 \gamma , \ ;\ ;\ ;\ ;\ ;
\tan 2 \gamma = -\frac{2b}{\Delta}.
\end{equation}
```

You can adjust the range of space by using multiple \;, and this gives:

$$\tan 2\gamma = -b \cos 2\gamma, \quad \tan 2\gamma = -\frac{2b}{\Delta}. \quad (3.10)$$

There are several ways to create sizes of space. Here is a table:

Commands	Size of space	Note
\quad	Single-byte	in both math and text modes
\quad	Double-byte	in both math and text modes
\qquad	Twice quad	in both math and text modes
\,	One sixth of quad	in both math and text modes
\>	Two ninths of quad	only in math mode
\;	Five eighteenth of quad	only in math mode
\!	One sixth of quad	only in math mode

It is necessary to adjust the size of parentheses and brackets sometimes depending on the equations. Let us consider the following:

$$\left(\frac{\sin \theta}{\tan \theta} - 1\right) = \gamma \quad (3.11)$$

The simple parentheses don't fit well as shown. In order to adjust them automatically, you should use \left(and \right). For instance,

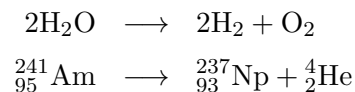
```
\begin{equation}
\left(\frac{\sin\theta}{\tan\theta}-1\right)=\gamma
\end{equation}
```

Then it will show:

$$\left(\frac{\sin\theta}{\tan\theta}-1\right)=\gamma \quad (3.12)$$

This command can be used for the other brackets, such as `[`, `{`, and `|`. If you want to specify the size of bracket, you can also use the following commands: `\big(`, `\Big(`, and `\bigg(`, and they look like `(`, `(`, and `(`. It also depends on the type of L^AT_EX, its version, and packages, so check out each manual when you have any errors.

Expressing chemical reactions is an application of subscripts, but expressions of nuclear reactions need superscripts and subscripts opposite side. Here are a couple of examples:



The following is the way you would command:

```
\begin{eqnarray*}
2\mathrm{H}_2 \mathrm{O} & \& \longrightarrow & 2\mathrm{H}_2 + \mathrm{O}_2 \\
{}^{241}_{95}\mathrm{Am} & \& \longrightarrow & {}^{237}_{93}\mathrm{Np} \\
+ {}^4_2\mathrm{He} & & & 
\end{eqnarray*}
```

The square-root command takes two arguments. One of them is usually neglected when it is a normal square root. In L^AT_EX, they are expressed as

```
\begin{displaymath}
\sqrt{x^2+y^2+z^2}, \quad \sqrt[a]{3b^4}
\end{displaymath}
```

As you see, the index of the root is described by square brackets and the radicand is placed in curly brackets. The above will be:

$$\sqrt{x^2 + y^2 + z^2}, \quad \sqrt[a]{3b^4}$$

3.2 Arrays and Matrices

The following is one of the simple arrays:

$$\begin{array}{cccc}
 a + b + c & uv & x - y & 27 \\
 a + b & u + v & z & 112 \\
 a & 3u - vw & xyz^2 & 2,338
 \end{array}$$

The L^AT_EX expression is: ²

```

\[\begin{array}{cclcr}
a+b+c & & & & \\
a+b & & & & \\
a & & & & \\
\end{array}\]

```

An array or matrix starts with `\begin{array}` and ends at `\end{array}`. This has arguments shown as `{cclcr}`. This is an alignment information for each column. `l`, `c`, and `r` indicates “left”, “center”, and “right”, respectively. As you can see, each column is aligned as designated. Also note that “&” and “\” separate each column and row, respectively.

The following is a little complicated, but a good example to understand how arrays work this way:

$$\begin{array}{rcc}
 a_1 & & \\
 x - \vdots & - & u - v \quad 13 \\
 a_n & & 12 \\
 u + w & & -982
 \end{array}$$

The above is expressed in L^AT_EX as:

```

\[\begin{array}{c}
a_{1} \\
\vdots \\
a_{n} \\
\end{array}
\begin{array}{tcl}
- & & \\
u-v & & 13 \\
u+w & & \\
12 & & -982 \\
\end{array}
\]

```

²You can use the “displaymath” mode instead of `\[...\]`.

There are three arrays in this expression. The first one consists of a_1 , \vdots , and a_2 as a one-column array. The other one is basically 2×2 array and it also contains an array inside.

The next two arrays are the application from what you have learned so far.

$$\left(\begin{array}{c} \left| \begin{array}{cc} x_{11} & x_{12} \\ x_{21} & x_{22} \end{array} \right| \\ y \\ z \end{array} \right)$$

This is coded as follows:

```
\[ \left( \begin{array}{c}
\left| \begin{array}{cc}
x_{11} & x_{12} \\
x_{21} & x_{22}
\end{array} \right| \\
y \\
z
\end{array} \right)
```

The next example is:

$$x = \begin{cases} y & \text{if } y > 0 \\ z + y & \text{otherwise} \end{cases}$$

The above expression will be written as follows:

