Chapter 1

Math

1.1 Text over and under symbols

1.1.1 Place text using overset & underset

```
1  \usepackage{amsmath} % align
2
3  \begin{align}
4    a \overset{why?}{=} b \\
5    a \underset{why?}{=} b
6  \end{align}
```

$$a \overset{why?}{=} b \tag{1.1}$$
$$a \underset{why?}{=} b \tag{1.2}$$

1.1.2 Remove extra spaces with mathclap

```
1  \usepackage{amsmath} % align
2  \usepackage{mathtools} % mathclap
3
4  \begin{align}
5    a \overset{
6      \mathclap{why?}
7    }{=} b \\
8    a \underset{
9      \mathclap{why?}
10   }{=} b
11 \end{align}
```

$$a \overset{why?}{=} b \tag{1.3}$$
$$a \underset{why?}{=} b \tag{1.4}$$

1.1.3 Multiple lines with substack

```
1  \usepackage{amsmath} % align, substack
2  \usepackage{mathtools} % mathclap
3
4  \begin{align}
5    a \overset{
```

```
 6        \mathclap{
 7          \substack{
 8    why?     \\
 9          how?
10        }
11      }
12    }{=} b \\
13    a \underset{
14      \mathclap{
15        \substack{
16    why?     \\
17          how?
18        }
19      }
20    }{=} b
21  \end{align}
```

$$a \overset{\substack{why? \\ how?}}{=} b \tag{1.5}$$

$$a \underset{\substack{why? \\ how?}}{=} b \tag{1.6}$$

1.1.4 Place arrows

```
 1  \usepackage{amsmath} % align, substack
 2  \usepackage{mathtools} % mathclap
 3
 4  \begin{align}
 5    a \overset{
 6      \mathclap{
 7        \substack{
 8    why?       \\
 9    how?       \\
10          \downarrow
11        }
12      }
13    }{=} b    \\
14    a \underset{
15      \mathclap{
16        \substack{
17    \uparrow \\
18    why?       \\
19          how?
20        }
21      }
22    }{=} b
23  \end{align}
```

$$a \overset{\substack{why? \\ how? \\ \downarrow}}{=} b \tag{1.7}$$

$$a \underset{\substack{\uparrow \\ why? \\ how?}}{=} b \tag{1.8}$$

1.1.5 Use long arrows with \big

```
 1  \usepackage{amsmath} % align, substack
 2  \usepackage{mathtools} % mathclap
```

```
3
4  \begin{align}
5    a \overset{
6      \mathclap{
7        \substack{
8  why?        \\
9  how?        \\
10         \big \downarrow
11      }
12    }
13  }{=} b      \\
14    a \underset{
15      \mathclap{
16        \substack{
17  \big \uparrow \\
18  why?        \\
19         how?
20      }
21    }
22  }{=} b
23  \end{align}
```

$$a \overset{\substack{why?\\how?\\\downarrow}}{=} b \tag{1.9}$$

$$a \underset{\substack{\uparrow\\why?\\how?}}{=} b \tag{1.10}$$

1.2   Curly braces over and under equations

```
1  \begin{align}
2    x
3    = \overbrace{a \cdot b \cdot c}^{explanation}
4    + \underbrace{d \cdot e \cdot f}_{explanation}
5  \end{align}
```

$$x = \overbrace{a \cdot b \cdot c}^{explanation} + \underbrace{d \cdot e \cdot f}_{explanation} \tag{1.11}$$

1.2.1   Inside square root or \left & \right parentheses etc.

```
1  \begin{align}
2    x
3      & = \sqrt{
4      \underbrace{a \cdot b \cdot c}_{explanation}
5    }           \\
6    y & = \left[
7      \underbrace{d \cdot e \cdot f}_{explanation}
8      \right]
9  \end{align}
```

$$x = \sqrt{\underbrace{a \cdot b \cdot c}_{explanation}} \tag{1.12}$$

$$y = \left[\underbrace{d \cdot e \cdot f}_{explanation} \right] \tag{1.13}$$

1.2.2 Use smash to write explanation outside

```latex
\begin{align}
  x
    & = \sqrt{
    \smash[b]{
      \underbrace{a \cdot b \cdot c}_{explanation}
    }
  }              \\
  y & = \left[
    \smash[b]{
      \underbrace{d \cdot e \cdot f}_{explanation}
    }
    \right]
\end{align}
```

$$x = \sqrt{\underbrace{a \cdot b \cdot c}_{explanation}} \tag{1.14}$$
$$y = [\ \underbrace{d \cdot e \cdot f}_{explanation}\ ] \tag{1.15}$$

