1 Mathematical styles

Inline mathematics is typeset using matched pairs of dollar signs `$`. An alternate punctuation is `\(` and `\)` which are better suited for editors with syntax highlighting.

```
We now introduce mathematics
by typesetting the Pythagorean
theorem: $c^2 = a^2 + b^2$.
```

We now introduce mathematics by typesetting the Pythagorean theorem: $c^2 = a^2 + b^2$.

In order to typeset longer equations, we will display them:

```
And so, Newton's second law is:
\begin{displaymath}
F = m a
\end{displaymath}
which means the net force is equal
to the product of the object's mass
and its acceleration.
```

And so, Newton's second law is:

$$F = ma$$

which means the net force is equal to the product of the object's mass and its acceleration.

Numbered equations are possible as well.

```
\begin{equation} \label{eq:eps}
\epsilon > 0
\end{equation}
As you can see,
from (\ref{eq:eps})\ldots
```

$$\epsilon > 0 \tag{1}$$

As you can see, from (1)...

Inline mathematics are typeset in `\textmath` while displayed equations are typeset in `\displaymath`.

```
\(\lim_{n \to \infty}
\sum_{x=1}^n \frac{1}{x^2}
= \frac{\pi^2}{6}\)
```

$\lim_{n \to \infty} \sum_{x=1}^n \frac{1}{x^2} = \frac{\pi^2}{6}$

```
\begin{displaymath}
\lim_{n \to \infty}
\sum_{x=1}^n \frac{1}{x^2}
= \frac{\pi^2}{6}
\end{displaymath}
```

$$\lim_{n \to \infty} \sum_{x=1}^n \frac{1}{x^2} = \frac{\pi^2}{6}$$

Whitespace is insignificant. You must force spacing yourself with spacing commands such as `\,`, `\quad`, `\qquad`.

```
\begin{equation}
\forall x \in \mathbf{R}:
\qquad x^2 \geq 0.
\end{equation}
```

$$\forall x \in \mathbf{R}: \qquad x^2 \geq 0. \tag{2}$$

Text must be set specifically in math mode. You can get "blackboard bold" by using the amsfonts or amssymb packages.

```
\begin{equation}
x^2 \geq 0\qquad
\textrm{for all }x \in \mathbb{R}.
\end{equation}
```

$$x^2 \geq 0 \qquad \text{for all } x \in \mathbb{R}. \tag{3}$$

2 Basics

Things can be grouped in math mode by enclosing them in braces { }.

```
\begin{equation}
a^x+y \neq a^{x+y}
\end{equation}
```

$$a^x + y \neq a^{x+y} \tag{4}$$

Greek letters are useful:

```
$\alpha \beta \gamma \delta
 \epsilon \zeta \eta \theta
 \iota \kappa \lambda \mu
 \nu \xi o \pi
 \rho \sigma \tau \upsilon
 \phi \chi \psi \omega$\\
$A B \Gamma \Delta
 E Z H \Theta
 I K \Lambda M
 N \Xi O \Pi
 P \Sigma T Y
 \Phi X \Psi \Omega$
```

$\alpha\beta\gamma\delta\epsilon\zeta\eta\theta\iota\kappa\lambda\mu\nu\xi o\pi\rho\sigma\tau\upsilon\phi\chi\psi\omega$
$AB\Gamma\Delta EZH\Theta IK\Lambda MN\Xi O\Pi P\Sigma TY\Phi X\Psi\Omega$

Fractions are done two ways:

```
\begin{displaymath}
22/7 \qquad
\frac{22}{7}
\end{displaymath}
```

$$22/7 \qquad \frac{22}{7}$$

Multiplication is usually implicit, but you can break up long multiples if you group chunks.

```
\[c = a_0 \cdot a_1 b_0 \cdot b_1\]
```

$$c = a_0 \cdot a_1 b_0 \cdot b_1$$

In order to generate exponents and subscripts, use ^ and _.

```
\[n_0 \qquad
  x^2 \qquad
  e^{i\pi} \qquad
  a^{3}_{ij} \qquad
  e^{x^2} \neq {e^x}^2\]
```

$$n_0 \qquad x^2 \qquad e^{i\pi} \qquad a^{3}_{ij} \qquad e^{x^2} \neq {e^x}^2$$

Roots are done using the `\sqrt` command. The sign can be generated using `\surd`.

```
\[\sqrt{x} \qquad
  \sqrt{ x^2 + \sqrt{y} } \qquad
  \sqrt[3]{2} \qquad
  \surd (x^2 + y^2)\]
```

$$\sqrt{x} \qquad \sqrt{ x^2 + \sqrt{y} } \qquad \sqrt[3]{2} \qquad \surd (x^2 + y^2)$$

Lines can be generated using `\overline` and `underline`.

```
\begin{displaymath}
\underline{0.15p} \qquad
\overline{m+n}
\end{displaymath}
```

$$\underline{0.15p} \qquad \overline{m+n}$$

Braces can be generated as well

```
\begin{displaymath}
\underbrace{a+b+\cdots+z}_{26} +
\overbrace{\alpha+\beta+\dots+\omega}
  ^{24}
\end{displaymath}
```

$$\underbrace{a+b+\cdots+z}_{26} + \overbrace{\alpha+\beta+\dots+\omega}^{24}$$

The names of functions are typeset in an upright font. These are commands to use for typesetting such functions.

