

# WSKmaths — Useful mathematical definitions.

Wilfrid S. Kendall\*

This version 17th September 2019

This package ensures that a number of useful mathematics packages are loaded, provides a number of useful theorem-like environments, and defines a number of significant mathematics macros. The concluding section offers a few general remarks about writing in L<sup>A</sup>T<sub>E</sub>X.

## 1 Packages

The mathematics and associated packages loaded by this package are

- `amsmath`,
- `amsfonts`,
- `amsthm`,
- `framed`,
- `caption`,
- `xspace`.
- `natbib`.
- `enumitem`.

It is worth looking at the documentation for `amsmath` (<ftp://ftp.ams.org/pub/tex/doc/amsmath/amsl.doc.pdf>) and `amsthm` (<ftp://ftp.ams.org/pub/tex/doc/amscs/amsth.doc.pdf>); depending on your writing style, some constructions in these might save much time and effort.

## 2 Theorem-like environments

The package defines theorem-like environments as follows, all numbered consecutively as a whole:

- in theorem-style:
  - `thm` (theorems),
  - `prop` (propositions),
  - `lem` (lemmas),
  - `cor` (corollaries),
  - `exercise` (exercises);
- in separate styles:
  - `defn` (definitions, in definition style),
  - `rem` (remarks, in remark style).
  - `qn` (questions, in remark style).

Proofs should be enclosed in a `\begin{proof} ... \end{proof}` environment.

---

\*E-mail: [w.s.kendall@warwick.ac.uk](mailto:w.s.kendall@warwick.ac.uk)

### 3 Mathematical macros

It is convenient to replace commonly used mathematical constructions by L<sup>A</sup>T<sub>E</sub>X macros. This makes it easier to maintain notational consistency, and also it is then easier to change notation if (for example) it becomes apparent that notation clashes. The package defines these macros:

<code>\CFTP</code>	<ul style="list-style-type: none"> <li>The Coupling from the Past algorithm is abbreviated by <i>CFTP</i>: use <code>\CFTP</code> (text mode). This and the following two textual macros do not save much typing, but facilitate textual consistency and coherent typographical style.</li> </ul>
<code>\Ito</code>	<ul style="list-style-type: none"> <li>For Itô (as in the Itô differential), use <code>\Ito</code> (text mode).</li> </ul>
<code>\MCMC</code>	<ul style="list-style-type: none"> <li>Abbreviate Markov chain Monte Carlo by <i>MCMC</i>: use <code>\MCMC</code> (text mode).</li> </ul>
<code>\Borel</code>	<ul style="list-style-type: none"> <li>Denote the Borel <math>\sigma</math>-algebra by <math>\mathfrak{B}</math>: use <code>\Borel</code>.</li> </ul>
<code>\Expect</code>	<ul style="list-style-type: none"> <li>Write <math>\mathbb{E}[X]</math> for the expectation of the random variable <math>X</math>: use <code>\Expect{X}</code>. The enclosing square brackets will change size to encompass the argument. (For multi-line expectations, you'll have to do this the hard way, using <code>\mathbb{E}\Big[...\Big]</code>, or variants.)</li> </ul>
<code>\Indicator</code>	<ul style="list-style-type: none"> <li>Write <math>\mathbb{I}[A]</math> for the indicator of the event <math>A</math>: use <code>\Indicator{A}</code>. The enclosing square brackets will change size to encompass the argument. Note that Williams (1991)'s notation <math>\mathbb{E}[X ; A]</math> (<code>\Expect{X\;;\;A}</code>) is more concise and ultimately more readable than the equivalent <math>\mathbb{E}[X \mathbb{I}[A]]</math>. For conditional expectation use <code>\Expect{X\; \;Y}</code>.</li> </ul>
<code>\Integers</code>	<ul style="list-style-type: none"> <li>Denote the set of integers by <math>\mathbb{Z}</math>: write <code>\Integers</code>.</li> </ul>
<code>\Hess</code>	<ul style="list-style-type: none"> <li>Denote the Hessian (covariant second derivative) of a function <math>f</math> in directions <math>U</math> and <math>V</math> by <math>\text{Hess } f(U, V)</math>: use <code>\Hess f(U,V)</code>.</li> </ul>
<code>\Law</code>	<ul style="list-style-type: none"> <li>Write <math>\mathcal{L}(X)</math> for the law of the random variable <math>X</math>: use <code>\Law{X}</code>.</li> </ul>
<code>\Leb</code>	<ul style="list-style-type: none"> <li>Write <math>\text{Leb}(A)</math> for the Lebesgue measure of a set <math>A</math>: use <code>\Leb(A)</code>.</li> </ul>
<code>\Numbers</code>	<ul style="list-style-type: none"> <li>Denote the set of natural numbers by <math>\mathbb{N}</math>: use <code>\Numbers</code>.</li> </ul>
<code>\Prob</code>	<ul style="list-style-type: none"> <li>Write <math>\mathbb{P}[A]</math> for the probability of the event <math>A</math>: use <code>\Prob{A}</code>. The enclosing square brackets will change size to encompass the argument. (For multi-line probabilities use <code>\mathbb{P}\Big[...\Big]</code> etc.) For conditional probability use <code>\Prob{A\; \;Y}</code>.</li> </ul>
<code>\Rationals</code>	<ul style="list-style-type: none"> <li>Denote the set of rational numbers by <math>\mathbb{Q}</math>: use <code>\Rationals</code>.</li> </ul>
<code>\Reals</code>	<ul style="list-style-type: none"> <li>Denote the set of real numbers by <math>\mathbb{R}</math>: use <code>\Reals</code>.</li> </ul>
<code>\Var</code>	<ul style="list-style-type: none"> <li>Write <math>\text{Var}[X]</math> the variance of the random variable <math>X</math>: use <code>\Var{X}</code>. The enclosing square brackets will change size to encompass the argument.</li> </ul>
<code>\Cov</code>	<ul style="list-style-type: none"> <li>Write <math>\text{Cov}[X, Y]</math> the covariance of the random variables <math>X</math> and <math>Y</math>: use <code>\Cov{X,Y}</code>. The enclosing square brackets will change size to encompass the argument.</li> </ul>
<code>\ball</code>	<ul style="list-style-type: none"> <li>The metric ball of centre <math>x</math> and radius <math>r</math> is denoted by <math>\text{ball}(x, r)</math>: use <code>\ball{x,r}</code>. In exposition one should always be clear about whether one means the open or the closed ball!</li> </ul>
<code>\origin</code>	<ul style="list-style-type: none"> <li>The origin of Euclidean space is denoted by <math>\mathbf{o}</math>: use <code>\origin</code>.</li> </ul>
<code>\d</code>	<ul style="list-style-type: none"> <li>Some publishers (eg Cambridge University Press) advise that the differential notation in the integral <math>\int f(x) \, dx</math>, or derivative <math>\frac{d}{dx}f(x)</math> should use a specially defined symbol <code>\d</code>, as in <code>\int f(x) \, \d{x}</code> or <code>\tfrac{\d}{\d{x}}f(x)</code>. Note that this overloads an original L<sup>A</sup>T<sub>E</sub>X definition which uses <code>\d</code> to generate a dot below a symbol. Note also the use of a thin space <code>\,</code> before <code>\text{d}</code> in the definition of <code>\d</code>. This can clarify complicated expressions.</li> </ul>



the text. In fact it is a good rule, when typing L<sup>A</sup>T<sub>E</sub>X source, to follow each full-stop and each major punctuation mark by a line-break. This aids clarity when reading the L<sup>A</sup>T<sub>E</sub>X source (a task which one performs continually when writing and editing a document), makes it easier to check which text has changed between one version and the next when using a file difference utility such as `diff` or its visual equivalents `vdiff` or `kdiff3`, and also works better if you are using a L<sup>A</sup>T<sub>E</sub>X editing environment such as *Kile* <http://kile.sourceforge.net/> or *TeXnicCentre* <http://www.texniccenter.org/> or *TeXshop* <http://pages.uoregon.edu/koch/texshop/>, any of which will compile L<sup>A</sup>T<sub>E</sub>X and then jump to the appropriate line in the previewer. (And there are *many* other advantages of using such an editing environment!)

I noted above, `amsmath` has a variety of excellent mathematics display environments: get familiar with them! Two of the most useful are `multline` for multi-line single equations, and `align` for aligned groups of equations. (But don't forget the use of `\nonumber` to suppress equation numbers for all but perhaps one of the aligned equations.)

While writing L<sup>A</sup>T<sub>E</sub>X, stay aware of the possibility of defining commonly used quantities using L<sup>A</sup>T<sub>E</sub>X macros. This makes it possible to change notation globally. Suppose you speak a great deal about a Sobolev space  $W^2$  and then decide you want to change to  $L^{2,1}$ , for example. This is easy if you have used `\Sobolev`, coupled with `\newcommand{\Sobolev}{W^2}` in your preamble.

