

math

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Contents

index	5
I A Minimal Book Example	7
1 About	9
1.1 Usage	9
1.2 Render book	9
1.3 Preview book	9
2 Hello bookdown	11
2.1 A section	11
3 Cross-references	13
3.1 Chapters and sub-chapters	13
3.2 Captioned figures and tables	13
4 Parts	15
5 Footnotes and citations	17
5.1 Footnotes	17
5.2 Citations	17
6 Blocks	19
6.1 Equations	19
6.2 Theorems and proofs	19
6.3 Callout blocks	19
7 Sharing your book	21
7.1 Publishing	21
7.2 404 pages	21
7.3 Metadata for sharing	21
II by discipline	23
8 test cross-link	25
8.1 link and reference	25
8.2 number and reference equations	25
8.3 footnote	26
8.4 citation	26

8.5 bookdown environment for definition, theorem, proof 26

9 test cross-link 2 **29**

10 math **31**

equivalence relation **33**

equivalence class **35**

partition **37**

11 physics **39**

12 plot **41**

TiKZ **43**

12.1 3D 55

xy-pic **57**

III by date **59**

13 by date **61**

partition **63**

202401281000 **65**

equivalence class **67**

equivalence relation **69**

14 Python **71**

TiKZ **75**

14.1 3D 87

xy-pic **89**

15 RMarkdown **91**

15.1 Markdown 91

15.2 Bookdown 91

references **93**

index

math on bookdown started on 2024/01/28

Part I

A Minimal Book Example

Chapter 1

About

This is a *sample* book written in **Markdown**. You can use anything that Pandoc’s Markdown supports; for example, a math equation $a^2 + b^2 = c^2$.

1.1 Usage

Each **bookdown** chapter is an `.Rmd` file, and each `.Rmd` file can contain one (and only one) chapter. A chapter *must* start with a first-level heading: `# A good chapter`, and can contain one (and only one) first-level heading.

Use second-level and higher headings within chapters like: `## A short section` or `### An even shorter section`.

The `index.Rmd` file is required, and is also your first book chapter. It will be the homepage when you render the book.

1.2 Render book

You can render the HTML version of this example book without changing anything:

1. Find the **Build** pane in the RStudio IDE, and
2. Click on **Build Book**, then select your output format, or select “All formats” if you’d like to use multiple formats from the same book source files.

Or build the book from the R console:

```
bookdown::render_book()
```

To render this example to PDF as a `bookdown::pdf_book`, you’ll need to install XeLaTeX. You are recommended to install TinyTeX (which includes XeLaTeX): <https://yihui.org/tinytex/>.

1.3 Preview book

As you work, you may start a local server to live preview this HTML book. This preview will update as you edit the book when you save individual `.Rmd` files. You can start the server in a work session by using the RStudio add-in “Preview book”, or from the R console:

```
bookdown::serve_book()
```

Chapter 2

Hello bookdown

All chapters start with a first-level heading followed by your chapter title, like the line above. There should be only one first-level heading (#) per .Rmd file.

2.1 A section

All chapter sections start with a second-level (##) or higher heading followed by your section title, like the sections above and below here. You can have as many as you want within a chapter.

An unnumbered section

Chapters and sections are numbered by default. To un-number a heading, add a {.unnumbered} or the shorter {-} at the end of the heading, like in this section.

Chapter 3

Cross-references

Cross-references make it easier for your readers to find and link to elements in your book.

3.1 Chapters and sub-chapters

There are two steps to cross-reference any heading:

1. Label the heading: `# Hello world {#nice-label}`.
 - Leave the label off if you like the automated heading generated based on your heading title: for example, `# Hello world = # Hello world {#hello-world}`.
 - To label an un-numbered heading, use: `# Hello world {-#nice-label}` or `{# Hello world .unnumbered}`.
2. Next, reference the labeled heading anywhere in the text using `\@ref(nice-label)`; for example, please see Chapter 3.
 - If you prefer text as the link instead of a numbered reference use: [any text you want can go here](#).

3.2 Captioned figures and tables

Figures and tables *with captions* can also be cross-referenced from elsewhere in your book using `\@ref(fig:chunk-label)` and `\@ref(tab:chunk-label)`, respectively.

See Figure 3.1.

```
par(mar = c(4, 4, .1, .1))
plot(pressure, type = 'b', pch = 19)
```

Don't miss Table 3.1.

```
knitr::kable(
  head(pressure, 10), caption = 'Here is a nice table!',
  booktabs = TRUE
)
```

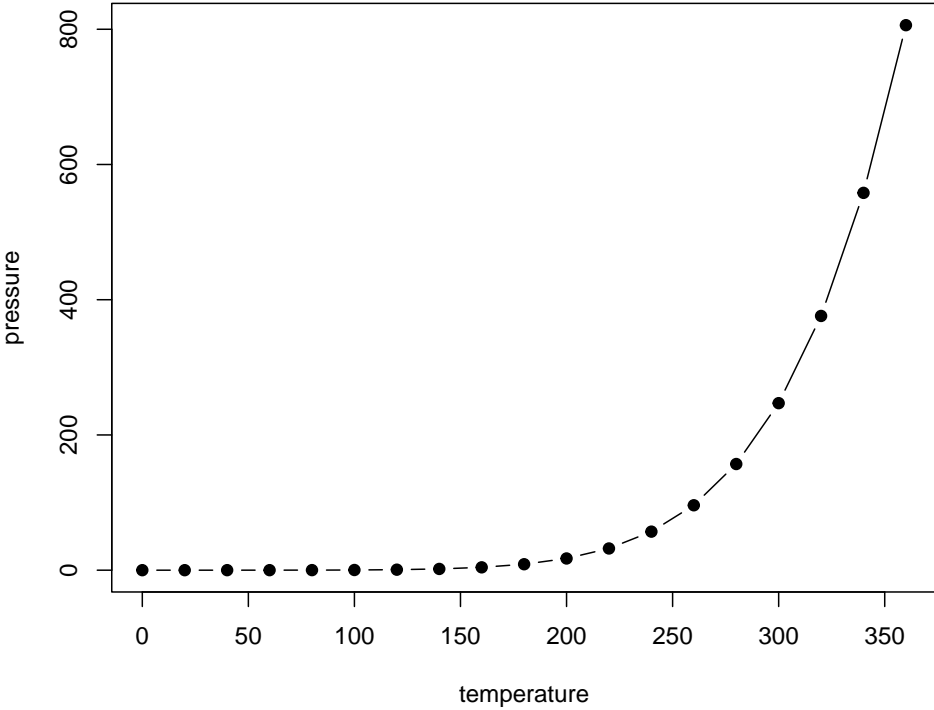


Figure 3.1: Here is a nice figure!

Table 3.1: Here is a nice table!

temperature	pressure
0	0.0002
20	0.0012
40	0.0060
60	0.0300
80	0.0900
100	0.2700
120	0.7500
140	1.8500
160	4.2000
180	8.8000

Chapter 4

Parts

You can add parts to organize one or more book chapters together. Parts can be inserted at the top of an .Rmd file, before the first-level chapter heading in that same file.

Add a numbered part: `# (PART) Act one {-}` (followed by `# A chapter`)

Add an unnumbered part: `# (PART*) Act one {-}` (followed by `# A chapter`)

Add an appendix as a special kind of un-numbered part: `# (APPENDIX) Other stuff {-}` (followed by `# A chapter`). Chapters in an appendix are prepended with letters instead of numbers.

Chapter 5

Footnotes and citations

5.1 Footnotes

Footnotes are put inside the square brackets after a caret `^[]`. Like this one ¹.

5.2 Citations

Reference items in your bibliography file(s) using `@key`.

For example, we are using the **bookdown** package¹ (check out the last code chunk in `index.Rmd` to see how this citation key was added) in this sample book, which was built on top of R Markdown and **knitr**² (this citation was added manually in an external file `book.bib`). Note that the `.bib` files need to be listed in the `index.Rmd` with the YAML `bibliography` key.

The RStudio Visual Markdown Editor can also make it easier to insert citations: <https://rstudio.github.io/visual-markdown-editing/#/citations>

¹This is a footnote.

Chapter 6

Blocks

6.1 Equations

Here is an equation.

$$f(k) = \binom{n}{k} p^k (1-p)^{n-k} \quad (6.1)$$

You may refer to using `\@ref{eq:binom}`, like see Equation (6.1).

6.2 Theorems and proofs

Labeled theorems can be referenced in text using `\@ref{thm:tri}`, for example, check out this smart theorem 6.1.

Theorem 6.1. *For a right triangle, if c denotes the length of the hypotenuse and a and b denote the lengths of the **other** two sides, we have*

$$a^2 + b^2 = c^2$$

Read more here <https://bookdown.org/yihui/bookdown/markdown-extensions-by-bookdown.html>.

6.3 Callout blocks

The R Markdown Cookbook provides more help on how to use custom blocks to design your own callouts: <https://bookdown.org/yihui/rmarkdown-cookbook/custom-blocks.html>

Chapter 7

Sharing your book

7.1 Publishing

HTML books can be published online, see: <https://bookdown.org/yihui/bookdown/publishing.html>

7.2 404 pages

By default, users will be directed to a 404 page if they try to access a webpage that cannot be found. If you'd like to customize your 404 page instead of using the default, you may add either a `_404.Rmd` or `_404.md` file to your project root and use code and/or Markdown syntax.

7.3 Metadata for sharing

Bookdown HTML books will provide HTML metadata for social sharing on platforms like Twitter, Facebook, and LinkedIn, using information you provide in the `index.Rmd` YAML. To setup, set the `url` for your book and the path to your `cover-image` file. Your book's `title` and `description` are also used.

This `gitbook` uses the same social sharing data across all chapters in your book- all links shared will look the same.

Specify your book's source repository on GitHub using the `edit` key under the configuration options in the `_output.yml` file, which allows users to suggest an edit by linking to a chapter's source file.

