LaTeX

Victor Eijkhout

Notes for CS 594 – Fall 2004

What is a macro language?

- Macros are abbreviations for sequences of commands or text

  `\TeX` *gives* '*TEX*'
- Macro language can have the full power of a programming language; variables, conditionals, recursion
- Typesetting macro languages like TEX/LATEX have commands for document processing.

Logical markup

- Macros introduce an abstraction level

  `\section{Introduction}`

  instead of (so to speak)

  `\MaybePageBreak \aLittleSpace \BiggerFont Introduction`
- Style no longer hardwired in the document: specified independently

Characters

- For most characters: type an ‘a’, get an ‘a’ on paper
- Exceptions:
  - Commands start with a backslash: `\section`
  - Braces indicate macro arguments, as with section command, or grouping:

    ```
    not bold {\bfseries then bold} then not
    ```

    gives ‘not bold **then bold** *then not’*
  - Spaces are ignored at beginning/end of line and after control sequence (except. . .); multiple spaces equivalent to one. After one blank line, others are ignored.

More special characters

- Dollars indicate inline math; in math ^ is superscript and _ is subscript:

  'and `$x_{i+1}^2$ is positive'` *looks like*
  'and x_{i+1}^2 *is positive'*

- & is used in tables, # in macro definitions, ~ is non-breaking space
- % is the comment character
- To get these characters, use `\%`, `\$` et cetera.
- Exception: `$\backslash$` for '\'

Character pitfalls

- Characters not available in all styles:

  the <> characters come out '¡¿' in text font;
  however, `$\langle$A$\rangle$` *is '⟨A⟩'*

- After control symbols – backslash followed by anything but a letter – spaces are not ignored; they are after \␣ control space.

A bit more about spaces

- Multiple spaces count as one; line end inserts a space:

  ```
  \section{
  The Long Title}
  ```

  has an unwanted space. Prevent with

  ```
  \section{%
  ```

- Spaces are ignored after control sequences:

  '`\LaTeX␣is␣fun`' *is '*LaTeX*is fun'; but* '`\LaTeX\␣is␣\LaTeX{}␣is␣fun`' *is '*LaTeX *is* LaTeX *is fun'; and* '`\LaTeX{}ing is fun`' *is '*LaTeX*ing is fun'*

Document structure

- Minimum elements:

```
\documentclass[<options>]{<class name>}
  <preamble>
\begin{document}
  <text>
\end{document}
```

- Classes are `article`, `report`, `IEEEproc`, `beamer`, et cetera. Class options: `twoside`, `a4paper`, `12pt`, et cetera.
- Preamble has definitions and parameter settings, also

```
\usepackage[<options>]{<package>}
```

Usual start of scientific prose

- In preamble or text:

```
\title{My lecture notes}
\author{John Doe}
\date{August 2004} % leave out, get today's date
```

  and in the text `\maketitle`.

- Maybe also

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

Running LaTeX

- Traditionally, executable `latex` translates `.tex` file to `.dvi`, also generating `.log` and `.aux` (maybe more).
- Preview `dvi` with `xdvi`
- Translate `dvi` to Postscript with `dvips`, then Pdf with `ps2pdf`.
- Better: use `pdflatex` executable

External resources

- Comprehensive TeX Archive Network: `\http://www.ctan.org/`
- Newsgroup `comp.text.tex`; readable and archived through Google groups.
- Lots more stuff on the web.

Text element

Conceptual model

- Paragraph: one long strip, cut into lines when everything has been set.
- Page: one long scroll, cut into pages when all material has been assembled
- Upshot: asking 'on what line/page is this text' is pretty hard

Sectioning

- Write `\section{Introduction}`, also `\subsection` and `\subsubsection`; `\chapter` and `\part` in `report` and `book` style only.
- Use `\section*` for unnumbered.

Input files

- Use `\input <file>`, `\input <file>.tex`, `\input{<file>}`
- Input on new page: `\include`
- On Unix, search locations are in `TEXINPUTS` environment variable.

Environments

- `\begin{<name>} .... \end{<name>}`
- Main use: group a section of text for different processing.
- 'Abstract' already mentioned
- Different text treatment: `flushleft`, `flushright`, `center`

Verbatim text

- Problem: how to print all of LaTeX's special characters?
- Also: listing of code input (programming, HTML, TeX itself)
- Short snippets: `\verb+&$^_\}+`
- Longer:

```
\begin{verbatim}
  TeX example
\end{verbatim}
```

- Whole files: `\verbatiminput{<file>}`
- TeXnical stuff: verbatim command and environment can not be used in `\SomeCommand{.. \verb ...}` context; usually possible in environments.