`\arccos`	`\cos`	`\csc`	`\exp`	`\ker`	`\limsup`	`\min`
`\arcsin`	`\cosh`	`\deg`	`\gcd`	`\lg`	`\ln`	`\Pr`
`\arctan`	`\cot`	`\det`	`\hom`	`\lim`	`\log`	`\sec`
`\arg`	`\coth`	`\dim`	`\inf`	`\liminf`	`\max`	`\sin`
`\sinh`	`\sup`	`\tan`	`\tanh`			

```
\[\lim_{h \to 0} \frac{\sin h}{h}=1\]
```

$$\lim_{h \to 0} \frac{\sin h}{h}=1$$

3 Specialisations

Vectors can be made using the `\vec` command. For longer vectors, you should use `\overrightarrow` and `\overleftarrow`.

```
\begin{displaymath}
\vec{a} \qquad \overrightarrow{AB}
\end{displaymath}
```

$$\vec{a} \qquad \overrightarrow{AB}$$

For binomial co-efficients, you want to use either `\choose` or `\atop`. Note, if you are using the `amsmath` package, you should use `\binom` and `\genfrac` instead.

```
\[{n \choose r} \qquad {x \atop y+2}\]
```

$${n \choose r} \qquad {x \atop y+2}$$

For calculus, you are sure to want to sum, integrate, and product. The upper and lower limits to these commands are specified using the `^` and `_` prefixes, much like superscripts and subscripts.

```
\begin{displaymath}
\sum_{i=1}^n \qquad
\int_0^{\frac{\pi}{2}} \qquad
\prod_\epsilon
\end{displaymath}
```

$$\sum_{i=1}^n \qquad \int_0^{\frac{\pi}{2}} \qquad \prod_\epsilon$$

For binary relations, the `\stackrel` command allows you to combine operators by putting the first argument above the second.

```
\[\int f_N(x) \stackrel{!}{=} 1\]
```

$$\int f_N(x) \stackrel{!}{=} 1$$

4 Braces

Typically, braces can be entered plain-text. However, braces must be escaped `\{` and `\}`.

```
\[(1, 2) \qquad
  [a_1\ a_2\ a_3] \qquad
  {a,b,c} \neq \{a,b,c\}\]
```

$$(1, 2) \qquad [a_1\ a_2\ a_3] \qquad {a,b,c} \neq \{a,b,c\}$$

In order to automatically grow braces, you need to use the `\left` command in front of an opening delimiter and `\right` command in front of a closing delimiter. Each `\left` *must* be accompanied by a corresponding `\right`. If you don't want any closing delimiter, use `\right.` which is an invisible close.

```
\[1 + \left( \frac{1}{1-x^2} \right)^3\]
```

$$1 + \left(\frac{1}{1-x^2} \right)^3$$

Sometimes you need to nest braces and make some of them larger.

```
\[\Big( (x+1) (x-1) \Big)^2\]
\begin{displaymath}
\Bigg< \bigg< \Big< \big< \langle \qquad
\} \big\} \Big\} \bigg\} \Bigg\} \qquad
\Bigg\| \bigg\| \Big\| \big\| \|
\end{displaymath}
```

$$\Big((x+1) (x-1) \Big)^2$$

$$\Bigg\langle \bigg\langle \Big\langle \big\langle \langle \qquad \} \big\} \Big\} \bigg\} \Bigg\} \qquad \Bigg\| \bigg\| \Big\| \big\| \|$$

5 Spacing

If the spaces within fomulæare not correct, they can be adjusted with the spacing commands. `\,` for thin spaces (␣), `\:` for medium spaces (␣), `\;` for thick spaces (␣), `\ ` for normal spaces (␣), `\quad` for large spaces (␣␣), `\qquad` for very large spaces (␣␣␣). `\!` generates a negative thin space.

```
\newcommand{\ud}{\mathrm{d}}
\[\int\int_{D} g(x,y) dx dy\]
in ugly compared to
\[\int\!\!\!\int_{D} g(x,y)
  \,\ud x \,\ud y\]
```

$$\int\int_{D} g(x,y) dx dy$$

in ugly compared to

$$\int\!\!\!\int_{D} g(x,y) \,\mathrm{d} x \,\mathrm{d} y$$

For integrals, you can also use the amsmath package's integration commands: `\iint`, `\iiint`, `\iiiint`, and `\idotsint`.

```
\newcommand{\ud}{\mathrm{d}}
\[\iint_{D} g(x,y) \,\ud x \,\ud y\]
```

$$\iint_{D} g(x,y) \,\mathrm{d} x \,\mathrm{d} y$$

Phantoms are useful to reserve space for characters that do not show up in the final output.

```
\begin{displaymath}
{}^{12}_{6}\textrm{C}
\qquad \textrm{versus} \qquad
{}^{12}_{\phantom{1}6}\textrm{C}
\end{displaymath}
```