Read more about the features of this output format here:

<https://pkgs.rstudio.com/bookdown/reference/gitbook.html>

Or use:

```
?bookdown::gitbook
```


Part II

by discipline

Chapter 8

test cross-link

script^{superscript}_{subscript}

8.1 link and reference

$E = mc^2$

(8.1)

```
\@ref(nice-label) 10

[link to partition][partition] link to partition

[partition] \@ref(partition)

partition [#partition] (10) \@ref(#partition)

[equivalence class] \@ref(equivalence class)

equivalence class [#equivalence class] (@ref(equivalence class)) \@ref(#equivalence class)

[equivalence-class] [#equivalence-class] (10) \@ref(#equivalence-class)

[equivalence-class.html] [equivalence-class.html#equivalence-class] (@ref(equivalence-class.html))
@ref(equivalence-class.html#equivalence-class)

equivalence relation [#equivalence relation] (@ref(equivalence relation)) \@ref(#equivalence relation)

[equivalence-relation] [#equivalence-relation] (10) \@ref(#equivalence-relation)

[equivalence-relation.html] [equivalence-relation.html#equivalence-relation] (@ref(equivalence-
relation.html)) @ref(equivalence-relation.html#equivalence-relation)
```

8.2 number and reference equations

<https://bookdown.org/yihui/rmarkdown/bookdown-markdown.html#equations>

\#eq:emc \@ref(eq:emc)

C is an equivalence class of a on A

$$\Leftrightarrow [a]_{\sim} = C = \left\{ x \mid \begin{cases} a \in A \\ x \in A \\ x \sim a \\ \sim \text{ is an equivalence relation over } A \times A = A^2 \end{cases} \right\} \subseteq A \neq \emptyset$$

$$\Leftrightarrow [a] = [a]_{\sim} = \left\{ x \mid \begin{cases} a \in A \\ x \in A \\ x \sim a \\ \sim \text{ is an equivalence relation on } A \end{cases} \right\} \subseteq A \neq \emptyset$$

$$\Rightarrow [a]_{\sim} = \{x \mid x \sim a\} \subseteq A \neq \emptyset$$

<https://bookdown.org/yihui/rmarkdown/bookdown-markdown.html#cross-referencing>

This cross reference is the Fig. 8.1

<https://stackoverflow.com/questions/51595939/bookdown-cross-reference-figure-in-another-file>

I ran into the same issue and came up with this solution if you aim at compiling 2 different pdfs. It relies on LaTeX's xr package for cross references: <https://stackoverflow.com/a/52532269/576684>

8.3 footnote

noun¹

8.4 citation

<https://stackoverflow.com/questions/48965247/use-csl-file-for-pdf-output-in-bookdown/49145699#49145699>

citation 1³ citation 2³

citation 3⁴ citation 4⁴

8.5 bookdown environment for definition, theorem, proof

<https://bookdown.org/yihui/rmarkdown/bookdown-markdown.html>

Theorem 8.1 (Theorem Name). *Here is my theorem.*

Proof Name. Here is my proof. □

Theorem 8.2 (Pythagorean theorem). *For a right triangle, if c denotes the length of the hypotenuse and a and b denote the lengths of the other two sides, we have*

$$a^2 + b^2 \stackrel{8.1}{=} c^2$$

¹This is a footnote.

Definition 8.1 (Definition Name). Here is my definition.

number and reference equations

(??)

(8.1)

8.2

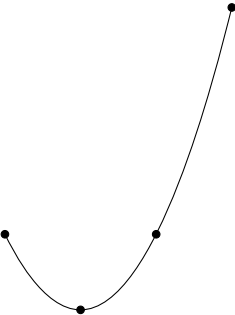


Figure 8.1: parabola arc with points

Chapter 9

test cross-link 2

Chapter 10

math

equivalence relation 10

equivalence class 10

partition 10

equivalence relation

等價關係 equivalence relation

R is an equivalence relation over $A \times B$

$$\Leftrightarrow \begin{cases} R = \sim = \{\langle x, y \rangle | x \sim y\} \subseteq A \times B & \text{(e) equivalence 等價} \\ \vdots & \vdots \end{cases}$$

$$\Leftrightarrow \begin{cases} R = \{\langle x, y \rangle | xRy\} \subseteq A \times B & (R) \text{ relation} \\ \forall \langle x, y \rangle \in R (xRx) & (r) \text{ reflexive} \\ \forall \langle x, y \rangle \in R (xRy \Rightarrow yRx) & (s) \text{ symmetric} \\ \forall \langle x, y \rangle, \langle y, z \rangle \in R \left(\begin{cases} xRy \\ yRz \end{cases} \Rightarrow xRz \right) & (t) \text{ transitive} \end{cases} \Leftrightarrow \begin{cases} R = \{\langle x, y \rangle | xRy\} \subseteq A \times B & \text{關係} \\ \forall \langle x, y \rangle \in R (\langle x, x \rangle \in R) & \text{自反} \\ \forall \langle x, y \rangle \in R (\langle y, x \rangle \in R) & \text{對稱} \\ \forall \langle x, y \rangle, \langle y, z \rangle \in R (\langle x, z \rangle \in R) & \text{遞移} \end{cases}$$

equivalence class

C is an equivalence class of a on A

$$\Leftrightarrow [a]_{\sim} = C = \left\{ x \mid \left\{ \begin{array}{l} a \in A \\ x \in A \\ x \sim a \\ \sim \text{ is an equivalence relation over } A \times A = A^2 \end{array} \right. \right\} \subseteq A \neq \emptyset$$

$$\Leftrightarrow [a] = [a]_{\sim} = \left\{ x \mid \left\{ \begin{array}{l} a \in A \\ x \in A \\ x \sim a \\ \sim \text{ is an equivalence relation on } A \end{array} \right. \right\} \subseteq A \neq \emptyset$$

$$\Rightarrow [a]_{\sim} = \{x \mid x \sim a\} \subseteq A \neq \emptyset$$

where the definition of **equivalence relation** can be found in 10.

number and reference equations

(??)

(8.1)

8.2

partition

$$\{A_i\}_{i \in I} = \{A_i | i \in I\} \text{ is a partition of a set } A \\ \Leftrightarrow \begin{cases} \forall i \in I (A_i \neq \emptyset) \\ A = \bigcup_{i \in I} A_i \\ \forall i, j \in I (i \neq j \Rightarrow A_i \cap A_j = \emptyset) \end{cases}$$

https://proofwiki.org/wiki/Definition:Set_Partition

Chapter 11

physics

Chapter 12

plot

TikZ

TikZ and PGFplots

What's the relation between packages PGFplots and TikZ?

<https://tex.stackexchange.com/questions/285925/whats-the-relation-between-packages-pgfplots-and-tikz>

<https://www.youtube.com/watch?v=bQugbYq0BVA>

<https://www.youtube.com/watch?v=ft4Kg9emK1k&list=PLg5nrpKdkk2DWcg3scb75AknF7DJXs8lk&index=18>

```
\begin{tikzpicture}
  \def\{a{1.5} % amplitude
  \def\{b{2} % frequency
  \draw[->] (-0.2,0) -- (4.2,0) node[right, font=\small] {\$x\$};
  \draw[->] (0,-4) -- (0,0.5) node[above] {\$y\$};
  \draw[domain=0:4,smooth,variable=\t,blue,thick]
    plot ({\a * (\b*\t - sin(deg(\b*\t)))},{-\a * (1 - cos(deg(\b*\t)))});
  % \node[above] at (2, 0.5) {Brachistochrone Curve};
  \node[above, font=\footnotesize] at (2, 1) {Brachistochrone Curve};
  \node[above, font=\footnotesize] at (2, 0) {\$\\begin{aligned}
& x=r(t-\sin t) \\
& y=r(1-\cos t)
\end{aligned}\$};
\end{tikzpicture}
```

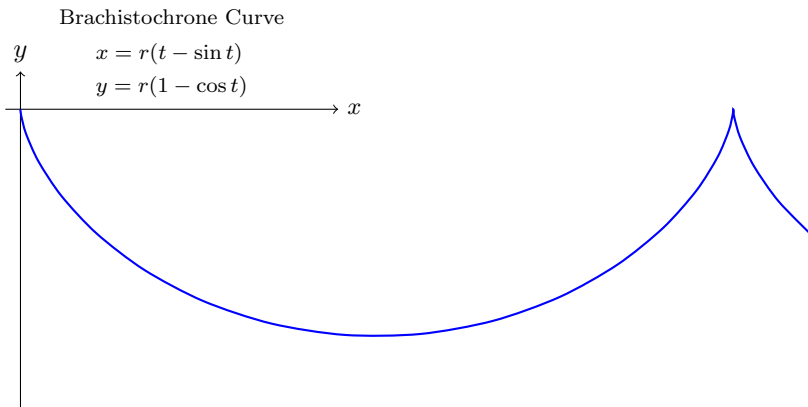


Figure 12.1: Brachistochrone Curve

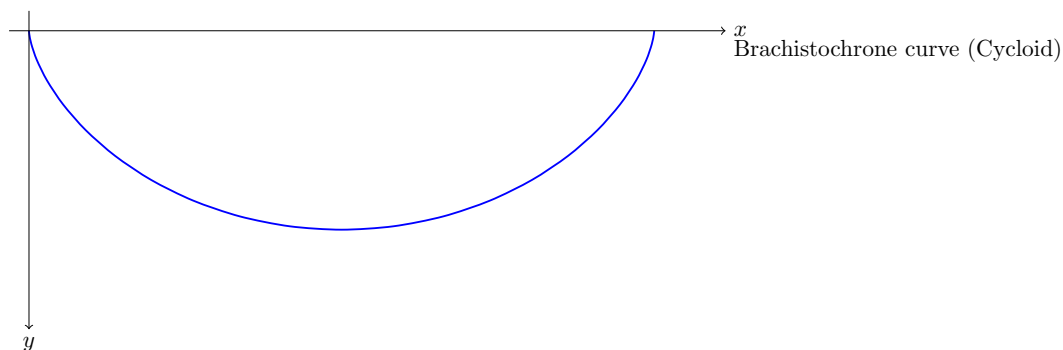
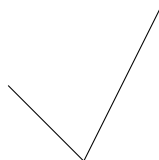
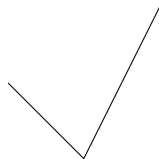