```
\[ x = \left\{ \begin{array}{l}
y & \mbox{if } \$y>0\$ \\
z+y & \mbox{otherwise}
\end{array} \right.
```

The command, `\mbox`, makes us use text characters in the equation mode. Also note that the dot next to `\right` command, which is necessary not to have right side of bracket.

3.3 Accents and Constructs for Math

For an expression of boolean algebra, you can have the following as an example:

$$\overline{\overline{A + B}} = \overline{\overline{A}} \cdot \overline{\overline{B}} \tag{3.13}$$

This is the \LaTeX description of the above:

```

\begin{equation}
\overline{\overline{A}+B}=\overline{\overline{A}} \cdot \overline{B}
\end{equation}

```

The command, `\underline`, can also be used in the text mode. For example, `\underline{important}` gives important. The other example is:

$$a + \overbrace{b + \cdots + y}^{35} + z \quad (3.14)$$

The \LaTeX is:

```

\begin{equation}
\underbrace{a + \overbrace{b + \cdots + y}^{35} + z}_{52}
\end{equation}

```

You can also express $\widehat{a+b}$ with `\widehat{a+b}`, etc. The command, a `\stackrel{f}{\longrightarrow} b`, will give you: $a \xrightarrow{f} b$. `\stackrel` takes two arguments. The first one is placed above and the second is placed below. Here is the summary:

Commands	Display
<code>\widehat{a+b}</code>	$\widehat{a+b}$
<code>\widetilde{a+b}</code>	$\widetilde{a+b}$
<code>\overleftarrow{a+b}</code>	$\overleftarrow{a+b}$
<code>\overrightarrow{a+b}</code>	$\overrightarrow{a+b}$
<code>\overbrace{a+b}</code>	$\overbrace{a+b}$
<code>\underbrace{a+b}</code>	$\underbrace{a+b}$
<code>\overline{a+b}</code>	$\overline{a+b}$
<code>\underline{a+b}</code>	$\underline{a+b}$

3.4 Styles in Math Mode

In the math mode, \LaTeX has specific commands for various fonts and styles, which are shown in the next table. The following five fonts can be used for upper- and lower-case English letters, numbers, and upper-case Greek letters. For example, in physics, you may find the following expression:

$$\mathcal{L} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} + \frac{1}{c}j_{\mu}A^{\mu}$$

Fonts	Commands	Display
Italic	<code>\mathit{ABCabc123\Gamma\Pi}</code>	<i>ABCabc123ΓΠ</i>
Roman	<code>\mathrm{ABCabc123\Gamma\Pi}</code>	ABCabc123ΓΠ
Bold face	<code>\mathbf{ABCabc123\Gamma\Pi}</code>	ABCabc123ΓΠ
Sans Serif	<code>\mathsf{ABCabc123\Gamma\Pi}</code>	ABCabc123ΓΠ
Typewriter	<code>\mathtt{ABCabc123\Gamma\Pi}</code>	ABCabc123ΓΠ

This is the Lagrangian density of electromagnetic fields and the symbol of Lagrangian is expressed in a calligraphic style. The L^AT_EX description is:

```
\begin{displaymath}
{\cal L} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu}+\frac{1}{c}j_{\mu}A^{\mu}
\end{displaymath}
```

You have to use `\cal` with another set of curly brackets such as `{\cal L}`; otherwise, other letters will be converted due to `\cal`.³ Also we should note that `\cal` command is only for upper case letters of alphabet. If you use it with a lower case letter, `{\cal a}`, you will get a different character like `⌵`. Other types of fonts are shown in the next table. Calligraphic and Mathbb take

Fonts	Commands	Display
Calligraphic	<code>\mathcal{ABCDEFG}</code>	<i>ABCDEFG</i>
Mathbb	<code>\mathbb{ABCDEFG}</code>	ABCDEFG
Mathfrak	<code>\mathfrak{ABCabc123}</code>	℔℔Cabc123

only uppercase English letters. Mathfrak takes both upper and lower cases of English letters and numbers, but not Greek letters. These are used only in the math mode.

You can also change the font sizes in the math mode. Here are the commands:

Commands	Display
<code>{\scriptscriptstyle \oint \vec{B}\cdot d\vec{A}=0}</code>	$\oint \vec{B}\cdot d\vec{A}=0$
<code>{\scriptstyle \oint \vec{B}\cdot d\vec{A}=0}</code>	$\oint \vec{B}\cdot d\vec{A}=0$
<code>{\textstyle \oint \vec{B}\cdot d\vec{A}=0}</code>	$\oint \vec{B}\cdot d\vec{A}=0$
<code>{\displaystyle \oint \vec{B}\cdot d\vec{A}=0}</code>	$\oint \vec{B}\cdot d\vec{A}=0$

³`\mathcal` command does not need this treatment.

3.5 Referring to Equations

It is not a smart idea to refer to many of equations by looking at the compiled dvi (or pdf) file to check out the number each time. You may have to relabel all of the numbers when you add or delete some of the equations. The label command can register each equation to refer. Let us see an example:

