Chapter 1

Math

1.1 Text over and under symbols

1.1.1 Place text using overset & underset

```
\usepackage{amsmath} % align

\begin{align}
  a \overset{why?}{=} b \\
  a \underset{why?}{=} b
\end{align}
```

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

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

1.1.2 Remove extra spaces with mathclap

```
\usepackage{amsmath} % align
\usepackage{mathtools} % mathclap

\begin{align}
  a \overset{
    \mathclap{why?}
  }{=} b \\
  a \underset{
```

```
    \mathclap{why?}
  }{=} b
\end{align}
```

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

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

1.1.3 Multiple lines with substack

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

\begin{align}
  a \overset{
    \mathclap{
      \substack{
  why?   \\
        how?
      }
    }
  }{=} b \\
  a \underset{
    \mathclap{
      \substack{
  why?   \\
        how?
      }
    }
  }{=} b
\end{align}
```

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

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

1.1.4 Place arrows

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

```
\begin{align}
  a \overset{
    \mathclap{
      \substack{
  why?     \\
  how?     \\
        \downarrow
      }
    }
  }{=} b   \\
  a \underset{
    \mathclap{
      \substack{
  \uparrow \\
  why?     \\
        how?
      }
    }
  }{=} b
\end{align}
```

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

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

1.1.5 Use long arrows with \big

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

\begin{align}
  a \overset{
    \mathclap{
      \substack{
  why?     \\
  how?     \\
        \big \downarrow
      }
    }
  }{=} b   \\
```

```
  a \underset{
    \mathclap{
      \substack{
  \big \uparrow \\
  why?     \\
        how?
      }
    }
  }{=} b
\end{align}
```

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

$$a = b \tag{1.10}$$

$$\underset{\substack{why?\\how?}}{\overset{\big\uparrow}{a = b}}$$

1.2 Curly braces over and under equations

```
\begin{align}
  x
  = \overbrace{a \cdot b \cdot c}^{explanation}
  + \underbrace{d \cdot e \cdot f}_{explanation}
\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.

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

```
    \right]
\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

```
\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}
```

$$x = \sqrt{\underbrace{a \cdot b \cdot c}_{explanation}} \tag{1.14}$$

$$y = \left[\underbrace{d \cdot e \cdot f}_{explanation} \right] \tag{1.15}$$

1.2.3 Add vertical space

```
\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}
```

$$x = \sqrt{\underbrace{a \cdot b \cdot c}_{explanation}} \tag{1.16}$$

$$y = \left[\underbrace{d \cdot e \cdot f}_{explanation} \right] \tag{1.17}$$

1.3 Vector notations

- arrow: $\vec{x}$
- bold: $\mathbf{x}$
- bm package: $\boldsymbol{x}$

1.4 Derivative notations

```
\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}
```

```
\begin{align}
  a
  = \cancel{b}
  + \bcancel{c}
  + \xcancel{d}
  + \cancelto{x}{e}
\end{align}
```

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

1.6 Multiline equations

```
\usepackage{amsmath}
```

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

```
\begin{align}
  \begin{split}
    x
    & = a \cdot b \cdot c \\
    & + d \cdot e \cdot f
  \end{split}
\end{align}
```

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