

Writing a Scientific Research Paper using LaTeX

Part 3

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Mathematic equations

LaTeX has two modes of interpreting the commands

- **Text mode** for general text.
- **Math mode** for mathematic equations.

The LaTeX default mode is text mode. But we can switch into math mode easily.

Mathematic equations

There are a numbers of way to switch into math mode

1. Using the \$ symbol to switch between text mode/
math mode

$$a = b$$

2. Using the delimiters \[and \] for math mode.

Mathematic equations

3. Using math environment commands such as

`\begin{equation}`

$a = b$

`\end{equation}`

some commands in math mode need to load packages such as `amsmath` or `amssymb`

Mathematical operators

Operator	symbol	L ^A T _E X command	output
addition	+	<code>a + b</code>	$a + b$
subtraction	-	<code>a - b</code>	$a - b$
multiplication	<code>\times</code>	<code>a \times b</code>	$a \times b$
division	<code>\div</code>	<code>a \div b</code>	$a \div b$
superscript	<code>^{\}</code>	<code>x^{3}</code>	x^3
subscript	<code>_{\}</code>	<code>x_{3}</code>	x_3

See [example3-1.tex](#)

Greek characters

α	<code>\alpha</code>	θ	<code>\theta</code>	o	<code>o</code>	τ	<code>\tau</code>
β	<code>\beta</code>	ϑ	<code>\vartheta</code>	π	<code>\pi</code>	υ	<code>\upsilon</code>
γ	<code>\gamma</code>	ι	<code>\iota</code>	ϖ	<code>\varpi</code>	ϕ	<code>\phi</code>
δ	<code>\delta</code>	κ	<code>\kappa</code>	ρ	<code>\rho</code>	φ	<code>\varphi</code>
ϵ	<code>\epsilon</code>	λ	<code>\lambda</code>	ϱ	<code>\varrho</code>	χ	<code>\chi</code>
ε	<code>\varepsilon</code>	μ	<code>\mu</code>	σ	<code>\sigma</code>	ψ	<code>\psi</code>
ζ	<code>\zeta</code>	ν	<code>\nu</code>	ς	<code>\varsigma</code>	ω	<code>\omega</code>
η	<code>\eta</code>	ξ	<code>\xi</code>				
Γ	<code>\Gamma</code>	Λ	<code>\Lambda</code>	Σ	<code>\Sigma</code>	Ψ	<code>\Psi</code>
Δ	<code>\Delta</code>	Ξ	<code>\Xi</code>	Υ	<code>\Upsilon</code>	Ω	<code>\Omega</code>
Θ	<code>\Theta</code>	Π	<code>\Pi</code>	Φ	<code>\Phi</code>		

Relational Symbols

Symbol	L ^A T _E X command	Symbol	L ^A T _E X command
$=$	<code>=</code>	\parallel	<code>\parallel</code>
\neq	<code>\neq</code>	\perp	<code>\perp</code>
\equiv	<code>\equiv</code>	$>$	<code>></code>
\sim	<code>\sim</code>	\geq	<code>\geq</code>
\approx	<code>\approx</code>	\gg	<code>\gg</code>
\simeq	<code>\simeq</code>	$<$	<code><</code>
\cong	<code>\cong</code>	\leq	<code>\leq</code>
\propto	<code>\propto</code>	\ll	<code>\ll</code>

<https://en.wikibooks.org/wiki/LaTeX/Mathematics>

See example3-2.tex

Referencing equations

- Math equations in math mode with $...$ and $[\dots]$ can not be referenced.
- Referencing can be done only with math environment command `\begin{equation} ... \end{equation}`
- Referencing use `\label{name}` for naming the equation and `\ref{name}` to refer to equation with `\label{name}`
- We can set the number of equation by

`\setcounter{equation}{num-equations}`

See [example3-3.tex](#)

Eqnarray environment

- In case, we need multiple-line equations we need to use **eqnarray** environment

`\begin{eqnarray}`

`:`

`\end{eqnarray}`

- In **eqnarray** environment we made a newline using `\\` and align symbols with `&`

Eqnarray environment

- The **eqnarray** environment will number all lines automatically.
- `\nonumber` will suppress the number on the line.
- Set the number of the equation by

`\setcounter{equation}{num-equations}`

See [example3-4.tex](#)

Eqnarray environment

- In case we do not need to number the equations, we could use asterisk.

```
\begin{eqnarray*}  
:  
\end{eqnarray*}
```

- The asterisk will work only with

```
\usepackage{amsmath}
```

See [example3-4.tex](#)

Align environment

- Another environment **align** which will align the equations anywhere with &
- The environment works in a similar way to **eqnarray**.

