Typesetting Mathematics in LaTeX

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$\mathcal{A}\mathcal{M}\mathcal{S}$-LaTeX

The American Mathematical Society (AMS) have produced a package called $\mathcal{A}\mathcal{M}\mathcal{S}$-LaTeX that makes it easier to typeset difficult mathematics in LaTeX. To use this package you must include the following line in the preamble of your LaTeX document

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\usepackage[options]{amsmath}
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with options being any particular option you require for `amsmath` (I don't use any).

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with options being any particular option you require for `amsmath` (I don't use any).
For the purposes of general mathematical typesetting I would suggest that you extend this by loading one other $\mathcal{AMS}$ package too:

```
\usepackage{amsmath,amssymb}.
```

using \usepackage

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However, if you need individual options for each package then you must use the second type of formatting.

Descriptions

amsmath This package is the primary enhancement package of $\mathcal{AMS}$-LaTeX. $\mathcal{AMS}$-LaTeX provides additional mathematical environments for multiline equations, more symbols in boldface type, easier construction of new symbols and much more. `amsmath` automatically loads `amsgen`, `amsbsy`, `amsopn` and `amstext`.

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amssymb This package makes many mathematical symbols available that are not available in plain LaTeX. Look at the Tables on pages 552–554 of Kopka & Daly or §8.9 in Mittlebach & Goossens for a full list. `amssymb` automatically loads `amsfonts`.

Single-line Formulæ

Mathematical formulæ are generally typeset in one of two ways: *inline*, meaning as part of the current line, or *displayed*, meaning on a separate line. For now we will concentrate on single-line formulæ.

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```
\begin{equation}
mathematics
\end{equation}.
```

(To suppress the numbering in any environment use `\begin{envname*} mathematics \end{envname*}`.)

Numbering and Referencing

LaTeX provides a very simple system for numbering and referencing equations. If we wish to refer to an equation we must simply insert a `\label` command as follows:

```
\begin{equation}
\label{soln}
u(x,t)=\int_{\mathbb{R}^N}
   f((x-z)t^{-1/2})u_0(z) \, \mathrm{d}z.
\end{equation}
```

Then we may refer to this equation with the command `\eqref{soln}`, which produces (1) since this was the equation I typed on the previous slide. The command `\eqref` is preferable to the command `\ref` here since it automatically includes the surrounding brackets and uses the correct fonts regardless of the type of font you are using. (`\ref` would simply produce 1.)

Customising Equation Numbering

You can tell LaTeX how you want your equations numbered by using the `\numberwithin` command in the preamble. For example, if an article is to have the equations in each section numbered as `sectionnumber.equationnumber` use

```
\numberwithin{equation}{section}
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to redefine the equation numbers to include the section number. The general syntax is `\numberwithin{ctr1}{ctr2}` and it defines `ctr1` to be a subcounter of `ctr2`, meaning that `ctr1` is reset every time `ctr2` is incremented. Here are a few examples
`\numberwithin{figure}{subsection}`
`\numberwithin{table}{section}`.

Basic Mathematics

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$$\frac{a+b}{c} = \frac{a}{c} + \frac{b}{c}.$$

You could of course put this equation inline $\frac{a+b}{c} = \frac{a}{c} + \frac{b}{c}$ but the fractions look small and perhaps reverting to $(a+b)/c = a/c + b/c$ is better for inline formulæ.

Mathematical commands

Subscripts are generated by using an underscore _ and superscripts by the caret symbol ^. For example x^y is gained by typing `$x^y$`. Only the letter or number immediately after ^ is taken to be a superscript. Thus, to gain x^{y+z} one must type `$x^{y+z}$` so that LaTeX treats $y + z$ as a single object. The same rules apply to subscripts.

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A full list of available mathematical commands can be found Chapter 5 of Kopka & Daly or Chapter 8 of Mittlebach & Goossens.

Conventions

There are a few important conventions in mathematical typesetting that LaTeX does not automatically deal with. The first one is the typesetting of the "$\mathrm{d}t$" at the end of the integral. Contrast the following two examples:

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The first one is what results if you just type `$\int t dt$`. The problem is that LaTeX ignores all white space inside mathematical environments, so tdt just ends up looking like lots of variables clumped together. To fix this you need to tell LaTeX that you want a small white space between the t and the dt. This is done by using the `\,` command.