```
\begin{equation}
i \hbar \frac{\partial}{\partial t} \Psi = \left[ -\frac{\hbar^2}{2m} \nabla^2
+ V \right] \Psi \tag{eq:schr}
\end{equation}
```

The above will give you the following:

$$i\hbar \frac{\partial}{\partial t} \Psi = \left[-\frac{\hbar^2}{2m} \nabla^2 + V \right] \Psi \tag{3.15}$$

You can find `\label{ }` in the equation. The name can be anything. The reason why “eq:” is put in the label usually because it is convenient to tell that it is referring to an equation. If you want to refer to the equation in the sentences, you will put `\ref{eq:schr}` in an appropriate place. This is an example:

The Schrödinger equation `\ref{eq:schr}` describes mechanics of quantum regions.

Then, you will see as

The Schrödinger equation (3.15) describes mechanics of quantum regions.

You can also refer to tables, figures, and other locations. The table of cross-reference commands is shown in Table 7.1.

Chapter 4

Formatting Texts

4.1 Special Characters and Symbols

Languages other than English have a variety of accents and special symbols to express their particular pronunciations.

- Accents and special pronunciations

Spanish, French, German and other languages have accents and particular pronunciations. Español and Ampère are the examples. These are expressed in L^AT_EX as `Espa\~{n}o1` and `Amp\‘{e}re`. You have to type backslash and a symbol right before the letter to modify. The letter has to be in the curly brackets. Other accents are shown in the following table:

Commands	Display
<code>\’{E}l est\’{a} aqu\’{i}</code>	Él está aquí
<code>Schr\“{o}dinger</code>	Schrödinger
<code>M\o1ler</code>	Møller
<code>Gau\ss</code>	Gauß
<code>\oe</code>	œ
<code>\aa</code>	å
<code>\AA</code>	Å
<code>\ae</code>	æ
<code>\={o}</code>	ō
<code>\c{o}</code>	ø
<code>\t{oo}</code>	ö

Table 4.1: Accents and Pronunciations

- Other special symbols

The other symbols and special punctuations are shown in the next table:

Commands	Display
<code>\dag</code>	†
<code>\ddag</code>	‡
<code>\S</code>	§
<code>\copyright</code>	©
<code>\P</code>	¶
<code>\pounds</code>	£
<code>!'</code>	!
<code>?'</code>	?

Table 4.2: Special Symbols

4.2 Fonts, Sizes, etc.

In the text mode, the fonts and the sizes are changed as follows:

Commands	Display	Commands	Display
<code>\tiny</code>	tiny	<code>\rm</code>	roman
<code>\scriptsize</code>	script size	<code>\tt</code>	typewriter
<code>\footnotesize</code>	footer	<code>\sf</code>	sans serif
<code>\small</code>	small	<code>\sc</code>	SMALL CAPS
<code>\nomalsize</code>	normal	<code>\bf</code>	bold face
<code>\large</code>	large	<code>\it</code>	<i>italic</i>
<code>\Large</code>	Large	<code>\sl</code>	<i>slant</i>
<code>\LARGE</code>	LARGE	<code>\em</code>	<i>emphasized</i>
<code>\huge</code>	huge		
<code>\Huge</code>	Huge		

Table 4.3: Fonts and sizes

4.3 Tables

Here is a typical table for a science journal and its L^AT_EX commands are described below:

m (kg)	x and l (m)	T_S (s)	T_P (s)	% difference (%)
0.200	0.293	1.091	1.088	0.303
0.300	0.438	1.329	1.329	0.015
0.400	0.583	1.525	1.533	0.576

Table 4.4: m is the hanging mass. x is the displacement of the spring with a certain hanging mass...

```

\begin{table}[h]
\begin{center}
\begin{tabular}{ccccc}\hline
$m$ (kg) & $x$ and $l$(m) & $T_S$ (s) & $T_P$ (s) & \% difference (\%) \\
\hline \hline
0.200 & 0.293 & 1.091 & 1.088 & 0.303 \\
0.300 & 0.438 & 1.329 & 1.329 & 0.015 \\
0.400 & 0.583 & 1.525 & 1.533 & 0.576 \\
\hline
\end{tabular}
\end{center}
\caption{$m$ is the hanging mass. $x$ is the displacement of the spring with
a certain hanging mass...}
\end{table}

```

The usage of `&` and `\\` are the same as making arrays. `&` is to separate the columns and `\\` is to start the next row. In order to center the table, you have to use the `center` command as shown above. It is important to place it right after the table command. The `\hline` command is for drawing a horizontal line. For the argument of the `tabular` command, `{ccccc}`, this is also the same as the array commands. You need to put each information of the alignment for each column.¹ For the table command, there is an argument, `[h]`. There are four different parameters: These specify the preferable location of the table to be displayed. They are `h`, `t`, `b`, and `p`, which indicates “here”, “top”, “bottom”, and “page”, respectively. If you use `p`, the tables will be located in particular pages only for tables. If you want to prioritize your request, you will put !

¹l, c, and r represent left, center, and right, respectively.

next to the parameter, such as `[h!]`.² Also you can put every parameter if you don't have any priority. The caption can be included with the caption command as you see in the example.

Two more basic techniques will be explained here. Some case needs to draw vertical lines in a table. This doesn't require any command. Simply put `vertical bars` in the tabular option. In the above example, if you want to have a vertical line between the second and the third columns, you can make it as, `{cc|ccc}`. You can see other examples:

Table 4.5: `{|cc}`

A	B
1	0
0	1

Table 4.6: `{c|c}`

A	B
0	0
0	1

Table 4.7: `{|cc|}`

A	B
1	0
0	0

Table 4.8: `{|c|c|}`

A	B
0	1
0	0

Some item of a table may take multiple columns and rows. The following is an example:

Title		
Items 1 and 2		Item 3
A	B	Category 1
I	II	
α	β	Category 2

Table 4.9: Multiple columns and rows