Figure 12.2: Brachistochrone Curve

https://zhuanlan.zhihu.com/p/127155579?utm_psn=1741479950987960320

1

```
\begin{tikzpicture}
  \draw (-1,1)--(0,0)--(1,2);
\end{tikzpicture}
```



2

3

```
\begin{tikzpicture}
  \draw[rounded corners] (-1,1)--(0,0)--(1,2)--(-1,1);
\end{tikzpicture}
```

```
\begin{tikzpicture}
  \draw[rounded corners] (-1,1)--(0,0)--(1,2)--cycle;
\end{tikzpicture}
```

```
\begin{tikzpicture}
  \draw (0,0) rectangle (4,2);
\end{tikzpicture}
```

```
\begin{tikzpicture}
  \draw (0,0) rectangle (2,2);
\end{tikzpicture}
```

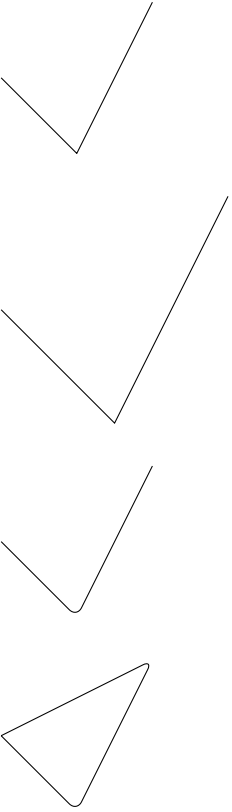


Figure 12.3: rounded corner pseudo-closed triangle

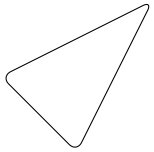


Figure 12.4: rounded corner triangle

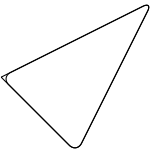


Figure 12.5: triangle vs. pseudo-closed triangle



Figure 12.6: rectangle

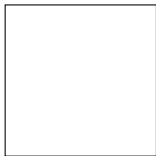


Figure 12.7: square

```
\begin{tikzpicture}
  \draw (0,0) circle (1);
\end{tikzpicture}
```

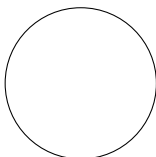


Figure 12.8: circle

```
\begin{tikzpicture}
  \draw (0,0) circle (1);
  \draw (0,0) rectangle (2,2);
\end{tikzpicture}
```

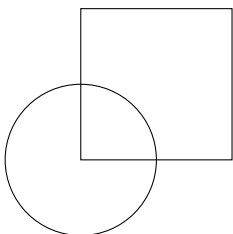


Figure 12.9: circle and square

```
\begin{tikzpicture}
  \draw (1,1) ellipse (2 and 1);
\end{tikzpicture}
```

```
\begin{tikzpicture}
  \draw (1 ,1) arc (0:270:1);
  \draw (6 ,1) arc (0:270:2 and 1);
\end{tikzpicture}
```

```
\begin{tikzpicture}
  \draw (-1,1) parabola bend (0,0) (2,4);
\end{tikzpicture}
```

```
\begin{tikzpicture}
  \draw (-1,1) parabola bend (0,0) (2,4);
```

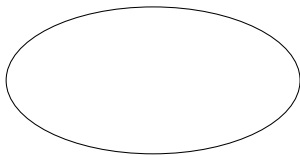


Figure 12.10: ellipse



Figure 12.11: circle and ellipse arcs

```
\filldraw
  (-1,1) circle (.05)
  ( 0,0) circle (.05)
  ( 1,1) circle (.05)
  ( 2,4) circle (.05);
\end{tikzpicture}
```

```
\begin{tikzpicture}
  \draw [step=20pt] (0,0) grid (3,2);
  \draw [help lines ,step=20pt] (4,0) grid (7,2);
\end{tikzpicture}
```

```
\begin{tikzpicture}[scale=0.25]
  \draw [->] (0,0)--(9,0);
  \draw [<-] (0,1)--(9,1);
  \draw [<->] (0,2)--(9,2);
  \draw [>->>] (0,3)--(9,3);
  \draw [|<->|] (0,4)--(9,4);
\end{tikzpicture}
```

```
\begin{tikzpicture}
  \draw [line width =2pt] (0,6)--(9,6);
  \draw [dotted] (0,5)--(9,5);
  \draw [densely dotted] (0,4)--(9,4);
\end{tikzpicture}
```

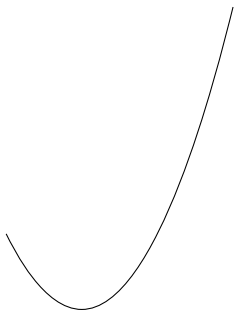


Figure 12.12: parabola arc

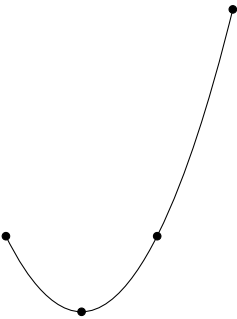


Figure 12.13: parabola arc with points

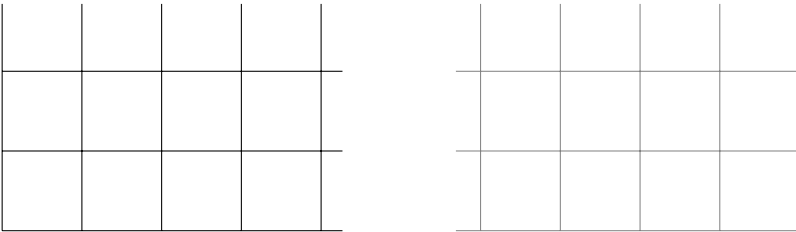


Figure 12.14: grid and help lines

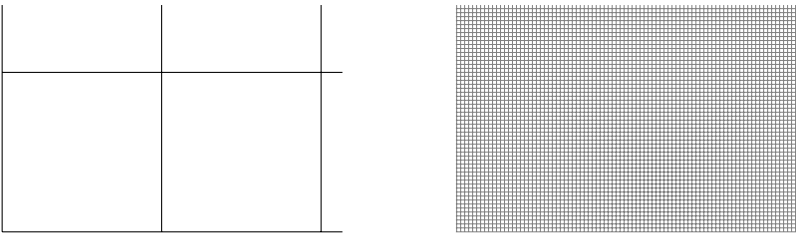


Figure 12.15: grid and help lines

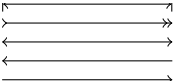


Figure 12.16: arrows


```

\draw [loosely dotted] (0,3)--(9,3);
\draw [dashed] (0,2)--(9,2);
\draw [densely dashed] (0,1)--(9,1);
\draw [loosely dashed] (0,0)--(9,0);
\end{tikzpicture}

```

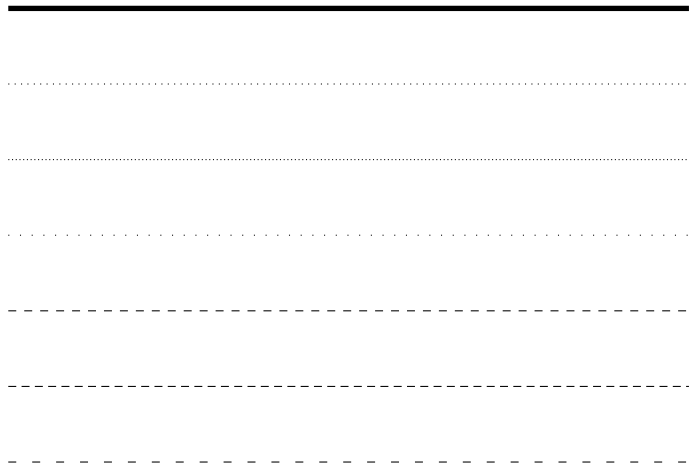


Figure 12.17: arrows

```

\begin{tikzpicture}[dline/.style={color= blue, line width=2pt}]
\draw[dline] (0,0)--(9,0);
\end{tikzpicture}

```



Figure 12.18: head styling

```

\begin{tikzpicture}
\draw (0,0) rectangle (2,2);
\draw[shift={( 3, 0)}] (0,0) rectangle (2,2);
\draw[shift={( 0, 3)}] (0,0) rectangle (2,2);
\draw[shift={( 0,-3)}] (0,0) rectangle (2,2);
\draw[shift={(-3, 0)}] (0,0) rectangle (2,2);
\draw[shift={( 3, 3)}] (0,0) rectangle (2,2);
\draw[shift={(-3, 3)}] (0,0) rectangle (2,2);
\draw[shift={( 3,-3)}] (0,0) rectangle (2,2);
\draw[shift={(-3,-3)}] (0,0) rectangle (2,2);
\end{tikzpicture}

```

```

\begin{tikzpicture}
\draw (0,0) rectangle (2,2);
\draw[xshift= 100pt] (0,0) rectangle (2,2);
\draw[xshift=-100pt] (0,0) rectangle (2,2);
\draw[yshift= 100pt] (0,0) rectangle (2,2);
\draw[yshift=-100pt] (0,0) rectangle (2,2);
\end{tikzpicture}

