THE PracTEX Journal

The online journal of the TeX Users Group
ISSN 1556-6994

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Approx. July 1st, 2008

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2008, Number 1
[Published 2008-04-01]

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In this issue

This first issue of 2008 is a small one, but each of the four papers teaches valuable new **LaTeXniques**, fitting the theme, as does Dave Walden's column.

All of these papers are hands-on technical papers. The first one, by Lapo Filippo Mori shows the use of many different packages, tools and TeXniques that will come in handy when writing a thesis. Most of this article will, however, be equally useful to people working on different kinds of manuscripts.

Jim Hefferon shows us a LaTeXnique *pur sang*: how to employ LaTeX in an automated work flow. His particular project is a way to automatically generate nicely laid out reports from a database, but his TeXniques are applicable in other situations as well.

Ista Zahn shows the use of the Sweave package which allows one to weave code written in the statistical language R into LaTeX source code, for one integrated document. He also teaches the use of the APA classes in this context.

Yogeshwarsing Calleecharan uses BibTeX for purposes it was not originally intended for. He shows that BibTeX can be very useful indeed for working with information that is not bibliographic in nature. Such information can often be stored in BibTeX databases, making it easy to format the output exactly as desired.

Dave Walden, in his column, has provided us with a new type of thought break, and — at least as important, if not more so — his diligent exploration of the various ways of implementing this symbol using a plethora of tools.

Thank you and enjoy this issue!

Next issue: Class and Style

For the next issue we invite readers to submit articles on *Class and Style*. How do you create the overall look of your paper? How do you design your chapter titles? How is this done in ConTeXt, how in LaTeX and how in ePlain? Let us now by submitting your papers!

Send your article idea to the editors.

Thanks

Many people have collaborated directly or indirectly to the success of this electronic journal: the authors, particularly the ones who have worked with me in the revision process, the production editors, and the readers.

Thanks to my fellow issue editor Keith Jones, production editor Lance Carnes; reviewers Francisco Reinaldo, Will Robertson, and Jon Breitenbucher; and to others who proofread the articles and provided useful comments and feedback.

Editorial: LaTeXniques

TeX, LaTeX, ConTeXt, LuaTeX, Omega, Aleph, etc. all have one thing in common. Well, many things actually, but one thing that I would like to explore in depth here: the propensity for configuration, adaptation and automation. I don't think most serious users have written many papers before they started defining their own macros, searching CTAN for additional packages and programs, or even writing their own extensions of the system. Such TeXniques can make life a whole lot easier!

Two of the advantages of thinking things through properly and using a package or creating a macro rather than resorting to ad hoc hacks are that solutions to a problem encountered while working on one project can easily be transferred to the next project and the fact that improved solutions can easily be dropped in as a replacement of the previous version.

I'll give an example. As a biologist I used species names in many of my papers from the first time I used LaTeX in 1995 onwards. Species names traditionally consist of two names, the first one of which (the genus name) is capitalised, the second one of which is never capitalised, and both are italicised. An example is *Homo sapiens*. It is possible to add the name of the taxonomist who first described the species and the year this happened. Those bits of information should never be italicised.

My naive first approach was to use `\emph{}` every time I used a species name. I quickly fell into the trap of getting things wrong that way. One journal used `\emph{}` to typeset the abstract in italics, which meant my species names were no longer italicised in the abstract. Luckily I didn't just go ahead and change every `\emph{}` around a species name into `\itshape{}`. I did at least realise that if this was again not the best way of doing it, I wouldn't want to go over my document again. Instead, I created a new command

```
\newcommand[1]{\species}{\itshape{#1}}
```

and changed every affected `\emph{}` into a `\species{}`.

That solved the problem, and is — of course — a trick that even most absolute beginners already master. Over the years, however, I have made additions to my `\species{}` command, which I use when working on a book. The command also automatically adds entries into my *Index Taxonomicus*, an index of species names. The basic version of this command is defined like this:

```
\newcommand[1]{\species}{\itshape{#1}\index{#1}}
```

Soon I needed more than that still. If I had several species in the same genus, I'd want them to be indexed together: *Barbus tetrazona*, *Barbus cumingii* and *Barbus melanampyx*, all as sub items

under the *Barbus* item, for example. So I came up with:

```
\newcommand[2]{\species}{\itshape{#1 #2}\index{#1!#1 #2}}
```

This is, of course, a rather significant alteration. It requires changing each and every `\species{}` command in the text into `\species{}{}`. Luckily I already had a `\species{}` command to begin with, and *all* of them had to be changed (as opposed to the `\emph{}` situation where only some had to be changed, but not all), so a clever macro in my text editor (jed) sufficed.

And still it didn't end. When one keeps on using the same names over and over again in the same paper, one tends to abbreviate the genus name: *Barbus tetrazona* becomes *B. tetrazona*. If I did that, I still wanted them to be indexed properly, so I needed an optional argument in which I could pass the full genus name, for indexing purposes.

To cut a potentially long story short, after one or two years of continuous improvements and changes, I had come up with a solution that seemed to cover most cases fairly well. The code had grown in length and complexity, and I started passing it on to some of my fellow LaTeX users within the department. It seemed to be becoming a proper *LaTeXnique* saving people work.

Since there were still an increasing number of exceptions popping up — though luckily they were also increasingly rare or even downright obscure uses of species names — that had to be dealt with by hand, and since the code was by now ugly, incomprehensible to others and not unlike a spaghetti bolognese, I thought it wasn't quite ready for submission to CTAN yet. Maybe I was just too shy. I intended to clean up the code, write some proper documentation (in Web, of course) and maybe along the way deal with some more of the exceptional cases.

Unfortunately, research, other work with and on TeX, and maybe even Real Life kept on providing me with excuses not to clean up my `species` code base. Excuses I seemed all too eager to grab. I even fixed one or two rather minor bugs in AMS-LaTeX rather than publish my first ever package. And then in 2001 — 6 years after my first feeble attempt — Pieter Edelman published his package `biocon`. It does many things much better than my package ever did. It also does things I hadn't solved yet or hadn't even realised. It doesn't do indices though. So instead of making my own code publication-ready I decided to see if I could merge my code for dealing with indices with Pieter's code, and propose to him that he submit an updated version.

And that was in 2001. Now it is 2008. I have spent lots of time on Biology, on TeX, and on life in general. I have published several papers, a book and several megabytes worth of source code. What I haven't even started, though, is merging my `species` code with `biocon`.

So if you were reading this editorial hoping for a Good Example, I have probably disappointed you. The authors of the various papers in this issue, however, will certainly not disappoint you. I urge you, therefore, to bravely soldier on to the rest of this issue.

Happy TeXing!

Yuri Robbers.

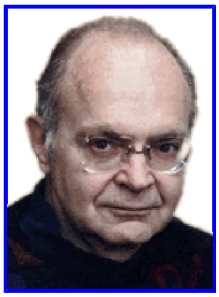
THE PracTEX Journal

News from Around: TeX program updates; Bigelow introduces Grotesque; Day of LaTeX; Keming (?)

The Editors

- Comment on this paper
- Send submission idea to editor

Knuth updates TeX
Bigelow introduces Grotesque
Day of LaTeX
Keming??



Don Knuth's recent TeX and METAFONT program bug fixes

The programs that format our LaTeX and TeX documents are based on the TeX program, developed by Donald Knuth during 1978-1982. MetaPost, a program for drawing figures, is based on Knuth's METAFONT. Professor Knuth updates these programs from time to time. Recently he released a set of corrections for "a few minor bugs", and gives his rationale for not correcting all known bugs.

Reading his note is instructive and shows his concern for the stability of the underlying system. References such as "TeX \S9" and "MF \S9" refer to sections in the actual code of TeX (see TeX: The Program) and METAFONT (see METAFONT: The Program). The "TAOCP" he mentions is *The Art of Computer Programming*, currently a three-volume set, with Volume Four in preparation. Many of the concepts and algorithms presented in TAOCP are used in the implementation of TeX and METAFONT.

There are several people in the TeX community who maintain the programs we all use, for example pdfeTeX, and more recently XeTeX, which are based on Knuth's TeX program. The maintainers will decide how to incorporate his changes so that a future release of your TeX or LaTeX system will include Professor Knuth's updates.

Some trivia: the current version of TeX is 3.1415926 (which is closing in on *pi*), and the current version of METAFONT is 2.718281 (approaching the mathematical constant *e*). The reward for the first finder of a bug in TeX or METAFONT is $327.68 (software types reading this will

recognize that sum as a power of two). Given the (currently) weak dollar, that amount of money will probably buy only a beer and a pizza outside the U.S., but most bug finders who receive a check from Don Knuth don't cash it but keep it as a souvenir. See "Rewards" at http://www-cs-faculty.stanford.edu/~knuth/abcde.html#abcde for information on his bug-finding bounties.

Bigelow introduces Grotesque

Charles Bigelow, the designer of Lucida and other typefaces, will appear at the Dryden Theater's series on Graphic Design in Film. The movie "Helvetica" will be shown there on April 19 and 20, and Charles will introduce the April 19 showing with a talk on the evolution of the "grotesque" style of type, of which Helvetica is the most famous example.

If you are in Rochester in mid-April catch Chuck and the movie http://dryden.eastmanhouse.org/program-highlights/a-curious-type-graphic-design-in-film/.

Day of LaTeX

Since there are no scheduled LaTeX or TeX meetings in the US this year, would you like to attend a Day of LaTeX?

A Day of LaTeX is usually held in a meeting room equipped with a computer projector, and features several speakers who present hands-on tutorials on the use of LaTeX. Each presenter prepares a 60-90 minute tutorial on some aspect of LaTeX, such as LaTeX basics, LaTeX and graphics, typing math, and others. Each presenter also provides one or more sample documents which attendees will work on during the session. Attendees are typically new LaTeX users, or those who want to brush up on their skills. Some recent days of LaTeX were sponsored by UK TUG and PCTeX.

(To be a presenter doesn't mean you have to be a LaTeX expert. Your job is to introduce a subject to beginners that you have some experience with. For example, if you have written documents that include bibliographies you can show how *you* do this.)

If you are interested in being a presenter or attendee, or if you would like to host a Day of LaTeX, please send a note to the editor. Some possible venues are San Francisco, Los Angeles, New York, Boston, Chicago, or your town or campus.

If you are in Europe, consider attending workshops at one of the scheduled conferences: TUG08 in Ireland, or BachoTeX in Poland.

New advances in typography department: keming

The TeX Tuneup of 2008

[Email to tex-implementors@tug.org list from Don Knuth, 2008-03-18]

I've written this note while going through the long, long file of bug reports
and suggestions that were submitted during the years 2003--2007. You know
that I am committed to keeping TeX and MF as stable as possible, while
also correcting serious blunders that are likely to be harmful if left as is.
It is certainly not always obvious where to draw the line; I intend to keep
drawing it as close to the existing implementations as I can, without
feeling extremely guilty.

The index to Digital Typography lists eleven pages where the importance
of stability is stressed, and I urge all maintainers of TeX and MF to read
them again every few years. Any object of nontrivial complexity is non-optimum,
in the sense that it can be improved in some way (while still remaining
non-optimum); therefore there's always a reason to change anything that
isn't trivial. But one of TeX's principal advantages is the fact that
it does not change --- except for serious flaws whose correction is
unlikely to affect more than a very tiny number of archival documents.

Let me give two examples. First, David Kastrup observes that TeX doesn't
do the best possible rounding when it converts units. One inch is
exactly 72.27 points, which is exactly 4736286.72 scaled points.
When you say `1in', TeX converts it to 4736286sp; when you say `72.27pt',
TeX converts it 4736287sp, which is about 23.6 Angstrom units closer
to the truth. With a simple change to TeX \S458, namely to add
`denom div 2' before dividing by `denom', the rounding would be slightly
better. But that would invalidate the line-break and page-break decisions
of an enormous number of documents. It's unthinkable to change TeX
in such a way today. But of course the authors of other systems should
adopt superior methods when they want to.

Second, I recently installed MetaPost version 0.993, which corrected
a bug in the calculation of the bounding box of its outputs.
I'm a user of MetaPost, not a developer; but I'm sort of glad that the
developers had fixed this bug. On the other hand it was a tremendous
headache for me, because it affected nearly 200 of the illustrations for
The Art of Computer Programming, and caused severe changes to the layouts
of more than a dozen pages, even though the individual corrections to
the box sizes were typically 2pt or less! I spent three days going over
everything so that I could once again typeset the volumes of my main
life's work. I couldn't reasonably insist that the MetaPost developers
retain such a serious bug as a ``feature.'' With TeX, on the other hand,
it's a different story, because people's accumulated investment in
TeX documents is more than a million times the total current investment
in MetaPost documents. If a comparable bug had showed up in TeX,
I would {\it not\/} have changed it.

Let me also observe that I never intended TeX to be immune to vicious
``cracker attacks''; I only wish it to be robust under reasonable
use by people who are trying to get productive work done. Almost every
limit can be abused in extreme cases, and I don't think it useful to
go to extreme pain to prevent such things. Computers have general
protection mechanisms to keep buggy software from inflicting serious

damage; TeX and MF are far less buggy than the software for which such mechanisms were designed. For instances of the philosophy that I had while writing these programs, see for instance TeX \S9 and MF \S9, which say that I expected the programs to be run with arithmetic overflow interrupt turned on; also TeX \S104: ``TeX does not check for overflow when dimensions are added or subtracted ... the chance of overflow is so remote that such tests do not seem worthwhile"; MF \S369 says that the total weight in a picture ``will be less than 2^{31} unless the edge structure has more than 174,762 edges"; MF \S558, ``we shall assume that the coordinates are sufficiently non-extreme"; MF \S930, ``users aren't supposed to be monkeying around with really big values."

------ a proposal re file errors ----------

I think the following change would be nice for the next versions of TeX, MF, etc.: In place of the current message
Please type another %s file name:
produced by prompt_file_name, let's substitute
Please type another %s file name (or quit):
and then if the user's response is `quit' we do the equivalent of control-C. If the response is null, let's give a help message.

This modification should be handled by change files, keeping the master files tex.web and mf.web and whatever.web as they are. I never have intended to control the aspects of user interaction on particular systems.

Maybe also introduce a finite loop, with `(or quit)' replaced by `(or I'll quit)' the third or fourth time. I agree that infinite loops are evil, and I'm sorry that prompt_file_name is invoked only within infinite loops in my own programs. If I had thought of this idea earlier, I'd have added a global variable like max_prompt_repeats, and initialized it to 3 or 4 just before those infinite loops; then prompt_file_name would decrement it, or give up if it's zero.

Another possibility is `(or quit or retry)', except the last time. That wording is a bit more suited to computer geeks, who have ideas about fixing things by repairing file permissions, etc.; if the user responds with either `retry' or null, the intention is clearly to try again because of some reason to hope for success. Still, I prefer the non-geek version, because it reaches more people and enables the null-for-help option. Let the geeks type a few more keystrokes --- they get satisfaction in other ways.

------ TeX ----------
TeX version 3.1415926 corrects a few minor bugs, following major studies by David Fuchs. A summary of the noteworthy changes to the Pascal code in tex.web can be found near the end of the (long) file errata/tex82.bug. Here are the most significant ones, in decreasing order of importance:

1. Leaders with \mskip glue never worked properly; this feature has now been disallowed.

2. Error recovery was incorrect when an extra right brace appeared within a macro parameter.

3. TeX's inner loop now runs a bit faster.

4. The size of insert boxes is now displayed more accurately by \showlists.

5. A restriction on .tfm files enforced by TFtoPL (namely that there must
be at least one entry in each of the width, height, depth, and italic
correction tables) is now enforced also by TeX, since noncompliance could
cause a mess.

6. TeX used to leak four words of memory if arithmetic overflow occurred
when \multiply or \divide was applied to glue or muglue.

7. The old iniTeX could leak four words of memory in another way (but at
most four total), if "last_glue" pointed to a glue specification when
the format file was created.

There's an undocumented feature, which is inconvenient to explain anywhere
in The TeXbook: \pagedepth is cleared to zero when the current page disappears
into \box255; but \pagetotal, \pagestretch, \pagefilstretch, \pagefillstretch,
\pagefilllstretch, and \pageshrink are zeroed later, when the current
page becomes nonempty. (That's the time \pagegoal is set, and recorded
in the log file with a %% line if you're tracing pages.) I don't recall
why there is a discrepancy, but I certainly don't want to diddle with
any of that logic at this late date.

Here are some other things that I don't want to touch:

i. David Kastrup found a glitch in plain TeX's footnote-splitting
mechanism. Everything works according to the documentation in The TeXbook,
and I can't possibly make a change to such a sensitive part of TeX's
logic at this late date. But his example is quite interesting, and I'd like
to discuss it here for the benefit of people planning other systems.

Here's his construction (to be used with plain TeX):

```
\def\testpage#1{\dimen0=#1
\vrule height .5\dimen0 depth .5\dimen0 \quad #1\par
Some text.\footnote*{A bigbreak follows...
\bigbreak
A bigbreak preceded.}
\par\vfill\supereject}
\testpage{8.17in}
\testpage{8.23in}
\testpage{8.2in}
```

The first test page is an example where the entire footnote fits fine.
In the second one, the footnote needs to be split; so two pages are
generated, one with the first half of the footnote, as desired.

The third test page illustrates the problem: Plain TeX uses the worst
of both strategies! Namely, it generates two pages, in which the
first is underfull, while the second has the text and footnote
that would have fit on the first page.

Why does plain TeX screw up here? Well, TeX knows that the footnote
doesn't fit, when typeset at its natural height+depth of 36pt. So it
tries to split it, by choosing a height threshold: It says
to the vsplit routine, ``Please give me your best break that doesn't
exceed a height of 30.089pt." (That is what's left after we start
with plain TeX's vsize of 8.9in and subtract the page-total-so-far,

which is 8.2in for the vrule, plus 1pt of lineskip, plus 7.5pt
for the height of `Some text.', plus 12pt to separate the text
from its first footnote.) The vsplit algorithm discovers two ways
to break the footnote: One has height 8.5pt (the height of
`* A bigbreak follows...'), depth 1.94444pt, and penalty -200
(at the bigbreak); the other has natural height 32.5pt, depth 3.5pt
(which comes from a strut placed by plain TeX), and penalty -10000
(the force-out penalty at the very bottom of the footnote).
This latter break is considered viable because 4pt of glue shrinkage
is available to bring the height down to 30.089pt. Naturally vsplit
chooses the latter alternative.

Then TeX does something dumb. It records the result of the split
in the list of contributions to the current page, in such a way
that the first part of the split will be included on the page only
if there's room for its natural height+depth, namely 36pt in this
case. (And in this case, the ``first part of the split'' actually
turns out to be the whole footnote.) Therefore, when TeX next
finds a legal breakpoint, the current page limit has been exceeded,
and the line with its footnote is deemed not to be permissible.
The previous break, which leaves an underfull vbox, is chosen
instead of ``overfilling'' the page --- even though there is
really enough shrinkability to bring the page back to size.

As I said, it's too late now to correct my age-old faulty reasoning.
If I'd known about the problem twenty years ago, I may well have
decided to make the change that seems most appropriate to me
today, which is this:

@x module 974
best_height_plus_depth:=cur_height+prev_dp;
@y
best_height_plus_depth:=cur_height+prev_dp;
if (best_height_plus_depth>h+prev_dp) and (b<awful_bad) then
best_height_plus_depth:=h+prev_dp;
@z

In other words, the log file (with tracingpages=1) now gets the line
% split254 to 30.08878,36.0 p=-10000
but after that patch it would instead say
% split254 to 30.08878,33.58878 p=-10000
and the footnote would wind up on the first page where it belongs.

When I made the mistake ages ago, I probably wasn't thinking of
shrinkability inside the footnote, only in the ``virtual'' amount
of space within \skip254 that separates the text from its footnotes.
Indeed, the present problem goes away if one sets \skip254=12pt minus 8pt.
But that workaround would be appropriate only for this particular example.

ii. Section 798 could be made more robust with "until q=cur_align"
moved down one line. Implementors can put this into a change file if they like.

iii. The format plain.tex leaves \box0=\hbox{\tenex B}; and it also defines
\\ to be a macro such that "\\10pt" expands to "10." (for example).
I could have cleaned these up by saying something like
{\setbox1=\box0} \let\\=\undefined
but I decided not to change it, since plain.tex is so widely used as is.

iv. Frank Mittelbach reported a construction of Morten H{\o}gholm Pedersen:
\parindent=0pt
\setbox0=\hbox{p} \hsize=\wd0
\discretionary{m-}{h}{p}\par
It gives an overfull box, because TeX doesn't see any feasible breakpoint.
(More precisely, the pre-break part exceeds the line width, and TeX
doesn't look ahead to see if some fairy godmother is going to save us.)
Thus TeX is resigned to making an overfull box, and it takes the
only legal breakpoint it knows.

This must be considered a feature of TeX's line-break algorithm.
Namely, a discretionary break is normally never taken when the
pre-break part would make an overfull box; but it is always taken
in the unusual case that no other feasible break is possible (without
looking ahead at the third, ``unbroken'' alternative of the discretionary).
A problem can arise only if an unhyphenated word is actually shorter
than its first hyphenated fragment. What, me worry?

Amusingly, if you put the line
\spaceskip=0pt plus 1fill \discretionary{p}{\kern-2em}{}
before the other discretionary, you get two p's and nothing overfull.

v. Jonathan Kew mentioned some of the surprising effects that occur
when you try to do things in the command line (or in the very first
line of TeX's input, at the ** prompt). There are many, many such.

Before TeX knows the job name, it outputs just to the terminal.
Log file output won't happen until an \input command has occurred,
or input line one has been processed, whichever comes first,
because the log file is given its name at that time.

For example,
**\showhyphens{whatever}
will show `what-ever' on the terminal, but not in the log file. Same for
**\showhyphens{whatever} \input foo
but in this case the log file is called foo.log instead of texput.log. With
**\input foo \showhyphens{whatever}
you see what-ever also in foo.log.

