hepthesis v1.5.2

A class for typesetting academic theses

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December 12, 2017

Abstract

The `hepthesis` class provides an attractive framework in which to write a PhD or Masters' degree dissertation. The commands provided by this package permit most structural aspects of the thesis to be defined more or less semantically, rather than in terms of raw text sizings and position shifts.

1 Introduction

When I began my PhD in 2001, I was surprised to find that there was no standard LaTeX thesis class used by students in my field (*h*igh-*e*nergy *p*article physics, hence the "hep"). In retrospect, this is not so surprising — research groups often have an informal system of handing down slightly tailored thesis templates (complete with in line `\vspaces`, `\Huges` and all the rest) through generations of students without ever formalising the style and attempting to do it "properly".

By the time it came to write my own thesis it was obvious that I would only retain my sanity through measures of extreme procrastination and so this package came to be. It has now been edited and hacked on and off since roughly mid-2004, taking stylistic features from other theses that I've thought attractive and adding features based on my own pickiness and user requests. The typography isn't motivated by

any formal understanding of the subject, though, so I'm sure there's still plenty of room for improvement.

This document documents the structure of `hepthesis` and how to make it work with you rather than against you. I may be unable to resist including other hints and tips on how to make your thesis-writing go smoothly. Please contact me with suggested improvements, either to the package or to this documentation.

2 Features

Why would you want to use `hepthesis`? Here's a list of features, so you can decide for yourself:

- Semantic macros for defining the front page, abstract, preface, acknowledgements, etc.
- Macros for quotes, including a full-page quote and chapter-wise quotes
- Attractive header and footer structures
- Pre-set margins suitable for binding or for screen viewing
- Nicely (re-)defined figure, table and equation environments
- Optional mode for generating hyper-links when building PDF files
- Built-in draft copy mode with line numbering
- Maths in section titles etc. will automatically be boldened if appropriate

3 Recommended usage

The basic usage mode for `hepthesis` is to place

```
\documentclass{hepthesis}
```

in the preamble of your document. This will then set up the document's appearance and provide the `hepthesis` macros as do the standard LaTeX classes like `article` and `report`. A more sophisticated and flexible approach is described in Appendix A.

Although strictly unrelated to `hepthesis`, it is usual to write each thesis chapter as a separate `.tex` file and to include it with `\include` or `\input`. You may find it useful to set your `LATEXINPUTS` environment variable to ensure that the `\input`'d files are found by LaTeX.

`hepthesis` takes several optional arguments. Personally, I use

```
\documentclass[hyperpdf,bindnopdf]{hepthesis}
```

which produces page-centered, hyper-linked PDF files and PostScript files with margins suitable for binding and no hyper-links, depending on whether you build the document using `latex` or `pdflatex`. The details of the `hepthesis` options are described in Section 5 of this document.

4 Requirements

As `hepthesis` aims to allow produce a fairly final version of a thesis without much additional tweaking, there are quite a few required packages. Most should be natively available in your TEX distribution; the rest from CTAN.

Here's the mandatory packages:

- **scrbook** [2] (from KOMA-scripts)
- **setspace** [4]
- **fancyhdr** [5]
- **rotating** [6]
- **comment** [?]
- **tocbibind** [7]
- **caption** [9]
- **changepage** [11]
- **varwidth** [12]

> *Note that the subfig [8] (previously subfigure) and ccaption [10] packages, which were required up to version 1.3, are no longer needed. If you need sub-figures then you should* `\usepackage` *the package as usual in your document preamble or custom class file, and make use of the* `\ContinuedFloat` *command for continuation captions, which is provided by the mandatory caption package.*

Additionally, there are several packages which are only required depending on the class options:

- **csquotes** [13]**:** very standard. Quotation commands will use this if loaded.
- **babel** [14]**:** very standard. Quotation commands will use this if loaded.

- **a4wide [15]:** very standard. Disabled with any paper size option other than `a4paper`
- **amsmath [16]:** very, *very* standard. Disabled with the `noams` option
- **hyperref [17]:** very standard. Enabled with the `hyper` option
- **booktabs [18]:** very standard. Disable with the `nobooktabs` option
- **draftcopy [19]:** very standard. Enable with the `draft` option
- **lineno [20]:** non-standard (?). Enable with the `draft` option
- **titling [21]:** non-standard (?). Enable with the `titling` option

Some other handy packages (which aren't required at all for compatibility with `hepthesis` but may well help you to write your thesis) are summarised in Section 7.

4.1 Troublesome interactions

Unfortunately not all LaTeX packages get on well with each other — if you are unlucky then you may get some of TeX's wondertully cryptic error messages on trying to use hepthesis. Here are the problems that I'm aware of...

- If you have problems with LaTeX complaining about bad definitions of `\pdfstringdefPreHook`, you may be using an old version of csquotes, which doesn't interface well to hyperref. I think this is fixed in csquotes version 3.2 and later — it certainly works for version 3.7. Try including the csquotes package with

  ```
  \usepackage{csquotes}[2007/03/25]
  ```

  so that sufficiently recent version will be used.
- Similarly, version 0.9 of the varwidth package has a deformed version string which means that the package doesn't load properly. This version seems to have made its way into some LaTeX package distributions, so if you see such an error then version 0.9a or later can be obtained from CTAN and will work properly. hepthesis will check to make sure that the version is as required and issue a warning if the version on your system is earlier than those known to be good.

5 Class options

5.1 `oneside` | `twoside`

Typeset the thesis for printing in one- or two-sided format: for example, you may wish to present preview and draft copies in two-sided format, but the final submission may be required to be single-sided. Changing to single-sided form will remove the blank facing pages and only use the margins and header/footer format specified for right-hand pages.