```

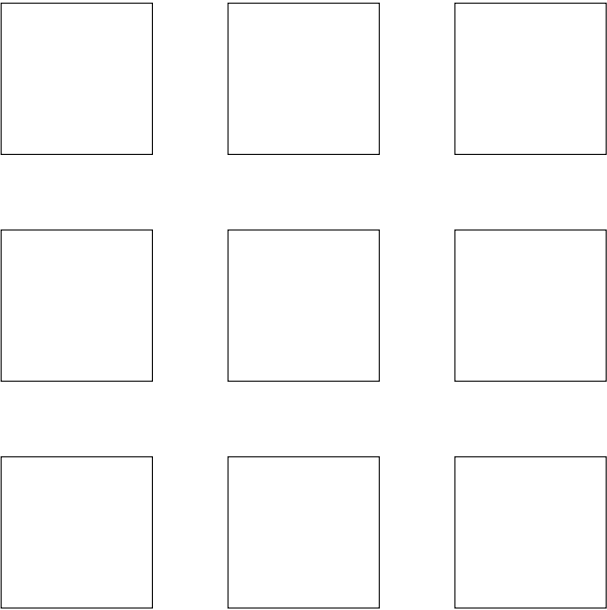


Figure 12.19: transform: shift

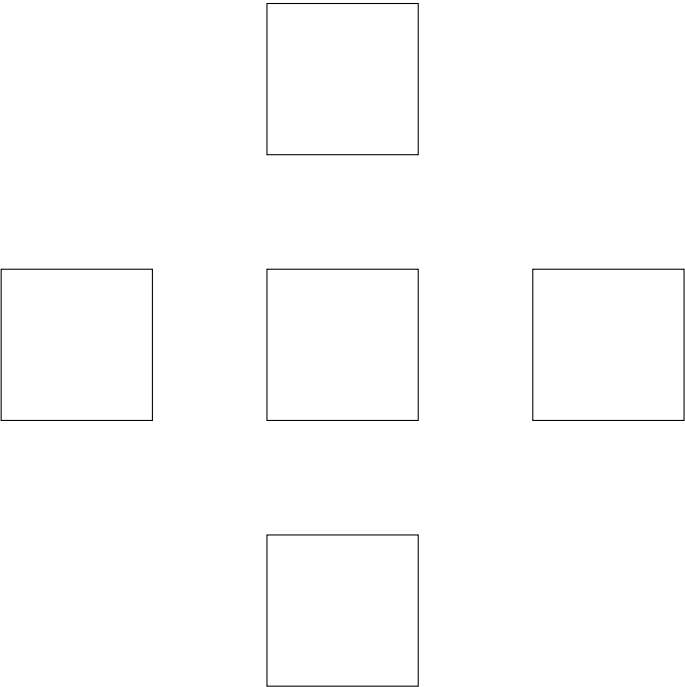


Figure 12.20: transform: shift x, y

```

\begin{tikzpicture}
  \draw (0,0) rectangle (2,2);
  \draw[xshift= 100pt, xscale=1.5] (0,0) rectangle (2,2);
  \draw[yshift= 100pt, xscale=0.5] (0,0) rectangle (2,2);
  \draw[xshift=-100pt, yscale=1.5] (0,0) rectangle (2,2);
  \draw[yshift=-100pt, yscale=0.5] (0,0) rectangle (2,2);
\end{tikzpicture}

```

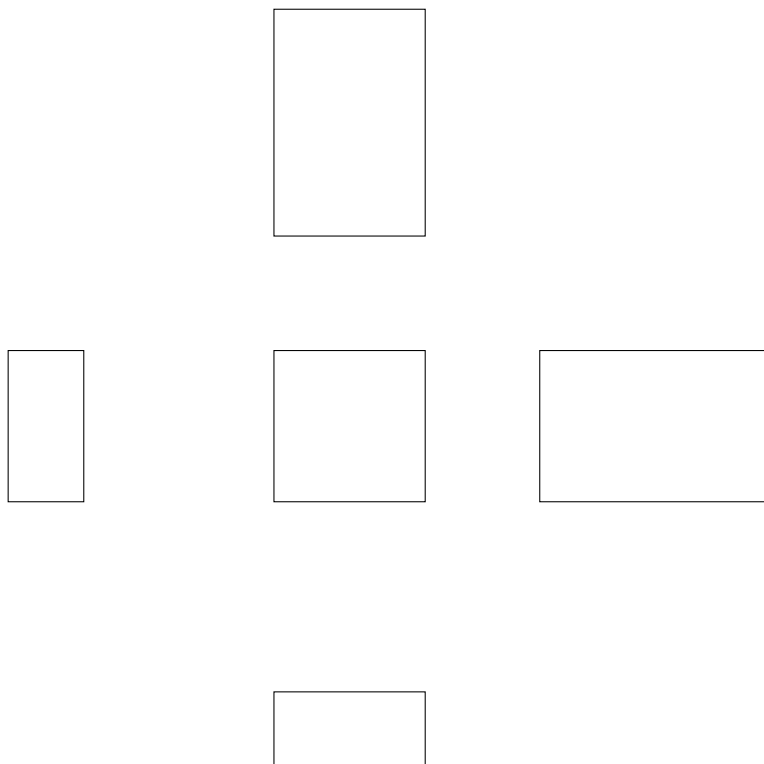


Figure 12.21: transform: scale x, y

```

\begin{tikzpicture}
  \draw (0,0) rectangle (2,2);
  \draw[xshift= 100pt, xscale=1.5] (0,0) rectangle (2,2);
  \draw[yshift= 100pt, yscale=1.5] (0,0) rectangle (2,2);
  \draw[xshift=-100pt, xscale=0.5] (0,0) rectangle (2,2);
  \draw[yshift=-100pt, yscale=0.5] (0,0) rectangle (2,2);
\end{tikzpicture}

```

```

\begin{tikzpicture}
  \draw (0,0) rectangle (2,2);
  \draw[xshift=125pt,rotate=45] (0,0) rectangle (2,2);
  \draw[xshift=175pt,rotate around={45:(2,2)}] (0,0) rectangle (2,2);
\end{tikzpicture}

```

```

\begin{tikzpicture}
  \draw (0,0) rectangle (2,2);

```

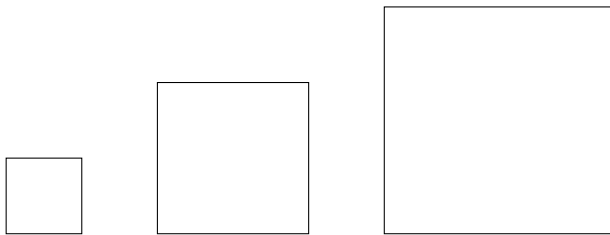


Figure 12.22: transform: scale

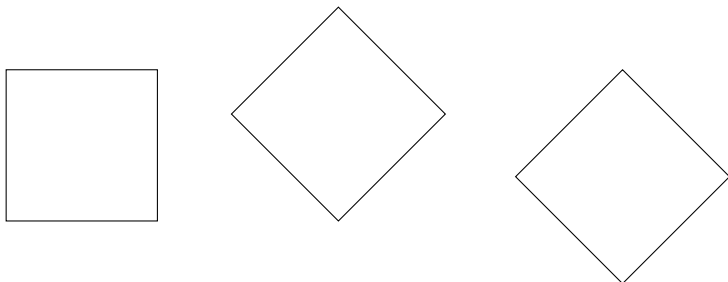


Figure 12.23: transform: rotate

```
\draw[xshift=70pt,xslant=1] (0,0) rectangle (2,2);
\draw[yshift=70pt,yslant=1] (0,0) rectangle (2,2);
\end{tikzpicture}
```

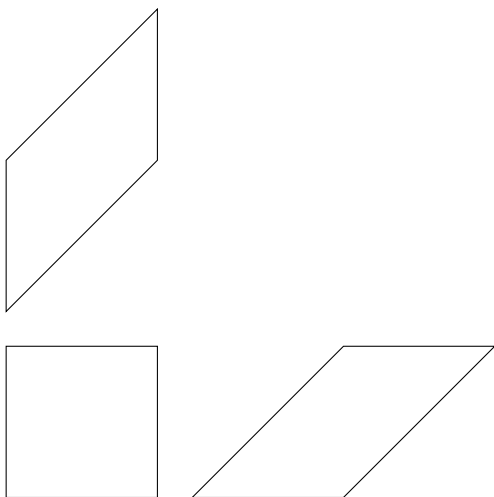


Figure 12.24: transform: slant

```
\tikzset{
  box/.style={
    draw=blue,
    rectangle,
    rounded corners=5pt,
    minimum width=50pt,
```

```

    minimum height=20pt,
    inner sep=5pt
}
}
\begin{tikzpicture}
  \node[box] (1) at(0,0) {1};
  \node[box] (2) at(4,0) {2};
  \node[box] (3) at(8,0) {3};
  \draw[->] (1)--(2);
  \draw[->] (2)--(3);
  \node at(2,1) {a};
  \node at(6,1) {b};
\end{tikzpicture}

```

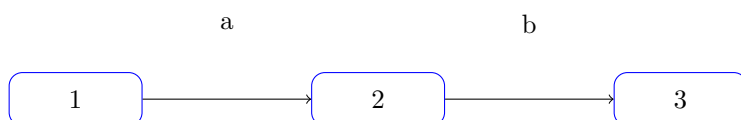


Figure 12.25: flowchart

```

\tikzset{
  box/.style={
    draw=blue,
    fill=blue!20,
    rectangle,
    rounded corners=5pt,
    minimum height=20pt,
    inner sep=5pt
  }
}
\begin{tikzpicture}
  \node[box] {1}
    child {node[box] {2}}
    child {node[box] {3}
      child {node[box] {4}}
      child {node[box] {5}}
      child {node[box] {6}}
    };
\end{tikzpicture}

```

```

\begin{tikzpicture}
  \draw[->] (-0.2,0)--(6,0) node[right] {$x$};
  \draw[->] (0,-0.2)--(0,6) node[above] {$f(x)$};
  \draw[domain=0:4] plot (\x,{0.1*exp(\x)}) node[right] {$f(x)=\frac{1}{10}e^x$};
\end{tikzpicture}

```

<https://stackoverflow.com/questions/64897575/tikz-libraries-in-bookdown>

It turns out that you can simply put the `\usetikzlibrary{...}` command directly before the `\begin{tikzpicture}` and everything works fine :)

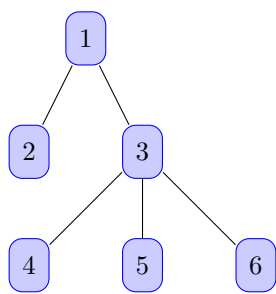


Figure 12.26: tree

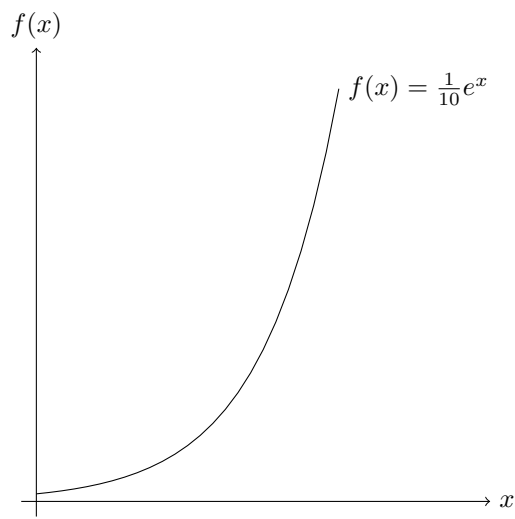


Figure 12.27: tree

<https://stackoverflow.com/questions/56211210/r-markdown-document-with-html-docx-output-using-latex-package-bbm>

