

# Latex math notations and Example R codes with PDF output

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## Section 1: Building blocks

Goal	How to get it	Notes
$\alpha, \beta, \omega, \Omega$	<code>\alpha, \beta, \omega, \Omega</code>	Spell names of Greek letters.
$\bar{X}, \hat{\beta}, \tilde{\beta}$	<code>\bar{X}, \hat{\beta}, \tilde{\beta}</code>	Can't do stats without $\bar{X}$ . Can't do econometrics without $\hat{\beta}$ !
$\mathbf{X}, \boldsymbol{\beta}$	<code>\mathbf{X}, \boldsymbol{\beta}</code>	Bold math symbols. To make Latin-letters bold, you can use <code>\boldsymbolfrom "bm" package: \usepackage{bm}</code>
$\sigma^2$	<code>\sigma^2</code>	Superscripts.
$\sim$	<code>\sim</code>	For example, $X \sim N(0, 1)$
$\succ, \succsim$	<code>\succ, \succsim</code>	Preference relations in micro
$\xrightarrow{p}, \xrightarrow{d}$	<code>\xrightarrow{p}, \xrightarrow{d}</code>	Convergence in probability, and convergence in distribution
$\geq, \leq, >, <$	<code>\geq, \leq, &gt;, &lt;</code>	Inequality
$X_i, \sigma_{ij}$	<code>X_i, \sigma_{ij}</code>	Subscripts. When a sub(super)script has more than one symbol, like the $ij$ , braces around it are needed to say where the sub(super)script ends.
$\sum_{i=1}^n X_i$	<code>\sum_{i=1}^n X_i</code>	Summation.
$\prod_{i=1}^n X_i$	<code>\prod_{i=1}^n X_i</code>	Products.
$\int_{x=-\infty}^{\infty} x dx$	<code>\int_{x=-\infty}^{\infty} x\,dx</code>	Integrals.
$\frac{1}{1-\beta}$	<code>\frac{1}{1-\beta}</code>	Fractions. Braces enclose numerator and denominator.
$\frac{\partial f(x,y)}{\partial x}$	<code>\frac{\partial f(x,y)}{\partial x}</code>	Partial derivative.
$\log(x), \exp(x)$	<code>\log(x), \exp(x)</code>	Named functions. Looks better if you don't omit the <code>\</code> .
$\sqrt{V+1}$	<code>\sqrt{V+1}</code>	Square root.
$\begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{pmatrix}$	<code>\begin{pmatrix} 1 &amp; 2 &amp; 3 \\ 4 &amp; 5 &amp; 6 \end{pmatrix}</code>	Matrices.
$\begin{bmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \end{bmatrix}$	<code>\begin{bmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \end{bmatrix}</code>	Matrices.

## Section 2: Example math equations

### Example 1: Aligning equations with expression after equal sign

Syntax:

```
\begin{align*}
\hat{\beta}
&= \mathbf{(X^{\prime}X)^{-1} (X^{\prime}Y)} \\
&= \mathbf{(X^{\prime}X)^{-1} (X^{\prime} (X \beta + \mathbf{e}))} \\
&= \mathbf{(X^{\prime}X)^{-1} X^{\prime}X \beta + (X^{\prime}X)^{-1} X^{\prime} e} \\
&= \beta + \mathbf{(X^{\prime}X)^{-1} X^{\prime} e}
\end{align*}
```

becomes:

$$\begin{aligned}\hat{\beta} &= (\mathbf{X}'\mathbf{X})^{-1}(\mathbf{X}'\mathbf{Y}) \\ &= (\mathbf{X}'\mathbf{X})^{-1}(\mathbf{X}'(\mathbf{X}\beta + \mathbf{e})) \\ &= (\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'\mathbf{X}\beta + (\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'\mathbf{e} \\ &= \beta + (\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'\mathbf{e}\end{aligned}$$

### Example 2: Writing equations within a curly brace

Syntax:

```
\begin{equation*}
F(x) =
\begin{cases}
0 & \text{if } x < 0 \\
x & \text{if } 0 \leq x \leq 1 \\
1 & \text{if } x > 1
\end{cases}
\end{equation*}
```

becomes:

$$F(x) = \begin{cases} 0 & x < 0 \\ x & 0 \leq x \leq 1 \\ 1 & x > 1 \end{cases}$$

### Example 3: Including comments within equations

Syntax:

```
\begin{align*}
Z_n =
\begin{cases}
-n & \text{with probability } 1/n \\
0 & \text{with probability } 1-2/n \\
n & \text{with probability } 1/n
\end{cases}
\end{align*}
```

becomes:

$$Z_n = \begin{cases} -n & \text{with probability } 1/n \\ 0 & \text{with probability } 1 - 2/n \\ n & \text{with probability } 1/n \end{cases}$$