$${}^{12}_{6}\textrm{C} \qquad \textrm{versus} \qquad {}^{12}_{6}\textrm{C}$$

```
\begin{displaymath}
\Gamma_{ij}^{k}
\qquad \textrm{versus} \qquad
\Gamma_{ij}^{\phantom{ij}k}
\end{displaymath}
```

$$\Gamma_{ij}^{k} \qquad \textrm{versus} \qquad \Gamma_{ij}^{k}$$

6 Vertical alignment

In order to typeset matricies or arrays, we use the `array` environment. Notice how we separate lines using the `\\` command, and how we specify the dots.

```
\begin{displaymath}
\mathbf{X} = \left(\begin{array}{ccc}
  x_{11} & x_{12} & \ldots \\
  x_{21} & x_{22} & \ldots \\
  \vdots & \vdots & \ddots
\end{array}\right)
\end{displaymath}
```

$$\mathbf{X} = \left(\begin{array}{ccc} x_{11} & x_{12} & \ldots \\ x_{21} & x_{22} & \ldots \\ \vdots & \vdots & \ddots \end{array}\right)$$

You can also use the `array` environment for other things:

```
\begin{displaymath}
y = \left\{\begin{array}{rl}
  -1 & x < 0 \\
   0 & x = 0 \\
   1 & x > 0
\end{array}\right.
\end{displaymath}
```

$$y = \left\{\begin{array}{rl} -1 & x < 0 \\ 0 & x = 0 \\ 1 & x > 0 \end{array}\right.$$

They can also have lines:

```
\begin{displaymath}
\left[\begin{array}{c|c}
  \mathrm{T} & \mathrm{C} \\
  \hline
  \mathrm{S} & \mathrm{A}
\end{array}\right]
\end{displaymath}
```

$$\left[\begin{array}{c|c} \mathrm{T} & \mathrm{C} \\ \hline \mathrm{S} & \mathrm{A} \end{array}\right]$$

In order to typeset multiple equations in a row, we use the `eqnarray` environment. This appends equation numbers after every equation, but we can suppress that with `\nonumber`.

```
\begin{eqnarray}
f(x)  & = & \cos x  \\
f'(x) & = & -\sin x \\
\int_{0}^{x} f(y)\,\mathrm{y}
      & = & \sin x  \nonumber\\
      & = & - f'(x)
\end{eqnarray}
```

$$
\begin{aligned}
f(x) &= \cos x && (5)\\
f'(x) &= -\sin x && (6)\\
\int_{0}^{x} f(y)\,\mathrm{y} &= \sin x \\
&= -f'(x) && (7)
\end{aligned}
$$

Breaking an equation across a line needs to be done manually.

```
\begin{eqnarray*}
\sin x & = & x-\frac{x^3}{3!}+{}\\
  & & {}+\frac{x^5}{5!}-{}\cdots
\end{eqnarray*}
```

$$
\begin{aligned}
\sin x &= x-\frac{x^3}{3!}+{}\\
& \quad {}+\frac{x^5}{5!}-{}\cdots
\end{aligned}
$$

7 Theorems

LaTeX has built-in support for typesetting lemmas, definitions, axioms and such. We use the `\newtheorem` command to define theorem environments.

```
\newtheorem{theorem}{Theorem}
\begin{theorem}
A number is divisible by 9 if and
only if the sum of its digits is
divisible by 9.
\end{theorem}
\begin{theorem}
\normalfont A number is divisible
by 3 if and only if the sum of its
digits is divisible by 3.
\end{theorem}
```

Theorem 1 *A number is divisible by 9 if and only if the sum of its digits is divisible by 9.*

Theorem 2 A number is divisible by 3 if and only if the sum of its digits is divisible by 3.

You can make different theorem environments depend on other environments for numbering.

```
\newtheorem{lemma}{Lemma}
\newtheorem{theorem}[lemma]{Theorem}
\begin{lemma}
\normalfont If $b = qa + r$ then
\[\mathrm{GCD}(a,b) =
  \mathrm{GCD}(r,a).\]
\end{lemma}
\begin{theorem}
\normalfont If $a,b \in \mathbb{Z}$
then there exist $x,y \in
\mathbb{Z}$, that can be found by
the Euclidean algorithm, such that
\[ax + by = \mathrm{GCD}(a,b).\]
\end{theorem}
```

Lemma 1 If $b = qa + r$ then

$$\mathrm{GCD}(a,b) = \mathrm{GCD}(r,a).$$

Theorem 2 If $a, b \in \mathbb{Z}$ then there exist $x, y \in \mathbb{Z}$, that can be found by the Euclidean algorithm, such that

$$ax + by = \mathrm{GCD}(a,b).$$

Theorems can depend on section numbers, if you provide the optional argument.

```
\newtheorem{law}{Law}[section]
\begin{law}[Murphy]
If there are two or more ways
to do something, and
one of those ways can result
in a catastrophe, then someone
will do it.
\end{law}
```

Law 7.1 (Murphy) *If there are two or more ways to do something, and one of those ways can result in a catastrophe, then someone will do it.*