Differential equation:

Latex code:

$$

\frac{dQ}{dt} = \frac{ds}{dt}

$$

Output:

$$\frac{dQ}{dt} = \frac{ds}{dt}$$

Partial differential equation:

Latex code:

```
$$
\frac{\partial Q}{\partial t} = \frac{\partial s}{\partial t}
$$
```

Output:

$$\frac{\partial Q}{\partial t} = \frac{\partial s}{\partial t}$$

Exercises:

$$\frac{d^3y}{dx^3} + 2\left(\frac{d^2y}{dx^2}\right)^2 - \frac{dy}{dx} + y = 0$$

$$\left(\frac{d^2y}{dx^2}\right)^2 + \cos\left(\frac{dy}{dx}\right) = 0$$

$$\frac{dy}{dx} = (1 + x^2)(1 + y^2)$$

$$x^5 \frac{dy}{dx} = -y^5$$

$$\frac{d}{dx}\left(\frac{u}{v}\right) = \frac{v\frac{du}{dx} - u\frac{dv}{dx}}{v^2}$$

$$\frac{\partial^2 z}{\partial x \partial y} = \frac{\partial^2 z}{\partial y \partial x}$$

$$\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = \frac{\partial^2 u}{\partial r^2} + \frac{1}{r}\frac{\partial u}{\partial r} + \frac{1}{r^2}\frac{\partial^2 u}{\partial \theta^2}$$

Limits:

```
\begin{document}
Testing notation for limits
\[
\lim_{h \rightarrow 0 } \frac{f(x+h)-f(x)}{h}
\]
\end{document}
```

Output:

Testing notation for limits

$$\lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h}$$

Exercises:

$$\lim_{x\to 0}\frac{\sqrt{2+x}-\sqrt{2}}{x}$$

$$\lim_{y\to 2}\frac{y^{\frac{1}{2}}-2^{\frac{1}{2}}}{y-2}$$

$$\lim_{x\to \frac{\pi}{2}}(\sec x-\tan x)$$

$$\lim_{y\to 0}\frac{2\sin^2\frac{y}{2}}{2\sin\frac{y}{2}\cos\frac{y}{2}}$$

$$\lim_{h\to 0}\frac{2\cos\left(\frac{2x+h}{2}\right)\sin\frac{h}{2}}{2\cdot\frac{h}{2}}$$

Integration:

Syntax:
\int_{lower}^{upper}

Latex code:

```
$$\int_{a}^{b} x^2 dx$$
```

Output:

$$\int_a^b x^2 dx$$

Exercises:

$$\int_a^b f(x)\,dx = \int_a^b f(a+b-x)\,dx$$

$$\int_0^{2a} f(x)\,dx = \int_0^a f(x)\,dx + \int_0^a f(2a-x)\,dx$$

$$\int 2a(x)^{\frac{-1}{2}}\,dx - \int bx^{-2}\,dx + \int 3c\,x^{\frac{2}{3}}\,dx$$

$$\int \left(\frac{2a}{\sqrt{x}} - \frac{b}{x^2} + 3c\sqrt[3]{x^2} \right) dx$$

$$\int_0^{\frac{\pi}{2}} \frac{\tan^7 x}{\cot^7 x + \tan^7 x}\,dx$$

$$\int_0^{\frac{\pi}{2}} \frac{\tan^7\left(\frac{\pi}{2} - x\right)}{\cot^7\left(\frac{\pi}{2} - x\right) + \tan^7\left(\frac{\pi}{2} - x\right)}\,dx$$

Sum:

Syntax: \sum_{lower}^{upper}

```
\sum_{i=1}^{10} t_i
```

$$\sum_{i=1}^{10} t_i$$

or

```
\displaystyle\sum_{i=1}^{10} t_i
```

$$\displaystyle\sum_{i=1}^{10} t_i$$

Exercises:

$$\sum n = 1 + 2 + 3 + \ldots + n = \frac{n\,(n+1)}{2}$$

$$\sum_{k=1}^{n} f\,(a+k) = 16(2^n - 1)$$

$$n^3 = 3\sum_{k=1}^{n} k^2 - 3\sum_{k=1}^{n} k + n$$

Brackets and Parentheses

The size of the brackets can be manually set, or they can be resized dynamically in your document, as shown in the next example:

```
\[
\left [
```

```
  \begin{matrix}
  1 & 5 & 8 \\
  0 & 2 & 4 \\
  3 & 3 & -8
  \end{matrix}
\right ]
\]
```

Output:

$$\left[\begin{matrix}
1 & 5 & 8 \\
0 & 2 & 4 \\
3 & 3 & -8
\end{matrix}\right]$$

Notice that to insert the brackets, the \left and \right commands are used. Even if you are using only one bracket *both* commands are mandatory.

Manually sized brackets use commands \Bigg and \big

Complete list of parentheses and sizes see here

LATEX commands	**Renders as**
`\big( \Big( \bigg( \Bigg(`	$\big(\Big(\bigg(\Bigg($
`\big] \Big] \bigg] \Bigg]`	$\big] \Big] \bigg] \Bigg]$
`\big\{ \Big\{ \bigg\{ \Bigg\{`	$\big\{ \Big\{ \bigg\{ \Bigg\{$
`\big \langle \Big \langle \bigg \langle \Bigg \langle`	$\big \langle \Big \langle \bigg \langle \Bigg \langle$

```
\big \rangle \Big \rangle \bigg \rangle \Bigg \rangle
```

$\big \rangle \Big \rangle \bigg \rangle \Bigg \rangle$

Matrices:

A basic matrix may be created using the matrix environment: in common with other table-like structures, entries are specified by row, with columns separated using an ampersand (&) and a new rows separated with a double backslash (\\)

Latex code:

```
$
\begin{matrix}
a & b & c \\
d & e & f \\
g & h & i
\end{matrix}
$
```

Output:

$$\begin{matrix} a & b & c \\ d & e & f \\ g & h & i \end{matrix}$$

Exercises:

$$\mathrm{A} = \begin{matrix} x & 4 & 3 \\ 4 & 3 & x \\ 3 & x & 4 \end{matrix}$$

$$\mathrm{A} = \begin{bmatrix} e^{2x}\sin x & e^{2x}\sin 2x \\ e^{4x}\sin x & e^{4x}\sin 2x \end{bmatrix}$$

$$\begin{bmatrix} 2x & 3 \end{bmatrix} \begin{bmatrix} 1 & 2 \\ -3 & 0 \end{bmatrix} \begin{bmatrix} x \\ 8 \end{bmatrix}$$

$$\begin{bmatrix} 2 & \frac{11}{2} & \frac{-5}{2} \\ \frac{11}{2} & 3 & \frac{3}{2} \\ \frac{-5}{2} & \frac{3}{2} & 4 \end{bmatrix}$$

Controlling horizontal spacing

Latex code:

```
\[ f(n) =
  \begin{cases}
    n/2       & \quad \text{if } n \text{ is even}\\
    -(n+1)/2  & \quad \text{if } n \text{ is odd}\\
  \end{cases}
\]
```

$$f(n) = \begin{cases} n/2 & \text{if } n \text{ is even} \\ -(n+1)/2 & \text{if } n \text{ is odd} \end{cases}$$

(Note that this particular example can be expressed in more elegant code by the cases construct provided by the **amsmath** package.)

LaTeX has defined two commands that can be used anywhere in documents (not just maths) to insert some horizontal space. They are \quad and \qquad.

Exercises:

$$f(x)=\begin{cases}\dfrac{1-\cos 4x}{8x^2}, & x\neq 0\\ k, & x=0\end{cases}.$$

$$f(x)=\begin{cases}x\sin\dfrac{1}{x}, & x\neq 0\\ 0, & x=0\end{cases}$$

$$f(x)=\begin{cases}x^2, \text{ if } x\geq 0\\ -x^2, \text{if } x<0\end{cases}$$

Spaces

The spacing depends on the command you insert, the example below contains a complete list of spaces and how they look like.