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To typeset this properly you must use the LaTeX command `\sin`. In doing this it is important to remember to leave a white space at the end of the `\sin` command because typing `$\sinx$` rather than `$\sin x$` will result in an error. LaTeX will think that you are asking it for a command called `\sinx`. This is true of all LaTeX commands - leave a white space after them.

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Some operators have options. For example `\int` and `\lim`. Operator options are typed using the superscript and subscript commands. For example `$\int^a_b$` produces $\int^a_b$.

Long Equations

We have dealt with single line displayed mathematics but what if you have one equation that is simply too long for one line? Thankfully, $\mathcal{AMS}$-LaTeX copes very well with this if you use its `split` or `multline` environments.

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We have dealt with single line displayed mathematics but what if you have one equation that is simply too long for one line? Thankfully, $\mathcal{AMS}$-LaTeX copes very well with this if you use its `split` or `multline` environments.

The `multline` environment is a variant of the equation environment for a *single* formula that is too long for one line. Line breaks occur where the user forces them with the \\ command. By default the first line is left justified, the last line right justified and the lines in between are centred. The equation number will appear at the right of the last line.

An Example

$$\begin{multline}(x+y)^n=x^n+nx^{n-1}y\\+\frac{n(n-1)}{1\cdot2}x^{n-2}y^2\\+\frac{n(n-1)(n-2)}{1\cdot2\cdot3}x^{n-3}y^3+\cdots\\+nxy^{n-1}+y^n \tag{2}\end{multline}$$

was produced with the code

```
\begin{multline}
\label{2long}
(x+y)^n=x^n+nx^{n-1}y\\+\frac{n(n-1)}{1\cdot2}x^{n-2}y^2\\
+\frac{n(n-1)(n-2)}{1\cdot2\cdot3}x^{n-3}y^3+\cdots\\
+nxy^{n-1}+y^n
\end{multline}
```

The `multline` Environment

To shift individual lines fully to the left or right use the commands `\shoveleft{line}` and `\shoveright{line}`. The entire formula text for that line except the `\\` is placed within their arguments.

$$\begin{multline}(x+y)^n=x^n+nx^{n-1}y\\
\shoveright{+\frac{n(n-1)}{1\cdot2}x^{n-2}y^2}\\
\shoveleft{+\frac{n(n-1)(n-2)}{1\cdot2\cdot3}x^{n-3}y^3
+\cdots}\\
+nxy^{n-1}=y^n \tag{3}
\end{multline}$$

was produced by the code

```
\begin{multline}\label{2long2}(x+y)^n=x^n+nx^{n-1}y\\
\shoveright{+\frac{n(n-1)}{1\cdot2}x^{n-2}y^2}\\
\shoveleft{+\frac{n(n-1)(n-2)}{1\cdot2\cdot3}x^{n-3}y^3
+\cdots}\\
+nxy^{n-1}=y^n
\end{multline}
```

The `split` Environment

Like `multline`, the `split` environment is meant for a single equation that does not fit on one line. The difference is that in each line there is an alignment marker & such that the lines are horizontally positioned to line up the markers.
The `split` environment does not automatically change into math mode or produce an equation number. That is because it is designed to be used inside an math environment. The most basic syntax is

```
\begin{mathenv}\begin{split}
maths & maths\\
& maths
\end{split}\end{mathenv}
```

An Example

The equation

$$\begin{split}\psi_k(\xi_0) = -c_k & \frac{(m-3)a}{(m-1)\xi_0}\\ & + \frac{\xi_0(\lambda_k-\mu_0)a}{2m|a|^{m-1}} - \frac{2a}{\xi_0},\end{split} \tag{4}$$

was generated by using the `split` environment. Notice that the equation number appears between the two lines, not at the end of the last line. The code used to generate this was

```
\begin{equation}
\begin{split}
\psi_k(\xi_0) =-c_k&\frac{(m-3)a}{(m-1)\xi_0}\\
&+\frac{\xi_0(\lambda_k-\mu_0)a}{2m|a|^{m-1}}
-\frac{2a}{\xi_0},
\end{split}
\end{equation}
```