------- plain TeX format ------
Version 3.141592653 of plain.tex is identical to version 3.14159265,
except that \errorstopmode is no longer invoked by the \tracingall
and \loggingall macros. (That mistake had been in plain.tex for more
than 25 years, and I thank David Kastrup for the wakeup call.)

------- MF --------------------
Turning now to METAFONT, Thorsten Dahlheimer gave the whole program a
much-needed scrutiny and came up with a number of bugs that have now been
corrected in version 2.718281. (Incidentally, he has also given me invaluable
help finding mistakes in the darker corners of TAOCP.) Only one of those
bugs was serious enough to affect real programs with high probability;
the others are the sorts of things that a good nitpicker will spot
when reading code, although the actual misbehavior requires weird scenarios.
As usual, you can find details of the significant changes to Pascal
code in the file errata/mf84.bug. The complete source file mf.web
shows many instances of improved commentary.

1. The serious bug arose from user input such as
boolean b[]; b1=true=b2;
earlier versions of MF would go into an infinite loop from such
constructions, so evidently nobody ever writes code like this.
(Strings, paths, and pictures have similar problems, not just booleans.)
No problem would occur if the statement had been "b1=b2=true" instead.
I forgot to include one instruction in my program, and it's a glaring
error in section 1003.

This bug is also in the METAPOST source, mp.web, which I assume somebody else
will fix. Whoever does that should also look carefully at the other
changes just made to mf.web, since so much of the code is common to both.

2. There also were problems in the TFM files when extremely large
characters or dimensions were present. For example, from
mode:=lowres; mode_setup; designsize:=10pt#;
beginchar("!",160pt#,-160pt#,160pt#); endchar; end
you get a tfm file with a bad character width and depth, because of an
off-by-one error in my code. (TFtoPL doesn't complain about the
character height, which violates some but not all of the documentation
of TFM files: A fix_word is supposed to lie between -2048 and 2048-2^{-20},
inclusive, but the MFbook says that no TFM dimension should result
in the fix_word value -2048. TeX has no problem inputting that value.)

3. Another TFM problem was tweaked with ultralarge design sizes:
fontmaking:=1; designsize:=2000; fontdimen 2: 3000; shipout nullpicture; end
used to set fontdimen 2 (the SPACE parameter) to be about 32000 points. The
correct behavior is to reduce fontdimen 2 to just less than 2048 points.

4. Weird behavior could previously occur with
transform T; T=identity xscaled 4 yscaled 3 rotated 180;
pickup pencircle transformed T; show currentpen;
which always came out correctly without the (redundant) rotation by 180.

5. Another bug arose in code fragments like
string a.b; a.b="lost"; outer a; numeric a.c; showvariable a;
the string a.b was indeed now lost. (METAPOST probably fails in the same way.)

6. METAFONT now checks that serial numbers don't overflow. Actually I
had recommended that the program always be run with arithmetic integer
overflow trapped; but this doesn't seem to be current practice. If
a user creates 2^{25} distinct numeric variables, the "METAFONT capacity
exceeded" error now occurs; formerly, this would have caused arithmetic
overflow. (Well, this correction was actually made already in TeX-live change
files some years ago; I've now introduced it into the master file mf.web,
in a slightly different way.)

Not a bug: The init_gf procedure has an assignment to str_start[str_ptr+1]
that looks like it could cause a segmentation fault if str_ptr=max_strings.
Actually, however, that can't happen. (The test "str_ptr+3>max_strings"
in end_name, together with the fact that area_delimiter=0 in that
procedure because cur_area="", provides the extra breathing space.)
But I changed init_gf anyway.

Anomalies that won't be changed: Autorounding does not work properly
when filling certain nonconvex shapes, such as

pickup makepen((-.6,0)--(.6,0)--cycle);
filldraw (2,0){up}..(0,1){down}..(1,0){down}..(0,-1){down}..cycle
at point (1,0). Pens whose width and height are not integers are deprecated;
there's no point cluttering up the code with stuff that benefits only them.

One of MF's (and MP's) most interesting algorithms is the way it chooses
control points and directions for paths that are partially specified. I ran
into a curious glitch some years ago when preparing an illustration for
my book Selected Papers on Computer Languages: The two paths
(0,0){dir45}...(15,0)...(0,0){dir150}
and (0,0){dir-45}...(15,0)...(0,0){dir-150}
turn out to have amazingly different shapes. (The first one twists around
almost unbelievably, while the second looks reasonable.) I tracked this
down to the equations in MF's "solve_choices" routine, which chooses the
desired "turning angle" at the point (15,0). In both cases this
value, psi[1], is set to n_arg(-983040,0); here -983040 is the
internal (scaled) representation of -15, and n_arg is supposed to
determine the value of angle(-15,0). [See page 67 of the MFbook.]
The answer is 180, which is appropriate in the second case,
but the first case really wants the answer to be -180.

------- Computer Modern ----------

I made a noticeable change to the shape of one (and only one)
letter in the CM family, namely the calligraphic F. The new one
has a slightly different swash, which pleases me more when I look
at it in The Art of Computer Programming. The change is small,
yet it would be nice if people would remake the Type 1 versions of
the fonts that use calu.mf, namely cmsy* and cmbsy*.

The lowercase Greek nu could develop a tiny notch at the bottom,
especially at high resolutions of boldface versions (brought to
my attention by Charles Duan, who conjectured its existence by
reading the source code!). So I corrected that problem.

Duan also found a few other places where the source code was
logically wrong in greekl.mf. I fixed those too. However, those changes
don't actually show up in the generated font, since the differences
in point positions are minuscule.

Karel Piska noticed that the bulbs of lowercase a and c are positioned
rather differently when the ``blacker'' parameter of a mode varies. (He
blamed it on varying resolution, but that's because my code was obscure.)
In those characters I essentially try to move strokes apart so that
there's twice as much white space as the thickness of the pen; therefore
a blacker pen makes the strokes go further apart. My logic was faulty,
because the ``blacker'' setting was intended to compensate for differences
in the device that make its apparent pen width too small, thereby making the
actual appearance after printing only as black as it would have been on
an ideal device; increasing ``blacker'' by 1 shouldn't make me reposition
any strokes. Yet I do actually reposition them, on the lowercase a,
by roughly 2 pixels per unit of blacker! And the bulb on c is positioned
to be like that of a. Still, the repositioned bulbs look OK, and I'm happy
to continue forever with this wart in the design.

-------- TeXware ----------
TFtoPL version 3.2 is identical to version 3.1 except that a (missing)

newline character now appears after one of the warning messages.

---- Computers & Typesetting ----
Dozens of corrections were made to Volumes A, B, C, D, and E of
the books Computers & Typesetting, bringing everything uptodate with
respect to the latest sources. (This includes The TeXbook, which is a
paperback Volume A, and The METAFONTbook, which is a paperback Volume C.)
Copies of the corrected books won't be available for sale until the
publisher's stock of already-printed volumes is depleted; but I've
prepared detailed errata from which you can make hardcopy inserts
to paste into the books you have.

-------- Summary ----------
All of the results of my changes appear in the following files:
tex/texbook.tex % source file for The TeXbook
tex/tex.web % complete master file for TeX in Pascal
tex/trip.fot % torture test terminal output
tex/tripin.log % torture test first log file
tex/trip.log % torture test second log file
tex/trip.typ % torture test output of DVItype
texware/tftopl.web % complete master file for TFtoPL in Pascal
mf/mfbook.tex % source file for The METAFONTbook
mf/mf.web % complete master file for METAFONT in Pascal
mf/trap* % (namely trap.fot, trapin.log, trap.log, trap.typ, trap.pl)
mf/trap.fot % torture test terminal output
mf/trapin.log % torture test first log file
mf/trap.log % torture test second log file
mf/trap.typ % torture test output of GFtype
mf/trap.pl % torture test output of TFtoPL
cm/calu.mf % master source file for calligraphic capital letters
cm/greekl.mf % master source file for lowercase greek letters
cm/symbol.mf % master source file for special symbols
errata/errata.ten % changes to Volumes ABCDE before 2001
errata/errata.eleven % changes to Volumes ABCDE in 2001
errata/errata.tex % changes to Volumes ABCDE since the 2001 boxed set
errata/tex82.bug % changes to tex.web since the beginning
errata/mf84.bug % changes to mf.web since the beginning
errata/cm85.bug % changes to Computer Modern metafont sources since 1985
These files are available in directory pub/tex/dist of the ftp server
cs.stanford.edu, which accepts "anonymous" as a login name. They are a
subset of the files in pub/tex/dist/tex08.tar.gz, which you can compare
to pub/tex/dist/tex03.tar.gz if you like. Hopefully they will be easy
to incorporate into the major distributions of TeX, and they will
presumably soon be available on CTAN.

In general the changes can be characterized as a general cleanup,
especially to the documentation. The new versions don't affect old
documents, except when the existing behavior was seriously incorrect.
(And except for the fact that TeX will often run a bit faster now.)

To do this revision I waded through more than 600K bytes of text files,
not counting the binary .pdf and .png files that were also submitted.
Barbara Beeton faithfully compiled all of this material during the
years 2003--2007, and organized it so that my task wasn't hopeless.
She had many volunteers helping to separate wheat from chaff; needless
to say, I'm extremely grateful for all of this assistance.

The total number of independent topics about which I had to make a decision, after they had come come through the filtering process, was approximately 335. Some of these needed several days of thought and careful study; some of them needed only a few seconds. More than a hundred of them were nontrivial, and I did my best.

So now I send best wishes to the whole TeX community, as I leave for vacation to the land of TAOCP --- until 31 December 2013. Au revoir!

THE PracTEX Journal

Writing a thesis with LaTeX

Lapo Mori

Abstract

This article provides the tools to write a thesis with LaTeX. It analyzes the typical problems that arise while writing a thesis and suggests solutions, mainly referring to existing packages. Many suggestions can also be applied to other kinds of document such as a book and a journal article.

Lapo Mori is a graduate student in Mechanical Engineering at Northwestern University (Evanston, IL, USA). He started using LaTeX in 2003 while working on his B.S. thesis and has been an enthusiastic user since then. He became a member of GuIT (Italian TUG) in 2003, an administrative member in 2003 and the vice president in 2007. He was among the founders of Ars TeXnica in 2006, the first Italian journal on TeX and LaTeX, and has served as an editor since then. You can reach Lapo at www.lapomori.com.

- PDF version of paper
- Article source
- Bibliography style file
- Bibliography database
- Additional style file
- Comment on this paper
- Send submission idea to editor

For submission to The PracTEX Journal
Draft of April 12, 2008

Writing a thesis with LaTeX

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Abstract This article provides useful tools to write a thesis with LaTeX. It analyzes the typical problems that arise while writing a thesis with LaTeX and suggests improved solutions by handling easy packages. Many suggestions can be applied to book and article styles, as well.

*I would like to thank Fabiano Busdraghi who helped me to write sec. 4, Massimiliano Dominici who took care of the Linux and UNIX systems in sec. 4.1.2 and Riccardo Campana who took care of the Macintosh system in sec. 6.2.2. I would also like to thank everyone else who contributed and in particular Valeria Angeli, Claudio Beccari, Barbara Beeton, Gustavo Cevolani, Massimo Guiggiani, Maurizio Himmelmann, Caterina Mori, Lorenzo Pantieri, Francisco Reinaldo, Yuri Robbers, and Emiliano Vavassori. Without their help this article wouldn't have reached the current form.

Contents

Preface

This article is not a guide on how to write a thesis but explains how to rightly use LaTeX resources when writing it. I will not cover all variant details because there are many, so I prefer to focus on specific problems and offer practical solutions. In order to follow this article, the reader should already know the basics of LaTeX and should already have read a guide [1, 2, 7, 12, 21, 25, 27] or a book [4, 8, 10, 11, 13, 14, 16–18].

1 The document class

The book class is the most suitable to write a thesis. The author has freedom to choose the following class options:

- font size (`10pt`),[1]
- paper size (typically `a4paper` or `letterpaper`),
- if having the text on both sides of the page (`twoside`) or only on the front (`oneside`),
- if placing the chapter titles only on right pages (`openright`) or any (`openany`).

The book class has some advantages over the report class since it defines three commands (`\frontmatter`, `\mainmatter`, and `\backmatter`)[2] that control the page number and chapter numbering formats. In the *frontmatter*, pages are numbered with lower case Roman numbers (i, ii, iii, etc.) and the chapters are not numbered (as if the asterisk version `\chapter*{}` was used). In the *mainmatter*, pages are numbered with Arabic numbers (the numbers start from 1) and the chapters are numbered with Arabic numbers as well. In the *backmatter*, the pages are numbered as in the mainmatter (numbering continues) but the chapters are not numbered.

The `twoside` option is recommended because:

- it halves the waste of paper,[3]
- it allows to have different headers for left and right pages,

1. For good readability on A4 and letter paper it is advisable to use a base font size of 11 pt.
2. Information on how to use these commands is reported in sec. 3.
3. Unfortunately most students try to use every typographic trick to increase the number of pages of their thesis (widening the margins, increasing the font size, increasing the line spacing, adding a lot of figures, printing on one side only, etc.). Beside the fact that the quality of the content is far more important than the quantity, these tricks usually produce an ugly layout. The advice is to focus on the content and leave the typographic job to LaTeX (which is, by the way, pretty good at it).

– it produces the same layout as most books.

For example, the following command formats the thesis on both faces of letter paper, with an 11 pt base font size, with chapter titles always on the right hand page:

```
\documentclass[11pt,letterpaper,twoside,openright]{book}
```

The memoir class is a good alternative since it is very flexible and customizable (headers and footers, chapter titles, footnotes, table of contents, other lists, etc.).

2 Organizing the files

Managing a complex document, such as a book or a thesis, can be complicated and so it is advisable to divide it into several files. LaTeX allows to work with several files, but a main file should control them with `\include` or `\input` commands. On the one hand, the `\input{filename}` command can be used to call a file. It can even be nested so that an `\input`ed file can `\input` files of its own. On the other hand, the `\include{filename}` command defines the command `\includeonly` with features to compile just some of the files that are called throughout the document, `\includeonly{filename1,filename2,...}`. When using `\includeonly{filename1,filename2,...}`, LaTeX compiles just the files that are between the curly braces and does not update the counters (i.e. page numbers, footnote numbers, etc.) making the process faster.

3 Sections of the thesis

The structure of a thesis is broadly discussed in specific books and especially by specific ISO rules that treat about the presentation of technical reports [15]. This section proposes a possible structure and analyzes the problems that arise for each section.

A thesis can have the following structure:[4]

- Title page°
- Dedication*°
- Abstract*°
- Acknowledgements*°
- Table of contents and other lists°
- Table of symbols and notation*
- Preface*

} frontmatter

- Inner chapters
- Appendices*

} mainmatter

- Bibliography
- List of acronyms*
- Index*

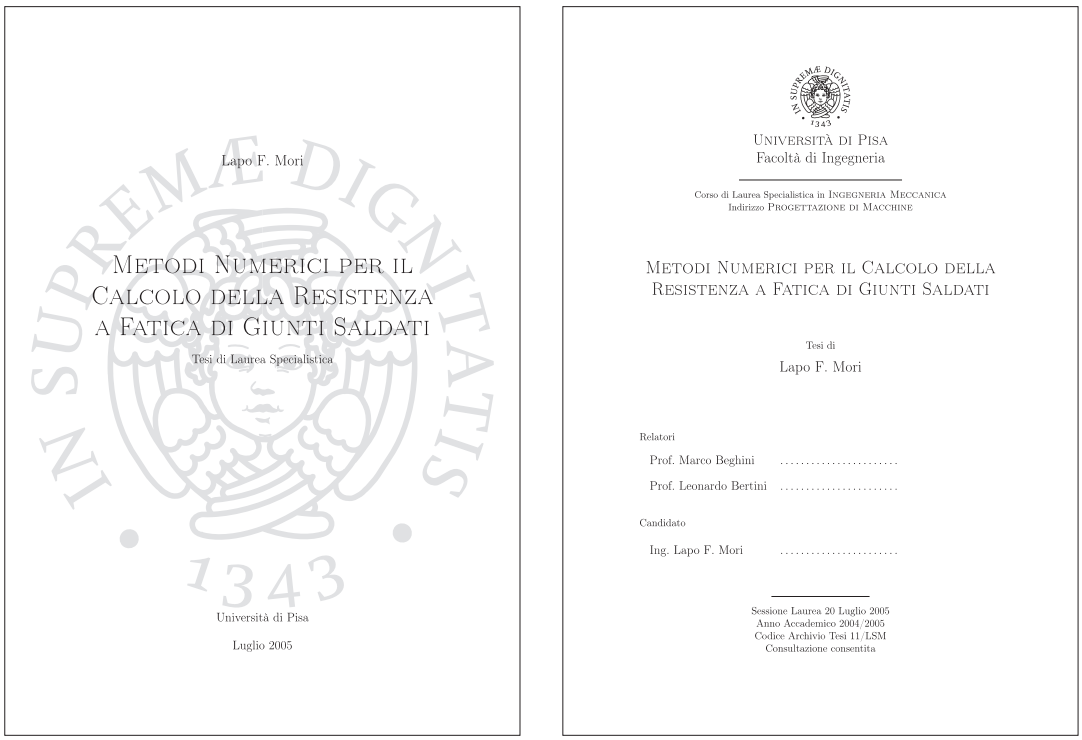
} backmatter

3.1 Title page

Since the thesis layout and contents are usually defined by university requirements, the title page often needs to be created *ad hoc*. The title page is often formed by two pages; the first one reports just the name of the candidate and the second one also that of the advisors, the department chair and their signatures. The standard LaTeX commands [4, 7, 8, 10, 16–18, 21] should be sufficient to create these pages. Some hints on how to set the code are available on the Web.[5]

4. The symbol * indicates optional sections and ° indicates sections that must not be in the table of contents.

5. http://zoonek.free.fr/LaTeX/LaTeX_samples_title/0.html



(a) **(b)**

Figure 1: Example of title page.

In order to place the university coat of arms in the page background as in Fig. 1a, the eso-pic package and the following command can be added to the preamble

```
\newcommand\AlCentroPagina[1]{%
    \AddToShipoutPicture*{\AtPageCenter{%
    \makebox(0,0){\includegraphics%
    [width=0.9\paperwidth]{#1}}}}}
```

and then use it as

```
\AlCentroPagina{seal_name}
```

The dots on which to place the signature (Fig. 1b) can be obtained with the `\dotfill` command. The titling package allows one to modify the behavior of

the `\maketitle` command. However, the thesis title page is usually so different from that produced by the standard LaTeX classes that it is easier to redefine it from scratch.

3.2 Dedication

The dedication, when present, can have many different formats depending on the author's taste. Usually (Fig. 2) it is just a line aligned to the right which can be obtained with

```
\begin{flushright}
...
\end{flushright}
```

The vertical position of the dedication can be arbitrary. An easy way to control it is with a couple of `\vspace{\stretch{...}}` commands which let the user decide the ratio between the space preceding and the one following the line. For example, in order to set the space following the dedication twice as wide as that preceding, it is possible to use the command

```
\null\vspace{\stretch{1}}
...
\vspace{\stretch{2}}\null
```

3.3 Abstract

The abstract is generated by the environment

```
\begin{abstract}
...
\end{abstract}
```

which is available for the article and report classes. When using the book class it is necessary to define the abstract in the preamble (the code that follows is the definition used by the report class).[6]

6. Instructions on how to use the fancyhdr package can be found in sec. 6.3.1.

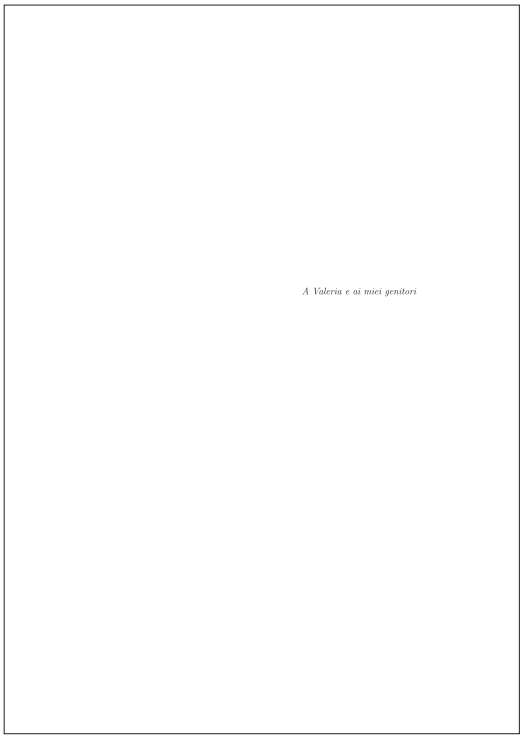


Figure 2: Example of dedication.

```
\usepackage{fancyhdr}
\pagestyle{empty}

\newenvironment{abstract}%
{\cleardoublepage\null \vfill\begin{center}%
\bfseries \abstractname \end{center}}%
    {\vfill\null}
```

Sometimes it is useful to have the abstract written in two languages. The babel package can be used to select the correct name of the abstract and the hyphenation. If, for example, you need to write the abstract both in Italian and in English, you need to load the babel in the preamble with

```
\usepackage[english,italian]{babel}
```

and then use the following commands in the text:

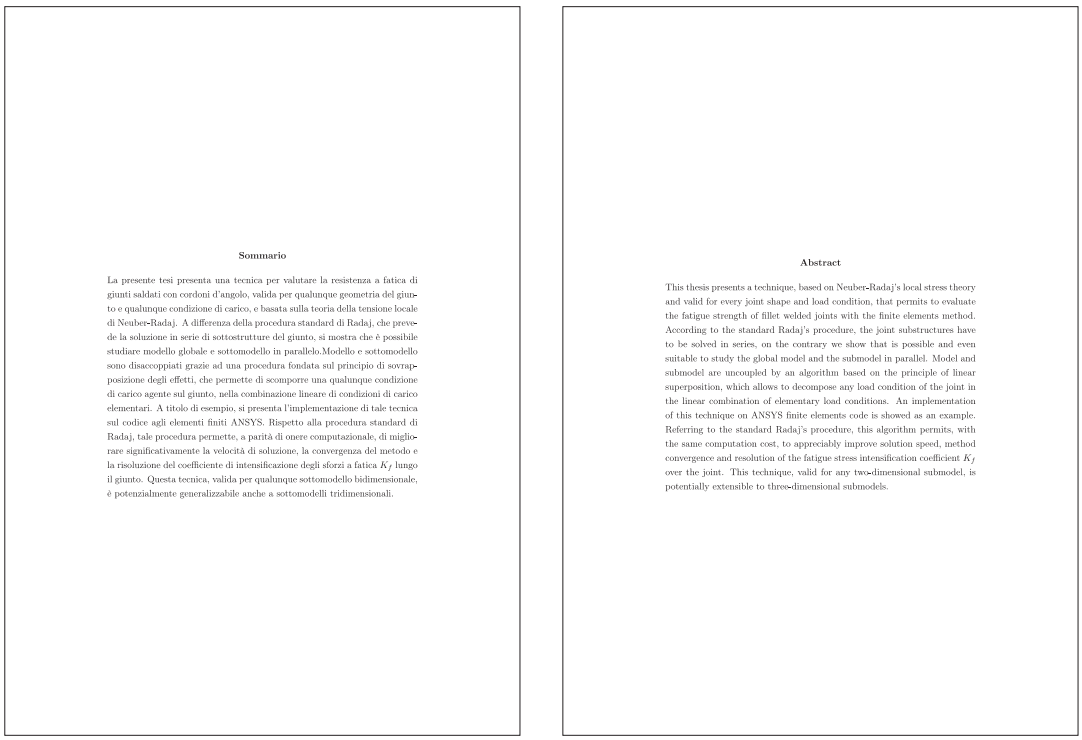


Figure 3: Example of abstract in two languages.

```
\selectlanguage{italian}%
\begin{abstract}
... versione del sommario in italiano ...
\end{abstract}

\selectlanguage{english}%
\begin{abstract}
... English version of the abstract ...
\end{abstract}
\selectlanguage{italian}%
```

The result is reported in Fig. 3.