1.2.3 Add vertical space

```latex
\begin{align}
  x
    & = \sqrt{
    \smash[b]{
      \underbrace{a \cdot b \cdot c}_{explanation}
    }
  }              \\[\baselineskip]
  y & = \left[
    \smash[b]{
      \underbrace{d \cdot e \cdot f}_{explanation}
    }
    \right]
\end{align}
```

$$x = \sqrt{\underbrace{a \cdot b \cdot c}_{explanation}} \tag{1.16}$$
$$y = [\ \underbrace{d \cdot e \cdot f}_{explanation}\ ] \tag{1.17}$$

1.3 Vector notations

- arrow: $\vec{x}$

- bold: $\mathbf{x}$

- bm package: $\boldsymbol{x}$

1.4 Derivative notations

```latex
\usepackage{derivative}
```

1.4.1 Ordinary derivative

```
\begin{align}
  & \frac{df}{dx} \\
  & \odv{f}{x} \\
  & \odv*{f}{x}
\end{align}
```

$$\frac{df}{dx} \tag{1.18}$$

$$\frac{\mathrm{d}f}{\mathrm{d}x} \tag{1.19}$$

$$\frac{\mathrm{d}}{\mathrm{d}x}f \tag{1.20}$$

1.4.2 Partial derivative

```
\begin{align}
  & \frac{\partial f}{\partial x} \\
  & \pdv{f}{x} \\
  & \pdv*{f}{x} \\
  & \pdv{f}!{x} \\
  & \pdv{f}{x,y}
  & \pdv[order={2,3}]{f}{x,y,z} \\
\end{align}
```

$$\frac{\partial f}{\partial x} \tag{1.21}$$

$$\frac{\partial f}{\partial x} \tag{1.22}$$

$$\frac{\partial}{\partial x}f \tag{1.23}$$

$$\partial_x f \tag{1.24}$$

$$\frac{\partial^2 f}{\partial x\,\partial y} \tag{1.25}$$

$$\frac{\partial^6 f}{\partial x^2\,\partial y^3\,\partial z} \tag{1.26}$$

1.4.3 Material derivative

```
\begin{align}
  & \frac{Df}{Dx} \\
  & \mdv{f}{x} \\
  & \mdv*{f}{x}
\end{align}
```

$$\frac{Df}{Dx} \tag{1.27}$$

$$\frac{\mathrm{D}f}{\mathrm{D}x} \tag{1.28}$$

$$\frac{\mathrm{D}}{\mathrm{D}x}f \tag{1.29}$$

1.4.4 Functional derivative

```
\begin{align}
  & \frac{\delta f}{\delta x} \\
  & \fdv{f}{x} \\
  & \fdv*{f}{x}
\end{align}
```

$$\frac{\delta f}{\delta x} \tag{1.30}$$

$$\frac{\delta f}{\delta x} \tag{1.31}$$

$$\frac{\delta}{\delta x}f \tag{1.32}$$

1.4.5 Average rate of change

```
\begin{align}
  & \frac{\Delta f}{\Delta x} \\
  & \adv{f}{x}
\end{align}
```

$$\frac{\Delta f}{\Delta x} \tag{1.33}$$

$$\frac{\Delta f}{\Delta x} \tag{1.34}$$

1.4.6 Jacobian

```
\begin{align}
  & \frac{
    \partial (f, g, h)
  }{
    \partial (x, y, z)
  } \\
  & \jdv{f, g, h}{x, y, z}
\end{align}
```

$$\frac{\partial(f,g,h)}{\partial(x,y,z)} \tag{1.35}$$

$$\frac{\partial\,(f,g,h)}{\partial\,(x,y,z)} \tag{1.36}$$

1.5 Cancel

`\usepackage{cancel}`

```
1  \begin{align}
2    a
3    = \cancel{b}
4    + \bcancel{c}
5    + \xcancel{d}
6    + \cancelto{x}{e}
7  \end{align}
```

$$a = \cancel{b} + \bcancel{c} + \xcancel{d} + \cancelto{x}{e} \tag{1.37}$$

1.6 Multiline equations

`\usepackage{amsmath}`

```
1  \multirow{<nrows>}{<text>}
```

```
1  \begin{align}
2    \begin{split}
3      x
4      & = a \cdot b \cdot c \\
5      & + d \cdot e \cdot f
6    \end{split}
7  \end{align}
```

$$\begin{split} x & = a \cdot b \cdot c \\ & + d \cdot e \cdot f \end{split} \tag{1.38}$$