5.2 `bind` | `nobind` | `bindnopdf`

Set the margins to be suitable for printing or screen-viewing. Using the `bind` option produces larger inner margins, so that left- and right-facing pages have LR-reflection symmetry. Using the `nobind` option makes the margins equal, so that the pages don't jump around when you flick through them in `gv` or Adobe Acrobat. The `bindnopdf` option will use binding margins when making a PostScript document and screen-view margins when building a PDF. Note that this option requires some carefulness with the `.aux` files: this is described in Appendix C.

5.3 `ams` | `noams`

Make use of the AMS mathematical package. This re-defines several `hepthesis` mathematical environments using more powerful macros and is enabled by default. If you don't plan on having any maths in your thesis, then disabling this option may speed up your build-time a little.

5.4 `alphafoot`

Use alphanumeric footnote markers.

5.5 `hidefront` | `hideback` | `hidefrontback`

Useful for draft builds, these options respectively hide the front matter, the back matter or both from the LaTeX compilation, giving a faster build time and meaning you don't have to flick through 20 pages of garbage before proof-checking the first real content. Note that hiding the back matter will fail to include the bit where you

generate your bibliography, so unless you make a work-around, all your citations will break.

5.6 draft

Prints "DRAFT" diagonally across the pages and numbers the lines, suitable for proof-reading. This makes use of the standard `draftcopy` and the less-standard `lineno` packages.

5.7 sftitles

Uses a sans-serif font for the title page and all chapter, section and subsection headings.

5.8 rmtitles

Uses a serif (roman) font for the title page and all chapter, section and subsection headings (this is the default).

5.9 booktabs | nobooktabs

Use the `booktabs` package to define the `hepthesis` tabular environment. `booktabs` produces publication quality tables, as opposed to TEX's rather ropey defaults, and so this option is enabled by default. You can disable it if your thesis doesn't have any tables and get a slightly faster build, but it is strongly encouraged that any table presentation uses the `booktabs` look and feel because it's so much better!

5.10 hyper

The `hyper` option is used to activate the `hyperref` package, with some reasonably sensible default options. Essentially, it's equivalent to putting

```
\usepackage[colorlinks=true,pdfpagemode=FullScreen, \
            bookmarks=true]{hyperref}
```

in the preamble of your document.

5.11 `hyperpdf`

`hyperpdf` has the effect of the `hyper` option when building PDF output, and no effect at all if building PostScript. This can be handy if you consider the PDFs to be for screen-reading purposes and the PS for printing: you probably don't want to print a version where all the references and URLs are coloured! Note that this option requires some carefulness with the `.aux` file, since alternating between PS and PDF builds involves repeatedly writing and removing hyperref tokens. A solution to this is described in Appendix C.

5.12 `index`

Include the `makeidx` package, to allow an index to be built. Note that you have to do this by hand and that it's probably best done as a retrospective feature after you've written the thesis. Not many people want to spend *more* time with their thesis when they've done enough to pass!

5.13 `titling`

Use the `titling` package to redefine the `\title` and `\author` commands so that their arguments are available through the document as `\thetitle` and `\theauthor`. This is used, for example, by the `\titlepage` command. If this option isn't passed, a more basic attempt is made to do this definition without needing an external package. It's unclear whether titling really helps but there may be complicated cases (such as those where the author includes a `\thanks`) where `titling` may do a better job. This is untested, though, and the result of using `\thanks` in a `hepthesis` document is to be considered undefined.

5.14 `a4paper` | `a4narrow` | `letterpaper` | `...`

Choose the paper size. Duh.

6 Environments and commands

The `hepthesis` environments and commands are a mix of new macros and tweaked versions of existing standard ones. The ones that re-define standard macros can't be disabled (at least, not in this version), so if you don't like them then you can

either hack `hepthesis` to be the way you'd like (preferably in a nice way which I can integrate into a future release) or use something else. The choice is yours!

Here are the environments and commands, roughly in the order that you'd use them:

6.1 `\set...spacing`{⟨*spacing*⟩}

A selection of spacing commands are available to change the overall line spacing of the thesis, or to change the spacing within specific document sections if for some reason you want to do that. (Personally, I wouldn't — inconsistent spacing is very disconcerting.) Here are the available commands, explicitly:

- `\setspacing` — set the following spacings all at once;
- `\setfrontmatterspacing`
- `\setmainmatterspacing`
- `\setappendixspacing`
- `\setbackmatterspacing`

Each command takes a single argument, which can take the values `single`, `onehalf` and `double`, for single spacing, one-and-a-half spacing and double spacing respectively. The default is `onehalf`, since I think that looks most elegant. If making a draft version, double spacing might be useful since it leaves a bit of room for annotations. I can't recommend single spacing — it just looks cramped.

```
\documentclass[...]{hepthesis}
\setmainmatterspacing{double}
...
\begin{document}
  ...
```

6.2 `\set...extramargins`{⟨*length*⟩}

A selection of commands are available to change the text width on a per-section basis. These shouldn't be tweaked too much, but in case you need it, the ability for configuration is available. The text width itself is not explicitly specified — instead the commands take as an argument the width to be added to both margins. Unless explicitly specified below, all these lengths are zero by default so any use of these

commands with a positive argument is likely to reduce the text width. Here are the "large-scale" extra margins commands:

- `\setextramargins{`⟨*len*⟩`}` — set the following lengths all at once;
- `\setfrontmatterextramargins{`⟨*len*⟩`}`
- `\setmainmatterextramargins{`⟨*len*⟩`}`
- `\setappendixextramargins{`⟨*len*⟩`}`
- `\setbackmatterextramargins{`⟨*len*⟩`}`

The following commands all add extra margin widths to subsections within the front matter. Note that they apply *in addition* to the front matter length.