3.4 Table of contents and other lists

The table of contents and the other lists usually come right after the abstract in the following order:

- table of contents
- list of figures
- list of tables
- other lists

These are automatically created with LaTeX using the commands:

```
\tableofcontents
\listoffigures
\listoftables
```

The float package, with the `\newfloat` and `\listof` commands, can be used to create lists of custom floating objects (e.g. programs, algorithms, etc.). The tocloft package can be used to modify their layout.

3.5 Table of symbols and notation

It is sometimes useful to give the reader a table with the symbols and the notation used in the thesis (Fig. 4). The nomencl package automatically generates such a list with the MakeIndex program. It is otherwise possible to manually create the table with the tabular environment.

3.6 Appendices

The appendices are normal chapters whose numbering is with the Roman alphabet letters. They can be created just by using the `\chapter{...}` command preceded by `\appendix`[7] as in the following example:

7. `\appendix` must be used only once even if there are multiple appendices.

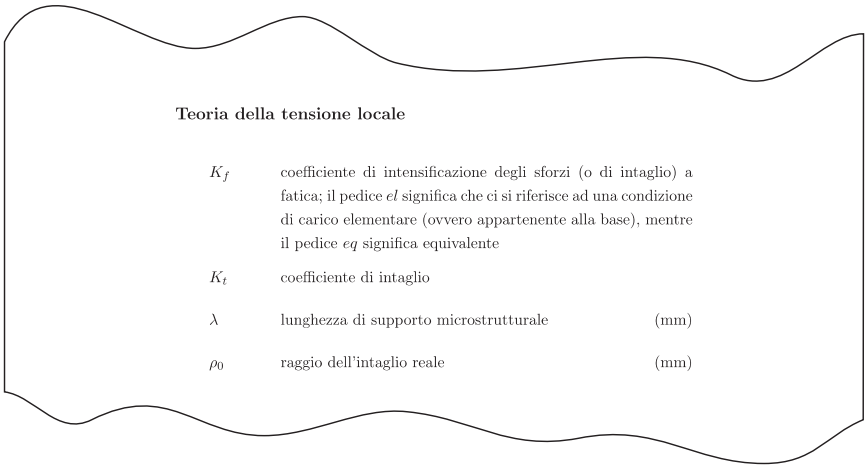


Figure 4: Example of a list of symbols.

```
...
\mainmatter
\include{chapter1}
\include{chapter2}
\include{chapter3}

\appendix
\include{appendix1}
\include{appendix2}
...
```

3.7 Index

The index can be automatically created with the makeidx package and the MakeIndex program. The `\makeindex` command must be in the preamble. In order to balance the columns of the last page of the index, it can be inserted into a `multicols` environment[8] redefining the `theindex` environment with the following code

```
\let\orgtheindex\theindex
```

8. This environment requires the multicol package.

```
\let\orgendtheindex\endtheindex
\def\theindex{%
  \def\twocolumn{\begin{multicols}{2}}%
  \def\onecolumn{}%
  \clearpage
  \orgtheindex
}
\def\endtheindex{%
  \end{multicols}%
  \orgendtheindex
}
```

3.8 Bibliography

The bibliography, like the index, can be automatically generated by LaTeX. It can be created with the thebibliography environment, but it is far better to use BibTeX, a program that allows to separate the content of the bibliography (stored in `.bib` databases) and the style (defined by `.bst` files). The `.bib` files are just text files that can be created with any text editor but it is advisable to use bibliography dedicated editors. JabRef[9] is one of the best bibliography managers and, being based on Java VM, it is available for all platforms (Windows, Linux, and Mac OS X).

The natbib package is a very useful and flexible tool to format both the bibliography and the references in text as it is thoroughly described in its guide. Every LaTeX distribution and the natbib package offer several bibliography styles; it is, however, possible to create a custom style. The user just needs to compile the `makebst.tex` file and interactively answer the questions. This process creates a `.dbj` file that just needs to be compiled with LaTeX to produce the `.bst` style. The `\url{}` command provided by the url package automatically breaks long URLs over several lines. The bibliography can be added to the table of contents with the `\addcontentsline` command.

9. http://jabref.sourceforge.net/

The following code typesets the references with the plain style, adds the bibliography to the table of contents (for a thesis the bibliography section is a chapter), and loads the `ThesisBib.bib` database. The name of the bibliography section is added to table of contents with the `\bibname` command in order to let it be dependent on the language used.[10]

```
\cleardoublepage
\bibliographystyle{plain}
\refstepcounter{chapter}
\addcontentsline{toc}{chapter}{\bibname}
\bibliography{ThesisBib}
```

4 Objects

4.1 Figures

Figures are one of the most popular subject for LaTeX guides. There are even guides and books [3, 9, 23] completely dedicated to this subject. The reader should refer to them for the details.

LaTeX users are usually faced with two kinds of problems regarding the figures. The first kind has its origin in the figure file itself and will be discussed in sec. 4.1.1, the second kind regards their placement and will be discussed in sec. 4.3.

4.1.1 Formats

Images can be divided into two big classes: vector images and bitmap images. The format to use should not be chosen arbitrarily since each one is suitable for different purposes. The first class, defined as groups of geometric shapes, can be scaled and deformed without losing definition or sharpness and is recommended

10. `\bibname` becomes "Bibliography" with the `english` option, "Bibliografia" with the `italian` option.

for graphs, schemes and every other image that can be defined in terms of simple geometric entities. The second class, defined as matrices of colored pixels, cannot be deformed without altering the information content and should be used only in cases in which vector graphics are not usable, i.e. for photographs, artistic paintings, etc.

The conversion between vector and bitmap graphics should always be avoided. In fact, on the one hand the conversion from vector (e.g. `.eps` or `.pdf`) to bitmap image (e.g. `.bmp`, `.jpg` or `.png`) eliminates all the information on the geometry contained in the figure and deteriorates the quality of the image and the possibility to resize it without losing any detail. On the other hand, the conversion from a bitmap to vector graphics does not improve its quality, it just inserts the bitmap inside a vector frame. The only way to obtain a true vector graphic image from a bitmap is to trace it with dedicated applications such as Potrace.[11]

The bounding box is a fundamental parameter of `.eps` files. It defines the size of the image and is used by LaTeX to compute how much space to assign to the figure. The bounding box should ideally be the minimum rectangle that contains the image. Sometimes, however, graphics applications leave margins (i.e. empty space) between the image and its bounding box. This may cause some confusion because, although LaTeX is assigning to the figure the right space, it may seem that the figure is too small, not centered, etc. Ghostview[12] can be used to open the figure, visualize the bounding box, and check if the dimensions are correct. If they are not, the best option is to change settings in the application that generated the `.eps`. Alternatively GSView[13] can compute the optimal bounding box[14] or the user can directly open the `.eps` file with a text editor and modify the values defining the bounding box, which are usually in the first few lines. The details on how to use figures with PDFLaTeX and to convert them from `.eps` to `.pdf` are reported in sec. 5.2.

11. http://potrace.sourceforge.net/
12. http://www.ctan.org/tex-archive/help/Catalogue/entries/ghostscript-afpl.html
13. http://www.ctan.org/tex-archive/help/Catalogue/entries/gsview.html
14. File - PS to EPS - Automatically calculate Bounding Box.

4.1.2 Useful packages

The graphicx package needs to be loaded in order to insert figures. Its guide is very useful.[15] Subfigures (Fig. 1) can be obtained with the subfig package.[16] In many cases this package is not even needed since more than one figure or table can be inserted into a figure or table environment, as shown in the following example

```
\begin{figure}[tb]
  \includegraphics[width=0.3\textwidth]{fig:a}
  \caption{caption:a}\label{fig:a}
  \hspace{4em}
  \includegraphics[width=0.3\textwidth]{fig:b}
  \caption{caption:b}\label{fig:b}
\end{figure}
```

This is a good way to reduce the number of floating objects and to facilitate their placement.

It is advisable to collect all the figures in one or more subfolders to keep the source files in order. If the `fig:a` figure is inside the `fol_1` folder, the user should specify it

```
\includegraphics{fol_1/fig:a}
```

By the way, it is far more convenient to specify the folder's name just once in the preamble with the command

```
\graphicspath{{fol_1/},{fol_2/}}
```

The path declared with `\graphicspath` can be relative to the folder hosting the main `.tex` file (as in the previous example), or absolute,[17] as, for example,

```
\graphicspath{{c:/documents/thesis/images/}}
```

The caption package allows to easily format captions.

15. http://tug.ctan.org/tex-archive/macros/latex/required/graphics/grfguide.pdf
16. This package supersedes the subfigure package, which has been declared obsolete by its own author.
17. On Linux or UNIX systems the absolute path cannot take advantage of the tilde expansion. For example `\graphicspath{{/home/lapo/documents/thesis/images/}}` should be used instead of `\graphicspath{{~/documents/thesis/images/}}`.

4.2 Tables

The ctable package improves the spacing of the standard tabular environment. The xcolor package with the table option can be used to color the background or rows, columns, and cells. When dealing with big tables, it is possible to:

- scale down the table, for example with the following commands:

```
\begin{center}
    \resizebox{0.95\textwidth}{!}{%
    \begin{tabular}
    ...
    \end{tabular}}
\end{center}
```

- rotate the table by 90° with the rotating package,[18]
- break the table over several pages with the supertabular package.

For further details the reader can refer to a specific guide, such as [20].

4.3 Controlling the floating objects

LaTeX users often complain about the position of figures (and of floating objects in general). In most cases this is due to a wrong use of the position options for the floating objects. This section explains what should be done while writing (sec. 4.3.1) and what while reviewing the text (sec. 4.3.2).

4.3.1 What to do while writing

First of all the user should accept the fact that LaTeX moves a floating object either because there is no space on a given page or for esthetic reasons. Luckily, when using the right commands, LaTeX does a very good job.

The very first thing to do is to avoid commands like `\clearpage` and let LaTeX choose automatically the position of the floating objects: while writing the thesis,

18. Other techniques to rotate tables and figures are reported in [28].

the author should be focused only on the content and not be concerned about the layout. Almost any interference in the complex routine that LaTeX uses to place the floats causes the result to be worse. The following suggestions assure that the floats are placed as close as possible to their insertion point without any intervention by the author.

One of the major causes of dissatisfaction is the use of the `[h]` option which asks LaTeX to place the figure at the same point where it appears in the code. Even worse than `[h]` are the `[htbp]` and the `[h!t]` options. It is common belief that this option is the best to guarantee that the object remains close to the point where it appears in the code. It actually works only when the object is very small (compared to `\textheight`). The only thing that the author should determine is whether the object is small enough to appear on a page with other text or will require a whole page to itself. In the first case the best option is `[tb]`, in the second `[p]`. If there are no floats left to place, then in the first case LaTeX will place the object just before its insertion point (which cannot happen when using `[h]`) or on the following page. When using the `[p]` option for big objects, they will be placed on a separate page right after the insertion point and not at the end of the chapter as in the case of `[tbp]`. This is what is done in every book with a good layout: the figures are either at the top or at the bottom of a page, in a blank page if very big, and in the text if very small. Some users are annoyed by figures that precede their reference in the text (e.g. a figure that appears at the top of the page of its reference in the text). This problem can be easily solved with the flafter package that prevents the floating object from appearing before its definition in the text.

In general, LaTeX chooses a good place for figures if the ratio

$$\frac{\text{text}}{\text{figures}}$$

is sufficiently high. Thus it is advisable, not only from a typographic point of view, to write something interesting instead of filling up the thesis with figures.

If this ratio is too low, LaTeX may produce this error:

```
! LaTeX Error: Too many unprocessed floats.
```

This is due to the fact that LaTeX can allocate only a limited amount of memory to place the floating objects. If there are too many floats to be processed, this amount of memory might be insufficient [5]. This problem can be solved with the `\FloatBarrier` command, provided by the placeins package, which cannot be crossed by floating objects and forces LaTeX to place all the ones that are still in memory. If possible, even the `\clearpage` command can be used. It inserts a page break and also places all the unprocessed floats. The morefloats package increases the number of floats that can be held in memory from 18 to 36. Some journals require that all the figures are placed at the end of the draft. The endfloat package does that automatically.

Should all these tricks not be enough, the user can make some manual adjustments just before printing, as explained in the next section.

4.3.2 What to do while reviewing

Just before printing the thesis, it might be necessary to adjust manually the position of some floating objects such as tables and figures. The float package provides the `H` position option which make the floating objects non-floating and forces their placement in the exact place in the text. The `\FloatBarrier` command (see sec. 4.3.1) can even be used to fine tune the position of some objects. LaTeX provides some commands to globally control the floating objects:

`\setcounter{topnumber}{...}` maximum number of floats in `t` position for each page

`\def\topfraction{...}` maximum page fraction for floats in `t` position for each page

`\setcounter{bottomnumber}{...}` maximum number of floats in `b` position for each page

`\def\bottomfraction{...}` maximum page fraction for floats in `b` position for each page

`\setcounter{totalnumber}{...}` maximum number of floats in the same page

`\setcounter{dbltopnumber}{...}` maximum number of big floats in the same page

`\def\textfraction{...}` minimum fraction of the page for the text

`\def\floatpagefraction{...}` minimum page fraction for floats in `p` position for each page

`\def\dbltopfraction{...}` maximum part of a two-column text page that can be occupied by two-column floats at the top.

`\def\dblfloatpagefraction{...}` minimum part of a page that has to be occupied by two column wide floating objects before a 'float page' is produced.

5 Compiling the code

5.1 Choosing the format

The LaTeX code can be compiled to obtain a DeVice-Independent file (`.dvi`) or a Portable Document Format file (`.pdf`).[19] Each format has advantages and disadvantages. On the one hand, the `.dvi` allows a direct search (with a double click on the code inside the text editor, the `.dvi` viewer finds the corresponding output) and inverse search (with a double click on the output inside the `.dvi` viewer, the text editor positions the cursor at the corresponding position in the code) that are very useful when writing the thesis. Unfortunately most `.dvi` viewers do not render properly the effects of the graphicx package such as `\resizebox` and `\rotatebox`[20] and cannot take advantage of the microtype package (see sec. 5.2).

19. There is actually a third option, the PostScript file (`.ps`), but it has been substituted by the `.pdf` format as the *de facto* standard.

20. YAP (MiKTeX `.dvi` viewer) solved this problems since the 2.5 version.

The `.pdf` format, on the other hand, although it does not allow direct and inverse search,[21] renders correctly all the effects of the graphicx package, takes advantage of the microtype package, is a very popular format even outside the TEX and LATEX community, takes advantage of the hypertext links of the hyperref package, and allows to restrict the document access with a password.[22]

In conclusion, it is recommended to use the `.dvi` while writing and the `.pdf` for printing the thesis and distributing it in electronic format.

5.2 Creating a PDF

There are several ways to create a `.pdf` with LATEX, such as:

- converting a `.dvi` or a `.ps` file with Ghostscript,
- directly compiling the source `.tex` code with PDFLATEX.

Without going into the details, for which a good reference is [24], in order to exploit all the potential of the PDF format[23] it is necessary to use PDFLATEX which is available in most LATEX distributions.

The main difference between the two methods is the file format for the figures; while the conversion from `.dvi` or `.ps` files requires `.eps` images, PDFLATEX requires `.pdf` (if vector graphics) or `.jpg` and `.png` (if bitmap).[24] In order to use PDFLATEX, the user is required to convert all `.eps` into `.pdf` files. The conversion can be easily done with Ghostscript by using the graphical user interface eps2pdf.[25] If the document has to be compiled both with LATEX and PDFLATEX it is

21. The MacTeX distribution for Apple computers allows direct and inverse search even with `.pdf` files.

22. A password can be used to limit access to the document, to limit the print options (restrict it or allow it only at low resolution), and to limit changes (text extraction, page extraction or removal, etc.).

23. The PDF format allows to use hypertext, bookmarks, thumbnails, and document information which are not available when converting `.dvi` and `.ps` files.

24. The details about image format are reported in sec. 4.1.1.

25. eps2pdf is a graphical user interface for Windows and is available on CTAN (`http://www.ctan.org/tex-archive/support/eps2pdf/`). Linux users can use the homonymous `sh` procedure

advisable not to specify the extension of the image files in the `\includegraphics` command; if, for example, the document has the `figure_01.eps` image, the user need to convert it into `figure_01.pdf` with eps2pdf and then add to the code

```
\includegraphics{figure_01}
```

In this way, LaTeX automatically loads `figure_01.eps` and PDFLaTeX `figure_01.pdf`.

The hyperref package needs to be loaded in order to create hypertext links in a document.[26] To learn how to use TrueType fonts with TeX (LaTeX) and PDFTeX (PDFLaTeX) the reader can visit http://www.radamir.com/tex/ttf-tex.htm. The microtype package is highly recommended when using PDFLaTeX because it improves line filling with:

- *font expansion*: it horizontally expands the characters in order to optimally fill each line;
- *character protrusion*: it let some characters to protrude into the margins (typically the hyphens and punctuation signs).

These two modes are already enabled when the package is loaded without any options:

```
\usepackage{microtype}
```

6 Useful packages

6.1 Hyphenation

Hyphenation is controlled by the babel package and depends on the active language. If the thesis is in English, the following command should be used

```
\usepackage[english]{babel}
```

or epstopdf (both of them from command prompt). All these programs just use GhostScript to convert `.eps` into `.pdf`.

26. Even some `.dvi` viewers support hypertext links.

The babel package is necessary to have hyphenation but not sufficient: the file with the hyphenation patterns for the used language should be active (refer to the documentation of the LaTeX distribution used).[27] For English the definition file is `hyphen.tex`.

LaTeX correctly syllabifies almost every English word. However, in some cases, when using rare words or names, the author might need to suggest the correct hyphenation with the command `\hyphenation` in the preamble. The words must be between curly braces and separated by a space as in the following example

```
\hyphenation{hy-phen-a-tion mar-vel-ous-ly}
```

This command can even be used to force that some words are not syllabified: they just need to be written without hyphens as in the following example:

```
\hyphenation{MATLAB Mathematica}
```

When a word appears just once or only a few times, it is possible to suggest the hyphenation directly in the text with the `\-` command as in the following example

```
hy\-phen\-a\-tion
```

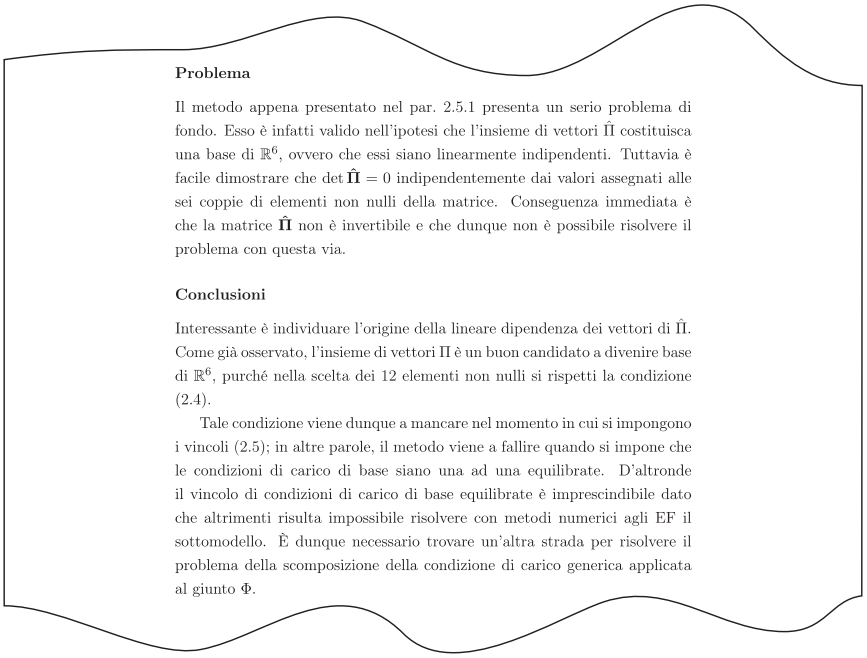
The author should always remember that all manual operations on the hyphenation should be done only during the review process immediately before printing. It is often better to rewrite a sentence that causes an `overfull` warning than to impose a certain hyphenation.