<https://tex.stackexchange.com/questions/171711/how-to-include-latex-package-in-r-markdown>

12.1 3D

https://zhuanlan.zhihu.com/p/431732330?utm_psn=1741857547550638080

```
\begin{tikzpicture}
  \coordinate (A) at ( 1, 1, 1);
  \coordinate (B) at ( 1, 1,-1);
  \coordinate (C) at ( 1,-1,-1);
  \coordinate (D) at ( 1,-1, 1);
  \coordinate (E) at (-1,-1, 1);
  \coordinate (F) at (-1,-1,-1);
  \coordinate (G) at (-1, 1,-1);
  \coordinate (H) at (-1, 1, 1);
  \draw (A) node[right=1pt] {$A$}--
        (B) node[right=1pt] {$B$}--
        (C) node[right=1pt] {$C$}--
        (D) node[right=1pt] {$D$}--
        (E) node[left= 1pt] {$E$}--
        (F) node[right=1pt] {$F$}--
        (G) node[right=1pt] {$G$}--
        (H) node[left= 1pt] {$H$}--
        (A) node[right=1pt] {$A$};
\end{tikzpicture}
```

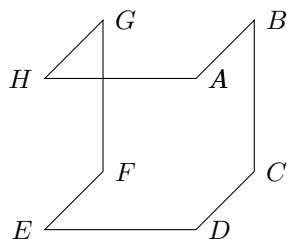


Figure 12.28: cube

<https://tex.stackexchange.com/questions/388621/optimizing-perspective-tikz-graphic>

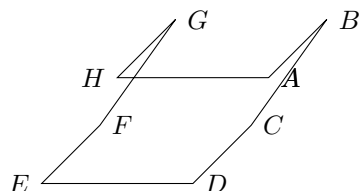


Figure 12.29: cube rotate

<https://github.com/XiangyunHuang/bookdown-broken/blob/master/index.Rmd>

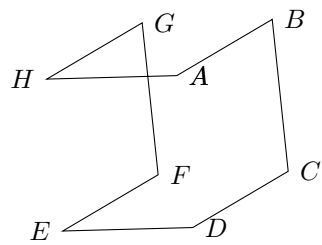


Figure 12.30: cube rotate



Figure 12.31: 《代形》的技能

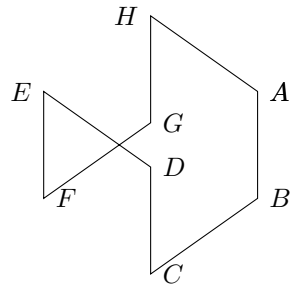


Figure 12.32: cube rotate

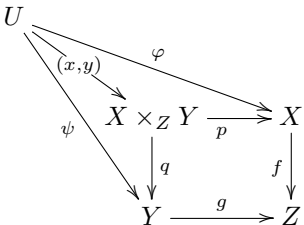
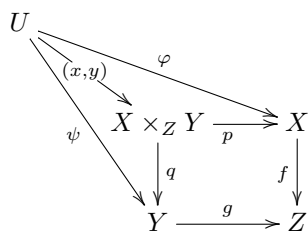
xy-pic

<https://bookdown.org/yihui/rmarkdown-cookbook/install-latex-pkgs.html>

```
tinytex::install_tinytex()
```

the following xymatrix from LaTeX package xy for xy-pic is not shown or rendered in HTML:

`\LaTeX` can only be used in HTML, not PDF



Part III

by date

Chapter 13

by date

partition

$$\{A_i\}_{i \in I} = \{A_i | i \in I\} \text{ is a partition of a set } A \\ \Leftrightarrow \begin{cases} \forall i \in I (A_i \neq \emptyset) \\ A = \bigcup_{i \in I} A_i \\ \forall i, j \in I (i \neq j \Rightarrow A_i \cap A_j = \emptyset) \end{cases}$$

https://proofwiki.org/wiki/Definition:Set_Partition

202401281000

equivalence class

C is an equivalence class of a on A

$$\Leftrightarrow [a]_{\sim} = C = \left\{ x \left| \left\{ \begin{array}{l} a \in A \\ x \in A \\ x \sim a \\ \sim \text{ is an equivalence relation over } A \times A = A^2 \end{array} \right. \right. \right\} \subseteq A \neq \emptyset$$

$$\Leftrightarrow [a] = [a]_{\sim} = \left\{ x \left| \left\{ \begin{array}{l} a \in A \\ x \in A \\ x \sim a \\ \sim \text{ is an equivalence relation on } A \end{array} \right. \right. \right\} \subseteq A \neq \emptyset$$

$$\Rightarrow [a]_{\sim} = \{x|x \sim a\} \subseteq A \neq \emptyset$$

where the definition of **equivalence relation** can be found in 10.

number and reference equations

(??)

(8.1)

8.2

equivalence relation

等價關係 equivalence relation

R is an equivalence relation over $A \times B$

$$\Leftrightarrow \begin{cases} R = \sim = \{\langle x, y \rangle | x \sim y\} \subseteq A \times B & \text{(e) equivalence 等價} \\ \vdots & \vdots \end{cases}$$

$$\Leftrightarrow \begin{cases} R = \{\langle x, y \rangle | xRy\} \subseteq A \times B & (R) \text{ relation} \\ \forall \langle x, y \rangle \in R (xRx) & (r) \text{ reflexive} \\ \forall \langle x, y \rangle \in R (xRy \Rightarrow yRx) & (s) \text{ symmetric} \\ \forall \langle x, y \rangle, \langle y, z \rangle \in R \left(\begin{cases} xRy \\ yRz \end{cases} \Rightarrow xRz \right) & (t) \text{ transitive} \end{cases} \Leftrightarrow \begin{cases} R = \{\langle x, y \rangle | xRy\} \subseteq A \times B & \text{關係} \\ \forall \langle x, y \rangle \in R (\langle x, x \rangle \in R) & \text{自反} \\ \forall \langle x, y \rangle \in R (\langle y, x \rangle \in R) & \text{對稱} \\ \forall \langle x, y \rangle, \langle y, z \rangle \in R (\langle x, z \rangle \in R) & \text{遞移} \end{cases}$$

Chapter 14

Python

<https://bookdown.org/yihui/rmarkdown/language-engines.html>

```
names(knitr::knit_engines$get())
```

```
## [1] "awk"          "bash"         "coffee"      "gawk"         "groovy"
## [6] "haskell"     "lein"         "mysql"        "node"         "octave"
## [11] "perl"        "php"          "psql"         "Rscript"      "ruby"
## [16] "sas"         "scala"        "sed"          "sh"           "stata"
## [21] "zsh"         "asis"         "asy"          "block"        "block2"
## [26] "bslib"       "c"            "cat"          "cc"           "comment"
## [31] "css"         "ditaa"        "dot"          "embed"        "eviews"
## [36] "exec"        "fortran"      "fortran95"    "go"           "highlight"
## [41] "js"          "julia"        "python"       "R"            "Rcpp"
## [46] "sass"        "scss"         "sql"          "stan"         "targets"
## [51] "tikz"        "verbatim"     "theorem"      "lemma"        "corollary"
## [56] "proposition" "conjecture"   "definition"   "example"      "exercise"
## [61] "hypothesis"  "proof"        "remark"       "solution"     "glue"
## [66] "glue_sql"    "gluesql"
```

https://rstudio.github.io/reticulate/articles/python_packages.html

```
x = 'hello, python world!'
print(x.split(' '))
```

```
## ['hello,', 'python', 'world!']
```

```
library(reticulate)
```

```
## Warning: package 'reticulate' was built under R version 4.2.3
```

```
virtualenv_python()
```

```
## [1] "D:/Users/115381/Documents/.virtualenvs/r-reticulate/Scripts/python.exe"
```

```
library(reticulate)
conda_list()
```

```
##               name               python
```

```
## 1          base                      D:\\Anaconda3\\python.exe
## 2          fiftyone                  D:\\Anaconda3\\envs\\fiftyone\\python.exe
## 3          keras                     D:\\Anaconda3\\envs\\keras\\python.exe
## 4          labelme                   D:\\Anaconda3\\envs\\labelme\\python.exe
## 5          manim                     D:\\Anaconda3\\envs\\manim\\python.exe
## 6          mmyolo                    D:\\Anaconda3\\envs\\mmyolo\\python.exe
## 7 rsconnect-jupyter D:\\Anaconda3\\envs\\rsconnect-jupyter\\python.exe
## 8          sandbox                   D:\\Anaconda3\\envs\\sandbox\\python.exe
## 9          sandbox-3.9               D:\\Anaconda3\\envs\\sandbox-3.9\\python.exe
```

```
library(reticulate)
virtualenv_list()
```

```
## [1] "r-reticulate"
```