```
\begin{table}[h]
\begin{center}
\begin{tabular}{c|c|l}
\hline
\multicolumn{3}{c}{Title}\hline
\hline\hline
\multicolumn{2}{c|}{\bf Items 1 and 2} & {\bf Item 3} \hline
A & B & Category 1 \hline
\cline{1-2}
I & II & \hline
\alpha & \beta & Category 2
\end{tabular}
\end{center}
\end{table}
```

²The L^AT_EX compiler tries to listen to your request, but it doesn't necessarily mean that it arranges exactly as you expect.

```

\cline{1-2}
\hline
 $\alpha$  &  $\beta$  & Category 2 \\
\hline
\end{tabular}
\end{center}
\caption{Multiple columns and rows}
\end{table}

```

The title cell is using 3 columns. The command is `\multicolumn{3}{c}{Title}`. For multiple rows for one item, you skip the item that you want to exclude and draw horizontal line from the certain column to the specified column by using `\cline{ }`. In the above example, it is designated as {1-2}. This means that the horizontal line is drawn from the first to second columns.

4.4 Quotations and Theorems

Here is an example with the quote or quotation command:

```

\begin{quote}
It takes decades to realize educational effect. Country's prosperity comes from
a long term efforts on education.
\end{quote}

```

This will be displayed from the above description:

It takes decades to realize educational effect. Country's prosperity comes from a long term efforts on education.

You can use `\begin{center}...\end{center}` to express a statement in a different paragraph in the center although this is not only for quotation.

In order to express a theorem-like statement, you will use `\newtheorem` to define the name of the theorem:

```

\newtheorem{guess}{Conjecture}
\begin{guess}
All conjectures are interesting, but some conjectures
are more interesting than others.
\end{guess}

```

The first argument in “newtheorem” is the name of the environment, and the second one is the statement to label the entire theorem. The above will show you following:

Conjecture 1 *All conjectures are interesting, but some conjectures are more interesting than others.*

When you quote a word with double-quotation marks, you may use (”) on the keyboard. The following is the example of using the simple double quotations:

”quoted”

It looks alright, but you can notice that this is not a correct pair. In L^AT_EX, you have to use twice (‘) and twice (’) to open and close the quotation. This (‘) is located under the escape key. This (’) is the normal apostrophe. Then, you have:

“quoted”

Now, it looks right.

4.5 Marginal Notes and Footnotes

A marginal note is displayed with the command, `\marginpar{ }`. Your comment will be inside the curly brackets. For example, `\marginpar{This is a marginal note.}`. This will be appeared This is a marginal
in the margin. marginal

You can also comment in the footer by using `\footnote{ }`. This can be used right after the note.
sentence you want to refer to. The command is, for example, `\footnote{The footnote is appeared here!}`.

³ This is labeled as a reference and you can see it at the bottom of the page.

4.6 Numbering and Bulleting

Listing some of items in a paragraph is required to have commands for bullets or numbers. For bulleting, you will set the range by using the `itemize` command. For example,

```
\begin{itemize}
\item This is what I want to say first.
\item This is what I want to say second.
\end{itemize}
```

The command, `\item`, makes a bullet in this range.

³The footnote is appeared here!

- This is what I want to say first.
- This is what I want to say second.

If you want to use numbers, you will use “enumerate” instead of “itemize.” The example is following:

```
\begin{enumerate}
\item The first item
\item The second item
\end{enumerate}
```

This will display:

1. The first item
2. The second item

You can also use your own label by using the description command:

```
\begin{description}
\item [{$\star$}] This is a star item.
\item [Label] It becomes bold.
\end{description}
```

This will give:

★ This is a star item.

Label It becomes bold.

The description command is a little different from the numbering and bulleting. The labeled items are not tabbed.

Chapter 5

Inserting Figures

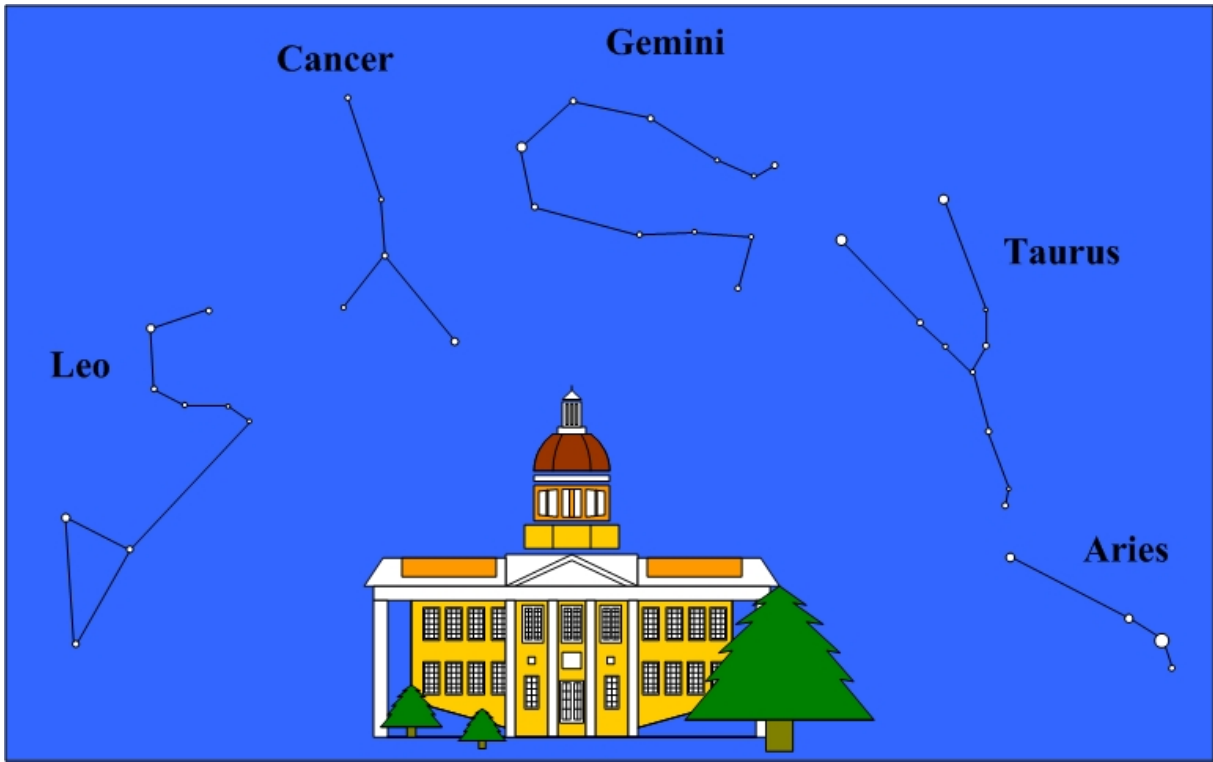
Some of the commands shown here may depend on operating systems, the version of \LaTeX , and the packages used. It is recommended that you refer to the correspondent manual. For instance, some picture formats cannot be recognized by the \LaTeX . On a Linux operating system, people usually make use of an encapsulated PostScript file for figures. The extension is denoted as eps.¹ In order to use the figure commands, you have to use `\usepackage{graphicx}`; and then, put the picture files into the same folder. The following is a basic set of commands to allocate a picture file in the document:

```
\begin{figure}[htbp]
  \begin{center}
    \includegraphics[width=4cm]{mypicture.eps}
    \caption{Picture 1}
    \label{fig:pic1}
  \end{center}
\end{figure}
```

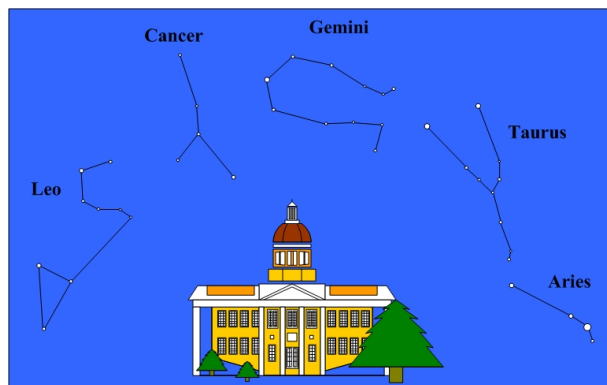
It will start with and end at the figure command. The command, `\includegraphics`, takes the arguments to determine the size and to indicate the picture file to display. There are more options besides `width`: The command, `height`, adjusts the height of the figure; `scale` changes the ratios; `angle` rotates the figure; and `clip` trims the original picture file when you make it `clip=true`. You can put multiple parameters using commas. If you want to center the picture, you will use the center command. The same picture file with two different sizes are posted as follows:

The command, `\label{ }` is for the cross reference of the figure.

¹The other formats can be recognized, but it depends on the operating system and \LaTeX .



16cm-width



8cm-width

Figure 5.1: Different sizes with the same picture

Chapter 6

Making Bibliography

BibT_EX is a convenient command to manage the list of references in a separate file. There is another command, “thebibliography”, which makes us include the references in the same L^AT_EX file. Similarly to other commands, it starts with and end at the “thebibliography” command. For instance,