6.2 Languages other than English

6.2.1 Indentation

In some languages (e.g. Italian) the first paragraph needs an indentation on the first line (Fig. 5). This can be easily achieved with the indentfirst package.

27. Here is reported as an example the procedure to activate the `hyphen.tex` file on MiKTeX: from the "languages" panel on "MiKTeX options" activate "english – hyphen.tex" and then update the formats with "Update Formats" in "General".



Problema

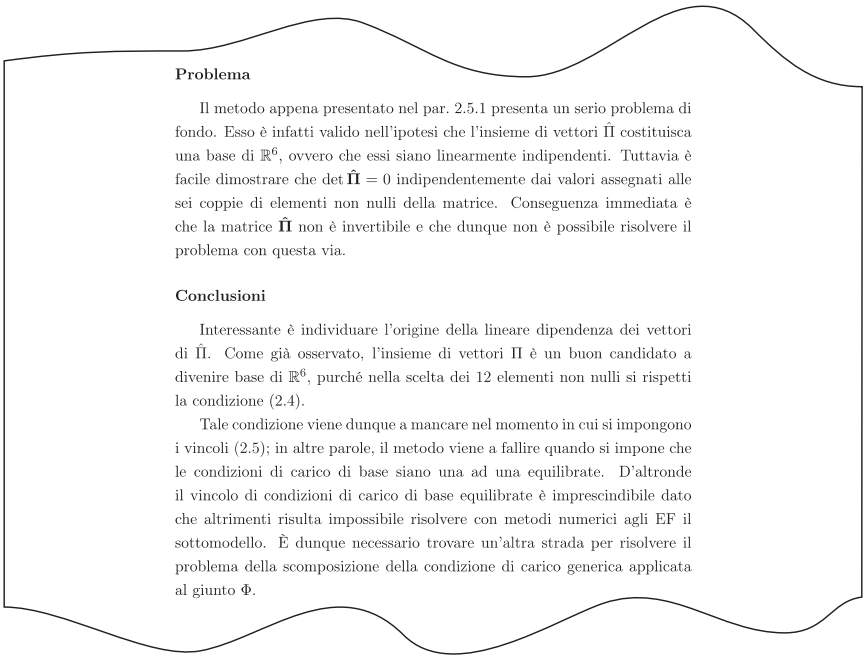
Il metodo appena presentato nel par. 2.5.1 presenta un serio problema di fondo. Esso è infatti valido nell'ipotesi che l'insieme di vettori $\hat{\Pi}$ costituisca una base di $\mathbb{R}^6$, ovvero che essi siano linearmente indipendenti. Tuttavia è facile dimostrare che $\det \hat{\mathbf{\Pi}} = 0$ indipendentemente dai valori assegnati alle sei coppie di elementi non nulli della matrice. Conseguenza immediata è che la matrice $\hat{\mathbf{\Pi}}$ non è invertibile e che dunque non è possibile risolvere il problema con questa via.

Conclusioni

Interessante è individuare l'origine della lineare dipendenza dei vettori di $\hat{\Pi}$. Come già osservato, l'insieme di vettori Π è un buon candidato a divenire base di $\mathbb{R}^6$, purché nella scelta dei 12 elementi non nulli si rispetti la condizione (2.4).

Tale condizione viene dunque a mancare nel momento in cui si impongono i vincoli (2.5); in altre parole, il metodo viene a fallire quando si impone che le condizioni di carico di base siano una ad una equilibrate. D'altronde il vincolo di condizioni di carico di base equilibrate è imprescindibile dato che altrimenti risulta impossibile risolvere con metodi numerici agli EF il sottomodello. È dunque necessario trovare un'altra strada per risolvere il problema della scomposizione della condizione di carico generica applicata al giunto Φ.

(a) without the indentfirst package



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(b) with the indentfirst package

Figure 5: Example of indentation on the first paragraph.

6.2.2 Accented letters

Accented letters can be inserted into LaTeX code with the standard commands[28] (\`{e}, \'{e}, etc.) or directly from the keyboard (è, é, etc.) using the inputenc package with the appropriate encoding. The inputenc options depend on the editor that is used. [ansinew] has to be used with most editors on Windows (e.g. WinEdt and TeXnik Center); [latin1] or [latin9] with most editors on Linux, UNIX, and Mac OS X; [applemac] with Macintosh computer using an operating system prior to OS X and even OS X depending on the encoding used by the editor;[29] [utf8x] can be used only on some editors such as on Linux and TeXShop on Mac OS X.

6.3 The layout

6.3.1 Headers and footers

The fancyhdr package is very useful to customize headers and footers. In a thesis, headers and footers usually differ from one part to the other. It is convenient to define commands that change their behavior as in the following example:

```
\newcommand{\fncyfront}{%
    \fancyhead[RO]{{\footnotesize\rightmark}}
    \fancyfoot[RO]{\thepage}
    \fancyhead[LE]{\footnotesize{\leftmark}}
    \fancyfoot[LE]{\thepage}
    \fancyhead[RE,LO]{}
    \fancyfoot[C]{}
    \renewcommand{\headrulewidth}{0.3pt}}
\newcommand{\fncymain}{%
```

28. See [22] for a list of these commands.

29. [applemac] corresponds to the MacOSRoman encoding which is used by default by Mac OS 9 and Mac OS X. It is however possible to use other encodings depending on the editor used. For example TeXShop allows to save files with every encoding (MacOSRoman by default, but also Latin1, Latin9, Unicode, and all the others). The software deriving from *nix systems on the Macintosh platform (e.g. Emacs) usually uses the [latin1] encoding.

```
    \fancyhead[RO]{{\footnotesize\rightmark}}
    \fancyfoot[RO]{\thepage}
    \fancyhead[LE]{{\footnotesize\leftmark}}
    \fancyfoot[LE]{\thepage}
    \fancyfoot[C]{}
    \renewcommand{\headrulewidth}{0.3pt}}
```

These commands are then used in the text as follows:

```
\pagestyle{fancy}
\fncyfront
\frontmatter
...
\fncymain
\mainmatter
```

The `openright` class option might cause a blank page at the end of the chapter. The following command can be added to the preamble to avoid headers and footers on this blank page:

```
\makeatletter
\def\cleardoublepage{\clearpage\if@twoside
\ifodd\c@page
\else\hbox{}\thispagestyle{empty}\newpage
\if@twocolumn\hbox{}\newpage\fi\fi\fi}
\makeatother
```

6.3.2 Page layout

University rules very often require a page layout different from that of the standard LaTeX classes. It could be changed using LaTeX primitive commands such as `\textwidth`, `\oddsidemargin`, etc., but this is not advisable for several reasons [5, 26]. A better solution consists in using rigid packages, such as layaureo,[30]

30. Other packages such as widemargins, a4, and a4wide, could be used to modify the layout but they are not suggested because they are obsolete.

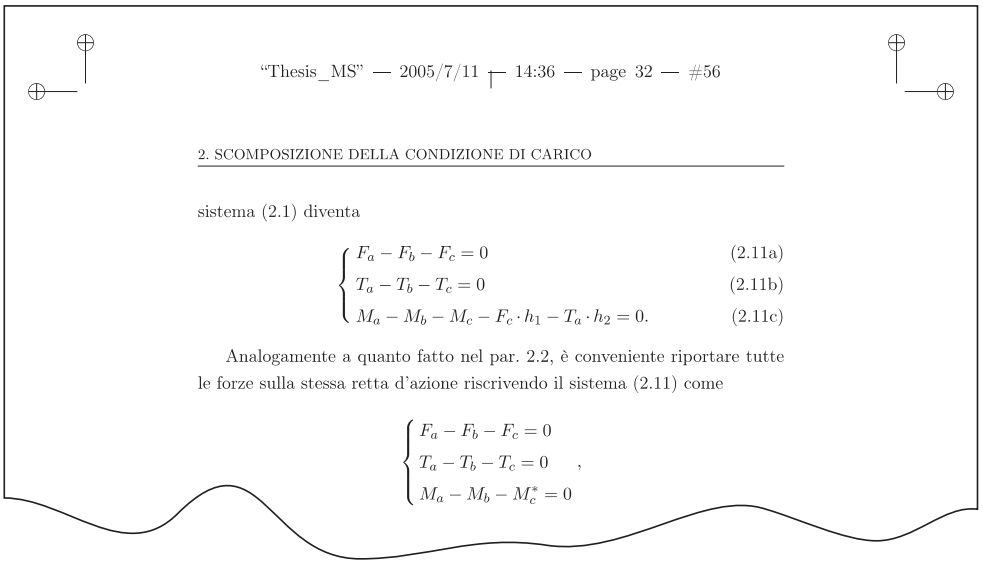


Figure 6: Example of page crop marks.

which are very easy to use[31] but do not let the user define the layout. If none of these rigid packages produces the desired layout, the geometry package, which is very flexible, is recommended. The chngpage package allows to change single pages or paragraphs.

In order to bind the thesis it might be convenient to indicate where to cut the pages (Fig. 6). This can be easily done with the packages geometry and crop.

LaTeX tries by default to cover the entire page height and, if necessary, it expands the space between paragraphs, list items, and so on. This behavior can be disabled with the `\raggedbottom` command[32] which leaves empty space at the bottom of pages if necessary. In order to improve page coverage it is possible to let the mathematical `display` environments break across two pages with the `\allowdisplaybreaks` command.

31. The layaureo package provides two layouts (with and without the `big` option) and allows to easily set the binding space with the `binding` command.

32. The default behavior is obtained with the `\flushbottom` command.

6.3.3 Line spacing

University rules often require a line spacing different from single spacing (which is the LaTeX default). There are many ways to modify the line spacing [26] but the best one is to use the setspace package. It provides three predefined line spacings with the commands `\singlespacing`, `\onehalfspacing`, and `\doublespacing`. If a different spacing is required then the `\setstretch{baselinestretch}` command can be used in the preamble to set the `baselinestretch` appropriately.

6.4 The style

6.4.1 Fonts

The T1 encoding, which is the new standard for LaTeX, should always be used. This encoding is not the default yet to guarantee backward compatibility, but can easily be selected with the command

```
\usepackage[T1]{fontenc}
```

Some problems, such as fuzzy fonts, might arise when visualizing the PDF [5]. The cm-super font is a simple solution to this problem since it provides a PostScript Type 1 font with the same shape as cm and tc families with several improvements such as support for non-ASCII characters.[33] In addition, the latin modern family is a vastly expanded computer modern, with even more support for non-ASCII characters than cm-super. Further details about this family can be found in its documentation and in [19]. When writing a scientific thesis, it is convenient to load the amsfonts package, which provides some mathematical fonts by the AMS, and the amsmath package, which provides several extensions to typeset mathematics. The relsize package allows to modify the size of the font with relative commands (`\smaller` and `\larger`) in addition to the standard LaTeX commands.[34]

33. http://en.wikipedia.org/wiki/ASCII

34. `tiny`, `scriptsize`, `footnotesize`, `small`, `normalsize`, `large`, `Large`, `LARGE`, `huge`, and `Huge`.

LaTeX users who come from the What-You-See-Is-What-You-Get (WYSIWYG) world,[35] at least in the beginning, often wish to change font. This phenomenon is probably due to the fact that the WYSIWYG software provides such bad topographic output that the disappointed user often tries to improve it changing the font. I suggest sticking with the LaTeX default font family, that is to say the Computer Modern family which was developed by the very same inventor of TeX, Donald Knuth. Changing a font with LaTeX is not as easy as with a WYSIWYG editor and for a reason. When changing a font, four families (Serif, Sans-serif, `Typewriter`, and mathematical fonts such as $\mathbb{A}$, $\mathbf{A}$, $\mathcal{A}$, and $\mathfrak{A}$) which form a good typographic combination need to be chosen. Moreover, most fonts do not provide all the mathematical symbols and so can be used just in the text.[36] If you do want to change the font, many packages can be used to change font (e.g. pxfonts, mathpazo, courier, eulervm, literat, lucida, pandora, mathptmx, helvet, courier, kerkis, kmath, qpxmath, qtxmath). Otherwise it is always possible to manually install a font as it is accurately explained in [19].

6.4.2 Chapter titles

The fncychap package allows to modify the format of chapter titles. The default format produced by the book class is reported in Fig. 8 while the command

```
\usepackage[Lenny]{fncychap}
```

was used in Fig. 7.

The quotchap package can also be used to customize the titles, altough it offers many fewer options than fncychap.

35. http://en.wikipedia.org/wiki/WYSIWYG
36. The Danish TUG hosts a web site that reports all the fonts that support mathematics (http://www.tug.dk/FontCatalogue/mathfonts.html) and other informartion can be found in [5].

6.4.3 Lists

The enumerate package allows to modify the item numbering of enumerate-like environments. It can change the counter style[37] and the delimiter symbol.[38]

6.4.4 Minitoc

When the chapters have a very complex structure, it may be convenient to report a table of contents of the chapter on its first page (Fig. 7). These "minitocs" can be automatically produced by the minitoc package.

6.4.5 Epigraphs

The epigraph package allows to insert an epigraph in the first page of each chapter. An example is reported in Fig. 8.

6.4.6 Footnotes

By default, LaTeX produces high quality footnotes. When it is really necessary, however, the user can change the footnote layout with some dedicated packages and commands. The footmisc package provides many options to control the footnotes, such as `bottom` which places the footnotes at the bottom of the page (Fig. 9).[39]

In order to prevent a single footnote from spreading over several pages, the user can set a high penalty to this behavior with the command

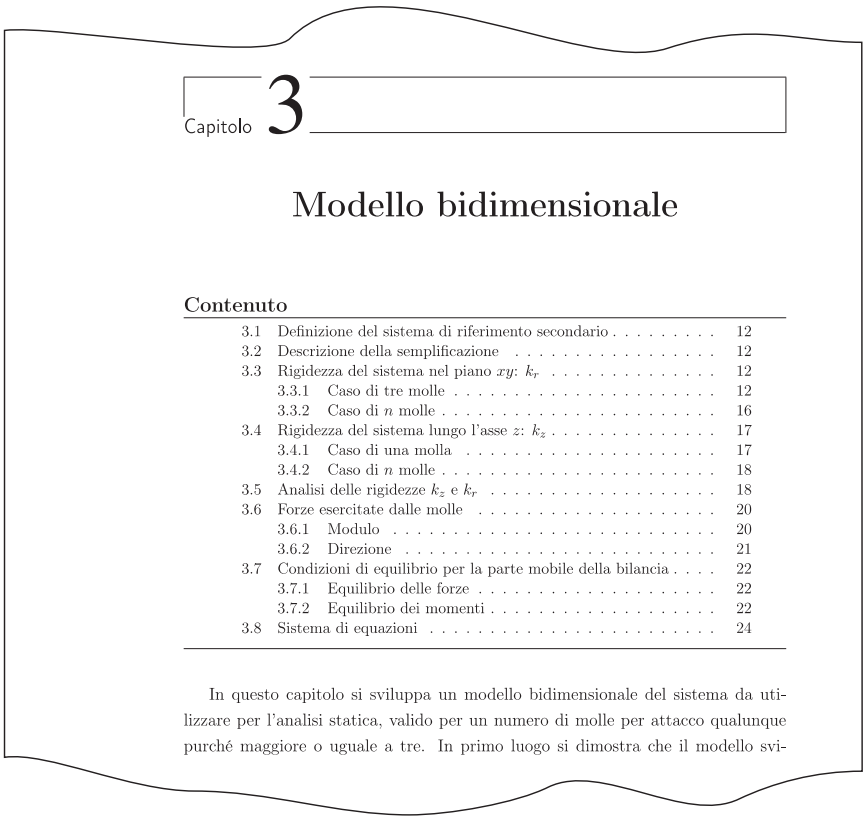
```
\interfootnotelinepenalty=10000
```

The part of the page assigned to the footnotes can be controlled with the command

37. It is possible to use Arabic numerals (1,2,3,...), uppercase (I,II,III,...) and lowercase (i,ii,iii,...) Roman numerals, uppercase (A,B,C,...) and lowercase (a,b,c,...) Roman alphabet letters.

38. Every character can be used as a delimiter obtaining for example 1), 1., 1 –,...

39. LaTeX by default places the footnotes after the last line of the page thus, when a page is not fully covered, the footnotes are not at the bottom of the page.


Capitolo 3

Modello bidimensionale

Contenuto

In questo capitolo si sviluppa un modello bidimensionale del sistema da utilizzare per l'analisi statica, valido per un numero di molle per attacco qualunque purché maggiore o uguale a tre. In primo luogo si dimostra che il modello svi-

Figure 7: Example of a "minitoc".

```
\dimen\footins=2cm
```

6.5 Mathematics

6.5.1 "Special" symbols

"Special" symbols are all the symbols that cannot be typed directly from the keyboard. For the mathematical symbols you should refer to the amssymb package provided by the AMS. For all the other kinds of symbols there are specific packages that can be easily identified with [22].

Figure 8: Example of an epigraph.

6.5.2 Numbers

numprint is a very useful package to represent numbers. Among the other functions provided, it can automatically insert a separator every three figures and approximate a number. For example,

```
\numprint{2.742647826672E-01}
```

gives

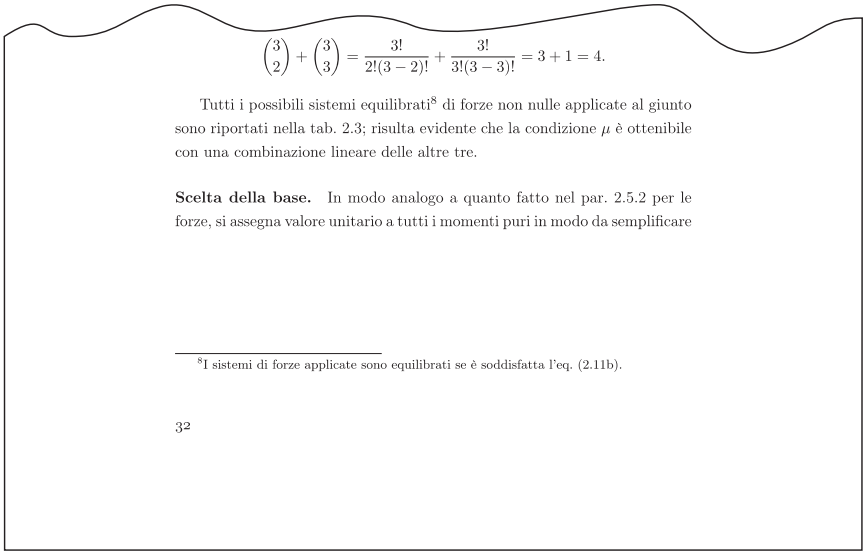
$2{,}743 \cdot 10^{-01}$

6.5.3 Units

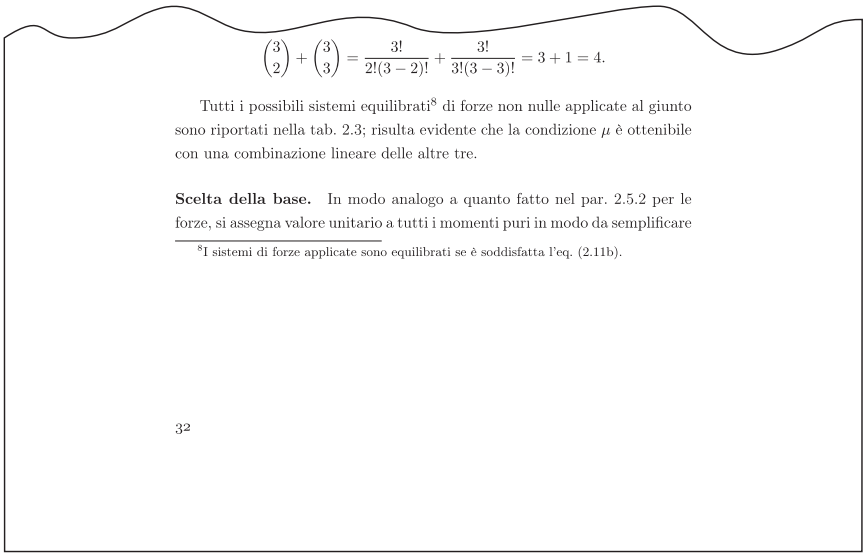
To avoid formatting by hand the units, it is advisable to use the Slunits package. For example

```
\unit{32,1}{\micro\metre}
```

gives



(a) with the `bottom` option



(b) without the `bottom` option

Figure 9: Position of the footnotes.

```
32,1 μm
```

6.5.4 Other packages

The empheq package can be used to highlight mathematical environments. The theorem package can be used to customize theorem-like environments. The xfrac package allows to write fractions in the text and in the mathematics (e.g. 5/7).

6.5.5 System of equations

It is sometimes useful to group a system of equations with a curly brace. A convenient way to do it is by defining a new environment:

```
\newenvironment{sistema}
  {\left\lbrace\begin{array}{@{}l@{}}}
  {\end{array}\right.}
```

For example the following code

```
\[\begin{sistema}
x_1=\sigma_b^2-\sigma_a\\
x_2=\sigma_a^2-\sigma_b
\end{sistema}\]
```

produces

$$\begin{cases} x_1 = \sigma_b^2 - \sigma_a \\ x_2 = \sigma_a^2 - \sigma_b \end{cases}$$

Similar results can be obtained with the cases environment provided by the amsmath package.

6.6 Acronyms

Acronyms can be conveniently handled with the acronym package which can automatically generate hypertext links between the acronyms in the text and their definition in the list of acronyms. An example of a list of acronyms is reported in Fig. 10.