https://rstudio.github.io/reticulate/reference/install_python.html

```
library(reticulate)
version <- "3.9.12"
# install_python(version)

# create a new environment
# virtualenv_create("r-reticulate", version = version)

# use_virtualenv("r-reticulate")

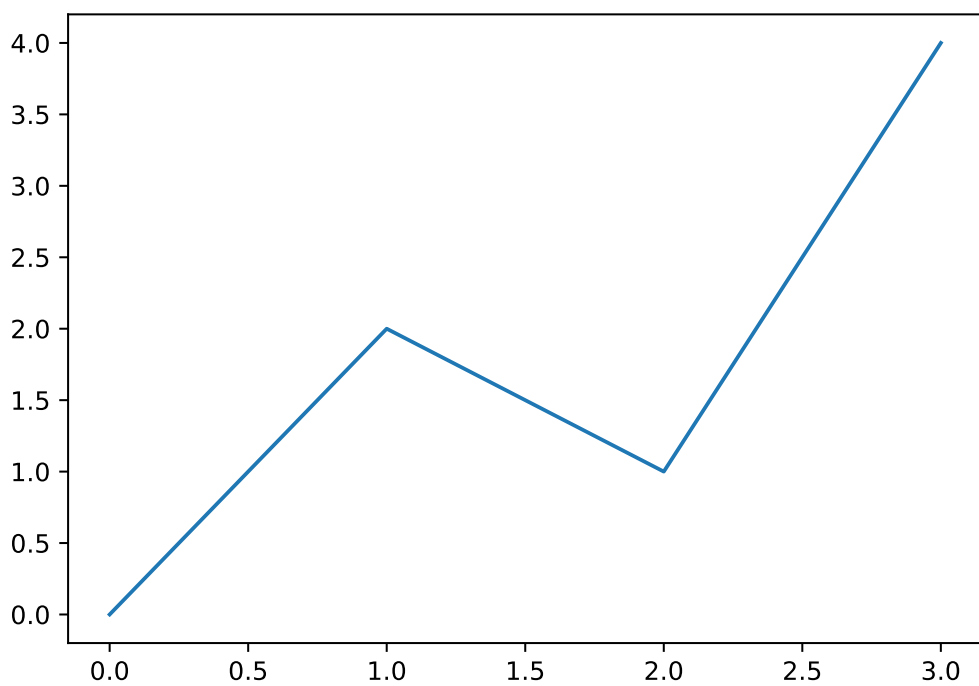
# install Matplotlib
# virtualenv_install("r-reticulate", "matplotlib")

# import Matplotlib (it will be automatically discovered in "r-reticulate")
matplotlib <- import("matplotlib")
```

copy C:\Users\RW\AppData\Local\r-reticulate\r-reticulate\pyenv\pyenv-win\versions\3.9.12\tcl and C:\Users\RW\AppData\Local\r-reticulate\r-reticulate\pyenv\pyenv-win\versions\3.9.12\tcl two folders to the folder C:\Users\RW\AppData\Local\r-reticulate\r-reticulate\pyenv\pyenv-win\venv

```
# library(reticulate)
# use_virtualenv("r-reticulate")
# # matplotlib <- import("matplotlib")
# matplotlib$use("Agg", force = TRUE)
```

```
import matplotlib.pyplot as plt
plt.plot([0, 2, 1, 4])
plt.show()
```

TikZ

TikZ and PGFplots

What's the relation between packages PGFplots and TikZ?

<https://tex.stackexchange.com/questions/285925/whats-the-relation-between-packages-pgfplots-and-tikz>

<https://www.youtube.com/watch?v=bQugbYq0BVA>

<https://www.youtube.com/watch?v=ft4Kg9emK1k&list=PLg5nrpKdkk2DWcg3scb75AknF7DJXs8lk&index=18>

```
\begin{tikzpicture}
  \def\a{1.5} % amplitude
  \def\b{2} % frequency
  \draw[->] (-0.2,0) -- (4.2,0) node[right, font=\small] {$x$};
  \draw[->] (0,-4) -- (0,0.5) node[above] {$y$};
  \draw[domain=0:4,smooth,variable=\t,blue,thick]
    plot ({\a * (\b*\t - sin(deg(\b*\t)))},{-\a * (1 - cos(deg(\b*\t)))});
  % \node[above] at (2, 0.5) {Brachistochrone Curve};
  \node[above, font=\footnotesize] at (2, 1) {Brachistochrone Curve};
  \node[above, font=\footnotesize] at (2, 0) {$\begin{aligned}$
& x=r(t-\sin t) \\
& y=r(1-\cos t)
\end{aligned}$};
\end{tikzpicture}
```

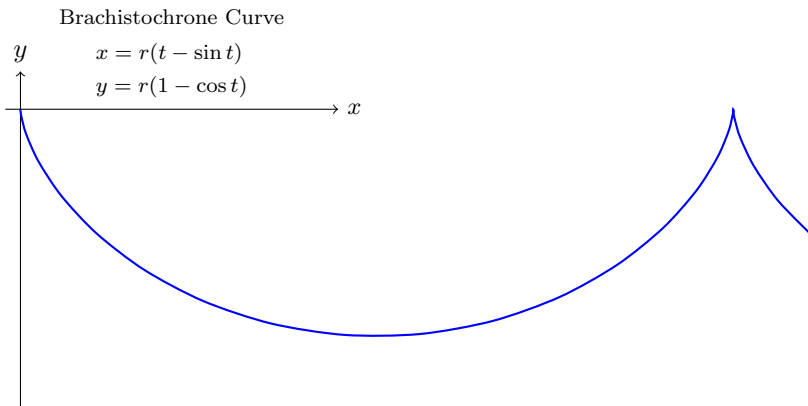


Figure 14.1: Brachistochrone Curve

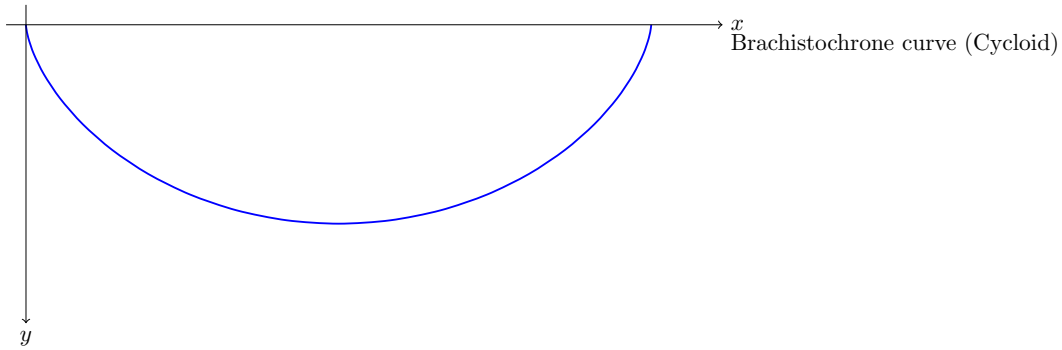
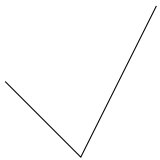
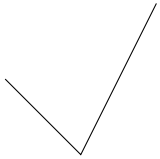


Figure 14.2: Brachistochrone Curve

https://zhuanlan.zhihu.com/p/127155579?utm_psn=1741479950987960320

1

```
\begin{tikzpicture}
  \draw (-1,1)--(0,0)--(1,2);
\end{tikzpicture}
```



2

3

```
\begin{tikzpicture}
  \draw[rounded corners] (-1,1)--(0,0)--(1,2)--(-1,1);
\end{tikzpicture}
```

```
\begin{tikzpicture}
  \draw[rounded corners] (-1,1)--(0,0)--(1,2)--cycle;
\end{tikzpicture}
```

```
\begin{tikzpicture}
  \draw (0,0) rectangle (4,2);
\end{tikzpicture}
```

```
\begin{tikzpicture}
  \draw (0,0) rectangle (2,2);
\end{tikzpicture}
```

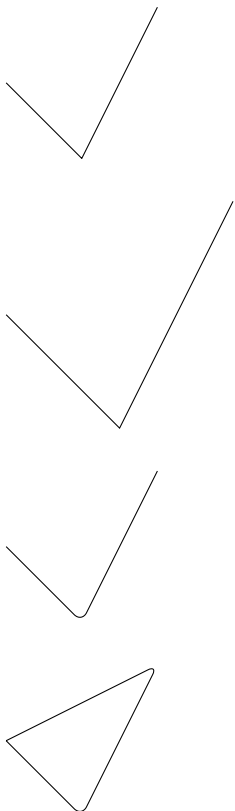


Figure 14.3: rounded corner pseudo-closed triangle

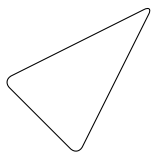


Figure 14.4: rounded corner triangle

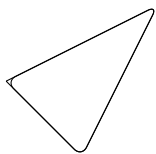


Figure 14.5: triangle vs. pseudo-closed triangle



Figure 14.6: rectangle



Figure 14.7: square

```
\begin{tikzpicture}
  \draw (0,0) circle (1);
\end{tikzpicture}
```

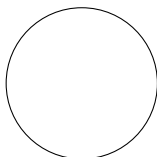


Figure 14.8: circle

```
\begin{tikzpicture}
  \draw (0,0) circle (1);
  \draw (0,0) rectangle (2,2);
\end{tikzpicture}
```

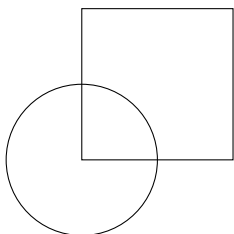


Figure 14.9: circle and square

```
\begin{tikzpicture}
  \draw (1,1) ellipse (2 and 1);
\end{tikzpicture}
```

```
\begin{tikzpicture}
  \draw (1 ,1) arc (0:270:1);
  \draw (6 ,1) arc (0:270:2 and 1);
\end{tikzpicture}
```

```
\begin{tikzpicture}
  \draw (-1,1) parabola bend (0,0) (2,4);
\end{tikzpicture}
```

```
\begin{tikzpicture}
  \draw (-1,1) parabola bend (0,0) (2,4);
```

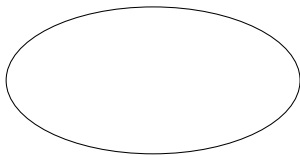


Figure 14.10: ellipse



Figure 14.11: circle and ellipse arcs

```
\filldraw
  (-1,1) circle (.05)
  ( 0,0) circle (.05)
  ( 1,1) circle (.05)
  ( 2,4) circle (.05);
\end{tikzpicture}
```

```
\begin{tikzpicture}
  \draw [step=20pt] (0,0) grid (3,2);
  \draw [help lines ,step=20pt] (4,0) grid (7,2);
\end{tikzpicture}
```

```
\begin{tikzpicture}[scale=0.25]
  \draw [->] (0,0)--(9,0);
  \draw [<-] (0,1)--(9,1);
  \draw [<->] (0,2)--(9,2);
  \draw [>->>] (0,3)--(9,3);
  \draw [|<->|] (0,4)--(9,4);
\end{tikzpicture}
```

```
\begin{tikzpicture}
  \draw [line width =2pt] (0,6)--(9,6);
  \draw [dotted] (0,5)--(9,5);
  \draw [densely dotted] (0,4)--(9,4);
\end{tikzpicture}
```