Description of spacing commands

LATEX code	Description
`\quad`	space equal to the current font size (= 18 mu)
`\,`	3/18 of `\quad` (= 3 mu)
`\:`	4/18 of `\quad` (= 4 mu)
`\;`	5/18 of `\quad` (= 5 mu)
`\!`	-3/18 of `\quad` (= -3 mu)
`\` (space after backslash!)	equivalent of space in normal text

`\qquad`	twice of `\quad` (= 36 mu)

Note: to see a description of the align environment see [Aligning equations with amsmath]*

```
Spaces in mathematical mode.
\begin{align*}
f(x) =& x^2\! +3x\! +2 \\
f(x) =& x^2+3x+2 \\
f(x) =& x^2\, +3x\, +2 \\
f(x) =& x^2\: +3x\: +2 \\
f(x) =& x^2\; +3x\; +2 \\
f(x) =& x^2\ +3x\ +2 \\
f(x) =& x^2\quad +3x\quad +2 \\
f(x) =& x^2\qquad +3x\qquad +2
\end{align*}
```

Spaces in mathematical mode.

$$
\begin{aligned}
f(x) =& x^2+3x+2 \\
f(x) =& x^2 + 3x + 2 \\
f(x) =& x^2 \, + 3x \, + 2 \\
f(x) =& x^2 \, + 3x \, + 2 \\
f(x) =& x^2 \, + 3x \, + 2 \\
f(x) =& x^2 \, + 3x \, + 2 \\
f(x) =& x^2 \quad + 3x \quad + 2 \\
f(x) =& x^2 \qquad + 3x \qquad + 2
\end{aligned}
$$

Aligning equations:

If there are several equations that you need to align vertically, the *align* environment will do it:

```
\begin{align*}
x&=y           &  w &=z               &  a&=b+c\\
2x&=-y         &  3w&=\frac{1}{2}z    &  a&=b\\
-4 + 5x&=2+y   &  w+2&=-1+w          &  ab&=cb
\end{align*}
```

$$\begin{aligned}
x &= y & w &= z & a &= b + c \\
2x &= -y & 3w &= \frac{1}{2}z & a &= b \\
-4 + 5x &= 2 + y & w + 2 &= -1 + w & ab &= cb
\end{aligned}$$

Exercises:

$$\begin{aligned}
f'(x) &= \lim_{h \to 0} \frac{f(x+h) - f(x)}{h} \\
&= \lim_{h \to 0} \frac{(x+h)^3 - x^3}{h} \\
&= \lim_{h \to 0} \frac{x^3 + h^3 + 3xh\,(x+h) - x^3}{h} \\
&= \lim_{h \to 0} (h^2 + 3x\,(x+h)) = 3x^2
\end{aligned}$$

Mathematical fonts

```
\begin{align*}
3x^2 \in R \subset Q \\
\mathnormal{3x^2 \in R \subset Q} \\
\mathrm{3x^2 \in R \subset Q} \\
\mathit{3x^2 \in R \subset Q} \\
\mathbf{3x^2 \in R \subset Q} \\
\mathsf{3x^2 \in R \subset Q} \\
\mathtt{3x^2 \in R \subset Q}
\end{align*}
```

$$3x^2 \in R \subset Q$$

$$3x^2 \in R \subset Q$$

$$3\mathrm{x}^2 \in \mathrm{R} \subset \mathrm{Q}$$

$$\mathit{3x^2 \in R \subset Q}$$

$$\mathbf{3x^2 \in R \subset Q}$$

$$3\mathsf{x}^2 \in \mathsf{R} \subset \mathsf{Q}$$

$$3\mathtt{x}^2 \in \mathtt{R} \subset \mathtt{Q}$$