- `\setabstractextramargins{`⟨*len*⟩`}` — `1.5cm` by default;
- `\setdeclarationextramargins{`⟨*len*⟩`}` — `1.5cm` by default;
- `\setacknowledgementsextramargins{`⟨*len*⟩`}`
- `\setprefaceextramargins{`⟨*len*⟩`}`

Each command takes a single argument, which is just a TEX length. Here's an example:

```
\documentclass[...]{hepthesis}
\setfrontmatterextramargins{1.5}
...
\begin{document}
  ...
```

6.3 `\title{`⟨*title*⟩`}` and `\author{`⟨*author*⟩`}`

The usual commands for setting the author and title. Don't use `\thanks` in the `hepthesis` author argument: the results are undefined!

```
\title{A study of \BToKPi decays with the \LHCb experiment}
\author{Andrew Gordon Buckley}
...
\begin{document}
  ...
```

Once these commands have been executed, the title and author strings are available via the `\thetitle` and `\theauthor` commands. These are used by `\titlepage`.

N.B. Up to version 1.3, a special `\definethesis` command was used to specify the thesis author and title. While this is still retained for backwards compatibility, it is deprecated and you should use the standard `\title` and `\author` macros instead. **`\definethesis` will be removed in version 1.5**

6.4 `frontmatter`, `mainmatter`, `appendices` and `backmatter` environments

Use these to delimit the auxiliary parts of your thesis from the main feature (being all that clever work you spent years working on). In practice, these commands change the page-numbering style and set/reset some section counters appropriately: the frontmatter and backmatter environments will not use chapter numbering but will insert the un-numbered chapter titles in the table of contents. Note that this means appendices should be placed in the appendices environment between mainmatter and backmatter, rather than in the back matter itself, which is intended for such things as the bibliography, colophon etc.

6.5 `\titlepage`

The `\titlepage` macro generates a title page for the thesis and as such should probably be the first item in the front matter. It takes two arguments: an optional elaboration of the author name and the description of the award for which the thesis is being submitted. You may need to use a different macro if your institution has a very different prescribed format for the layout of thesis title pages: in such a case, the `\theauthor` and `\thetitle` commands will probably be useful. Here's an example of usage:

```
\titlepage[of \\ Churchill College]%
{A dissertation submitted to the University of Cambridge\\
for the degree of Doctor of Philosophy}
```

Additionally, the `\maketitle` command has been redefined to behave as `\titlepage` with two empty arguments. This is only provided to not confuse users who convert to `hepthesis` from a standard LaTeX class and expect `\maketitle` to work:

`\titlepage` is a more powerful command and should be used by those who are aware of it. That includes you!

6.6 `abstract` environment

Where you present the summary of your thesis: this should be within the `frontmatter` environment. The `abstract` environment takes one optional argument, which will be the heading above the abstract. If this isn't specified, the heading will simply be "Abstract". This may be useful for providing a stand-alone summary page, with a snippet like:

```
\begin{abstract}%
  [\smaller\thetitle\\ \vspace*{1cm} \smaller{\theauthor}]
\thispagestyle{empty}
This thesis describes all the really cool work I did on...
\end{abstract}
```

6.7 `declaration` environment

Where you declare that the thesis was all your own work, lies within word limits, etc. Use it in the front matter area, of course, with something like

```
\begin{declaration}
  This dissertation is the result of my own work...
  \vspace*{1cm}
  \begin{flushright}
    Andy Buckley
  \end{flushright}
\end{declaration}
```

6.8 `acknowledgements` environment

A nice little environment for putting all those gushing thank-you's (and the obligatory thanks to a supervisor). Use it (in the front matter again) like:

```
\begin{acknowledgements}
  Of the many people who deserve thanks, some are
  particularly prominent, for example...
\end{acknowledgements}
```

6.9 `preface` environment

Here's where you summarise the structure of the thesis to come, just before the main matter starts, with something like:

```
\begin{preface}
  This thesis describes my research on various aspects of...
\end{preface}
```

6.10 `\dedication`{⟨*text*⟩}

Dedicate your thesis to someone/something:

```
\begin{mainmatter}
  \dedication{For Jo}
  ...
  \end{frontmatter}
```

6.11 `\frontquote[`⟨*lang*⟩`]`{⟨*quote*⟩}{⟨*who*⟩}

Use this at the start of the main matter if you want to present the ethos of your thesis in a few choice words, for example:

```
\frontquote%
{Writing in English is the most ingenious torture\\
 ever devised for sins committed in previous lives.}%
{James Joyce}
...
\end{frontmatter}
```

`\frontquote` also takes an optional argument indicating which language the quote is in. This will change the quotation mark and hyphenation styles, if the babel and csquotes packages are loaded:

```
\frontquote[french]%
{Le savant n'\'etudie pas la nature parce que cela est utile; \\
il l'\'etudie parce qu'il y prend plaisir et il y prend plaisir
parce qu'elle est belle.}%
{Henri Poincar\'e, 1854--1912}
...
\end{frontmatter}
```

6.12 `\chapterquote[`⟨*lang*⟩`]{`⟨*quote*⟩`}{`⟨*who*⟩`}`

Something flippant/emotive to put at the start of chapters:

```
\chapter{\CP violation in the \Bmeson system}
\label{chap:basictheory}
\chapterquote{Laws were made to be broken.}%
  {Christopher North 1785--1854}
  ...
```

As for `\frontquote`, an optional language argument can be used.

6.13 `colophon` environment

A colophon is an inscription placed at the end of a book or other work that talks about how the work was created and what things were used in its creation. This should go in the back matter of your thesis and is completely optional. Frankly, I've

only ever seen them in O'Reilly tech books (and my own thesis, of course). If you use this, please mention `hepthesis`' rôle in making your thesis! Here's an example:

```
\begin{backmatter}
\begin{colophon}
  This thesis was made with ``hepthesis'' and it blew my mind...
\end{colophon}
...
```

6.14 `table` environment

Tables — use like any other table (probably combined with the tabular environment). It has been slightly modified to be horizontally centered and have an slightly increased vertical spacing at the top. It supports the standard LaTeX "[!htbp]" float placement specifiers.