It is useful to follow a consistent pattern when labelling equations, sections, *etc.* Consider

$$\text{Poisson}(\lambda) = \frac{\lambda^n e^{-\lambda}}{n!} \quad \text{for } n = 0, 1, 2, \dots \quad (1) \quad \boxed{\text{eq:poisson}}$$

This equation (I) is written as

```
\begin{equation}\label{eq:poisson}
\text{\text{Poisson}}(\lambda) \quad \text{\text{quad}}=\quad \text{\text{quad}}
\frac{\lambda^n e^{-\lambda}}{n!}
\quad \text{\text{quad}}\text{\text{ for }} n=0,1,2,\ldots\,,.
\end{equation}
```

and is conveniently referred to by use of `\eqref{eq:poisson}`. Note that `\eqref` automatically surrounds the reference with brackets!

Similarly, for example, use `\label{thm:main-result}` for an instance of the theorem-like environment `thm`, and `\label{sec:intro}` for an introductory section.

Figures are made easier by the `Figure` environment. Label figures by `\label{fig:homer}`, *etc.*, taking care to label *within* the `caption` content!). Note that it is often convenient to store all graphics in a subdirectory `image`. The preamble command `\graphicspath{{./image/}}` allows one to dispense with `image/` when referring to an graphic in `includegraphics`.

Figure

```
\begin{Figure}
\includegraphics[width=3in]{under-construction}
\caption{Example of simple figure.}
\label{fig:homer}
\end{Figure}
```

When drafting a paper, consider using `\usepackage{showkeys}`. This `usepackage` invocation must occur *after* the invocations of `\usepackage{amsmath}` and `\usepackage{hyperref}`. As seen above, this will, for example, place `eq:poisson` in the margin by the relevant equation *et cetera* and will annotate references (I) appropriately.

Finally, a similar consistent labelling is useful for B<sup>B</sup>T<sub>E</sub>X references; consider for example this reference [Goossens, Mittelbach, and Samarin \(1994\)](#), which is labelled using my preferred `Authors-year` style<sup>4</sup> as follows: `\citete{GoossensMittelbachSamarin-1994}`. Perhaps this seems tedious to you? But (a) good L<sup>A</sup>T<sub>E</sub>X editing environments can be set up to auto-complete

<sup>4</sup> Why preferred? because I can then immediately and unambiguously check I have cited the correct reference in the PDF.

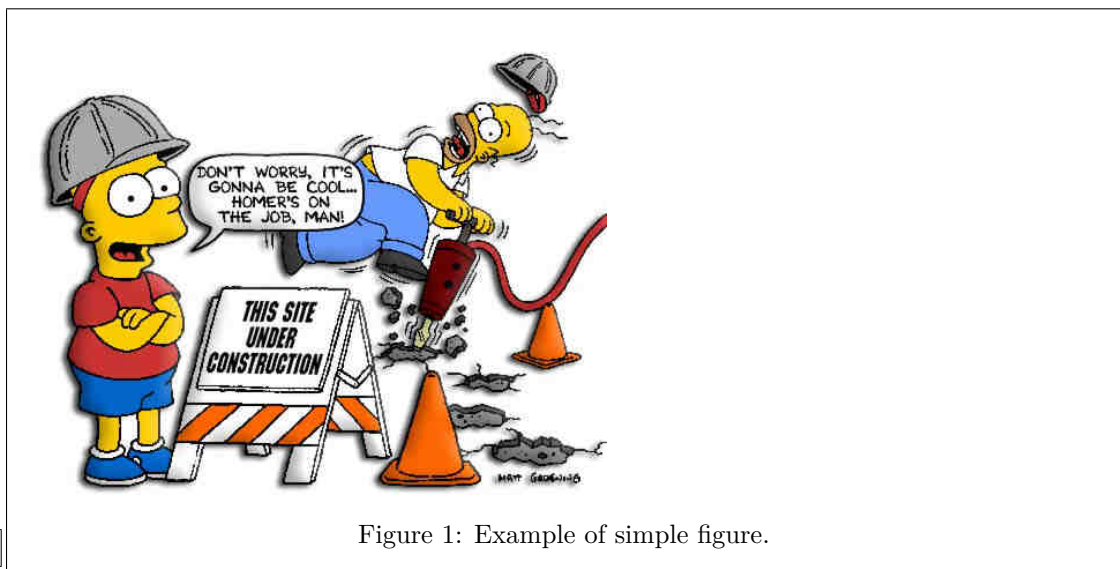


fig:homer

Figure 1: Example of simple figure.