Syntax:

```
\begin{align*}
\overline{X}_n =
\frac{1}{n} \sum_{i=1}^n X_i \xrightarrow{p} E[X]
\quad \text{as } n \rightarrow \infty
\end{align*}
```

becomes:

$$\overline{X}_n = \frac{1}{n} \sum_{i=1}^n X_i \xrightarrow{p} E[X] \quad \text{as } n \rightarrow \infty$$

### Example 4: Maximization problem

Syntax:

```
\begin{equation*}
\begin{aligned}
\max_{x_1, x_2} \quad & u(x_1, x_2) = \frac{1}{2} \log x_1 + \frac{1}{2} \log x_2 \\
\text{s.t.} \quad & w = p_1 x_1 + p_2 x_2
\end{aligned}
\end{equation*}
```

becomes:

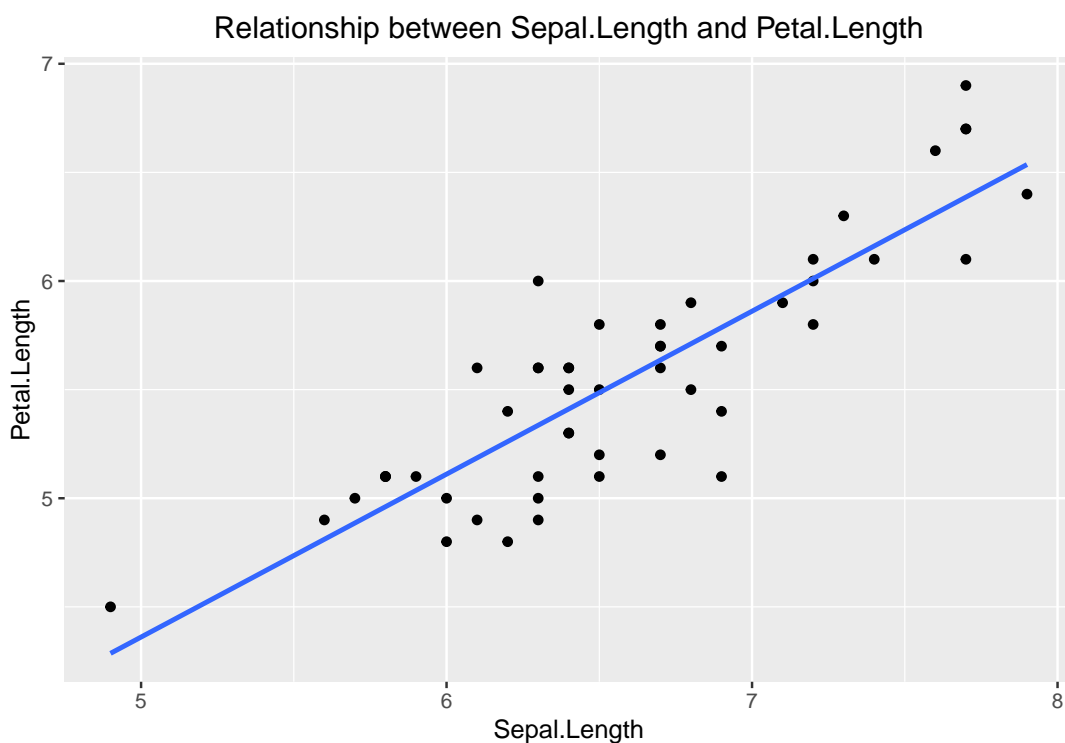
$$\begin{aligned} \max_{x_1, x_2} \quad & u(x_1, x_2) = \frac{1}{2} \log x_1 + \frac{1}{2} \log x_2 \\ \text{s.t.} \quad & w = p_1 x_1 + p_2 x_2 \end{aligned}$$

## Section 3: Write R codes

```
# === Load Packages === #
library(data.table)
library(ggplot2)

# === Data === #
#built-in dataset in R
data(iris)
# Convert the data into data.table
setDT(iris)
# Filter for the species "setosa"
virginica <- iris[Species == "virginica",]

# === Visualization === #
ggplot(virginica, aes(x=Sepal.Length, y=Petal.Length))+
  geom_point()+
  geom_smooth(method = lm, se = FALSE)+
  labs(title = "Relationship between Sepal.Length and Petal.Length")+
  theme(plot.title = element_text(hjust = 0.5))
```



## Section 4: Insert a picture to a document

Below is an example R chunk code to insert a picture.

```
`{r, fig.cap='A caption', out.width = '80%'}
knitr::include_graphics("path to the file")
`
```