6.15 `tabular` environment

If the `booktabs` package is used (enabled by default), then the tabular environment is re-defined to have a horizontal bar at top and bottom, which looks much nicer than TeX's default tables.

6.16 `figure` and `sidewaysfigure` environments

The `figure`, `figure*` and `sidewaysfigure` environments are re-defined to be automatically centered. They support the standard LaTeX "[!htbp]" float placement specifiers.

6.17 `equation` and `displaymath` environments

These environments and their starred versions are re-defined so that `equation` behaves like the normal `displaymath` environment. If the AMS package is used (which it is by default) then both are redefined to use the AMS `align` environment, which is much more powerful: it supports more intelligent label-placement, sub-equations and boasts a better alignment syntax than the default LaTeX displayed math environments. The AMS re-defined `equation` is suitable for most purposes — *all* my purposes, in fact.

6.18 `\verysubsection`{⟨*title*⟩}

A little command for in-line mini section headings, consisting of a boldened phrase specified by the argument, a bold colon and a space. Just for convenience, really, when all you want to do is label a paragraph without incurring all the vertical space of `\subsubsub...subsections`. Use it like:

```
\verysubsection{\Tevatron Run II experiments}
Since 1983 and until the commissioning of the \LHC is complete...
```

6.19 Semantic figure widths

Rather than specifying figure widths in raw terms, like centimetres, or document parameters like `\textwidth`, it's nice to be able to have a more semantic reference. Having a few standard width also helps to keep things looking consistent through the document. For these reasons, `hepthesis` provides four standard figure widths, `\smallfigwidth`, `\mediumfigwidth`, `\largefigwidth` and `\hugefigwidth`, which are defined in terms of the text width and chosen to avoid overflows. Use them like this:

```
\begin{figure}
  \includegraphics[width=\largefigwidth]{ckmfitter-alpha-combined}
  \caption{CKM Fitter constraints on \alphaCKM.}
  \label{fig:CKMFitter}
\end{figure}
```

Note also that this way of including images will automatically look for an `.eps` file when building PostScript and a `.pdf` file when building PDF. You may find the `eps2pdf` and `pdf2eps` utilities useful.

6.20 Standard in-document reference terms

It's nice to be able to refer to portions of your document with standard names, capitalisation, etc. For this reason, I've defined a bunch of macros which give consistent and sensible capitalisations. Using them systematically will ensure consistency in your references:

- `\Chapter` ⇒ Chapter

- `\Section` ⇒ Section
- `\Appendix` ⇒ Appendix
- `\Figure` ⇒ Figure
- `\Table` ⇒ Table
- `\Equation` ⇒ equation
- `\Reference` ⇒ reference
- `\Page` ⇒ page

Taking this consistency thing a step further, here are versions of the same commands which take the reference label as a argument:

- `\ChapterRef`
- `\SectionRef`
- `\AppendixRef`
- `\FigureRef`
- `\TableRef`
- `\EquationRef`
- `\ReferenceRef`
- `\PageRef`

Using these forms will ensure that the spacing between e.g. the worked "Chapter" and the chapter number is always the same, and that it won't wrap over line breaks. The equation, reference and page forms will call the `\eqref`, `\cite` and `\pageref` reference macros rather than `\ref`, which is used for all others.

7 Recommended extra packages

Here are some other packages it might be good to know about:

- **SIunits [22]:** *the* way to do units and get it right.
- **hepunits [23]:** my extension of `SIunits` to include some common HEP units not used elsewhere.
- **hepnames [24] and hepparticles [25]:** my packages for typesetting HEP particle names *properly*, with `hepnames` defining macros for a lot of the standard ones. Requires `maybemath` [26]

- **braket [27]:** decent implementation of Dirac bra and ket notation
- **cancel [28]:** the best way to do Feynman slashes (in my opinion)
- **feynmf/feynmp [29] and axodraw [30]:** various approaches to doing Feynman diagrams, especially in equations, inline contexts and so-on.

and some related software:

- **FeynDiagram [31] and Jaxodraw [32]**: for Feynman diagrams outside TEX. You might also be interested in my `pyfeyn` [33] program.
- **SLAC SPIRES' biblio tools service:** see `www.slac.stanford.edu/spires/`

8 An example `hepthesis` thesis

Here are some selected snippets from my thesis, which hopefully demonstrate the features described. I split my thesis into `preamble.tex` and `thesis.tex` files, with the front matter, back matter and chapters `\input`'d into `thesis.tex`. The output was built by running e.g.

```
pdflatex thesis.tex && bibtex thesis && pdflatex thesis.tex
```

(though I used a Makefile rather than do it directly). You should note that you might not be able to build this exact thesis due to missing packages: if you're writing a HEP thesis then I'd encourage you to use the `hepnames` LATEX package for typesetting particle names — it depends on the extra `hepparticles` and `maybemath` packages. The examples used here also rely on the `hepunits` package: you can all these extra packages from the CTAN [1]. See Appendix B for a quick guide on how to install personal copies of LATEX packages.