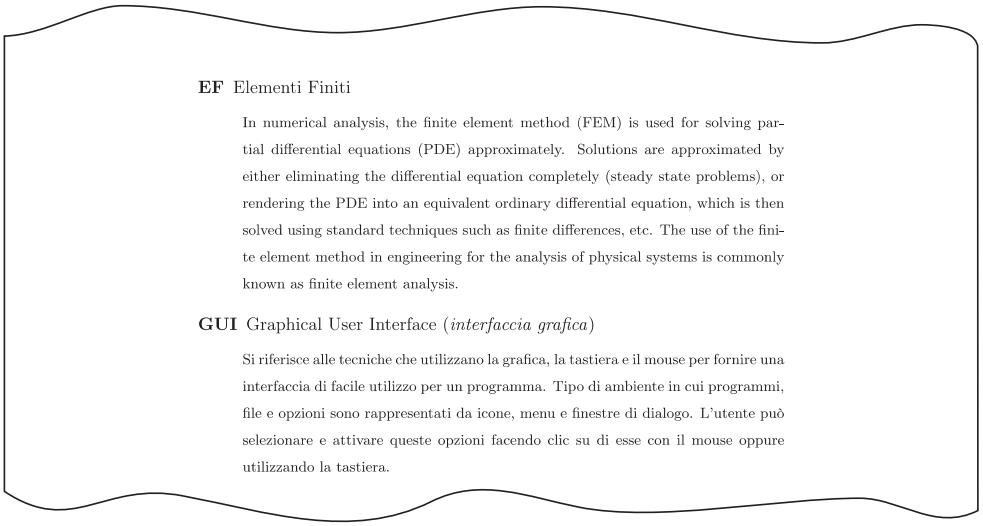


Figure 10: Example of list of acronyms.

6.7 Codes and algorithms

The verbatim package can be used to add pieces of code to the text. The listings package, which recognizes many computer programming languages, allows a broader control of the code typographic style. Another alternative is the fancyvrb package.

The algorithm and algpseudocode packages can be used for the algorithms: the first one generates floating objects, the second one non-floating objects.

6.8 Cross-references

Sometimes it might be useful to use the `\ref` and `\pageref` commands together to refer to figures and table, especially when there are several pages between the object and the reference. For this purpose some authors use commands like

```
\newcommand{\fullref}[1]{\ref{#1} on page~\pageref{#1}}
```

However, it is not possible to know beforehand the position of the object and may happen that the `\pageref` refers to the same page. The varioref package defines

the `\vref` command in order to take care of these exceptions. This package works together with babel to adapt to the language in use. For example

```
see Fig.~\vref{f5}
```

produces, depending on where is the figure, something like

see Fig. 3.1 on the next page

or

see Fig. 3.1 on page 24

As regards equations, the `\eqref{...}` command should be used instead of `(\ref{...})`. For example

```
defined in eq.~\eqref{e2}
```

produces

defined in eq. (3.6)

6.9 Reviewing the code

When reviewing the code, it is highly recommended to analyze accurately the `.log` file and to use the refcheck and showkeys packages to check how `\label` and `\ref` have been employed in the text. Moreover, the `draft` option of the `documentclass` can be used to highlight with black bands the points where the text goes out of the margins.

7 Useful websites

In addition to the guides and the manuals cited in the bibliography, the Web offers several resources to solve problems that might show up while writing a thesis with LaTeX.

Google provides, besides the traditional one,[40] a search engine dedicated to

40. http://www.google.com/

LaTeX.[41] The Usenet newsgroup comp.text.tex,[42] available also in other languages, contains a lot of information. The Comprehensive TeX Archive Network (CTAN),[43] which hosts most of the TeX and LaTeX material available in the Web, has a powerful search engine. Sarovar[44] is a large catalog of packages and programs connected with TeX and LaTeX. Among the types of search provided, the "topical" is particularly useful when you don't know the name of a package but you know what it should be able to do.

Many universities and research labs offers guides on LaTeX, usually targeted to beginners. We will just mention here Cambridge University,[45] Nottingham University,[46] Helsinki University,[47] and Emory University.[48] Moreover, David R. Wilkins released his book *Getting Started with LaTeX* in `html` format.[49]

References

[1] American Mathematical Society (2002). *AMS-LaTeX User's Guide*. URL ftp://ftp.ams.org/pub/tex/doc/amsmath/amsldoc.pdf.

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THE PracTEX Journal

LaTeX goes with the flow

Jim Hefferon

Abstract

One advantage of TeX and friends is that they fit naturally into a work flow where there are many tools, each good at its own job. This paper gives an example involving a system for doing class evaluations online.

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The PracTEX Journal, 2008, No. 1
Article revision 2008/03/14

LaTeX goes with the flow

Jim Hefferon

Abstract One advantage of TEX and friends is that they fit naturally into a work flow where there are many tools, each good at its own job. This paper gives an example involving a system for doing class evaluations online.

My college gives students in every class a chance to provide feedback on that class. We now use a paper-based form but are looking toward online evaluations.

Some advantages of an online system would be: timeliness (reports for a class would be available immediately after the feedback period instead of six months later), flexibility (for instance, data could easily be tracked over time), and customizability (more on this below). So for the institution, all of the bullet points lead in the same direction.

We've had no luck finding a vendor. As one approach, I wrote some scripts. In my system, called Sphyg, part of the job involved moving the data from the database to the summary documents. For that, the right tool was LaTeX.

1 Sketch of the system

To understand how LaTeX fits into its flow, we must first understand the evaluation system.

1.1 Customizing the data in

Each semester's process starts with an email to the academic Vice President and to the Department Chairs. This mail has a link to an online form.

For instance, the VP's form allows the input of questions that will eventually appear on each evaluation seen by each student in each class in the college. These questions will appear either at the top of those evaluations or at the bottom.

Similarly, each Chair can enter questions for the courses in their department. These questions appear either at the top of the forms, below the VP's questions, or at the bottom above the VP's.

Each administrator's form comes up already filled out with last semester's questions. Thus if the administrator does not respond, or makes no changes, then last semester's questions will just be reused — this is what will typically happen.

If they do edit the form then for each question there is a place to write the text of the question, such as "I learned a great deal in this course." They also select among question types, including choose types such as choose-one-to-five, paragraph answer types, and many others (adding new types is easy). For choose types they also insert a space for students to make a brief comment.

Next, each instructor gets an email. It has links to a page where the instructor can add questions to the forms for their classes. One link allows them to put in questions on each form for any of their students. Other links go to different pages for each section that the instructor is teaching. That is, evaluation forms can be customized not only by college, by department, and by instructor, but also by section. As with the administrators, if an instructor does not respond then Sphyg uses the questions asked last semester by this instructor on all forms.

Now, with the forms made up, each student gets an email. It links to a page listing the student's classes and linking to the evaluations for those classes. Of course, students can submit at most one evaluation per section.

When the period for evaluations closes, Sphyg generates the reports. Each instructor gets a summary of all responses, for all questions, from students in each of their sections. That summary preserves the students's anonymity.

1.2 Customizing the data out

As described above, the system allows extensive customization of the input. But the output is customized as well.

Administrators do not get the same reports as instructors. The Vice President's report shows only the summaries for institution-wide questions. And, each Department Chair's report summarizes only the questions for the institution or for the department. This allows the instructor to ask developmental questions such as "What could I have done better?" that would not fit in an evaluative context.

However, this customization adds complexity to the production of the reports since they cannot just be forms into which the data is inserted.

2 The LaTeX generation

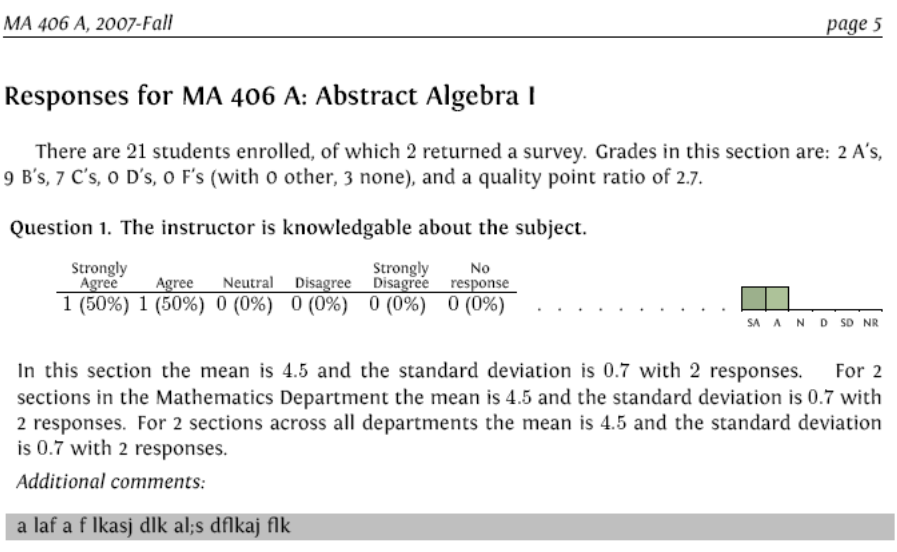
There are many ways to get data out of a database and into a report. Just to name one, the programming language Perl makes generating plain text reports straightforward. But plain text has shortcomings, such as a lack of graphics capability and colors, and character encodings can be awkward.

I wanted the reports to be nicer than that, for instance to show bar charts for choice-type questions. That, and also that everyone can read it, means that the natural format for the report is PDF. Since direct production of PDF would be very hard, generating the reports using LaTeX makes the most sense.

So Sphyg's document work flow is: a Python script takes the data from the database and outputs LaTeX source files. These are turned into a report by running them through XeLaTeX. The variant XeLaTeX was chosen because it makes convenient the use of a wider character set.

I wrote a custom `.sty` file for the reports. That means that less of the LaTeX code is mixed in with the Python.

Here is an example showing part of a page, using some of the sample data.



MA 406 A, 2007-Fall *page 5*

Responses for MA 406 A: Abstract Algebra I

There are 21 students enrolled, of which 2 returned a survey. Grades in this section are: 2 A's, 9 B's, 7 C's, 0 D's, 0 F's (with 0 other, 3 none), and a quality point ratio of 2.7.

Question 1. The instructor is knowledgable about the subject.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	No response
1 (50%)	1 (50%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

SA A N D SD NR

In this section the mean is 4.5 and the standard deviation is 0.7 with 2 responses. For 2 sections in the Mathematics Department the mean is 4.5 and the standard deviation is 0.7 with 2 responses. For 2 sections across all departments the mean is 4.5 and the standard deviation is 0.7 with 2 responses.

Additional comments:

a laf a f lkasj dlk al;s dflkaj flk

A number of things appear in this sample. For instance, LaTeX generates page headers that change depending on the class section. Also notice that the mean and standard deviation summary information about responses are given for this single section, across the department, and across the college. Finally, notice the optional comment shown with the question summary (here there is just one comment but had there been more they would have been listed in alternate shadings).

An advantage of using LaTeX in this work flow is that some of its features make easy things that might otherwise be quite hard.

One example is that the document style uses the graphicx package to make a macro to draw the bar charts, as shown in the screenshot above.

Another example of leveraging LaTeX is that the report style uses the longtable package to alternatively shade adjacent comments, and to automatically insert "*(continued on next page)*" where appropriate.

Still another example is that the hyperref package makes document navigation easy. For instance, administrative reports have a table of contents with a link from the instructor's name to the first page of the summary for that instructor. There is also an index with a link to the summary for each section of each course. Those links are created automatically, obviously.

The final aspect of the reports to note is that they can be quite long. The Vice President's report has a summary of all of the college-wide questions, including students's optional comments, for each instructor. In the tests using dummy data this report was over a thousand pages. While that length would be a cause for worry with some document-handling programs, LaTeX has no trouble. Further, compilation of the document takes less than a minute.

3 Status

Sphyg's LaTeX subsystem performed flawlessly. In particular, for the characters encountered in testing (only Latin-1 characters), XeLaTeX had no trouble at all.

The main challenge with the larger project of online evaluations is that students do not fill them out — in one of my experiments the most common return rate was 0%. A person can reflect on the desirability of collecting responses that users seem not keen on giving, but at my college there is a mandate to be proactive about feedback. So we need an incentive. One is to only allow students to see their grades online after they have filled out the evaluation. That is why in the

system described above students are sent to a page filled with links: once they have filled out the evaluation then in the place of the link appears their grade. For this incentive we must temporarily suppress access to the mechanism that ordinarily allows students to see their transcript online. At the moment the online evaluation initiative is stalled at this point (our online-transcript vendor wants a great deal of money). In short, whether Sphyg will ever get running is unclear.

What is clear, however, is that LaTeX fits well into this kind of flow. For example, if I had instead tried writing the PDF directly from the database then graphics and pagination would be quite a problem. Instead, with TeX and friends, it was a solved problem.

THE PracTEX Journal

Learning To Sweave in APA Style

Ista Zahn

Abstract

Until recently I used MS Word and clones such as OpenOffice to write academic manuscripts, as do most in my field. The standard software toolkit for many psychology professors and graduate students also includes SPSS for performing statistical analyses, and perhaps EndNote or similar reference manager software for generating bibliographies. These tools work, but my experience suggests that LaTeX based solutions have signicant advantages. This article describes how to use Sweave to write LaTeX documents in APA style, complete with results, tables, and figures generated by R.

Ista Zahn is a graduate student in the Department of Clinical and Social Sciences in Psychology at the University of Rochester in Rochester, NY. He started using LaTeX during the Summer of 2007 to typeset equations for use in powerpoint lectures, and now uses LaTeX to write scientific articles, presentations, and even posters. He has benefited greatly from the wealth of freely available information about LaTeX available on the World Wide Web, and has recently started work on a manual describing the use of LaTeX and R (an open source statistical programming environment), as a way of giving back to the community. You can reach Ista at .

- PDF version of paper
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- Send submission idea to editor

The PracTEX Journal, 2008, No. 1
Article revision 2008/4/4

Learning to Sweave in APA Style

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Abstract Until recently I used Micorsoft Word and clones such as OpenOffice to write academic manuscripts, as do most in my field. The standard software toolkit for many psychology professors and graduate students also includes SPSS for performing statistical analyses, and perhaps EndNote or similar reference manager software for generating bibliographies. These tools work, but my experience suggests that LaTeX based solutions have significant advantages. This article describes how to use Sweave to write LaTeX documents in APA style, complete with results, tables, and figures generated by R.

1 Why I made the switch to LaTeX and R

I am the only person in my department who uses LaTeX and R. Because Sweave[1] simply provides a way to integrate these two programs, it follows that I am the only Sweave user as well. Why have I taken the time and effort to learn these programs instead of following the crowd and sticking with Word and SPSS? Quite simply, I made the switch because using LaTeX and R is actually *easier*. It took me some time to become familiar with these programs, but after using them for a couple of months I am firmly convinced that I am more productive with these programs than I ever was with Word and SPSS.

1.1 Advantages to using LaTeX and R

There are a number of major advantages to using LaTeX and R rather than Word and SPSS. For example, LaTeX users who need to write documents in APA style can use

1. R is an open-source implementation of the S statistical programming language. Sweave stands for 'S-weave', i.e., weaving S code and results into a LaTeX document.

`apa.cls`[6] to completely specify the final appearance of the document. Unlike the writer using Word, the LaTeX user does not need to manually set page numbers, figure out where to place the running head, affiliation information etc. The LaTeX user does not even need to fiddle with the style of the headings. This is one especially irritating aspect of APA style; because the headings used differ depending on the number of headings, one must alter headings throughout the document if the number of heading levels is changed. With LaTeX these details are handled by the computer, allowing the author to (almost) forget about formatting and concentrate on the content of the article. There are additional advantages to using LaTeX was well, such as the ability to easily create indexed `.pdf` files that can be navigated using free `PDF` viewers like Acrobat Reader, and the ability to easily create reference lists without manual formatting.

When used together with R, the LaTeX document becomes an almost self-contained environment in which the author can perform statistical analyses, present the results in standard APA style, compose the prose of the article, and create and display tables and figures. All of these activities can take place within a single computer program (your favorite text editor), reducing distractions and facilitating complete immersion in the writing process. This article documents some of my experiences using LaTeX and R, and highlights some of the features I find most useful, including automatic formatting of title pages and section headers, the creation of tables and figures, cross referencing, and the generation of APA style reference lists.

LaTeX and R are both wonderful tools in their own right. LaTeX is a powerful, flexible, and free alternative to the more standard what you-see-is-what-you-get approach to document creation, such as taken by Microsoft Word and OpenOffice. R is a powerful, extremely flexible, and free tool for performing statistical analyses and computations. It can replace costly alternatives such as SPSS or STATA, and can easily handle the relatively simple analyses I need to perform, including analysis of variance, multiple regression, and structural equation modeling. Sweave is a system that brings these two wonderful tools together. A Sweave document is basically a LaTeX document interspersed with R code.

1.2 Disadvantages to using LaTeX and R

Unfortunately, there are also drawbacks to using LaTeX. The most serious drawback I have encountered is that it can be difficult to collaborate with colleagues who do

not use LaTeX. Those unfamiliar with LaTeX are unlikely to appreciate being sent a LaTeX file, and it can be difficult to convert LaTeX files to a format Word can read. If your collaborators (or perhaps more importantly, journal editors) won't accept LaTeX documents, you are going to have to figure out a way to do this conversion. I provide instructions for how to do this in Section 6.

The main disadvantage to using R is the startup cost in terms of learning the syntax. There are graphical user interfaces available (such as R Commander[2]), but generally speaking, if you want to use R you are going to have to learn to write R commands. In my case it took about two months to become comfortable enough with R to let my SPSS license lapse.

2 Formatting your document in APA style

Because I need to write documents in APA style, I am extremely fond of the APA document class[6]. Although this article is primarily about Sweave, I'm going to take a moment to highlight some of the features of this of `apa.cls` that I find most useful.

To use `apa.cls`, write `\documentclass[man]{apa}` in your preamble. This will cause your document to be typeset in APA manuscript style. If you want to see approximately what the published article will look like, you can use the *journal* mode by replacing `[man]` with `[jou]`.

2.1 Multiple authors and affiliations

`apa.cls` supports multiple authors by defining the commands `author`, `twoauthors`, and so on, up to `sixauthors`. For example, if you have three authors, specify the author information as follows:

```
\threeauthors{First Author}{Second Author}{Third Author}
```

If you specify multiple authors, you must specify an affiliation for each of them. For the example above, you could specify

```
\threeaffiliations{Institution A}{Institution B}{Institudion C}
```

You can specify up to six affiliations.

Note that some mixing-and-matching is possible here, and that the actual limit is six *affiliations* rather than six authors. For example, the following is perfectly reasonable:

```
\twoauthors{First Author}{Second Author and Third Author}
\twoaffiliations{Affiliation of First Author}{Affiliation of Second and Third Authors}
```

and will result in the affiliation of the first author being typeset below the first author's name, and the affiliation of the second and third author's being typeset below their names.

2.2 Title and header information

There are a total of four title and header related fields that can be specified. Note that if you do not specify all the fields the information from the fields you do specify will be used in place of the missing fields. The four fields are:

```
\title{}
\shorttitle{}
\rightheader{}
\leftheader{}
```

Note that there is some possibility for confusion here, as these commands are labeled according the where the information will go in the *published* version of the paper and *not* in the manuscript version. Thus the shorttitle command actually contains the information that will go in the *right header* of the manuscript, while the **\rightheader** command contains the information that will be printed as the *running head* in the manuscript. The **\leftheader** command contains information to be printed in the left header of the published manuscript (usually the author's name) and is not used in manuscript mode. Finally, the **\title** command contains the full title of the article.

2.3 Headings and heading levels

The APA manual specifies different heading styles depending on the total number of headings in a manuscript. In order for LaTeX to figure out how to set your headings, you therefore need to tell it how many headings you have. This is done by issuing the **\headinglevels**{} command in your preamble. Note that the number of headings is specified by *verbal* rather than *numeric* arguments. Thus if your manuscript has four headings, you need to issue the command **\headinglevels**{four}, *not* **\headinglevels**{4}. The manual specifies heading schemes for up to five heading levels.

Once you have specified the number of heading levels in the preamble, you issue section commands as follows:

```
\section{}
\subsection{}
```

\subsubsection{}
\paragraph{}
\subparagraph{}

Note that all of these may or may not be used, depending on the number of headings. For example, if you have only three heading levels, you should use only the \section, \subsection, and \subsubsection headings. If you decide to change the number of heading levels, LaTeX will automatically adjust the appearance of the headings appropriately.

2.4 Enumeration and seriation

Itemized and enumerated lists can appear in APA style manuscripts, but their use is not common. To create bulleted or numbered lists you can simply use the standard itemize and enumerate environments. More commonly in APA style documents, one wishes to have itemized lists that appear in the body of the text, like (a) this, (b) that, and (c) the other thing. This can be accomplished using the seriate environment, as in \begin{seriate} \item this, \item that, and \item the other thing \end{seriate} and has the advantage of being automatically relabeled if you change the order.

2.5 Cross-references, in-text citations, and reference lists

Cross referencing in LaTeX is easy and very useful. Basic cross referencing can be implemented using just two commands. In order to refer to something later on in your document, you need to give it a label, as in \label{ex:label}. Then you can refer to it by it's label, as in \ref{ex:label}. This is especially useful for tables and figures, because if you change the order, the in-text references to them will automatically be updated. You can also label sections, equations, and footnotes.

For citations, `apa.cls` uses the `apacite` package, which makes formatting citations a very easy process. For the most part, citations in APA style should be very familiar to BibTeX users. For example, assuming I have an entry for the present work in my `.bib` file with the cite-key `Zahn2008`, I can cite it by writing \cite{Zahn2008}. This will result in (Zahn, 2008) appearing in the text of the document, and the reference will be automatically inserted into the reference list at the end of the document. For details on the `apacite` package, refer to the manual[5].