See [example3-5.tex](#)

Advanced mathematic symbols

Symbol	L ^A T _E X command	Symbol	L ^A T _E X command
$=$	<code>=</code>	\parallel	<code>\parallel</code>
\neq	<code>\neq</code>	\perp	<code>\perp</code>
\equiv	<code>\equiv</code>	$>$	<code>></code>
\sim	<code>\sim</code>	\geq	<code>\gg</code>
\approx	<code>\approx</code>	\gg	<code>\leq</code>
\simeq	<code>\simeq</code>	$<$	<code><</code>
\cong	<code>\cong</code>	\leq	<code>\leq</code>
\propto	<code>\propto</code>	\ll	<code>\ll</code>

Advanced mathematic symbols

Symbol	L ^A T _E X command	Symbol	L ^A T _E X
\equiv	<code>\equiv</code>	\ni	<code>\ni</code>
\exists	<code>\exists</code>	\rightarrow	<code>\rightarrow</code>
\forall	<code>\forall</code>	\Rightarrow	<code>\Rightarrow</code>
\Leftrightarrow	<code>\Leftrightarrow</code>	\vee	<code>\vee</code>
\neq	<code>\neq</code>	\wedge	<code>\wedge</code>

https://en.wikibooks.org/wiki/LaTeX/Advanced_Mathematics

See `example3-6.tex`

Variable-size symbols

Operation	Symbol	L ^A T _E X command	output
summation	\sum	<code>\sum_{i=1}^n x_{i}</code>	$\sum_{i=1}^n x_i$
product	\prod	<code>\prod_{i=1}^n x_{i}</code>	$\prod_{i=1}^n x_i$
surd	$\sqrt{}$	<code>\sqrt{\sum_{i=1}^n x_i^2}</code>	$\sqrt{\sum_{i=1}^n x_i^2}$
integral	\int	<code>\int_a^b f(x) \, dx</code>	$\int_a^b f(x) \, dx$

See [example3-7.tex](#)

Hyperlink with LaTeX

- LaTeX can make a hyperlink which links texts to other parts in the document or outside the document.
- Hyperlinks can be created with the package

`\usepackage{hyperref}`

- After loading the package `hyperref`, we can set up hyperlinks by

`\hypersetup{options}`

Hyperlink with LaTeX

Command	Description
<code>\href{<i>URL</i>}{<i>text</i>}</code>	create <i>text</i> that link to <i>URL</i>
<code>\url{<i>URL</i>}</code>	create hyperlink to <i>URL</i>
<code>\hypertarget{<i>label</i>}{<i>target text</i>}</code>	create <i>target text</i> from \hyperlink

<https://en.wikibooks.org/wiki/LaTeX/Hyperlinks>

See [example3-8.tex](#)

Table of Contents

- LaTeX can easily create contents of the document by referencing the structural LaTeX commands

`\chapter{title}`

`\section{title}`

`\subsection{title}`

`\subsubsection{title}`

Table of Contents

- The table of contents can be generated automatically with the command

`\tableofcontents`

- The depth of the table of contents can be set using the command

`\setcounter{tocdepth}{num-depth}`

See [example3-9.tex](#)

List of tables / figures

- Commands for creating list of tables and list of figures.
- Only work for tables with environment table and figures with environment figure.

`\listoftables`

`\listoffigures`

See [example3-10.tex](#)

Indexing

- LaTeX can create an index (alphabetical list of words with the pages of the book) with

`\usepackage{makeidx}`

- Using the command `\makeindex` before `\begin{document}` and `\printindex` in the document
- The keyword is inserted with

`\index{keyword}`

See [example3-11.tex](#)

Indexing

Command	Description	Index Entry
<code>\index{ref}</code>	create index of <i>ref</i>	<i>ref</i> , 1
<code>\index{ref !sub-ref}</code>	create sub-index <i>sub-ref</i>	<i>ref</i> , 1 <i>sub-ref</i> , 2
<code>\index {ref }</code> <code>\index {ref })</code>	index start index end	<i>ref</i> , 1-2
<code>\index{ref1@ref2 }</code>	index <i>ref1</i> but display <i>ref2</i>	<i>ref2</i> , 1

<https://en.wikibooks.org/wiki/LaTeX/Indexing>

See `example3-11.tex` & `example3-12.tex`

Bibliography with LaTeX

- LaTeX has tool to make bibliography without loading other package.
- Using the environment thebibliography

```
\begin{thebibliography}  
    \bibitem{cite_key} citation  
\end{thebibliography}
```

See [example3-13.tex](#)

Bibliography with LaTeX

- Writing citation automatically using BibTeX
- BibTeX is a separate program that will automatically make citation from the database file .bib

```
@entryname{label,  
    field1=value1  
    field2=value2  
    field3=value3  
    :      :  
}
```


Bibliography with LaTeX

@article	article or magazine
@book	book, textbook
@manual	manual
@mastersthesis	master thesis
@misc	miscellaneous
@proceedings	conference proceedings
@unpublished	unpublished article

https://en.wikibooks.org/wiki/LaTeX/Bibliography_Management

Bibliography with LaTeX

Entry Fields	Example
author	author = {{Chantavat}, T. and {Gordon}, C. and {Silk}, J.}
title	title = ``{Probing the ... counts}"}
journal	journal = {Physical Review D}
year	year = 2009
volume	volume = 79
number	number = 8
page	pages = {083508}

https://en.wikibooks.org/wiki/LaTeX/More_Bibliographies

See `example3-14.tex`