LaTeX basics

1 Creating documents

Use LaTeX by first opening and editing a plain text file. Save the file with the `.tex` extension. The `.tex` file can be compiled to produce a `.pdf` file using either `pdflatex` or `xelatex`. The choice of compiler is usually an option in a drop down menu in LaTeX software packages or, if using the command line, can be invoked by entering `pdflatex filename.tex` or `xelatex filename.tex` in a terminal. The `pdflatex` option is faster and more established, but the `xelatex` option is better at handling fonts.

LaTeX files can also be edited and compiled on a third party web site such as `www.overleaf.com`. This is a fine option to get up and running quickly, but most serious users install LaTeX on their personal computer. There are many free options for downloading and installing LaTeX on each operating system:

- Windows users can use MikTeX. See `miktex.org/`.
- Apple users can use MacTex. See `www.tug.org/mactex/`.
- Linux should be able to figure it out themselves.

2 Entering mathematics

Mathematics can be typeset using the packages `amssymb`, `amsmath` and `amsthm`. These packages are maintained by the American Mathematical Society.

To produce inline "textstyle" mathematics, place mathematics between the symbols `\(` and `\)` or between the symbols `$` and `$`. To produce "displaystyle" mathematics on its own centered line, similar to

$$\frac{d}{dx}\arcsin x = \frac{1}{\sqrt{1-x^2}},$$

place mathematics between `\[` and `\]` or between `\begin{equation*}` and `\end{equation*}`. This is known as "displaystyle". Inline mathematics can appear as displaystyle using the `{\displaystyle .. }` command and displayed mathematics can appear as textstyle using `{\textstyle .. }`.

Mathematics symbols are typeset using commands such as `\(\Xi\)`, producing Ξ. LaTeX will complain if such a mathematics symbol is not called in math mode. A list of mathematics symbols can be found on pages 75–82 of our text. The web site

`http://detexify.kirelabs.org/classify.html`

can also help in finding symbols. *Use standard AMS packages whenever possible!*

The most frequently encountered functions and operators in mathematics have pre-defined command names. For example:

$$\sin x, \cos x, \tan x, \arcsin x, \ln x$$

Use `\operatorname{..}` if a function or operator does not have a predefined command, like this: $\operatorname{erf} x$.

Binomial coefficients: $1 + 2 + \cdots + n = \binom{n+1}{2}$, and matrices:

$$\begin{bmatrix} a & \dots & b \\ \vdots & \ddots & \\ -3 & \dots & 4 \end{bmatrix}$$

$$\begin{bmatrix} a & b \\ c & d \end{bmatrix} \quad \begin{vmatrix} a & b \\ c & d \end{vmatrix} \quad \begin{pmatrix} a & b \\ c & d \end{pmatrix} \quad \begin{matrix} a & b \\ c & d \end{matrix} \quad \begin{smallmatrix} a & b \\ c & d \end{smallmatrix} \quad \left[\begin{smallmatrix} a & b \\ c & d \end{smallmatrix}\right] \quad \begin{Vmatrix} a & b \\ c & d \end{Vmatrix}$$

By convention, matrices are not written in boldface but vectors such as $\mathbf{x}$ are. To typeset a transpose, use the `\intercal` symbol, such as $\mathbf{x}^\intercal$.

3 Spacing

Sometimes the spacing between mathematics symbols should be adjusted. The spacing commands to be used in math mode, in order of longest space to smallest space, are:

`\qquad` `\quad` `\ ` `\;` `\:` `\,` `\!`

These produce spaces equal to the width of two eMs, one eM (one quad), the width of inter-word spacing, $\frac{5}{18}$ quad, $\frac{4}{18}$ quad, $\frac{3}{18}$ quad, and $-\frac{3}{18}$ quad. It is proper form to use `\,` before differentials in integrals, like this

$$\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} e^{-(x^2+y^2)}\,dx\,dy = \int_0^{2\pi}\int_0^{\infty} e^{-r^2} r\,dr\,d\theta.$$

Here is the incorrect typesetting, without the proper spacing:

$$\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} e^{-(x^2+y^2)}dxdy = \int_0^{2\pi}\int_0^{\infty} e^{-r^2} rdrd\theta.$$

In rare cases spacing can be adjusted using `\phantom{stuff}` which creates a space of the same length as the typeset length of `stuff`. Using `\phantom` frequently is a sign of poor typesetting.

Parentheses of the correct size are given by `\left( .. \right)`. The parentheses do not have to be the same type. To suppress a parentheses, replace the parenthesis with a period. For example,

$$\left\{ x \in \mathbb{R} : \int_0^x \sin t\,dt \le 1 \right\}.$$

4 Multi-line mathematics

To display multi-line math example, use `\begin{align*}..\end{align*}`, where the `&` symbol controls where the alignment occurs and `\\` gives a new line. For instance, consider

$$\begin{aligned} \int_a^b x^n\,dx &= \left.\frac{x^{n+1}}{n+1}\right|_a^b && (1)\\ &= \frac{b^{n+1}}{n+1} - \frac{a^{n+1}}{n+1} \\ &= \frac{1}{n+1}(b^{n+1} - a^{n+1}). && (2) \end{aligned}$$

For long expressions that don't fit on one line, use `\begin{multline*}`, with `\\` denoting a new line:

$$\begin{multline*} \alpha+\beta+\gamma+\delta+\varepsilon+\zeta+\eta+\theta \\ +\iota+\kappa+\lambda+\mu+\nu+\xi+\pi+\rho \\ +\sigma+\tau+\upsilon+\varphi+\chi+\psi+\omega. \end{multline*}$$

Fractions can be displayed a couple of ways: $\frac{1}{2}$ versus $\dfrac{1}{2}$.