Using BibTeX is very simple, and it works great. I've used several different reference management software, and found most of them to be complicated and/or buggy. BibTeX on the other hand is easy to use and it just works.

3 Installing and setting up Sweave

The preceding sections focused on features of LaTeX that I find particularly useful. In this section, I show how the usefulness of LaTeX can be further enhanced by combining it with R.

The documentation accompanying R and various LaTeX distributions covers the installation and configuration of these programs quite well, and so I will not discuss their installation here. However, having these programs installed and working properly is a pre-requisite for setting up Sweave, so make sure you have both working on your computer before following the instructions below[2].

I prefer to run Sweave from within a text editor (I use TextMate on OS X), and therefore these instructions are geared towards setting things up this way. If you prefer to run Sweave from the command line, simply disregard the parts about configuring your text editor.

3.1 Setting up Sweave on a Windows computer

In the following I assume you are using TeXmaker with the MikTeX distribution of LaTeX, but the general procedure should be very similar with alternative LaTeX distributions/front ends.

Sweave comes with the standard distribution of R, and can be run from within the R program without any additional configuration. However, I prefer to run Sweave directly (i.e., from outside of R), and this requires a few extra steps. First, you will need to install a batch file[3] so you can call Sweave from your text editor. To install the file, you can either place it somewhere in your PATH, or simply place it anywhere you like and add the directory to your PATH.

At this point you should be able to run Sweave from the command line. If you prefer to call it directly from within your text editor, you will need to tell your text editor where to find the `sweave.bat` file. Open TeXmaker, and select `Edit` → `Preferences`. Next, select a function you won't need (I recommend `DVI viewer`), replace the command with sweave.bat −−pdf *%.Rnw*, and click `OK`.

2. I am currently working on a complete Sweave guide that (among other things) details the installation and set up of Sweave assuming no previous experience with either LaTeXor R. Please contact me at the e-mail address listed at the beginning of this document to obtain this guide.
3. You can download the file from http://cran.r-project.org/contrib/extra/batchfiles/.

On Windows, it is common to encounter difficulties because LaTeX cannot find the `Sweave.sty` file. To correct this, copy the `sweave.sty` file from `C:\Program Files\R\R-2.6.2\share\texmf` and paste it somewhere your LaTeXprogram can find it.

3.2 Setting up a Sweave on Mac OS X

The procedures involved in setting up a Mac OS X workstation are even easier than those required for setting up a Windows workstation. If you want to be able to call `Sweave` outside of R, you will need to install a shell script[4]. To install the script, copy it to `/usr/local/bin`, then open the Terminal program and type sudo chmod +x /usr/local/bin/Sweave.sh to make it executable.

At this point you should be able to call `Sweave` from the command line. If you want to call `Sweave` from within TeXshop you need to tell TeXShop where to find the `Sweave.sh` shell script. Open TeXShop and click `TeXShop` → `Preferences`. Click the `Misc` tab and type /usr/local/bin/Sweave.sh –ld in the `LaTeX Progam Personal Script` field.

3.3 Setting up Sweave on Linux

The procedures involved in setting up a Linux workstation are also very straightforward, although the details will vary depending on which distribution and text editor you are using. The present example is based on Kubuntu Linux, using Kile.

If you want to be able to call `Sweave` outside of R, you will need to install a shell script (see footnote 4). To install the script, copy it to `/usr/local/bin`, then open the Konsole program and type sudo chmod +x /usr/local/bin/Sweave.sh to make it executable.

Next, you may want to tell Kile where to find the `Sweave.sh` shell script. Open Kile and click `Settings` → `Configure Kile`. Click the `Tools` tab on the left-hand side of the preferences window, and select `Build`. Click the `New Tool` button at the bottom of the preferences window. Name the new tool `Sweave`, click `next`, and then `Finish`. In the resulting screen, type Sweave.sh in the top box, and –ld `\%source' in the bottom box.

4. You can download the `Sweave.sh` script from http://cran.r-project.org/contrib/extra/scripts/.

4 Sweave basics

In this section I give an overview of and basic introduction to Sweave. As you will soon find, it is not difficult to learn, but it does require that you have some knowledge of both R and LaTeX. To create a Sweave document, simply set up your LaTeX preamble as usual, use the `Sweave` package, and save the file with a `.Rnw` extension. For example, the first two lines of the present article read

```
\documentclass{pracjourn}
\usepackage{Sweave}
```

and the file is named `LearningToSweaveAPAStyle.Rnw`.

4.1 What happens when you run `Sweave`?

When you run `Sweave`, the output is a regular LaTeX file, with the R code and results included. If you have your system set up as described above, this is all hidden from view, because the program is set up to automatically run LaTeX on the Sweave output. But what looks like a single seamless process is actually a two-stage affair. This is useful in an important way, namely that we can run `Sweave`, and then edit the resulting `.tex` file to make any manual changes we wish to the results returned from R.

4.2 Details about `Sweave` syntax

Unlike LaTeX and R, `Sweave` is not extensive or complicated. This is because `Sweave` has a relatively simple purpose: it allows you to combine LaTeX and R code into a single document. The basic Sweave syntax consists simply of a << >>= marker indicating that we want to begin an R code section, followed by one or more R commands, followed by a @ marker indicating you are done writing R commands and wish to switch back to LaTeX. Although this basic syntax is extremely simple, it's actually slightly more complicated than this, because you can put option commands inside the openning marker. In the following, I discuss only a few of the more commonly used options; for a full description the available options, see the Sweave user manual[4].

In the examples that follow, I use a simple contrived data set that takes the following form:

```
<<echo=false>>=
Participant <- c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)
```

```
Condition <- factor(c(1, 1, 1, 1, 1, 2, 2, 2, 2, 2))
Score <- c(4, 3, 5, 4, 4, 2, 2, 6, 5, 6)
Data <- data.frame(Participant, Condition, Score)
Data
@
```

These R commands create the following simple data frame:

```
   Participant Condition Score
1            1         1     4
2            2         1     3
3            3         1     5
4            4         1     4
5            5         1     4
6            6         2     2
7            7         2     2
8            8         2     6
9            9         2     5
10          10         2     6
```

If you don't understand what these commands are doing, make sure to consult an introductory R guide[5] before proceeding.

4.3 The echo option

The *echo* option dictates whether the R *input* is incorporated into the typeset document. For example, if we want to calculate the grand mean of the `Score` variable for the `Data` dataset created above, we could say

```
<<echo=true>>=
mean(Score)
@
```

which gives us

```
> mean(Score)

[1] 4.1
```

or, we could say

```
<<echo=false>>=
mean(Score)
@
```

which gives

```
[1] 4.1
```

Notice that in the first case the command returned both the command and the result, while in the second case only the result appears.

5. Many excellent and free guides are available at http://www.r-project.org/.

4.4 The results option

The *results* option tells Sweave how we want the results formatted. We can hide the results completely, as in

```
<<echo=false, results=hide>>=
mean(Score)
@
```

We can return the results already formated in LaTeX code (useful especially when we have R create LaTeX tables for us; more on this later), as in

```
<<echo=false, results=tex>>=
mean(Score)
@
```

or we can have the result returned verbatim (the default), as in

```
<<echo=false, results=verbatim>>=
mean(Score)
@
```

The reader is encouraged to play around with these options in order to see what they do first-hand.

5 Including results from R into your document

The main purpose of Sweave is to allow you to perform statistical analyses and include the results directly into your LaTeX document, without the need to switch programs, copy-and-paste, or re-type results. In this section I provide examples illustrating how to do this. Many of the examples use the *Prestige* dataset from the `car`[1] R package. The Prestige data set contains six variables, as described in: the `car` package documentation:

education Average education of occupational incumbents, years, in 1971.

income Average income of incumbents, dollars, in 1971.

women Percentage of incumbents who are women.

prestige Pineo-Porter prestige score for occupation, from a social survey conducted in the mid-1960s.

census Canadian Census occupational code.

type Type of occupation. A factor with levels (note: out of order): bc, Blue Collar; prof, Professional, Managerial, and Technical; wc, White Collar.

In the following I'll present a number of examples using these data. First, I illustrate how to calculate statistics and included them in the text of you document.

Next, I'll show you how to make R create LaTeX tables for you. Finally, I'll show you how to create graphics in R and incorporate them into your LaTeX document.

5.1 Incorporating R results using the Sexpr command

There is another way to insert short chunks of R code into your LaTeX document. Quite simply, you can issue the **Sexpr**{} command, and put your R code inside the brackets.

For example, if I say **Sexpr**{2+2} I will get 4. The nice thing about this command is that the indexes (i.e., those pesky [1]'s peppered throughout the examples above) are automatically suppressed, and the result is returned in the same font as the rest of the normal text in your document.

The **Sexpr** command can be very useful. Instead of copying and pasting results from SPSS into Word, we can do all our calculations right in our LaTeX document. Here is a brief example:

```
The average income was
\Sexpr{mean(income)}, with a standard deviation of \Sexpr{sd(income)}.
The average level of education was
\Sexpr{mean(education)}, with a standard deviation of
\Sexpr{sd(education)}. The correlation between income and education was
\Sexpr{cor(income,education)}.
```

This will be typeset as:

> The mean income was 6798, with a standard deviation of 4246. The mean level of education was 11, with a standard deviation of 2.7. The correlation between income and education was 0.58.

Once I got used to reporting results this way, it's hard for me to imagine how I ever worked without it. It's so simple, so easy, that I can't help but wonder why anyone would go to all the trouble of having separate interfaces to their statistical and document preparation software. And it gets even better with Sweave, as we can do exactly the same kind of operations with tables and figures that we just did with single values.

5.2 Including tables in your document with `xtable`

There are two separate R libraries that can be used to create LaTeX tables in R. The first is the `xtable` package[8], which was designed exclusively for this purpose. The other is the `Hmisc` package[3], which includes the latex() command. I'm going to illustrate the use of `xtable` because I've found it easier to use. `xtable` formats table results in LaTeX style, turning the utilitarian R output into nicely formated tables. To load the `xtable` package, simply write **library**(xtable) inside a Sweave tag.

Once the libraries are loaded, you are almost ready to begin making tables. To make a table of descriptive statistics we need to do a bit of work in R before calling xtable. Specifically, we need our descriptive statistics to be formatted in a *data frame*, after which we can run xtable on the data frame. Here is an example that creates a table displaying descriptive statistics for the `income` and `education` variables found in the `Prestige` dataset:

```
<<echo=false,results=tex>>=
means <- c(mean(income), mean(education))
sds <- c(sd(income), sd(education))
mins <- c(min(income), min(education))
maxs <- c(max(income), max(education))
descriptives <- data.frame(means, sds, mins, maxs,
row.names =c("Income", "Education"))
names(descriptives) <- c("Mean", "SD", "Min", "Max")
descriptives.table <- xtable(descriptives, caption =
"Descriptive␣Statistics", label = "tab:descriptive2")
print(descriptives.table, include.rownames=TRUE)
```

This will produce the result displayed in Table 1.

Table 1: Descriptive Statistics

	Mean	SD	Min	Max
Income	6797.90	4245.92	611.00	25879.00
Education	10.74	2.73	6.38	15.97

The `xtable` package also has extensive methods for creating tables displaying the results of inferential statistics. For example, we can create an ANOVA table summarizing the results of a linear regression model predicting `income` from `education`, as follows:

```
<<echo=false, results=hide>>=
library(xtable)
```

```
xtable(anova(lm(income ~ education)),caption =
"ANOVA Table", label= "tab:anovatable1")
@
```

The results are displayed in Table 2. This basic method can be applied to just about any model object. About the only thing that you might object to is the somewhat unconventional labels used across the top of the table. It is possible to modify these values in the model object before calling xtable, but I find that this is often more trouble than it's worth, and I'm usually better off just using xtable to get an approximate result of what I want, and then tweaking the table (by editing the LaTeX file that Sweave produces) to get the details right.

Table 2: ANOVA Table

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
education	1.00	607421386.02	607421386.02	50.06	0.00
Residuals	100.00	1213392025.00	12133920.25		

To do this, simply open up the file, and find the table generated by `xtable`. In the present case, we find

```
% latex table generated in R 2.6.2 by xtable 1.5-2 package
% Fri Mar 28 13:02:56 2008
\begin{table}[ht]
\begin{center}
\caption{ANOVA Table}
\label{tab:anovatable1}
\begin{tabular}{lrrrrr}
  \hline
 & Df & Sum Sq & Mean Sq & F value & Pr($>$F) \\
  \hline
education & 1 & 607421386.02 & 607421386.02 & 50.06 & 0.0000 \\
  Residuals & 100 & 1213392025.00 & 12133920.25 &  &  \\
   \hline
\end{tabular}
\end{center}
\end{table}
```

Now all we need to do is edit the table to make it look exactly like we want it to, and re-typeset the document.

5.3 Graphics in Sweave documents

The beauty of Sweave is that we can use R to create the graphics, and include the results all from a single, unified, and consistent interface (i.e., our text editor). In the following sections, I will walk you through a way of doing exactly this. R comes with robust plotting capabilities, and there are several add-on packages that extend these capabilities. I'm going to use the `ggplot2` package[7] in the following examples, but the general procedure should work even if you use another plotting package.

To generate a figure, we simply place the required R code inside the <<>> = ... @ tags. There are actually a few different ways to go about inserting the figure. The method I'm going to present here is specifically chosen because it makes it easier to produce figures that are sized appropriately, with appropriately sized axis labels and legends (something that can be tricky with other methods). Specifically, I recommend creating your graphic and saving it to a `.pdf` file, and then inserting the image into a figure environment. For example, we can easily represent the relations among `income`, `education`, `type` of occupation, percentage of `woman` in a field, and the `prestige` of a field, all in one information-dense graphic. The code for doing all this is simply

```
<<echo=false,results=hide>>=
pdf(file="splot12.pdf", width=6, height=5)
qplot(education,income, shape=type, size=women, colour=prestige,
xlab="Education", ylab="Income")
dev.off()
@
\begin{figure}
\centering
\includegraphics[width=6in, height=5in]{splot12.pdf}
\caption{A scatterplot displaying the relationships
among Income, Education, Prestige, Type of occupation,
and percentage of Women in the field.}
\label{fig:fig12}
\end{figure}
```

The result is displayed in Figure 1, and really shows off the impressive capabilities of `qplot()`.

The R command `pdf()` tells R to save the graph to a `.pdf` file. Then we include the graph with the standard `\includegraphics[]{}` command making sure to specify the same size in the options as we did in the options to the `pdf()` command. Note that the `pdf()` command expects the units to be in inches, so just write the number of inches you want, while the `\includegraphics[]{}` command needs to be told that the values are in inches (i.e., write `\includegraphics[width = 3in]{file}` rather than just `\includegraphics[width=3]{file}`, which will make LaTeX complain that you didn't tell it what to do).

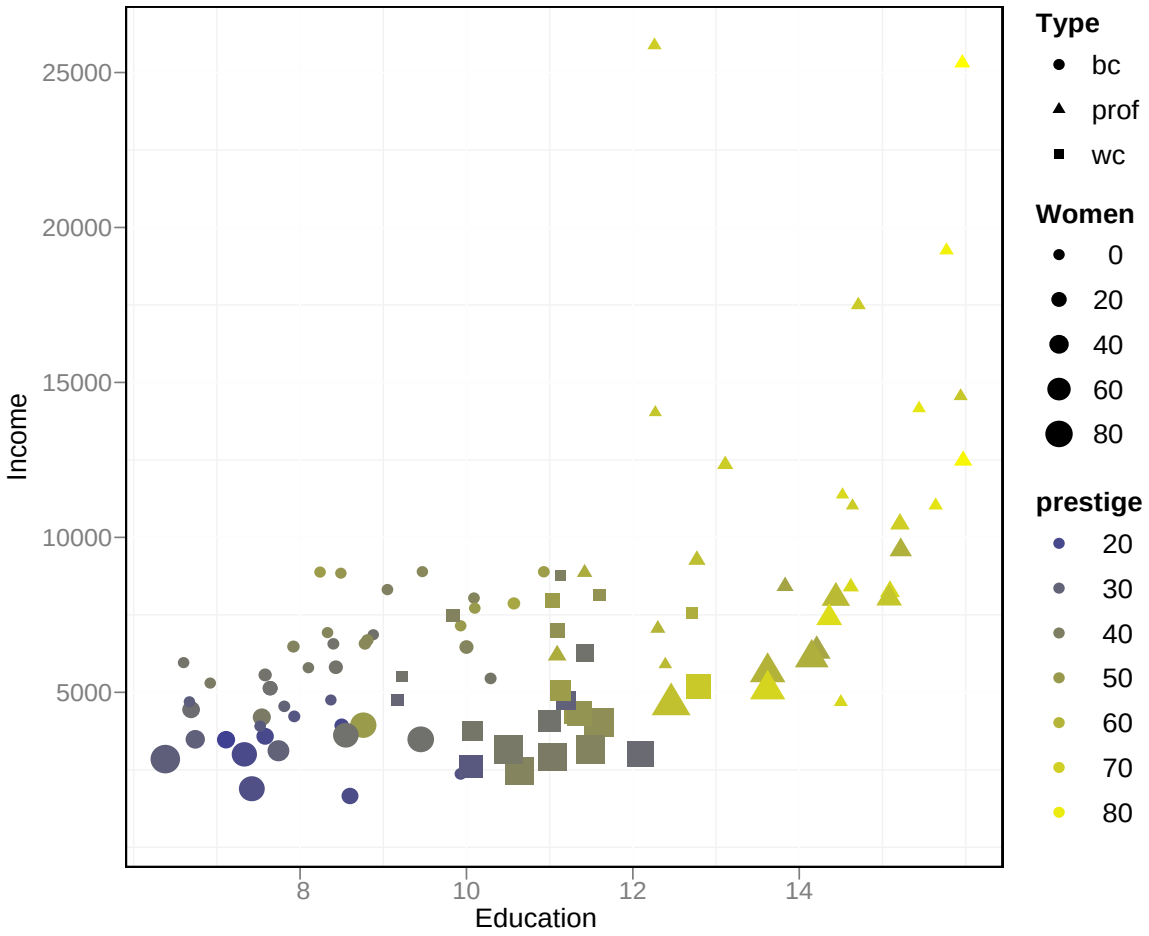

Figure 1: A scatterplot displaying the relationships among Income, Education, Prestige, Type of occupation, and percentage of Women in the field.

6 Collaborating with those who don't use Sweave

One of the most frustrating things about learning to use Sweave is that it can be difficult to collaborate with colleagues who do not. A related concern is that journals will not accept articles in LaTeX format. Both of these are valid concerns. They can be worked around, but in my experience there is no completely satisfying solution.

There are a number of programs that can convert simple LaTeX files to `.rtf` or `.html`, both of which can be read by most word processors, including Microsoft

Word. Such programs include latex2rtf and latex2html, and others[6]. Unfortunately, my experience is that such converters do not handle APA formated LaTeX documents well, if they can even be coaxed into producing any output at all.

As strange as it sounds, my advice is to forget about converting your LaTeX document to a Word-readable file directly. Instead, typeset the document as a `.pdf` file, and then convert the `.pdf` file to `.html` (`.html` files can be read by most modern word processors, including Microsoft Word). There are stand-alone conversion programs that will do this for you, such as the excellent pdftohtml[7]. If you have Gmail you can send the `.pdf` document to yourself, and click the `View as HTML` button in the `Gmail` web interface. Finally, Adobe has an on-line converter[8] that can convert `.pdf`'s to `.html`, although this can be slow for long documents. Once you have the `.html` formated document, open it in your word processor and fix the formatting (which will usually be close but not exactly right), and save it in `.doc` format.

The conversion to `.doc` format will usually be easier if you set your LaTeX document to left-justified (aka 'ragged right'; `\raggedright`), and if the margin settings in LaTeX match the margin settings in your word processor. If you use `apa.cls` in manuscript mode you shouldn't have too much trouble.

7 Conclusions and final thoughts

The preceding sections document some of the things I've learned to do with LaTeX and R. Some sections descended into detailed discussions of various techniques, taking us a long way from the general, largely personal tone of the opening section. In this final section, I want to step back from the discussion of specific techniques, and offer my personal thoughts about using Sweave.

In the summer of 2006, I was looking for a calculator program for OS X. I had trouble finding one I liked, and eventually started using R as a simple calculator. I can almost hear the R developers shrieking in horror to think that someone would use their powerful and sophisticated program as a *calculator*, but the truth is that R serves this function very well. As time went on, I started using R for analysis of variance and linear regression as well. Over the course of several months, I gradually began using R more and more, and SPSS less and less.

6. A list of conversion programs is available at http://www.tug.org/utilities/texconv/textopc.html
7. Available at http://sourceforge.net/projects/pdftohtml/
8. Available at http://www.adobe.com/products/acrobat/access_onlinetools.html

In the summer of 2007, I taught an introductory statistics course. I needed to prepare lecture slides that included a lot of math, and Google pointed me towards LaTeXit, a small OS X program for typesetting math, based on LaTeX. I was so impressed with LaTeXit, that I started teaching myself to use LaTeX. It didn't take long for me to find out about Sweave, and since that time I've used LaTeXand R for all my papers, as well as my presentations (using the `Beamer` package).

In this way, I found myself using tools that are completely different from those used by the majority of my colleagues, and different from the tools I've learned to use since grade school. In general, my impressions so far are that (a) LaTeX is both easier to use and produces better output than Word, and (b) R is easier to use and produces better output that SPSS. Of course neither of those statements were true when I first started. Indeed, I almost gave up on R at one point because it seemed more difficult than SPSS. But once I took a few months to learn it, it became quite natural and easy to use.

Overall then, I am quite happy to be the only one in my department using LaTeX and R. I don't have to pay expensive licensing fees, and I get to take advantage of all the wonderful features of LaTeX and friends. In addition, I've learned how to convert `.pdf`'s to `.html`, which means I can still collaborate effectively with Word users, and I can always convert my documents before submitting them for publication if I have to. In sum, my experience with LaTeXand R have been very rewarding. I hope that by sharing these experiences and giving a few pointers I have inspired you to give Sweave a try.