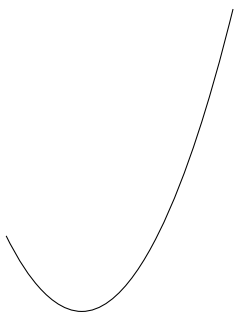


Figure 14.12: parabola arc

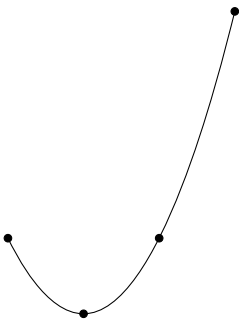


Figure 14.13: parabola arc with points

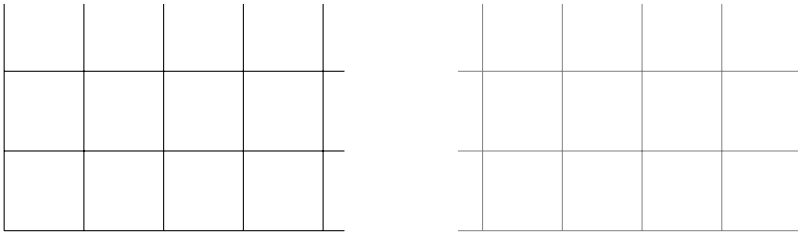


Figure 14.14: grid and help lines

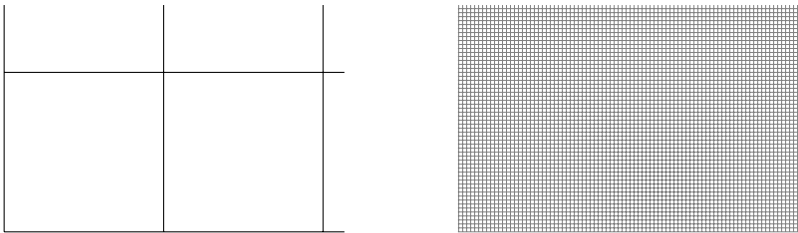


Figure 14.15: grid and help lines

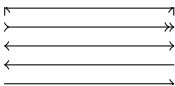


Figure 14.16: arrows


```

\draw [loosely dotted] (0,3)--(9,3);
\draw [dashed] (0,2)--(9,2);
\draw [densely dashed] (0,1)--(9,1);
\draw [loosely dashed] (0,0)--(9,0);
\end{tikzpicture}

```

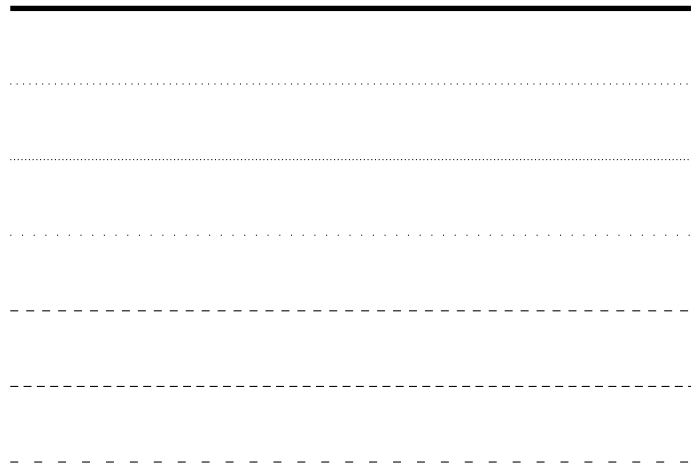


Figure 14.17: arrows

```

\begin{tikzpicture}[dline/.style={color= blue, line width=2pt}]
\draw[dline] (0,0)--(9,0);
\end{tikzpicture}

```



Figure 14.18: head styling

```

\begin{tikzpicture}
\draw (0,0) rectangle (2,2);
\draw[shift={ ( 3, 0) }] (0,0) rectangle (2,2);
\draw[shift={ ( 0, 3) }] (0,0) rectangle (2,2);
\draw[shift={ ( 0,-3) }] (0,0) rectangle (2,2);
\draw[shift={ (-3, 0) }] (0,0) rectangle (2,2);
\draw[shift={ ( 3, 3) }] (0,0) rectangle (2,2);
\draw[shift={ (-3, 3) }] (0,0) rectangle (2,2);
\draw[shift={ ( 3,-3) }] (0,0) rectangle (2,2);
\draw[shift={ (-3,-3) }] (0,0) rectangle (2,2);
\end{tikzpicture}

```

```

\begin{tikzpicture}
\draw (0,0) rectangle (2,2);
\draw[xshift= 100pt] (0,0) rectangle (2,2);
\draw[xshift=-100pt] (0,0) rectangle (2,2);
\draw[yshift= 100pt] (0,0) rectangle (2,2);
\draw[yshift=-100pt] (0,0) rectangle (2,2);
\end{tikzpicture}

```

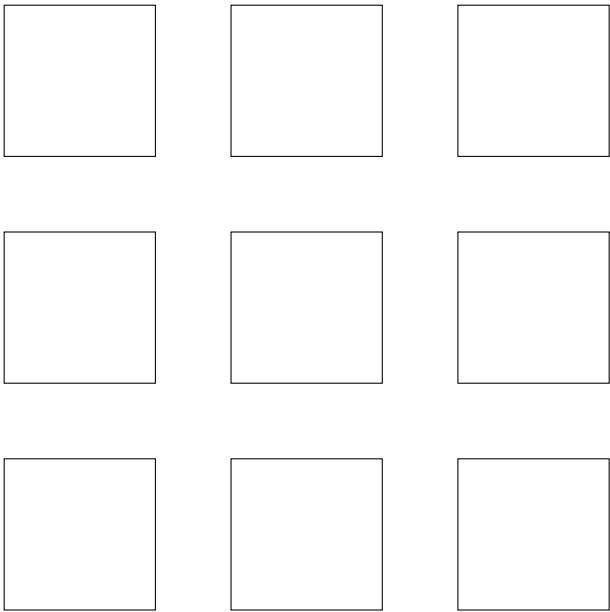


Figure 14.19: transform: shift

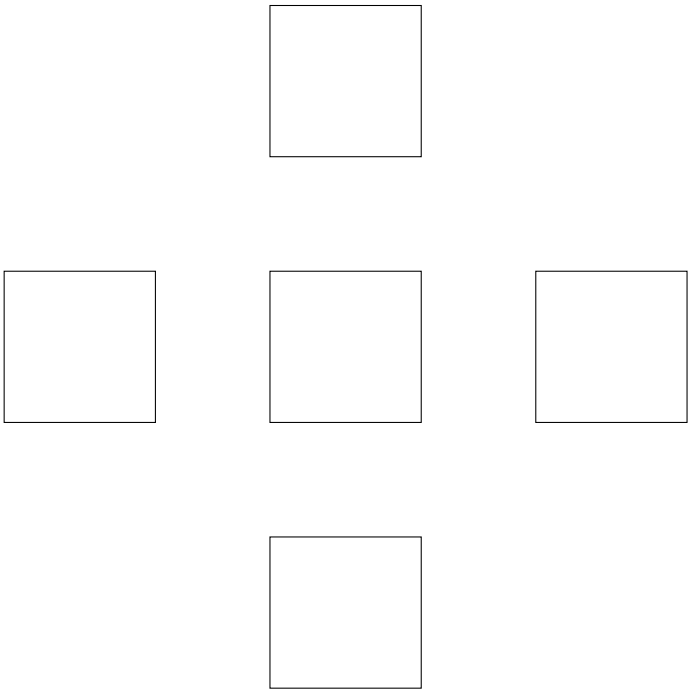


Figure 14.20: transform: shift x, y

```

\begin{tikzpicture}
  \draw (0,0) rectangle (2,2);
  \draw[xshift= 100pt, xscale=1.5] (0,0) rectangle (2,2);
  \draw[yshift= 100pt, xscale=0.5] (0,0) rectangle (2,2);
  \draw[xshift=-100pt, yscale=1.5] (0,0) rectangle (2,2);
  \draw[yshift=-100pt, yscale=0.5] (0,0) rectangle (2,2);
\end{tikzpicture}

```

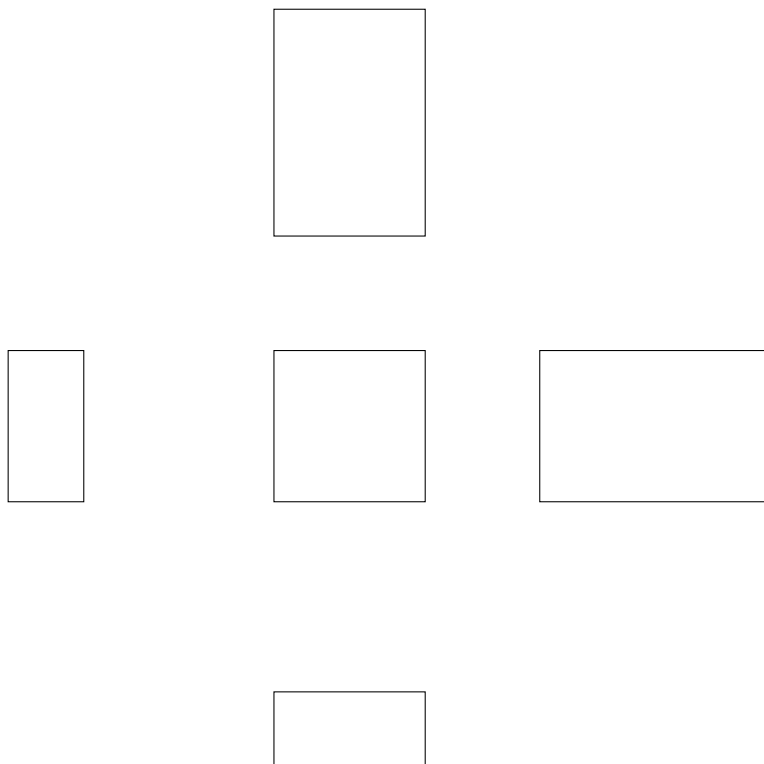


Figure 14.21: transform: scale x, y

```

\begin{tikzpicture}
  \draw (0,0) rectangle (2,2);
  \draw[xshift= 100pt, xscale=1.5] (0,0) rectangle (2,2);
  \draw[yshift= 100pt, yscale=1.5] (0,0) rectangle (2,2);
  \draw[xshift=-100pt, xscale=0.5] (0,0) rectangle (2,2);
  \draw[yshift=-100pt, yscale=0.5] (0,0) rectangle (2,2);
\end{tikzpicture}