\citet{Goos...}, (b) it is easy to copy-and-paste GoossensMittelbachSamarin-1994 from the .bib file entry (see below), (c) you can then easily and consistently identify the cited reference from the source as well as the PDF output.

The .bib file contains this entry in the following form:

```
@book{GoossensMittelbachSamarin-1994,
  author = {Goossens, Michel and Mittelbach, Frank and Samarin, Alexander},
  booktitle = {Human Factors},
  pages = {528},
  title = {{The LaTeX Companion}},
  publisher = {Addison-Wesley},
  address = {reading, Massachusetts},
  year = {1994}
}
```

I prefer to use \usepackage{natbib} with a name-date system (the default for natbib). The natbib offers considerable flexibility, for example using \citep for a reference in parentheses (Goossens et al., 1994). See the natbib quick reference for more details: <http://merkel.zoneo.net/Latex/natbib.php>. (I generally use a modified bst file plainnattrimmed, which removes doi fields and month data following the advice in [tex.stackexchange.com/questions/125133/remove-issn-doi-url-when-using-plainnat-and-natbib](http://tex.stackexchange.com/questions/125133/remove-issn-doi-url-when-using-plainnat-and-natbib).) I have modified \usepackage{showkeys} to \usepackage[notcite]{showkeys}, so as to avoid annotating citations with keys, redundant if one constructs citations as Authors-year.

It is beyond the scope of this note, but be aware that one can save huge amounts of time by using a bibliography manager such as Mendeley <http://www.mendeley.com/>. My set-up allows collection of references from the web using Zotero <https://www.zotero.org/> with a single click. These then transfer automatically to Mendeley. When dragged into a particular Mendeley group, they are stored in BibTeX form in various .bib files which can then be used directly by my various writing projects. Get this set up correctly, and you can then easily add references in final form as you are drafting the L<sup>A</sup>T<sub>E</sub>X. Why might you want to do this? (a) Completing the bibliography is a tedious chore at the end of a writing project, but easily done bit-by-bit when writing; (b) A steadily increasing bibliography is a great motivator when writing!

Saving time and effort in all these ways makes mathematical writing much easier.

## 5 References

bachSamarin-1994

Michel Goossens, Frank Mittelbach, and Alexander Samarin. *The LaTeX Companion*. Addison-Wesley, reading, Massachusetts, 1994.

Williams-1991

David Williams. *Probability with martingales*. Cambridge Mathematical Textbooks. Cambridge University Press, Cambridge, 1991. ISBN 0-521-40455-X; 0-521-40605-6.

## 6 Index

Numbers written in *italic* refer to the page where the corresponding entry is described; numbers underlined refer to the code line of the definition; numbers in *roman* refer to the code lines where the entry is used.

<b>B</b>		<b>G</b>		<b>N</b>	
<code>\ball</code> .....	<i>2</i>	<code>\grad</code> .....	<i>3</i>	<code>\Numbers</code> .....	<i>2</i>
<code>\Borel</code> .....	<i>2</i>	<b>H</b>		<b>O</b>	
<b>C</b>		<code>\half</code> .....	<i>3</i>	<code>\origin</code> .....	<i>2</i>
<code>\CFTP</code> .....	<i>2</i>	<code>\Hess</code> .....	<i>2</i>	<b>P</b>	
<code>\Cov</code> .....	<i>2</i>	<b>I</b>		<code>\Prob</code> .....	<i>2</i>
<b>D</b>		<code>\Indicator</code> .....	<i>2</i>	<b>R</b>	
<code>\d</code> .....	<i>2</i>	<code>\Integers</code> .....	<i>2</i>	<code>\Rationals</code> .....	<i>2</i>
<code>\dist</code> .....	<i>3</i>	<code>\Ito</code> .....	<i>2</i>	<code>\Reals</code> .....	<i>2</i>
<b>E</b>		<b>L</b>		<b>S</b>	
environments:		<code>\Law</code> .....	<i>2</i>	<code>\sgn</code> .....	<i>3</i>
<code>Figure</code> .....	<i>4</i>	<code>\Leb</code> .....	<i>2</i>	<b>V</b>	
<code>\eps</code> .....	<i>3</i>	<b>M</b>		<code>\Var</code> .....	<i>2</i>
<code>\Expect</code> .....	<i>2</i>	<code>\MCMC</code> .....	<i>2</i>		
<b>F</b>		<b>V</b>			
<code>Figure</code> (environment) .....	<i>4</i>				