```
\begin{thebibliography}{99}
\bibitem{Razavy} Razavy, Mohsen. 2005.
    \textit{Classical and Quantum Dissipative Systems}. Imperial College Press
\end{thebibliography}
```

After the `thebibliography` command, there is a parameter, `{99}`. This indicates that the maximum reference number would have up to 2 figures. The `\bibitem{ }` command labels the name for citation. The `\bibitem` takes two arguments, such as `\bibitem[remark]{key}`. The “remark” is the name shown as the reference. You can remove the remark as in the example above; then, the number will be appeared as the reference instead. For the cross-reference, you will use `\cite{Razavy}` at the proper place in the document when you need to cite the reference.

The following shows a preamble for the format of American Physical Society. This can be copied and pasted into your T_EX file or the homepage of APS may provide an example source file.

```
\begin{thebibliography}{99}

%%%%% preamble %%%%%%
\expandafter\ifx\csname natexlab\endcsname\relax\def\natexlab#1{#1}\fi
\expandafter\ifx\csname bibnamefont\endcsname\relax
    \def\bibnamefont#1{#1}\fi
\expandafter\ifx\csname bibfnamefont\endcsname\relax
```

```

\def\bibfnamefont#1{#1}\fi
\expandafter\ifx\csname citenamefont\endcsname\relax
\def\citenamefont#1{#1}\fi
\expandafter\ifx\csname url\endcsname\relax
\def\url#1{\texttt{#1}}\fi
\expandafter\ifx\csname urlprefix\endcsname\relax\def\urlprefix{URL }\fi
\providecommand{\bibinfo}[2]{#2}
\providecommand{\eprint}[2][\url{#2}]