8.1 `preamble.tex`

```
\usepackage{xspace}
\usepackage{tikz}
\usepackage{morefloats,subfig,afterpage}
\usepackage{mathrsfs} % script font
\usepackage{verbatim}

%% Using Babel allows other languages to be used and mixed-in easily
%\usepackage[ngerman,english]{babel}
\usepackage[english]{babel}
\selectlanguage{english}
```

```
%% Citation system tweaks
\usepackage{cite}
% \let\@OldCite\cite
% \renewcommand{\cite}[1]{\mbox{\!\!\!\@OldCite{#1}}}

%% Maths
% TODO: rework or eliminate maybemath
\usepackage{abmath}
\DeclareRobustCommand{\mymath}[1]{\ensuremath{\maybebmsf{#1}}}
% \DeclareRobustCommand{\parenths}[1]{\mymath{\left({#1}\right)}\xspace}
% \DeclareRobustCommand{\braces}[1]{\mymath{\left\{{#1}\right\}}\xspace}
% \DeclareRobustCommand{\angles}[1]{\mymath{\left\langle{#1}\right\rangle}\xspace}
% \DeclareRobustCommand{\sqbracs}[1]{\mymath{\left[{#1}\right]}\xspace}
% \DeclareRobustCommand{\mods}[1]{\mymath{\left\lvert{#1}\right\rvert}\xspace}
% \DeclareRobustCommand{\modsq}[1]{\mymath{\mods{#1}^2}\xspace}
% \DeclareRobustCommand{\dblmods}[1]{\mymath{\left\lVert{#1}\right\rVert}\xspace}
% \DeclareRobustCommand{\expOf}[1]{\mymath{\exp{\!\parenths{#1}}}\xspace}
% \DeclareRobustCommand{\eexp}[1]{\mymath{e^{#1}}\xspace}
% \DeclareRobustCommand{\plusquad}{\mymath{\oplus}\xspace}
% \DeclareRobustCommand{\logOf}[1]{\mymath{\log\!\parenths{#1}}\xspace}
% \DeclareRobustCommand{\lnOf}[1]{\mymath{\ln\!\parenths{#1}}\xspace}
% \DeclareRobustCommand{\ofOrder}[1]{\mymath{\mathcal{O}\parenths{#1}}\xspace}
% \DeclareRobustCommand{\SOgroup}[1]{\mymath{\mathup{SO}\parenths{#1}}\xspace}
% \DeclareRobustCommand{\SUgroup}[1]{\mymath{\mathup{SU}\parenths{#1}}\xspace}
% \DeclareRobustCommand{\Ugroup}[1]{\mymath{\mathup{U}\parenths{#1}}\xspace}
% \DeclareRobustCommand{\I}[1]{\mymath{\mathrm{i}}\xspace}
% \DeclareRobustCommand{\colvector}[1]{\mymath{\begin{pmatrix}#1\end{pmatrix}}\xspace}
\DeclareRobustCommand{\Rate}{\mymath{\Gamma}\xspace}
\DeclareRobustCommand{\RateOf}[1]{\mymath{\Gamma}\parenths{#1}\xspace}

%% High-energy physics stuff
\usepackage{abhep}
\usepackage{hepnames}
\usepackage{hepunits}
\DeclareRobustCommand{\arXivCode}[1]{arXiv:#1}
\DeclareRobustCommand{\CP}{\ensuremath{\mathcal{CP}}\xspace}
\DeclareRobustCommand{\CPviolation}{\CP-violation\xspace}
\DeclareRobustCommand{\CPv}{\CPviolation}
\DeclareRobustCommand{\LHCb}{LHCb\xspace}
\DeclareRobustCommand{\LHC}{LHC\xspace}
\DeclareRobustCommand{\LEP}{LEP\xspace}
\DeclareRobustCommand{\CERN}{CERN\xspace}
\DeclareRobustCommand{\bphysics}{\Pbottom-physics\xspace}
\DeclareRobustCommand{\bhadron}{\Pbottom-hadron\xspace}
\DeclareRobustCommand{\Bmeson}{\PB-meson\xspace}
```

```
\DeclareRobustCommand{\bbaryon}{\Pbottom-baryon\xspace}
\DeclareRobustCommand{\Bdecay}{\PB-decay\xspace}
\DeclareRobustCommand{\bdecay}{\Pbottom-decay\xspace}
\DeclareRobustCommand{\BToKPi}{\HepProcess{ \PB \to \PK \Ppi }\xspace}
\DeclareRobustCommand{\BToPiPi}{\HepProcess{ \PB \to \Ppi \Ppi }\xspace}
\DeclareRobustCommand{\BToKK}{\HepProcess{ \PB \to \PK \PK }\xspace}
\DeclareRobustCommand{\BToRhoPi}{\HepProcess{ \PB \to \Prho \Ppi }\xspace}
\DeclareRobustCommand{\BToRhoRho}{\HepProcess{ \PB \to \Prho \Prho }\xspace}
\DeclareRobustCommand{\X}{\thesismath{X}\xspace}
\DeclareRobustCommand{\Xbar}{\thesismath{\overline{X}}\xspace}
\DeclareRobustCommand{\Xzero}{\HepGenParticle{X}{}{0}\xspace}
\DeclareRobustCommand{\Xzerobar}{\HepGenAntiParticle{X}{}{0}\xspace}
\DeclareRobustCommand{\epluseminus}{\Ppositron\!\Pelectron\xspace}
\DeclareRobustCommand{\protonproton}{\Pproton\APantiproton\xspace}
```

8.2 thesis.tex

```
%% For normal draft builds (figs undisplayed hence fast compile)
%\documentclass[hyperpdf,nobind,draft,oneside]{hepthesis}
%\documentclass[hyperpdf,nobind,draft,twoside]{hepthesis}

%% For short draft builds (breaks citations by necessity)
%\documentclass[hyperpdf,nobind,draft,hidefrontback]{hepthesis}

%% For Cambridge soft-bound version
\documentclass[hyperpdf,bindnopdf]{hepthesis}
%% For Cambridge hard-bound version (must be one-sided)
%\documentclass[hyperpdf,oneside]{hepthesis}

%% Load special font packages here if you wish
%\usepackage{lmodern}
\usepackage{mathpazo}
%\usepackage{euler}

%% Put package includes etc. into preamble.tex for convenience
\input{preamble}

%% You can set the line spacing this way
%\setallspacing{double}
%% or a section at a time like this
%\setfrontmatterspacing{double}


%% Define the thesis title and author
\title{A study of \BToKPi decays with\\ the \LHCb experiment}
```

```
\author{Andrew Gordon Buckley}

%% Doc-specific PDF metadata
\makeatletter
\@ifpackageloaded{hyperref}{%
\hypersetup{%
  pdftitle = {Studying B to K pi decays with LHCb},
  pdfsubject = {Andy Buckley's PhD thesis},
  pdfkeywords = {LHCb, B, physics, LHC, heavy flavour},
  pdfauthor = {\textcopyright\ Andy Buckley}
}}{}
\makeatother


%% Start the document
\begin{document}

%% Define the un-numbered front matter (cover pages, rubrik and table of contents)
\begin{frontmatter}
  \input{frontmatter}
\end{frontmatter}

%% Start the content body of the thesis
\begin{mainmatter}
  %% Actually, more semantic chapter filenames are better, like "chap-bgtheory.tex"
  \input{chap1}
  \input{chap2}
  \input{chap3}
  %% To ignore a specific chapter while working on another, making the build faster, comment it out:
  %\input{chap4}
\end{mainmatter}

%% Produce the appendices
\begin{appendices}
  \input{appendices}
\end{appendices}

%% Produce the un-numbered back matter (e.g. colophon,
%% bibliography, tables of figures etc., index...)
\begin{backmatter}
  \input{backmatter}
\end{backmatter}

%% Close
\end{document}
```