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THE PracTEX Journal

Using BiBTeX to produce customized layouts

Yogeshwarsing Calleecharan

Abstract

Normal LaTeX and TeX usage does not require touching existing .bst files nor creating new ones. However, BibTeX offers several interesting commands which can be used to do many things apart bibliography generation. In this article, it is demonstrated how customized layouts for a database can be created without much trouble.

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- PDF version of paper
- datab.bst
- datab.bib
- datab.tex
- Comment on this paper
- Send submission idea to editor

For submission to The PracTEX Journal
Article revision 2008/02/07

Using BiBTeX to produce customized layouts

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Abstract Normal LaTeX and TeX usage does not require touching existing .bst files nor creating new ones. However, BibTeX offers several interesting commands which can be used to do many things apart bibliography generation. In this article, it is demonstrated how customized layouts for a database can be created without much trouble.

1 Introduction

To many LaTeX users, BibTeX and its commands remain a mystery. Yet as pointed out in [1], LaTeX users can play with BibTeX commands and use it for purposes other than bibliography generation. Since I started using LaTeX in 2005, I realized that handling LaTeX and TeX as programming languages can really make one abandon traditional word processing packages as the sky certainly becomes the limit.

The article [1] is regarded as the most exhaustive source of information on BibTeX. BibTeX is a powerful tool for handling a database and in this article, I have a modest goal: To show how BibTeX can be used to create customized layouts for a database. I am sure that any LaTeX user will be able to create more interesting layouts given here and to adapt them for their own needs.

2 A Simple Example

Programming books often begin their first program with the traditional words `Hello World!` displayed on the screen. We shall remain faithful to this tradition and use BibTeX to this end. By displaying just two words, the codes shown next serve to outline the minimal structure of a `.bst` file which is the key file in creating any desired style or layout.

Normally where a .bib file is involved, it is useful to run the minimal commands: LaTeX BibTeX LaTeX LaTeX in succession. I use the TeXMAKER [2] IDE to do the compilation and the IDE built-in Quick Build tool permits constructions of macro-like commands that save button presses. Further time can be saved by giving the same filename to the .tex, .bib and .bst files as in first.tex, first.bib and first.bst as this allows running the Quick Build tool on any of these files.

Enough of talking now! Displaying the words Hello World! has nothing to do with formatting a database of information but it can be useful to illustrate the structure of a .bst style file. For a database one would normally start with the .bib file and think of the fields required for different entry types. But here for this simple example, we directly create the .bst file as one entry is enough to display Hello World!. We will need to create three files: first.bst, first.bib and first.tex. Next is shown the first.bst file listing:

```
1  ENTRY
2    { toDisplay
3      } {} {}
4  FUNCTION{print}
5  {
6   cite$ pop$
7  }
8  FUNCTION{style1}{
9  print toDisplay write$
10 }
11 FUNCTION {fin}
12 {newline$
13 }
14 READ
15 ITERATE{call.type$}
16 EXECUTE {fin}
```

We shall give a short attempt to dissect the first.bst file listing and detailed information of the commands used are available in [1]. We begin on line 1 with the BibTeX ENTRY command which is used to create a field named toDisplay

which will be defined later in the `first.bib` file. The two pairs of matching braces on line 3 are for internal variables and will not be discussed further. The next important command is `FUNCTION`. All the macro functions in our example are user-defined. Furthermore, a function can also be made to run via the `EXECUTE` command (refer to line 16).

The `FUNCTION` command takes as first argument the name of the function and as second argument its definition which usually contains a useful sequence of instructions. On line 9 we find the internal command `write$` which interprets the sequence of instructions between the function argument name `print` and itself on the same line, and it writes the output in a `.bbl file`, which is generated on running BibTeX. On line 4 is the first function called `print` which will pop out the topmost item from the stack via the `pop$` command. The user can change the argument name `print` on line 4 to anything that he or she likes e.g. `rambo` provided the same argument name is written on line 9 as well. But as in programming, it is always better to work with meaningful names. Finally, the other important function is on line 8 and it takes as first argument `style1` and defines the sequence of instructions on line 9 as second argument. This function also defines an entry type (`style1`) which shall appear in the `first.bib` file as well.

Moving further down in the file listing `first.bst` to line 14 is the `READ` command which is advisable to be placed after all functions have been defined. Occurring just once in a `.bst` file, it processes only from the `first.bib` file the entries listed in the `first.aux` file (generated on LaTeX compilation). Next on line 15 is the `ITERATE` command which should come after the `READ` command. This command is executed for a number of times that equals to the number of entries in the `first.bib` file (subject that an entry is called in the `first.tex` file). In this first example, there is just one entry as will be seen later in the file `first.bib`. The `ITERATE` command has as argument `call.type$` which looks for the name of each entry to be executed in the `first.bib` file and takes this name as argument. And this `call.type$` command works together with the `cite$` on line 6 to treat each entry in the `first.bib` file in turn.

Finally on line 16 is the `EXECUTE` command which is required to generate an output from a `.bst` file. It has been found necessary to add an arbitrary function named `fin` (with `newline$` as argument) so that BibTeX compiles correctly. The `newline$` command begins a new line.

The next step is to write the `.bib` file where one entry is sufficient to display the words `Hello World!`. Thus we will have the entry type `style1` defined in `first.bst`, a key named arbitrarily as `Elem1` and then one field named `toDisplay` taking as argument the words `Hello World!`. The listing of the `first.bib` file is:

```
1 @style1{Elem1,
2   toDisplay = {Hello World!}
3   }
```

In last we write the `first.tex` file. Omitting for brevity the compulsory `\documentclass` commands and the `document` environment, the listing of the `.tex` file is:

```
1 \nocite{Elem1}
2 \bibliographystyle{first}
3 \bibliography{first}
```

We should note two things here. Firstly, the `\nocite` command is used instead of the usual `\cite` for bibliography generation. The interested reader can try the latter command to see why `\nocite` is better. Secondly, since we have created a custom `.bst` file whose objective is not principally for bibliography generation, we choose the `bibliographystyle` and the `bibliography` to be the style file `first.bst`.

After running LaTeX for the first time, `.aux` and `.log` files are generated. Then, running BibTeX yields `.bbl` and `.blg` files, and finally a run with LaTeX twice again gives the `.dvi` file with the words `Hello World!` displayed. There is nonetheless one serious drawback to use BibTeX as we have been showing. Most of the time, the user will make a BibTeX related error in the `.bib` and `.bst` files. In this case, BibTeX will only complain of undefined citation(s). During compilation, many files are created and the TeXMAKER [2] IDE offers a tool to clean these compilation-time files except for the `.blg` file. This is a convenient feature that allows to isolate the `.tex`, `.bib` and `.bst` files quickly and hence investigate any mistake(s).

3 A Database Example

Table 1 shows a few entries of a tiny database which contains some information on the first three elements of the Periodic Table. We will see how BibTeX may be used to create a custom layout to present the data in Table 1 in a different way. Here unlike in our first example, we will first identify the fields from Table 1 and thus create the `.bib` file. There are five fields namely: Atomic Number, Element, Symbol, Type and Group. The second line from Table 1 concerning the element Helium for instance is converted to a `bib` entry as shown next.

Table 1. First Three Elements in the Periodic Table

Atomic #	**Element**	**Symbol**	**Type**	**Group**
1	Hydrogen	H	Nonmetal	I
2	Helium	He	Noble gas	VIII
3	Lithium	Li	Alkali metal	I

```
@style2{Elem2,
  atomicNumber = {2},
  name = {Helium},
  symbol = {He},
  type = {noble gas},
  group = {VIII},
  note = {A very light gas}
 }
```

We have taken the liberty to add a field named `note` in the `style2` function and it will become useful in Section 4.1. The next file to write is the `.bst` file and here we will concentrate on writing the `style2` function. The reader is referred to the available file `datab.bst` which contains this function. The `style2` function is given next:

```
1  FUNCTION{style2}{
2  " {\bf " write$ print atomicNumber write$ " }" write$%
3   print "{ \kern-2.6mm}" write$ ". " write$ name write$%
4   ", " write$ symbol write$ newline$ newline$
5  print "\\" write$ " It is classified as " write$ type write$%
6   " and is found in group " write$ group write$%
7   newline$ newline$
8  print "\\" write$ " {\sl " write$ "Note: " write$%
9   newline$ print note write$ " }" write$
10 print "\\" write$
11 print "\\" write$
```

In the `style2` function, the symbol `%` denotes that the successive line does not start a new line but instead continues just afterwards. In essence there are just five lines (with formatting commands) starting on line numbers 2, 5, 8, 10 and 11 respectively and they act as second argument to the `style2` function. More will be said on the formatting techniques used in Section 3.1. The final step is to write the `.tex` file. Here we have three entries corresponding to the three elements of Table 1 and as in the previous section, the entries can be outputted through `\nocite{Elem1}`, `\nocite{Elem2}` and `\nocite{Elem3}` respectively. The output for instance from a `.dvi` file, if a dvi viewer has been called, is shown in Fig. 1.

1. Hydrogen, H
It is classified as nonmetal and is found in group I
Note:

2. Helium, He
It is classified as noble gas and is found in group VIII
Note: A very light gas

3. Lithium, Li
It is classified as alkali metal and is found in group I
Note: Lithium salts are known to enhance moods

Figure 1. Customized layout 1 obtained with style2.

Two things are noteworthy here. Firstly, one is free to output the information that is desired. This can be achieved in two ways. Commenting the whole of line 8

of the `style2` function in the `.bst` file listing would prevent the `note` field from being outputted. Inserting the `%` symbol (normally after `write$`) in the `style2` function enables one to control which information is to be outputted. This is a huge convenience in getting desired information from a database. That said, the attention of the reader is drawn to the verbatim `style2` function listed where the `%` symbols have only been included so as the listing can fit within the text width of this article.

A second method is to extract only specific entries by choosing which of the three entries from Table 1 is to be outputted. This can be easily be done in two easy ways: Either the entry to be hidden is commented in the `.tex` file as `%\nocite{Elem3}` for the key entry of `Elem3` for instance (defined in the `.bib` file) or the entry in question is modified by removing the `@` symbol appearing in front of the key entry in the `.bib` file. This feature helps the user to pick out which entry that he or she needs. This issue will be re-visited with the final example in Section 4.

3.1 Formatting Techniques

In this subsection, we will focus a bit on the formatting used in the previous `.bst` file listing. Formatting with BibTeX commands bears resemblance to those of LaTeX but there are some new commands like `write$` and `newline$` which have to be inserted at the right places. The `print` function plays a central role here. It has the effect to get something outputted after compilation. For example, the sequence of instructions `print " It is classified as " write$` will output the line `It is classified as` and typing `print type write$` as on line 9 will output the `type` of the element as per Table 1.

If more complex formatting is desired as shown on line 2, the following sequence of instructions

```
" {\bf " write$ print atomicNumber write$ " }" write$
```

will write the `atomicNumber` in bold. Finally, the `newline$` command is a native BibTeX that functions as the `newline \n` command in C programming. However, `newline$` on its own might not suffice and it has been found that two `newline$` commands, one after the other, will force BibTeX to move to a new line. If an

empty line is to be inserted, then the sequence of instructions on line 10 will do the job.

3.2 Taking It A Bit Further

In the same `.bst` file (`datab.bst`), the user can define another function say `style3` that produces a different formatting from that of the `style2` function. Considering more elements in the Periodic Table, a user can choose between `style2` and `style3` the formatting style that he or she would like to apply to an individual element (and its associated information like Atomic Number etc.). Now it might be a good idea also to have the possibility to group the elements pertaining to one formatting style under a heading or title. But what if the information outputted spans more than a page? Then it will be convenient to have the relevant headings at the beginning of each page. This issue will be covered in the next section.

4 An Elaborate Example

This section aims to combine some various features of BibTeX commands so as to give the reader a bigger perspective of what can be done. We will still work with the Periodic Table. Since formatting with BibTeX can be trickier than LaTeX, it should be noted that the examples given only serve to introduce the capabilities of BibTeX and as such these examples only offer basic formatting techniques that do not necessarily comply with typographic conventions.

Essentially, two features will be demonstrated and the codes accompanying the discussions are available. Briefly the two features are as follows: Firstly, it will be shown how to add another function which will give a different formatting style to other entries. In addition the function will be created in a manner so that it will have the possibility to filter out a field (which is `note` in our case) when it is empty. Secondly, a different layout in the form of a table will be created and as in the first case, we shall see how we can take advantage of table properties from a LaTeX package.

4.1 Filtering Out An Irrelevant Field

Referring to Fig. 1 in Section 3, we see that unlike the elements Helium and Lithium, Hydrogen has an `note` field. Say that a user would not like BibTeX to output a blank `note` field as he or she considers it to be a waste of space. Besides, say the user would not like information contained within the field `group` for the element to be displayed. In this case, one has to write another function say `style3`. This new function can be included in the same `.bst` file (`datab.bst`) containing the function `style2` listed in Section 3. Also one might want to include headings in the output file so that the two styles `style2` and `style3` can be distinguished from each other. To our rescue, there is the well-established `longtable` [3] package.

We will start with putting headings in our style files. The `longtable` [3] package offers a convenient feature to have a table spanning the full width of a page via the commands `\setlength\LTleft{0pt}` and `\setlength\LTright{0pt}`. A function arbitrarily named `createsection` containing mostly commands from the `longtable` [3] package permits headings to be created and classification (and demarcation) of entries (refer to the `datab.bib` file attached). One can further make use of commands like `\endfirsthead` and `\endhead` for better structure.

The next thing that we shall investigate is how to display the `note` field only when this field in the `.bib` file is not empty. To this end, we shall make use of the BibTeX commands `if$` and `empty$`. The `if$` internal command, like in programming languages, allows decisions subject to some defined conditions while the `empty$` command elegantly fits our specific need here as in combination with an `if$` command, it allows an output to be written or not. The output from the `style3` function is shown in Fig. 2 and the reader is invited to compare this figure to Fig. 1 from Section 3. The reader is also directed to [1] for deeper insights.

Headings do not accompany Fig. 2 in order to save space but the user is reminded again that the `createsection` function is responsible for the headings and also commands like the key environment `%\nocite{begcla1}` and `%\nocite{endcla1}` are required (refer to the file `datab.tex`).

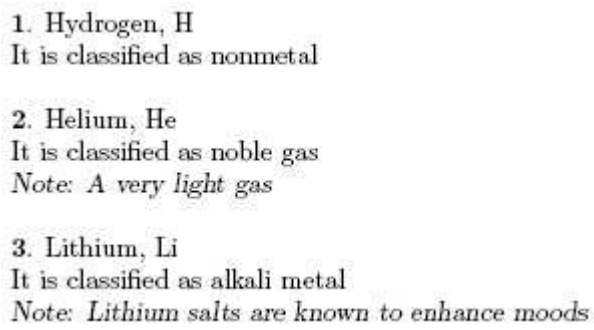


Figure 2. Customized layout 2 obtained with style3.

4.2 Yet Another Formatting Style

The objective here is to create a tabular structure like Table 1 but this time displaying only three fields: `Atomic Number`, `Element` and `Symbol`. The function is named `style4` and by making use of the `longtable` [3], running headings can be easily made for example when a table continues to a new page. The function `tablesection` given in the attached `datab.bst` file handles the headings in this case. It contains only some basic formatting and a user can easily bring modifications.

5 Some Useful Information

The user is referred to the `datab.bib` and `datab.tex` files where entry types (`style2, style 3 and style4`) or styles are grouped under argument key environment such as `begcla2` and `endcla2`. The user is invited to mix styles under a given argument key environment.

Nevertheless, BibTeX is stubborn in that it will not allow a key (referring here to elements `Elem1`, `Elem2` etc. as in the `datab.bib` file) to be repeated. A simple workaround would be to give the duplicate key a different name (as under the `tablesection` function in the `datab.bib` file) and to adjust the corresponding entries in the `.tex` file accordingly.

6 Conclusion

By writing this article, I hope that more LaTeX (and TeX) users will be encouraged to consider digging into BibTeX commands. BibTeX is a well-suited tool to handle static database information. The user is expected to realize that almost any information which can be treated as a database can benefit from the formatting techniques shown.

Readers conversant with the Extensible Markup Language (XML) will find that BibTeX perhaps is not as flexible in terms of simplicity and capabilities. But let us remind ourselves of two important things: Firstly, BibTeX and XML were created for different purposes, and secondly BibTeX has been here before XML came to life. Hence, any comparison is unfounded and unfair.

That said, this gap can lessened if BibTeX is combined with JabRef [4] to unveil similar XML capabilities like filtering, sorting and information retrieval [5]. JabRef [4] is a very flexible tool where the user can create custom fields and maybe through custom filters, it can produce better results than given in this article. I will not venture in this alley as tweaking deep with JabRef [4] remains a mystery for me.

Nevertheless, even without JabRef [4], smart constructs can be made with BibTeX as we have seen in Section 4 with commands like `if$` and `empty$`. With the sky being the limit for LaTeX, TeX fans, who knows how BibTeX will spice up our world in the future?

Disclaimer

The codes available with this article are named `datab.tex`, `datab.bib` and `datab.bst` respectively. Compilation is achieved through running LaTeX BibTeX LaTeX LaTeX sequentially. No guarantee is made for the accuracy of the information contained in the database nor the codes provided are warranted to be fit for any particular application.

References

[1] Nicolas Markey. Tame the Beast: The B to X of BibTeX, Version 1.3, October 2005.

[2] TeXMAKER 1.2.1. 2004-2005, http://www.xm1math.net/texmaker/.

[3] David Carlisle. The longtable Package, CTAN: http://www.ctan.org/tex-archive/help/catalogue/entries/longtable.html.

[4] JabRef Reference Manager 2.3.1. 2008, http://jabref.sourceforge.net/.

[5] Michael J. Young. *Formation Á XML*. Microsoft Press, 2000, Translated to French from English: James Guerin.

THE PracTEX Journal

Travels in TeX Land: Another ornament for "thought breaks"

David Walden

Abstract

In this column in each issue I muse on my wanderings around the TeX world. In this issue I touch again on a topic from my column in TPJ 2005-4 -- another ornament to use for "thought breaks."

David Walden is retired after a career as an engineer, engineering manager, and general manager involved with research and development of computer and other high tech systems. More information is available at www.walden-family-com. He may be contacted at dave@walden-family.com. A complete list of his "travels in TeX Land" pieces is at http://www.walden-family.com/dave/index.htm#travels-in-texland.

- PDF version of paper
- two-half-ornaments.jpg
- half-ornament.mp
- yuri.mp
- Comment on this paper
- Send submission idea to editor

The PracTEX Journal, 2008, No. 1
Article revision 2008/02/20

Travels in TEX Land: Another ornament for "thought breaks"

David Walden

Abstract In this column in each issue I muse on my wanderings around the TEX world. I suggested at the end of section 2 of my last column that I would continue my investigation of colors and TEX in this issue. However, I was distracted for much of the period between issues by a health problem (now resolved). Thus, in this issue I only have time to touch *briefly* again on a topic from my column in TPJ 2005-4 — another ornament to use for "thought breaks."

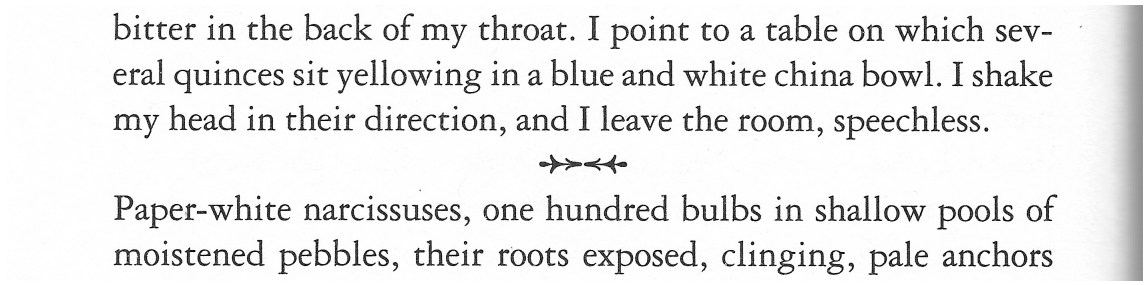
Another ornament to use with "thought breaks"

Before reading the rest of this column, you might look up my column in issue 2005-4 and read section 4 on "thought breaks": http://www.tug.org/pracjourn/2005-4/walden/. You might also look at Steve Peter's piece in the same issue on "swelled rules": http://www.tug.org/pracjourn/2005-4/peter/.

In the previous column I began using the words "thought breaks" to describe those points in the text of a book or article where a new train of thought begins without there being a section or subsection title. Such breaks are often indicated by some extra vertical space and some sort of ornament or by some extra vertical space and perhaps a different font face for a character, few characters, or few words, as shown at the beginning of the following paragraph (this particular style of thought break, including the seemingly odd half line indent, is used in the U.S. hardback edition of Robertson Davies' book *The Cunning Man*, published by Viking in 1994).

During my health situation, I spent some of my time reading *The Book of Salt* by Monique Truong. I read the paperback edition from the "A Mariner Book" imprint of Houghton Mifflin Company

(Boston and New York) that was first published in 2004. This book used an ornament to indicate thought breaks (see page 36, for example) that I greatly admire. Thus, I thought I would try to replicate it ...


bitter in the back of my throat. I point to a table on which several quinces sit yellowing in a blue and white china bowl. I shake my head in their direction, and I leave the room, speechless.

Paper-white narcissuses, one hundred bulbs in shallow pools of moistened pebbles, their roots exposed, clinging, pale anchors

... in some way that allowed me to use it with TEX.