%%%%% start bibliography %%%%%
\bibitem[{\citenamefont{Rut11}}]{Rut11}
\bibinfo{author}{\bibfnamefont{E.}\~\bibnamefont{Rutherford}},
\bibinfo{journal}{Phil. Mag.} \textbf{\bibinfo{volume}{21}},
\bibinfo{pages}{669} (\bibinfo{year}{1911}).
\end{thebibliography}

```

The source file of this document is also provided. Please refer to how `\thebibliography` is used in this L^AT_EX file.

Chapter 7

Command Reference

This chapter provides useful symbols, letters, and commands as a reference. In order to express some symbols, it requires packages, `\usepackage{amsmath}` and `\usepackage{amssymb}`. The symbols introduced here are not all of the available ones. You can find more of them in some web pages and various books. A couple of documents [6, 7] are useful to refer to more symbols.

Greek Letters

(lower cases)

α <code>\alpha</code>	β <code>\beta</code>	γ <code>\gamma</code>	δ <code>\delta</code>
ϵ <code>\epsilon</code>	ε <code>\varepsilon</code>	ζ <code>\zeta</code>	η <code>\eta</code>
θ <code>\theta</code>	ϑ <code>\vartheta</code>	ι <code>\iota</code>	κ <code>\kappa</code>
λ <code>\lambda</code>	μ <code>\mu</code>	ν <code>\nu</code>	ξ <code>\xi</code>
\omicron <code>o o</code>	π <code>\pi</code>	ϖ <code>\varpi</code>	ρ <code>\rho</code>
ϱ <code>\varrho</code>	σ <code>\sigma</code>	ς <code>\varsigma</code>	τ <code>\tau</code>
υ <code>\upsilon</code>	ϕ <code>\phi</code>	φ <code>\varphi</code>	χ <code>\chi</code>
ψ <code>\psi</code>	ω <code>\omega</code>		\varkappa <code>\varkappa</code>

Greek Letters

(upper cases)

Γ <code>\Gamma</code>	Δ <code>\Delta</code>	Θ <code>\Theta</code>	Λ <code>\Lambda</code>
Ξ <code>\Xi</code>	Π <code>\Pi</code>	Σ <code>\Sigma</code>	Υ <code>\Upsilon</code>
Φ <code>\Phi</code>	Ψ <code>\Psi</code>	Ω <code>\Omega</code>	F <code>\digamma</code>

Operation Symbols

\pm <code>\pm</code>	\mp <code>\mp</code>	\times <code>\times</code>	\div <code>\div</code>
$*$ <code>\ast</code>	\star <code>\star</code>	\circ <code>\circ</code>	\bullet <code>\bullet</code>
\cdot <code>\cdot</code>	\cap <code>\cap</code>	\cup <code>\cup</code>	\vee <code>\vee</code>
\wedge <code>\wedge</code>	\wr <code>\wr</code>	\triangleup <code>\bigtriangleup</code>	\triangledown <code>\bigtriangledown</code>
\triangleleft <code>\triangleleft</code>	\triangleright <code>\triangleright</code>	\trianglelefteq <code>\unlhd</code>	\trianglerighteq <code>\unrhd</code>
\oplus <code>\oplus</code>	\ominus <code>\ominus</code>	\otimes <code>\otimes</code>	\oslash <code>\oslash</code>
\odot <code>\odot</code>	\bigcirc <code>\bigcirc</code>	\dagger <code>\dagger</code>	\ddagger <code>\ddagger</code>
\uplus <code>\uplus</code>	\sqcap <code>\sqcap</code>	\sqcup <code>\sqcup</code>	\triangleleft <code>\triangleleft</code>
\triangleright <code>\triangleright</code>	\diamond <code>\diamond</code>	\square <code>\Box</code>	\amalg <code>\amalg</code>

Relation Symbols

\propto <code>\propto</code>	\ll <code>\ll</code>	\gg <code>\gg</code>	\subset <code>\subset</code>
\supset <code>\supset</code>	\subseteq <code>\subseteq</code>	\supseteq <code>\supseteq</code>	\in <code>\in</code>
\ni <code>\ni</code>	\leq <code>\leq</code>	\geq <code>\geq</code>	\equiv <code>\equiv</code>
\sim <code>\sim</code>	\simeq <code>\simeq</code>	\approx <code>\approx</code>	\cong <code>\cong</code>
\neq <code>\neq</code>	\doteq <code>\doteq</code>	\perp <code>\perp</code>	\mid <code>\mid</code>
\parallel <code>\parallel</code>	\prec <code>\prec</code>	\succ <code>\succ</code>	\preceq <code>\preceq</code>
\succeq <code>\succeq</code>	\sqsubset <code>\sqsubset</code>	\sqsupset <code>\sqsupset</code>	\sqsubseteq <code>\sqsubseteq</code>
\sqsupseteq <code>\sqsupseteq</code>	\smile <code>\smile</code>	\frown <code>\frown</code>	\notin <code>\notin</code>
\models <code>\models</code>	\asymp <code>\asymp</code>	\bowtie <code>\bowtie</code>	\vdash <code>\vdash</code>
\dashv <code>\dashv</code>	\leqq <code>\leqq</code>	\geqq <code>\geqq</code>	\lesssim <code>\lesssim</code>
\leqslant <code>\leqslant</code>	\geqslant <code>\geqslant</code>	\lll <code>\lll</code>	\ggg <code>\ggg</code>
\trianglelefteq <code>\trianglelefteq</code>	\circeq <code>\circeq</code>	\lesssim <code>\lesssim</code>	\gtrsim <code>\gtrsim</code>

Arrows

\leftarrow <code>\leftarrow</code>	\rightarrow <code>\rightarrow</code>	\longleftarrow <code>\longleftarrow</code>
\longrightarrow <code>\longrightarrow</code>	\Leftarrow <code>\Leftarrow</code>	\Rightarrow <code>\Rightarrow</code>
\Longleftarrow <code>\Longleftarrow</code>	\Longrightarrow <code>\Longrightarrow</code>	\Uparrow <code>\uparrow</code>
\downarrow <code>\downarrow</code>	\Uparrow <code>\Uparrow</code>	\Downarrow <code>\Downarrow</code>
\leftrightarrow <code>\leftrightarrow</code>	\Leftrightarrow <code>\Leftrightarrow</code>	\longleftrightarrow <code>\longleftrightarrow</code>