8.3 frontmatter.tex

```
%% Title
\titlepage[of Churchill College]{%
  A dissertation submitted to the University of Cambridge\\ for the degree of Doctor of Philosophy}

%% Abstract
\begin{abstract}%[\smaller \thetitle\\ \vspace*{1cm} \smaller {\theauthor}]
  %\thispagestyle{empty}
  \LHCb is a \bphysics detector experiment which will take data at
  the \unit{14}{\TeV} \LHC accelerator at \CERN from 2007 onward\dots
\end{abstract}


%% Declaration
\begin{declaration}
  This dissertation is the result of my own work, except where explicit
  reference is made to the work of others, and has not been submitted
  for another qualification to this or any other university. This
  dissertation does not exceed the word limit for the respective Degree
  Committee.
  \vspace*{1cm}
  \begin{flushright}
    Andy Buckley
  \end{flushright}
\end{declaration}


%% Acknowledgements
\begin{acknowledgements}
  Of the many people who deserve thanks, some are particularly prominent,
  such as my supervisor\dots
\end{acknowledgements}


%% Preface
\begin{preface}
  This thesis describes my research on various aspects of the \LHCb
  particle physics program, centred around the \LHCb detector and \LHC
  accelerator at \CERN in Geneva.

  \noindent
  For this example, I'll just mention \ChapterRef{chap:SomeStuff}
  and \ChapterRef{chap:MoreStuff}.
\end{preface}
```

```
%% ToC
\tableofcontents


%% Strictly optional!
\frontquote{%
  Writing in English is the most ingenious torture\\
  ever devised for sins committed in previous lives.}%
  {James Joyce}
%% I don't want a page number on the following blank page either.
\thispagestyle{empty}
```

8.4 chap1.tex

```
\chapter{\CP violation in the \Bmeson system}
\label{chap:SomeStuff}

%% Restart the numbering to make sure that this is definitely page #1!
\pagenumbering{arabic}

%% Note that the citations in this chapter use the journal and
%% arXiv keys: I used the SLAC-SPIRES online BibTeX retriever
%% to build my bibliography. There are also quite a few non-standard
%% macros, which come from my personal collection. You can have them
%% if you want, or I might get round to properly releasing them at
%% some point myself.

\chapterquote{Laws were made to be broken.}%
{Christopher North, 1785--1854}%: Blackwood's Magazine May 1830

Symmetries, either intact or broken, have proved to be at the heart
of how matter interacts. The Standard Model of fundamental interactions
(SM) is composed of three independent continuous symmetry groups denoted
$\SUgroup{3} \times \SUgroup{2} \times \Ugroup{1}$, representing the
strong force, weak isospin and hypercharge
respectively~\cite{Phys.Rev.Lett.19.1264, Phys.Rev.D2.1285,hep-ph/0410370}.

\section{Neutral meson mixing}
\label{sec:neutralmixing}
We can go a long way with an effective Hamiltonian approach in
canonical single-particle quantum mechanics. To do this we construct
a wavefunction from a combination of a generic neutral meson state
$\ket{\Xzero}$ and its anti-state $\ket{\Xzerobar}$:
%
\begin{equation}
```

```
  \ket{\psi(t)} = a(t)\ket{\Xzero} + b(t)\ket{\Xzerobar}
\end{equation}
%
which is governed by a time-dependent matrix differential equation,
%
\begin{equation}
  \I \pdByd{}{t} \colvector{a \\ b}
  =
  \underbrace{%
  \twomatrix{ M_{11}-\frac{\I}{2}\Gamma_{11}
            & M_{12}-\frac{\I}{2}\Gamma_{12} }
            { M_{12}^\ast-\frac{\I}{2}\Gamma_{12}^\ast
            & M_{22}-\frac{\I}{2}\Gamma_{22} }
  }_{\boldmatrix{H}}
  \colvector{a \\ b}
  .
\end{equation}
```