```

```

\begin{tikzpicture}
  \draw (0,0) rectangle (2,2);
  \draw[xshift=125pt,rotate=45] (0,0) rectangle (2,2);
  \draw[xshift=175pt,rotate around={45:(2 ,2)}] (0,0) rectangle (2,2);
\end{tikzpicture}

```

```

\begin{tikzpicture}
  \draw (0,0) rectangle (2,2);

```

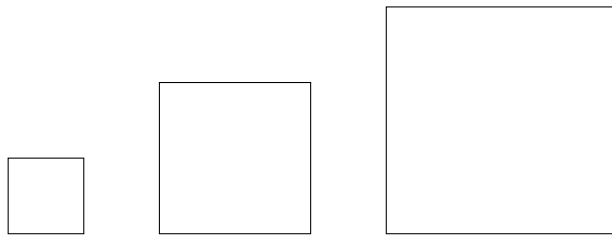


Figure 14.22: transform: scale

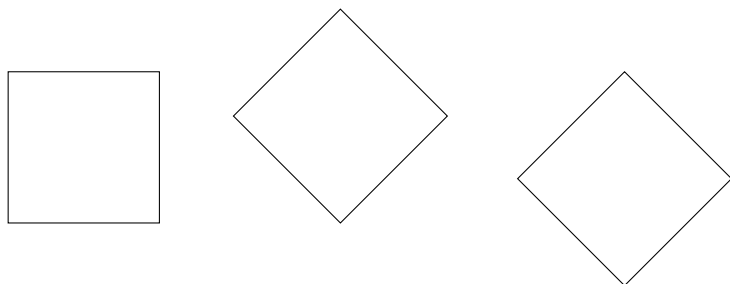


Figure 14.23: transform: rotate

```
\draw[xshift=70pt,xslant=1] (0,0) rectangle (2,2);
\draw[yshift=70pt,yslant=1] (0,0) rectangle (2,2);
\end{tikzpicture}
```

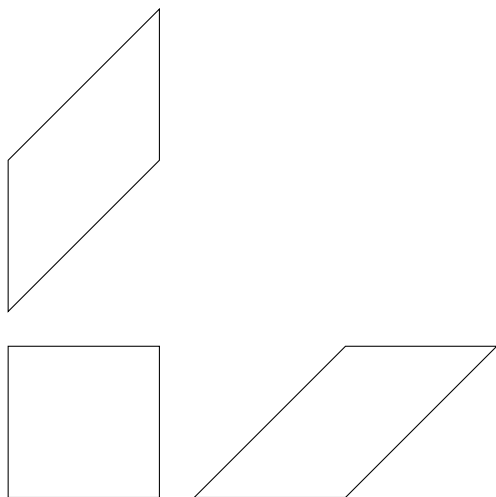


Figure 14.24: transform: slant

```
\tikzset{
  box/.style={
    draw=blue,
    rectangle,
    rounded corners=5pt,
    minimum width=50pt,
```

```

    minimum height=20pt,
    inner sep=5pt
}
}
\begin{tikzpicture}
  \node[box] (1) at(0,0) {1};
  \node[box] (2) at(4,0) {2};
  \node[box] (3) at(8,0) {3};
  \draw[->] (1)--(2);
  \draw[->] (2)--(3);
  \node at(2,1) {a};
  \node at(6,1) {b};
\end{tikzpicture}

```

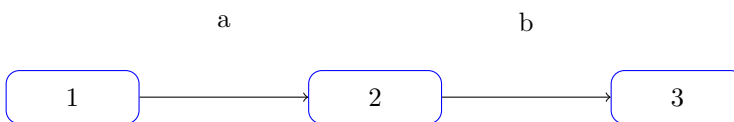


Figure 14.25: flowchart

```

\tikzset{
  box/.style={
    draw=blue,
    fill=blue!20,
    rectangle,
    rounded corners=5pt,
    minimum height=20pt,
    inner sep=5pt
  }
}
\begin{tikzpicture}
  \node[box] {1}
    child {node[box] {2}}
    child {node[box] {3}
      child {node[box] {4}}
      child {node[box] {5}}
      child {node[box] {6}}
    };
\end{tikzpicture}

```

```

\begin{tikzpicture}
  \draw[->] (-0.2,0)--(6,0) node[right] {$x$};
  \draw[->] (0,-0.2)--(0,6) node[above] {$f(x)$};
  \draw[domain=0:4] plot (\x ,{0.1* exp(\x)}) node[right] {$f(x)=\frac{1}{10}e^x$};
\end{tikzpicture}

```

<https://stackoverflow.com/questions/64897575/tikz-libraries-in-bookdown>

It turns out that you can simply put the `\usetikzlibrary{...}` command directly before the `\begin{tikzpicture}` and everything works fine :)

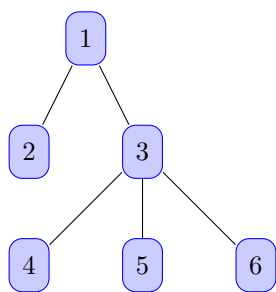


Figure 14.26: tree

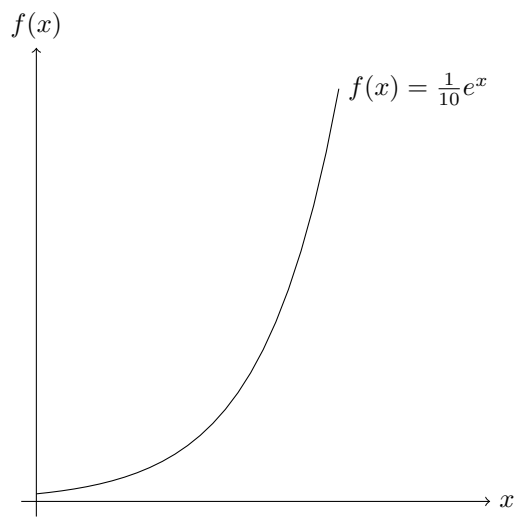


Figure 14.27: tree

<https://stackoverflow.com/questions/56211210/r-markdown-document-with-html-docx-output-using-latex-package-bbm>

<https://tex.stackexchange.com/questions/171711/how-to-include-latex-package-in-r-markdown>

14.1 3D

https://zhuanlan.zhihu.com/p/431732330?utm_psn=1741857547550638080

```
\begin{tikzpicture}
  \coordinate (A) at ( 1, 1, 1);
  \coordinate (B) at ( 1, 1,-1);
  \coordinate (C) at ( 1,-1,-1);
  \coordinate (D) at ( 1,-1, 1);
  \coordinate (E) at (-1,-1, 1);
  \coordinate (F) at (-1,-1,-1);
  \coordinate (G) at (-1, 1,-1);
  \coordinate (H) at (-1, 1, 1);
  \draw (A) node[right=1pt] {$A$}--
        (B) node[right=1pt] {$B$}--
        (C) node[right=1pt] {$C$}--
        (D) node[right=1pt] {$D$}--
        (E) node[left= 1pt] {$E$}--
        (F) node[right=1pt] {$F$}--
        (G) node[right=1pt] {$G$}--
        (H) node[left= 1pt] {$H$}--
        (A) node[right=1pt] {$A$};
\end{tikzpicture}
```

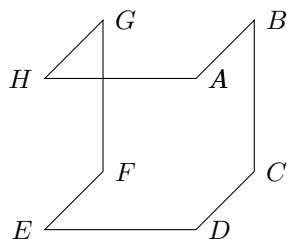


Figure 14.28: cube

<https://tex.stackexchange.com/questions/388621/optimizing-perspective-tikz-graphic>

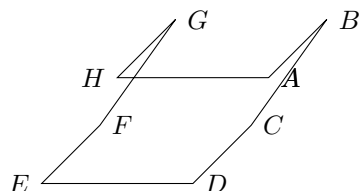


Figure 14.29: cube rotate

<https://github.com/XiangyunHuang/bookdown-broken/blob/master/index.Rmd>

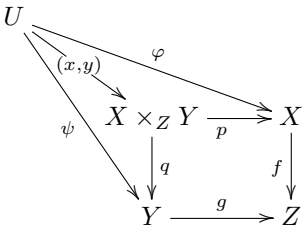
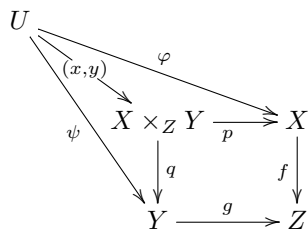
xy-pic

<https://bookdown.org/yihui/rmarkdown-cookbook/install-latex-pkgs.html>

```
tinytex::install_tinytex()
```

the following xymatrix from LaTeX package xy for xy-pic is not shown or rendered in HTML:

`\LaTeX` can only be used in HTML, not PDF



Chapter 15

RMarkdown

15.1 Markdown

15.2 Bookdown

references

1. Xie, Y. *Bookdown: Authoring Books and Technical Documents with r Markdown*. (2023).
2. Xie, Y. *Dynamic Documents with R and Knitr*. (Chapman; Hall/CRC, Boca Raton, Florida, 2015).
3. [Bookdown books on the web: Downloading and converting to pdf - R Markdown](#). *Posit Community* (2019).
4. ccjou. [二次型與正定矩陣](#). (2009).