\Leftrightarrow <code>\Leftrightarrow</code>	\Updownarrow <code>\Updownarrow</code>	\Updownarrow <code>\Updownarrow</code>
\nearrow <code>\nearrow</code>	\searrow <code>\searrow</code>	\swarrow <code>\swarrow</code>
\nwarrow <code>\nwarrow</code>	\mapsto <code>\mapsto</code>	\longmapsto <code>\longmapsto</code>
\leftharpoonup <code>\leftharpoonup</code>	\rightharpoonup <code>\rightharpoonup</code>	\leftharpoondown <code>\leftharpoondown</code>
\rightharpoondown <code>\rightharpoondown</code>	\hookrightarrow <code>\hookrightarrow</code>	\hookrightarrow <code>\hookrightarrow</code>
\rightleftharpoons <code>\rightleftharpoons</code>	\leadsto <code>\leadsto</code>	\Lsh <code>\Lsh</code>
\Rsh <code>\Rsh</code>	\curvearrowleft <code>\curvearrowleft</code>	\curvearrowright <code>\curvearrowright</code>

Accents

\hat{x} <code>\hat{x}</code>	\check{x} <code>\check{x}</code>	\dot{x} <code>\dot{x}</code>	\breve{x} <code>\breve{x}</code>
\acute{x} <code>\acute{x}</code>	\ddot{x} <code>\ddot{x}</code>	\grave{x} <code>\grave{x}</code>	\tilde{x} <code>\tilde{x}</code>
\mathring{x} <code>\mathring{x}</code>	\vec{x} <code>\vec{x}</code>	\bar{x} <code>\bar{x}</code>	

Dots

\dots <code>\dots</code>	\cdots <code>\cdots</code>	\vdots <code>\vdots</code>	\ddots <code>\ddots</code>
----------------------------	------------------------------	------------------------------	------------------------------

Delimiters

$ $ <code> </code>	\vert <code>\vert</code>	$\ $ <code>\ </code>	$\ $ <code>\ </code>	$\{$ <code>\{</code>	$\}$ <code>\}</code>
\langle <code>\langle</code>	\rangle <code>\rangle</code>	\lfloor <code>\lfloor</code>	\rfloor <code>\rfloor</code>	\lceil <code>\lceil</code>	\rceil <code>\rceil</code>
$//$ <code>//</code>	\backslash <code>\backslash</code>	$[$ <code>[</code>	$]$ <code>]</code>	\llcorner <code>\llcorner</code>	\lrcorner <code>\lrcorner</code>
\ulcorner <code>\ulcorner</code>	\urcorner <code>\urcorner</code>				

Mathematical Functions

\sin <code>\sin</code>	\cos <code>\cos</code>	\tan <code>\tan</code>	\arcsin <code>\arcsin</code>
\arccos <code>\arccos</code>	\arctan <code>\arctan</code>	\sinh <code>\sinh</code>	\cosh <code>\cosh</code>
\tanh <code>\tanh</code>	\exp <code>\exp</code>	\log <code>\log</code>	\ln <code>\ln</code>
\sec <code>\sec</code>	\csc <code>\csc</code>	\cot <code>\cot</code>	\max <code>\max</code>
\min <code>\min</code>	\dim <code>\dim</code>	\inf <code>\inf</code>	\lim <code>\lim</code>
\det <code>\det</code>	\arg <code>\arg</code>	\sup <code>\sup</code>	\deg <code>\deg</code>
\gcd <code>\gcd</code>	\Pr <code>\Pr</code>	\liminf <code>\liminf</code>	\limsup <code>\limsup</code>
\lg <code>\lg</code>	\hom <code>\hom</code>	\ker <code>\ker</code>	\coth <code>\coth</code>

Other Symbols

\aleph \aleph	$'$ \prime	\forall \forallforall	\hbar \hbarbar
\emptyset \emptyset	\exists \existsexists	\imath \imathmath	j \jmath
∇ \nabla	\triangle \triangle	\surd \surd	ℓ \ell
∂ \partial	\wp \wp	\Re \Re	\Im \Im
\angle \angle	\mho \mho	∞ \infty	\mathbb{k} \Bbbk
\sum \sum	\int \int	\oint \oint	\prod \prod
\coprod \coprod	\bigcap \bigcap	\bigcup \bigcup	\bigodot \bigodot
\bigotimes \bigotimes	\bigoplus \bigoplus	\bigvee \bigvee	\bigwedge \bigwedge
\complement \complement	\nexists \nexists	\neg \neg	\top \top
\bot \bot	\Finv \Finv	\varnothing \varnothing	\Join \Join
\biguplus \biguplus	\eth \eth	\sphericalangle \sphericalangle	\sphericalangle \sphericalangle
\spadesuit \spadesuit	\heartsuit \heartsuit	\clubsuit \clubsuit	\diamondsuit \diamondsuit
\sharp \sharp	\flat \flat	\natural \natural	\square \square
\iint \iint	\iiint \iiint	\Game \Game	\lozenge \lozenge
\textcircled{S} \textcircled{S}	\backprime \backprime	\bigstar \bigstar	\hslash \hslash

Cross References

Reference objects	Label commands	Reference Commands
Equations	$\label{eq:name}$	$\ref{eq:name}$
Figures	$\label{fig:name}$	$\ref{fig:name}$
Tables	$\label{tb:name}$	$\ref{tb:name}$
Chapters	$\label{ch:name}$	$\ref{ch:name}$
Sections	$\label{sec:name}$	$\ref{sec:name}$
Pages	$\label{page number}$	$\pageref{page number}$
Bibliography	\bibitem{name}	\cite{name}

Table 7.1: Referring directly to tables and figures requires captions.

Bibliography

- [1] D. E. Knuth, *The T_EXBook*. Addison-Wesley, Reading MA, 1986
- [2] L. Lamport, *L^AT_EX, a Document Preparation System*. Addison-Wesley, Reading MA, 1996
- [3] MiK_TE_X Project Page, <http://miktex.org/>
- [4] LaTeX Package Reference, http://en.wikibooks.org/wiki/LaTeX/Package_Reference
- [5] REVT_EX Home Page, <http://publish.aps.org/revtex>
- [6] University of Colorado at Boulder, Department of Applied Mathematics, <http://amath.colorado.edu/documentation/LaTeX/Symbols.pdf>
- [7] The UK T_EX Archive, <http://www.tex.ac.uk/tex-archive/info/symbols/comprehensive/symbols-a4.pdf>