8.5 chap2.tex

```
\chapter{The \LHCb experiment}
\label{chap:MoreStuff}

\chapterquote{There, sir! that is the perfection of vessels!}
{Jules Verne, 1828--1905}

\section{The \LHC}
The Large Hadron Collider (\LHC) at \CERN is a new hadron collider,
located in the same tunnel as the Large Electron-Positron collider
(\LEP)~\cite{Brianti:2004qq}. Where \LEP's chief task was the use
of \unit{90--207}{\GeV} \epluseminus collisions to establish the
precision physics of electroweak unification\dots

% \begin{figure}
%   \includegraphics[width=\largefigwidth]{ckmfitter-alpha-combined}
%   \caption[CKM Fitter constraints on \alphaCKM.]%
%   {CKM Fitter constraints on \alphaCKM from combined \BToPiPi,
%     \BToRhoPi and \BToRhoRho decay analyses.}
%   \label{fig:CKMFitter}
% \end{figure}

\section{The \LHCb experiment}
\label{sec:LHCbInDetail}

Since both \bhadron{s} are preferentially produced in the same direction
```

```
and are forward-boosted along the beam-pipe, the detector is not required
to have full $4\pi$ solid-angle coverage. \LHCb takes advantage of this
by using a wedge-shaped single-arm detector with angular acceptance
\unit{10-300}{\mrad} in the horizontal (bending) plane~\cite{Amato:1998xt}.

\vspace{1cm}

\begin{center}
{\hspace{1mm}\Large\vdots\hspace{1cm}}
\end{center}

\vspace{1cm}

The detector is illustrated in \FigureRef{fig:LHCbCrossSection}, showing
the overall scale of the experiment and the surrounding cavern structure.

\begin{sidewaysfigure}
  \begin{center}
  \includegraphics[width=0.8\textheight]{lhcb-detector-cross-section}
  \caption[Cross-section view of \LHCb, cut in the non-bending $y$--$z$ plane]%
    {Cross-section view of \LHCb, cut in the non-bending $y$--$z$ plane.}
  \label{fig:LHCbCrossSection}
  \end{center}
\end{sidewaysfigure}

The single-sided detector design was chosen in preference to a two-armed
design since the detector dimensions are restricted by the layout of the
IP8 (ex-Delphi) cavern in which \LHCb is located. Using all the available
space for a single-arm spectrometer more than compensates in performance
for the \about{50\percent} drop in luminosity.

\section{The \Cerenkov mechanism}
A Huygens construction in terms of spherical shells of probability for photon
emission as the particle progresses along its track shows an effective
``shock-front'' of \Cerenkov emission. This corresponds to an emission cone of
opening angle \thetaCerenkov around the momentum vector for each point on the
track,
%
\begin{subequations}
  \label{eq:cosThetaCk}
  \begin{equation}
    \cos\,\thetaCerenkov  &= \frac{1}{n \beta} +
                             \frac{\hbar k}{2p}%
                             \parenths{ 1 - \frac{1}{n^2} } \\
                          &\,\sim \frac{1}{n \beta}%
```

```
    \label{eq:cosThetaCkApprox}
  \end{equation}
\end{subequations}
%
where $\beta \equiv v/c$, the relativistic velocity fraction.

\section{Trigger system}
\label{sec:triggers}
An overview of the \LHCb trigger characteristics broken down by level
is shown in \Table~\ref{tab:TriggerDetails}.

\begin{table}[bp]
  \begin{tabular}{lllll}
                & L0              & L1              & HLT             \\
    \midrule\\
    Input rate  & \unit{40}{\MHz} & \unit{1}{\MHz}  & \unit{40}{\kHz} \\
    Output rate & \unit{1}{\MHz}  & \unit{40}{\kHz} & \unit{2}{\kHz}  \\
    Location    & On detector     & Counting room   & Counting room   \\
  \end{tabular}
  \caption{Characteristics of the trigger levels and offline analysis.}
  \label{tab:TriggerDetails}
\end{table}
```

8.6 backmatter.tex

```
\begin{colophon}
  This thesis was made in \LaTeXe{} using the ``hepthesis'' class~\cite{hepthesis}.
\end{colophon}

%% You're recommended to use the eprint-aware biblio styles which
%% can be obtained from e.g. www.arxiv.org. The file mythesis.bib
%% is derived from the source using the SPIRES Bibtex service.
\bibliographystyle{h-physrev}
\bibliography{mythesis}

%% I prefer to put these tables here rather than making the
%% front matter seemingly interminable. No-one cares, anyway!
\listoffigures
\listoftables

%% If you have time and interest to generate a (decent) index,
%% then you've clearly spent more time on the write-up than the
%% research ;-)
%\printindex
```

9 Wishlist / TODO

I'm not planning on writing another thesis, but maybe I'll add features if there's demand. If you add a nice feature, pass it on to me and I'll think about including it in the package (and will give you some credit, of course). But anyway, here's the TODO:

- Make the spacing in the `\SectionRef` etc. commands customisable.
- Allow the PDF page style to be specified as a class argument
- Allow section titles to be centre / right justified?
- User control of frontmatter title sizes and alignments? (Probably not...)
- Provide different styles for the titlepage etc.
- Themes, like for Beamer?
- Make the vertical spacings on the quote, dedication and title pages change by paper size

10 Feedback

`hepthesis` has taken a lot of work...I hope you think it was worthwhile and that you enjoy using it. Or at least, I hope you enjoy writing your thesis more than you would have done without it! If you're feeling appreciative, then a teeny credit in your thesis acknowledgements would be hugely appreciated.

Other than that, any feedback on the package is very welcome, especially if it's constructive criticism! Email your thoughts to `hepthesis@insectnation.org`, please.

11 Acknowledgements

I'd like to thank all the people who have provided bug reports, patches, suggestions and who have otherwise helped me to get `hepthesis` to the state it's in. See the `ChangeLog` file in the distribution for names!

A Using your own derived document class

If you're feeling sophisticated, then you can make your own document class based on `hepthesis` by placing

```
\LoadClass{hepthesis}
```

in your own class definition file. This is a rather nice way of working, since it allows you to tweak the `hepthesis` defaults without cluttering your `.tex` file with preamble junk.

B Installing personal copies of LaTeX packages

Since `hepthesis` depends on several non-standard LaTeX packages, you may have to download and install them yourself. If you don't have `root` access to the computer on which you're working then you'll probably have to install them into your own home directory or similar. Since I expect quite a few prospective users of `hepthesis` will be non-experts in the ways of TeX, this is a quick guide on what to do.