The easiest thing is to scan the ornament, clean it up a bit with Photoshop, and access it as a graphic, e.g.,

```
\noindent\hfil\scalebox{.12}
   {\includegraphics{salt-ornament-alone-3.jpg}}\hfil
```

which results in the following.

That looks pretty good (especially on the printed page — print it out). Blown up about eight times, it looks like this:

But those little imperfections aren't really visible in the size I would use it in a book, as shown above.

However, I thought that it might be "more pure" to somehow recreate the ornament in METAFONT, MetaPost, or some LATEX graphics package.

At this point, I got to chatting (via email) with issue editor, Yuri Robbers. He noted three possibilities that came to mind for him for creating the desired graphic:

1. using a large print on graph paper and hand coding the outline of the ornament
2. using `autotrace` and `pstoedit`
3. from MetaPost to METAFONT or an otherwise usable glyph or font

First approach

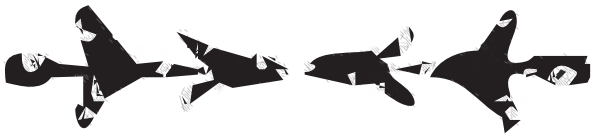
The first approach had already come to mind before I talked with Yuri. As Yuri noted, this was the approach used by Donald Knuth, and described in his *Digital Typography* book, to develop his early fonts and also used by Knuth with Zapf to develop the Euler Math Fonts. However, the 600 dpi scan I have would still need to be blown up by a factor of four or more to be big enough to measure and hand code its coordinates, but at that magnification it no longer is made up of smooth curves and straight lines — rather, it's made up of lots of pixels that would require lots of interpolation, e.g., using a French curve to draw the outline.

Second approach

The second approach had immediate appeal because it sounded like a program would do the tracing for me, as described by Karl Berry in "Making outline fonts from bitmap images," *TUGboat*, Volume 22 (2001), Number 4, pp. 281-295, which Yuri pointed me to. So, I downloaded an already-compiled Windows version of the `autotrace` program from `http://autotrace.sourceforge.net/`, unzipped it into a folder `autotrace`, opened `salt-ornament-alone-3.jpg` with Photoshop, saved it as a bitmapped file, `salt-ornament-alone-3.bmp` in the directory `autotrace`, read the `README` file a tiny bit, and gave the command

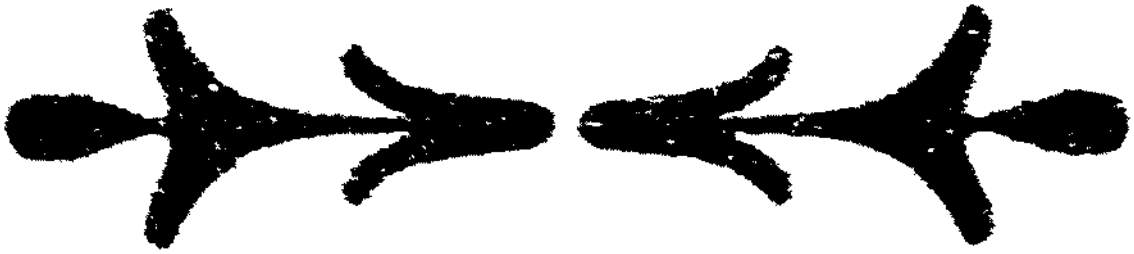
```
./autotrace.exe --output-format eps --output-file out.eps salt-ornament-alone.bmp
```

This ran to completion but produced the following file (blown up so you can see the details)

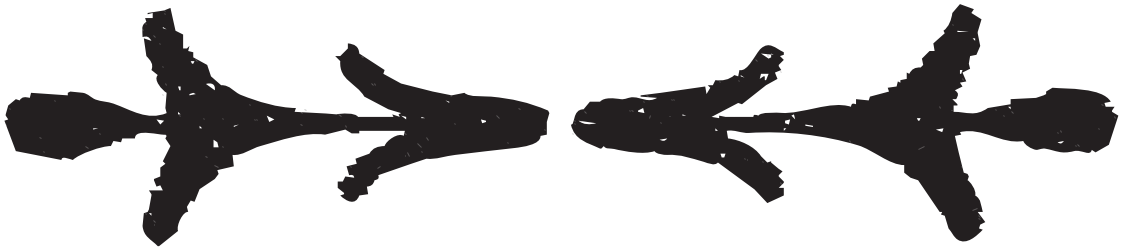


which is not usable. But it is sort of amazing that it managed to find the outline at all. To make `autotrace` do what I wanted was maybe going to take more reading of the options described in the `README` file.

But, before taking the big step of reading and understanding the `autotrace` `man` page (all the documentation it has, apparently), I decided to first bash ahead and see if a better scan of the ornament would help. I rescanned the ornament at 2400dpi (4 times more resolution than the first scan had) and specified for the scanner to directly output a bitmap image (rather than outputting a JPG which I later converted to a bitmap using Photoshop), and specified B&W rather than color (I had scanned the earlier image in color and later converted it to B&W in Photoshop). This resulted in approximately the following image



which has a few white spots and some non-smooth corners but looked pretty good. So I tried `autotrace` again, which resulted in the following as an EPS or PDF file.



That's only slightly worse than the scan — which still leaves me sort of impressed with that capabilities of `autotrace`. But, of course, I could have just converted my improved bitmap to EPS or PDF with Photoshop and skipped using `autotrace`, so it was actually not much help in my situation versus just using

the scan itself with `\includegraphics` embedded in a new LaTeX command such as `\dropinornament`.

See also the Appendix.

Third approach

Thus, it seemed like it was time to try Yuri's third suggestion — trying to figure out some curves in MetaPost, for instance, that approximate the desired ornament.

I looked at the documentation in the *Graphics Companion* for a few minutes and got discouraged about figuring out how to find the points to generate splines, Bézier curves, etc. (like many or perhaps most people, I have a pretty short attention span for reading documentation). So I looked again at the high resolution scan of the previous section, this time with Illustrator. With Illustrator it was pretty easy to select the pen tool, touch points approximately on the outline of the scan (fuzzy though it was at the edges), and read the X-Y coordinates of the pen position from Illustrator's GUI display.

Thus, I collected points along the top half of the left half of the ornament. I put these into Excel, thinking that I would use Excel to create a reflected set of points with which to draw the bottom half of the left half of the ornament. In the end, I didn't need Excel for this, but it was handy to have the points in Excel for converting all of the points to positions where both their X and Y coordinates were positive (MetaPost apparently didn't like points with negative X values that I had recorded from the images position in Illustrator).

I next looked up how to use MetaPost to draw a set of connecting curves from point by looking at the first 20 or so pages of Hans Hagen's MetaFun manual (`www.pragma-ade.com/general/manuals/metafun-p.pdf`). I tried one small test using his instructions on page 9 for running MetaPost directly, but immediately switched over to running ConTeXt's `texexec`, as also described on page 9, so I could easily go straight to a PDF without having to run Adobe's Distiller. (Of course, I could also have looked at MetaPost output using MiKTeX's YAP displayer of DVI files.)

It took me at least an extra hour to get all the X-Y coordinates typed correctly into my text editor (just using the scan directly is looking better all the time). Here is what I fed into MetaPost via `texexec`:

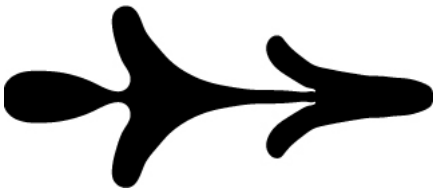
```
\starttext
\startuseMPgraphic{dummy}
  path p;
  p := (1,145)..
  (4,156.5)..
  (13.5,162.5)..
  (27.5,164)..
  (42,163)..
  (55.5,160)..
  (68.5,155)..
  (83,149)..
  (92,150)..
  (96,160.5)..
  (91,170)..
  (86,182.5)..
  (82.5,198.5)..
  (84,207.5)..
  (89,211.5)..
  (96,211.5)..
  (102,205)..
  (107,193.5)..
   (115,183)..
  (125,172)..
  (136.5,163.5)..
  (155,155.5)..
  (171.5,152)..
  (187,150)..
  (208.5,149.5)..
  (221.5,148.5)..
  (228,148.333)..
  (233.167,148.5)..
  (234.833,148.5)..
  (235,149.667)..
  (234.167,150.667)..
  (230,151.883)..
```

```
  (223.167,155)..
  (212.833,161.333)..
  (204.833,167.333)..
  (199.5,175)..
  (198.167,182.333)..
  (199.833,186.667)..
  (203.167,189.667)..
  (208.167,189.667)..
  (210.833,187)..
  (216.5,180.667)..
  (225.5,173.333)..
  (233.833,168)..
  (241.167,166)..
  (251.167,164)..
  (258.833,162.667)..
  (267.167,161.333)..
  (274.5,160.333)..
  (284.167,160)..
  (293.5,159)..
  (304.5,158)..
  (313.167,155.667)..
  (317.833,153.667)..
  (321.167,151)..
  (322.5,145.667)..
  (322.5,145)--cycle);
  fill p withcolor black;
  draw p;
  path q;
  q := p reflectedabout((0,145),(335,145));
  fill q withcolor black;
  draw q;

\stopuseMPgraphic
\useMPgraphic{dummy}
\stoptext
```

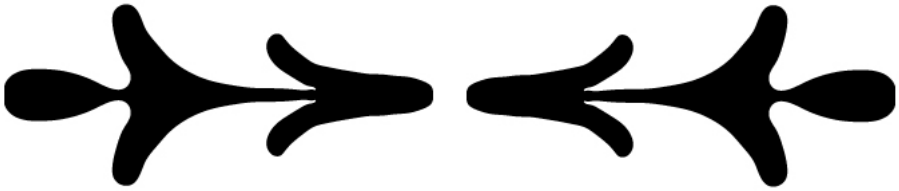
I learned about filling a closed cycle by glancing at Troy Henderson's "A beginner's guide to MetaPost for creating high-quality graphics" (http://www.ursoswald.ch/metapost/tutorial.html). I learned about creating the bottom half of the left half of the ornament by reflection in MetaPost from the same few pages at the beginning of Hans' manual.[1]

The figure produced by the above MetaPost code is the following, which I converted into a JPG so I could include it here using `includegraphics`:



Obviously at this point I could have tuned up some of the coordinates in my MetaPost file to eliminate slight imperfections in the ornament. However, when the ornament is reduced to the appropriate size for use in a book or paper, I doubt these imperfections will show, and so I will not bother trying to make things more perfect.

Now I suppose I need to learn how to give a name to the above drawing in my MetaPost code and then rotate it about a vertical axis to get the other half of the ornament. And I also suppose I need to learn to input the Postscript from MetaPost into LaTeX file. However, it really is easy to just copy the half ornament in Photoshop, rotate it, paste the rotated copy, and save the pair of half-ornaments as a graphic, e.g.,



which I can insert into any text file by defining a macro with the appropriate scaling and with an appropriate name, e.g., into a `thoughtbreak` macro such as I illustrated in my 2005-4 column:

```
\newcommand{\thoughtbreak}{\vskip2pt
```

1. You can get the file itself, `half-ornament.mp`, from the HTML page for this column.

```
\centerline{\scalebox{.05}{\includegraphics{two-half-ornaments.jpg}}}
\vskip2pt\noindent{}}
```


This looks pretty good compared with the scan from the book on page 2, so I think I'll end this column now. The graphic for this ornament is in the file `two-half-ornaments.jpg` which can be accessed via this column's HTML page.

Postscript

The 2008 Major League Baseball season is about to start, and the *Red Sox Annual 2008* from Maple Street Press (Hanover, MA) has been published and uses the following ornament for its thought breaks.

I love it.

Addendum

After I thought I was finished with this column, I received an email from Aditya Mahajan who had read the column on the journal's staging website before this issue was officially posted for public viewing. He said, "I do not understand why, ultimately, you are using the ornament as a jpg. Since you have created the ornament from MetaPost, you can simply include either a pdf or eps into your document. That way, you retain the advantage of having the ornament as a vector graphic. A jpg is a bitmap format and will not look good when zoomed in; the pdf/eps format will look good even when zoomed in.

"Since you are using MetaPost inside ConTEXt, you can just say

```
\starttext
\startMPpage
metapost code
```

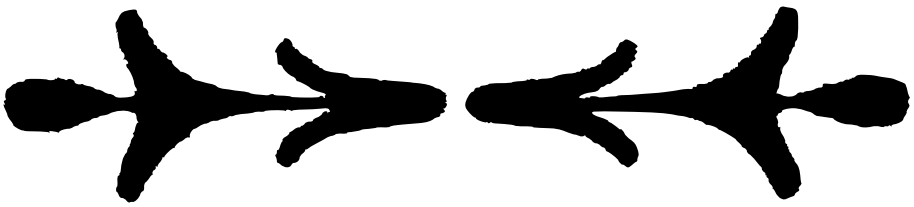
```
\stopMPpage
\stoptext
```

and you will get a pdf whose page size is same as the size of the ornament."

There were two reasons why I used a jpg. First, I only created half the ornament in MetaPost, and it was easier for me to use Photoshop to create the other half of the ornament and save the two halves as a jpg than it was to learn how to create the other half of the ornament using some symmetry operation in MetaPost. Second, I did not know how to get a PDF page which was only as big as the ornament when included as a graphic; Aditya Mahajan's set of commands above apparently solves that problem.

Appendix — Yuri's experiment with `autotrace`

After reading the subsection on my efforts with the second approach, Yuri Robbers tried the second approach himself using my 2400dpi scan. He cleaned up the scanned image using Gimp (the free equivalent of me using Photoshop) and then ran `autotrace`. The `autotrace` processing created the file `yuri.mp`, which in turn was converted into an EPS file which produce the following image:



His result is not quite as good as my result from using the third approach, but it is obviously a pretty good result.

The content of Yuri's MetaPost file (`yuri.mp`) can be seen by looking at the link on the HTML page for this column.

Acknowledgments

Issue editor Yuri Robbers provided editorial and editing help and other guidance and ideas. Karl Berry caught several typos and made other useful suggestions.

Biographical note

David Walden is retired after a career as an engineer, engineering manager, and general manager involved with research and development of computer and other high tech systems. He holds an undergraduate math degree and completed a graduate school sequence of courses in computer science. More history is at www.walden-family.com/dave.

THE PracTEX Journal

Ask Nelly:
How do I create math mode columns in tabular environments?
How do I find the files required to compile my document?

The Editors

Abstract

Ask Nelly is a question and answer column. Nelly is the quiet person who sits at the back corner desk, who knows a lot, and when asked any question is always ready with a patient answer. If Nelly doesn't know the answer, Nelly will know an expert who has the answer. Feel free to Ask Nelly about any aspect of LaTeX, TeX, Context, etc.

- Comment on this paper
- Send submission idea to editor

TpJ

Q: Dear Nelly: When I create tables with columns for which each and every cell contains mathematical content, I keep on switching into and out of Math mode all the time. Surely there is a better way to do this?

A: There is indeed! Frank Mittelbach and David Carlisle, names probably not unfamiliar to you, have solved this problem for you with their wonderful `array` package. This package, among many other things, redefines the `tabular` environment in such a way that it allows you to already declare mathematical mode when defining your table, so instead of — for example — using

```
\begin{tabular}{lll}
```

when you want all three columns to just contain material to be typeset in math mode anyway, you could use

```
\begin{tabular}{>{\(}l<{\)}>{\(}l<{\)}>{\(}l<{\)}}
```

which creates a table with three left aligned columns, all three of which are to contain mathematical content.

Should you want to create many such tables in your document, `array` even allows you to define new column types to make your life easier still. To define the mathematical equivalents of the three standard column types, just use

```
\newcolumntype{L}{>{\(}l<{\)}}
\newcolumntype{C}{>{\(}c<{\)}}
\newcolumntype{R}{>{\(}r<{\)}}
```

and then whenever you need to create a three column table with three left-aligned columns containing mathematical

contents all you need to do is

```
\begin{tabular}{LLL}
```

Although remember to use `\multicolumn` to change a cell back to regular type if you need non-mathematical information in a cell, as is often the case in, for example, column headings. An example, assuming the new column types having been defined as explained above:

```
\begin{tabular}{LLL}
\hline
\multicolumn{1}{l}{Function}&\multicolumn{1}{l}{Derivative}&\multicolumn{1}{l}{Primitive}\\
\hline
ax^n & nax^{n-1} & \frac{1}{n+1}ax^{n+1} + C\\
\sin(x) & \cos(x) & -\cos(x) + C\\
\cos(x) & -\sin(x) & \sin(x) + C\\
\hline
\end{tabular}
```

The above question was answered by **Yuri Robbers**, a member of the editorial board of this journal. He can be reached at yuri.robbers@gmail.com

TPJ

Q: Dear Nelly: When I tried to co-author a paper, I ran into trouble because my colleague did not have some of the files needed to properly compile the document. I am aware of the `\listfiles` directive, which can be added to the preamble in order to get a list of files included by LaTeX. In some cases, however, when trying to `locate` these files on my system I find multiple versions (Yes, I know, I should take better care of my system, but there you have it!). Is there a way to get the file list *with* the full path to each file?

A: The problem here is that the TeX engine is not actually aware of path names. Luckily, there is a way around this. If you use the option `-recorder` with `tex`, `latex`, `pdflatex` etc. you will get a file with extension `.fls` that contains every file opened for input as well as output, including their pathnames.

As an example I did a LaTeX run on a tiny example file, as follows:

```
pdflatex -recorder centaurtestje
```

And the resulting file `centaurtestje.fls` has the following contents:

```
PWD /home/yuri/texmf/knoeien
INPUT /home/yuri/.texlive2007/texmf-var/web2c/pdftex/pdflatex.fmt
INPUT centaurtestje.tex
OUTPUT centaurtestje.log
INPUT /usr/local/texlive/2007/texmf-dist/tex/latex/base/article.cls
INPUT /usr/local/texlive/2007/texmf-dist/tex/latex/base/article.cls
INPUT /usr/local/texlive/2007/texmf-dist/tex/latex/base/size10.clo
INPUT /usr/local/texlive/2007/texmf-dist/tex/latex/base/size10.clo
INPUT centaurtestje.aux
INPUT centaurtestje.aux
OUTPUT centaurtestje.aux
OUTPUT centaurtestje.pdf
INPUT /usr/local/texlive/2007/texmf-var/fonts/map/pdftex/updmap/pdftex.map
INPUT centaurtestje.aux
```

This is probably sufficient information for you. You could, however, go one better still, if you so desire. Scott Pakin

created the bundledoc package, available from CTAN. It can find all files needed to compile a LaTeX document and automatically bundle them in an archive file.

As a bonus, bundledoc includes the program arlatex, written in perl, which can create a single .tex file which contains all the other files needed to compile your document. Running the resulting .tex-file through latex recreates all the original files again, bypassing the need for external archievers such as tar, zip, etc.

bundledoc can easily be configured to use arlatex as its archiver.

The above question was answered by **Yuri Robbers**, a member of the editorial board of this journal. He can be reached at yuri.robbers@gmail.com

TpJ

THE PracTEX Journal

Distractions — Spirograph with PSTricks

The Editors

- Comment on this paper
- Send submission idea to editor

Spirograph with PSTricks

Once upon a time, 1965 to be precise, a children's toy called the Spirograph was invented by the British engineer Denys Fisher. It consisted of a set of gears of varying size. One gear was pinned to a sheet of paper, and one or two other gears were rotated along the fixed gear using a pen or pencil. This way a fascinating trail was left on the paper. A trail known to mathematicians as a Hypotrochoid when the fixed gear is circumambulated on the *inside*, or a Epitrochoid when the fixed gear is circumambulated on the *outside*.

Spirographs have remained popular ever since. The mechanical version is still for sale in many toy stores. It is, however, also possible to create these lovely figures with PSTricks!

The parametric equations for a hypotrochoid are:

$$x = (R-r)\cos\theta + d\cos\left(\frac{R-r}{r}\theta\right)$$

$$y = (R-r)\sin\theta - d\sin\left(\frac{R-r}{r}\theta\right)$$

And these can be entered into a simple PSTricks document, choosing — for example — R=100, r=2 and d=80:

```
\documentclass{article}
\usepackage{pstricks}
\usepackage{pstricks-add}
\usepackage{pst-plot}
\begin{document}
\thispagestyle{empty}
\psset{xunit=0.01in,yunit=0.01in,algebraic}
\begin{pspicture}[showgrid=false](-100,-100)(100,100)
  \parametricplot[plotstyle=curve,linewidth=0.1pt,plotpoints=1000]{0}{360}%
    {(100-2)*cos(t)+80*cos((100-2)/2*t)|(100-2)*sin(t)-80*sin((100-2)/2*t)}
\end{pspicture}
\end{document}
```

Note that I have had to fill in the numbers in the equations by hand. Also I have had to adjust the coordinates in the `\begin{pspicture}` command. I chose 100, because that is slightly more than R-r. Finally, I have had to adjust `xunit` and `yunit` so that the total picture ends up fitting on the page. In this case it'll be two by two inches.

The result looks like this:

Hypertrochoid example

Similarly, it is easy to convert the epitrochoid equations

$$x = (R+r)\cos\theta - d\cos\left(\frac{R+r}{r}\theta\right),$$

$$y = (R+r)\sin\theta - d\sin\left(\frac{R+r}{r}\theta\right).$$

into PSTricks code, choosing the same values as before, R=100, r=2, d=80:

```
\documentclass{amsart}
\usepackage{pstricks}
\usepackage{pstricks-add}
\usepackage{pst-plot}
\begin{document}
\thispagestyle{empty}
\psset{xunit=0.01in,yunit=0.01in,algebraic}
\begin{pspicture}[showgrid=false](-102,-102)(102,102)
  \parametricplot[plotstyle=curve,linewidth=0.1pt,plotpoints=1000]{0}{360}%
    {102*cos(t)-80*cos(51*t)|102*sin(t)-80*sin(51*t)}
\end{pspicture}
\end{document}
```

And the result of this code looks like this:

Epitrochoid example

Happy Spirographing!