1. Make a TeX directory tree in your home directory (or any other area you can write to), e.g.

   ```
   $ mkdir -p $HOME/local/texmf/tex/latex
   $ mkdir -p $HOME/local/texmf/bibtex/bib
   $ mkdir -p $HOME/local/texmf/bibtex/bst
   ```

2. Download the packages from CTAN [1] or wherever.

3. Follow the packages' installation instructions to install them into the `$HOME/local/texmf/tex/latex` directory you made above (or an appropriately-named sub-directory of it if you want to be neat). For simple `.sty` or `.cls` files, this will just involve copying them into your directory of choice. `.dtx` files will probably require running `latex` to build the files to be installed.

4. If you use the `bash` shell, add the following to your `~/.bashrc` file:

   ```
   export TEXINPUTS="$HOME/local/texmf/tex//:$TEXINPUTS"
   export LATEXINPUTS="$HOME/local/texmf/tex/latex//:$LATEXINPUTS"
   export BIBINPUTS="$HOME/local/texmf/bibtex//:$BIBINPUTS"
   ```

   or, if you use the `(t)csh` shell, add the following to your `~/.cshrc` file:

   ```
   setenv TEXINPUTS "$HOME/local/texmf/tex//:$TEXINPUTS"
   setenv LATEXINPUTS "$HOME/local/texmf/tex/latex//:$LATEXINPUTS"
   setenv BIBINPUTS "$HOME/local/texmf/bibtex//:$BIBINPUTS"
   ```

5. That's all: the lines above mean that LaTeX will look for input files such as classes, packages, images, `\input`'d `.tex` files etc. recursively under

`$HOME/local/texmf/tex/latex` and that BibTeX will look for its style and database files recursively under `$HOME/local/texmf/bibtex`.You can probably see how this can be extended to keep your thesis development directories neat, too!

C Distinguishing PS/PDF output in thesis builds

The options `bindnopdf` and `hyperpdf` change the behaviour depending on whether you're building PDF or PostScript output. This is fine if you only ever do one, but if you want to switch rapidly between these output formats then you'll have problems. This is because the `.aux` file, which records the reference keys and suchlike changes depending on whether you're making hyper-refs and if the changes of margins force sections on to different pages.

A nice solution to this involves using a Makefile, which you probably want to be doing anyway. You'll have to read up on the details of Makefiles (and possibly GNU automake) elsewhere, but to save on Make-newbie angst, I'll tell you that the indents in the following snippet *must* be tabs, rather than spaces! Here goes — put the following into a file called `Makefile`, change the `DOCNAME` variable to something which suits your project and run `make thesis` or `make thesispdf`:

```
# For a main thesis LaTeX file called ``thesis.tex''
DOCNAME = thesis

thesis: $(TEXSOURCES) $(DOCNAME).bbl
    test -f $(DOCNAME).aux.ps && cp $(DOCNAME).aux.ps \
      $(DOCNAME).aux || true
    latex $(DOCNAME)
    cp $(DOCNAME).aux $(DOCNAME).aux.ps
    ./thesisstats.sh >> buildlog.dat

thesispdf: $(TEXSOURCES) $(DOCNAME).bbl
    test -f $(DOCNAME).aux.pdf && cp $(DOCNAME).aux.pdf \
      $(DOCNAME).aux || true
    pdflatex $(DOCNAME)
    cp $(DOCNAME).aux $(DOCNAME).aux.pdf
    ./thesisstats.sh >> buildlog.dat
```

Otherwise you can just delete the `.aux` file when you change between using `latex` and `pdflatex`, but this will require more passes, since the `.aux` file has to be replaced each time.

References

[1] CTAN: `http://www.ctan.org`. `http://www.tex.ac.uk/tex-archive` is shortened to `ctan:` below.

[2] scrbook: `ctan:/macros/latex/contrib/komascript/`

[3] cite: `ctan:/macros/latex/contrib/cite/`

[4] setspace: `ctan:/macros/latex/setspace/`

[5] fancyhdr: `ctan:/macros/latex/contrib/fancyhdr/`

[6] rotating: `ctan:/macros/latex/contrib/rotating/`

[7] tocbibind: `ctan:/macros/latex/contrib/tocbibind/`

[8] subfig: `ctan:/obsolete/macros/latex/contrib/subfig/`

[9] caption: `ctan:/macros/latex/contrib/caption/`

[10] ccaption: `ctan:/macros/latex/contrib/ccaption/`

[11] changepage: `ctan:/macros/latex/contrib/changepage/`

[12] varwidth: `ctan:/macros/latex/contrib/varwidth/`

[13] csquotes: `ctan:/macros/latex/contrib/csquotes/`

[14] babel: `ctan:/macros/latex/contrib/babel/`

[15] a4wide: `ctan:/macros/latex/contrib/misc/a4wide.sty`

[16] amsmath: `ctan:/macros/latex/required/amslatex/math/`

[17] hyperref: `ctan:/macros/latex/contrib/hyperref/`

[18] booktabs: `ctan:/macros/latex/contrib/booktabs/`

[19] draftcopy: `ctan:/macros/latex/contrib/draftcopy/`

[20] lineno: `ctan:/macros/latex/contrib/lineno/`

[21] titling: `ctan:/macros/latex/contrib/titling/`

[22] SIunits: `ctan:/macros/latex/contrib/SIunits/`

[23] hepunits: `ctan:/macros/latex/contrib/hepunits/`

[24] hepnames: ctan:/macros/latex/contrib/hepnames/

[25] hepparticles: ctan:/macros/latex/contrib/hepparticles/

[26] maybemath: ctan:/macros/latex/contrib/maybemath/

[27] braket: ctan:/macros/latex/contrib/misc/braket.sty

[28] cancel: ctan:/macros/latex/contrib/misc/cancel.sty

[29] feynmf: ctan:/macros/latex/contrib/feynmf/

[30] axodraw: http://www.nikhef.nl/~form/FORMdistribution/axodraw/

[31] FeynDiagram: http://www.feyndiagram.com

[32] Jaxodraw: http://http://jaxodraw.sourceforge.net/

[33] PyFeyn: http://hepforge.cedar.ac.uk/pyfeyn/