Lists

- Bullet and numbered:

  ```
  \begin{itemize}
  \item One \item Two
  \end{itemize}
  ```

  Output:

  - *One*
  - *Two*

  ```
  \begin{enumerate}
  \item\label{first:item} One
  \item Two comes after \ref{first:item}
  \end{enumerate}
  ```

  Output:

  1. *One*
  2. *Two comes after 1*

- Bullet and number style changes with level

Description list

- ```
  \begin{description}
  \item[Do] A deer
  \item[\textbf{Re}] A beam
  \end{description}
  ```
  Output:

  Do *A deer*
  Re *A beam*
  ```

Tabular stuff

- Table data:

```
\begin{tabular}{|r|rl|}
\hline
instrument&\multicolumn{2}{|c|}{name}\\ \hline
drums: &"Philly" Joe & Jones\\
trumpet:& Dizzie & Gillespie\\
piano: &Art&Tatum\\ \hline
\end{tabular}
```

Output:

instrument	*name*	
drums:	*"Philly"* *Joe*	*Jones*
trumpet:	*Dizzie*	*Gillespie*
piano:	*Art*	*Tatum*

Footnotes

- Use `\footnote{<fn text>}` in the place where you want the marker or number to appear
- Tinkering: set the `footnote` counter, or use `\footnotemark` and `\footnotetext` to place the mark and text seperately.
- Latter option also for footnotes in tables and such

Text boxes

- `\parbox[pos]{width}{text}`
  where `pos` is `t`,`b` for top, bottom; center default

```
\begin{minipage}[pos]{width}  text  \end{minipage}
```

```
This \parbox{2in}{text, text, more text
  and yet more more more text}
```

Output:

This *text, text, more text and yet more more more text*

Tabbing

```
\begin{tabbing}
while \=\kill
do\>\{\\
\>$i_1\leftarrow{}$\=1\\
\>$\ldots$\>2\\
\>\}\\
while (1)
\end{tabbing}
```

Output:

do {
$i_1 \leftarrow 1$
$\ldots$ 2
}
while (1)

Fonts and typefaces

- Deprecated commands: `\bf`, `\it`, et cetera.
- Changes for short amount of text:

```
\begin{upshape} %kindly ignore this
Text \textbf{in bold}, \textsl{slanted},
\textsc{Small Caps}.
\end{upshape}
```

Output:

Text **in bold**, *slanted*, Small Caps.

- More general

family	roman \rmfamily, sans serif \sffamily, typewriter \ttfamily
series	bold \bfseries, medium weight \mdfamily
shape	upright \upshape, italic \itshape, slanted \slshape, small caps \scshape

```
\begin{rmfamily}\begin{upshape}text \textbf{bold}
  \begin{slshape}slant
  \end{slshape}\end{upshape}\end{rmfamily}
```

Output:

text **bold** *slant*

Comments

- Inline comments, use `line % comment`
- Longer:

```
\usepackage{comment} or usepackage{verbatim}
\begin{comment}
 }}} uns&n_tact$ical
\end{comment}
```

Hyphenation and line breaking

- Prevent line breaking: `\mbox{and the $1$}`. Also `do~not~break`.
- Repair: `Eijk\-hout` or `\hyphenation{Eijk-hout}`. *This is only as repair: using a different language takes more.*
- Good habits: start sentences with `A~further`, and end with `to~1`.

Tilde

- Tilde is an active character: non-breaking space.
- Tilde accent: '`ma\~nana`' is 'mañana'
- Tilde character: '`\~{}`' is '~'; '`$\sim$`' is '∼'; '`\char'\~` is '~'
- In URLs: `\url` is defined in the `url` and `hyperref` packages

Accents

- Accents are backslashed, before the character: `Sch\"on b\^et\'e` for 'Schön bêté'.
- Better: use package `inputenc` and select the proper code page.

Lines and boxes

- Do not underline!
- Rule:

  `1\ \rule[.5ex]{2cm}{.5mm}\ The title`

  Output:

  1 ——— *The title*
- `\fbox{text}` gives  .

Line and page breaking

- In general: leave it to LaTeX.
- `\linebreak` (`\linebreak[1..4]`) is suggested location for normal line break, with filling out the margin
- `\newline` breaks without adjusting margin
- `\pagebreak` and `\newpage` similar
- `\nolinebreak`, `\nopagebreak`

Spacing

- `\hspace`, `\vspace`, `\hspace*`, `\vspace*`

```
This is a short bit\hspace{2cm}of text with a
manually inserted space. That space would\hspace{1in}
disappear in a line break. This space\hspace*{31.4mm}
does not.
```

Output:

This is a short bit of text with a manually inserted space. That space would disappear in a line break. This space does not.

- Also: `\hspace{\fill}` for 'infinitely stretchable space': takes up whatever room there is.

Horizontal and vertical mode

- Horizontal mode: letters in paragraph
- Vertical mode: paragraphs in page
- Most of the time LaTeX does the right thing.
- Force vertical mode with `\par`
- Force horizontal by putting them in an `\mbox` (or use `\leavevmode`)

Fragile commands

- `\section{Fragile commands\footnote{like this}}` leads to strange error messages:

```
! Argument of \@sect has an extra }.
<inserted text>
                \par
1.691 ...gile commands\footnote{like this}}
```

Do `\section{...\protect\footnote{like this}}`

More text elements

Floats

- Big objects (tables, figures) may not fit at the current location
- Declare as floating object, leave placement to LaTeX

```
\begin{<table or figure>}[placement]
... table or figure material ...
\caption{Caption text}\label{tabfig:label}
\end{<table or figure>}
```

- placement example: `[htp]` means 'place here, otherwise top of page, otherwise page of its own'
- tables with `tabular` environment, figure see below
- `\listoftables`, `\listoffigures`

Getting into math mode

- Inline math: `$<formula$`, `\(...\)`
- Display math unnumbered: `\[...\]` or `displaymath` environment
- Display math numbered: `equation` environment; use `\label` and `\ref` to refer to the equation number
- Equations are centered, use `fleqn` (option, or use package) for flush left

Display vs inline

- Mostly visible in delimiter style:

text style: $\sum_{n=1}^{\infty} 1/n^2$

display style: $$\sum_{n=1}^{\infty} 1/n^2$$

Fonts in math

- Variables are italic: 'x'
- Functions are roman: '$\sin(x)$'
- Connecting text:

```
\[ \forall_x \quad \mbox{(sufficiently large)} \quad
   \colon \qquad x>5 \]
```

Output:

$$\forall_x \quad \textit{(sufficiently large)} \quad : \qquad x > 5$$

Long formulas

- Inline formulas can be broken, usually after operators ($+$) or relations ($=$). Prevent that with `hence~$x=\nobreak1$` or `hence~\mbox{$x=1$}`
- Display formulas are not broken, use

```
\begin{eqnarray}
x&=&3\\
y&>&2\sin y
\end{eqnarray}
```

Output:

$$x = 3 \tag{1}$$
$$y > 2\sin y \tag{2}$$

Sub and superscripts

- `$x_{i,j}^{n^2}$` is $x_{i,j}^{n^2}$
- also for delimiters: `\sum_i^j 1/i` is $\sum_i^j 1/i$
- complicated limits

```
\[ \sum_{\begin{array}{c}\scriptstyle i\geq0\\
                \scriptstyle j\geq0 \end{array}} i^j \]
```

Output:

$$\sum_{\begin{array}{c}\scriptstyle i\geq0\\ \scriptstyle j\geq0\end{array}} i^j$$

Matrices

- `array` environment much like `tabular`, but in math

```
\[ A=\left( \begin{array}{cc} 1&2\\ 3&4
        \end{array}\right) \]
```

Output:

$$A = \left(\begin{array}{cc} 1 & 2 \\ 3 & 4 \end{array} \right)$$

Delimiters

- Delimiters are `()[]\{\}`
- Use with matched `\left`, `\right`; omitted delimiter from `.`

```
\[ \left( \frac{1}{1-x^2} \right)
\left\{ \begin{array}{ccc}
    \mathrm{(a)}&\Rightarrow&x>0\\
    \mathrm{(b)}&\Rightarrow&x=0\\
    \mathrm{(c)}&\Rightarrow&x<0
        \end{array} \right. \]
```

Output:

$$\left(\frac{1}{1-x^2} \right) \left\{ \begin{array}{ccc} \mathrm{(a)} & \Rightarrow & x>0 \\ \mathrm{(b)} & \Rightarrow & x=0 \\ \mathrm{(c)} & \Rightarrow & x<0 \end{array} \right.$$

```
\[ A = \left( \begin{array}{cccccc}
      a_{11}&0&&\ldots&0&a_{1n}\\
      &a_{22}&0&\ldots&0&a_{2n}\\
      &&\ddots&\ddots&\vdots&\vdots\\
      &&&a_{n-2n-2}&0&a_{n-2n}\\
      &\emptyset&&&a_{n-1n-1}&a_{n-1n}\\
      &&&&&a_{nn}
    \end{array} \right) \]
```

Output:

$$A = \left(\begin{array}{cccccc} a_{11} & 0 & & \ldots & 0 & a_{1n} \\ & a_{22} & 0 & \ldots & 0 & a_{2n} \\ & & \ddots & \ddots & \vdots & \vdots \\ & & & a_{n-2n-2} & 0 & a_{n-2n} \\ & \emptyset & & & a_{n-1n-1} & a_{n-1n} \\ & & & & & a_{nn} \end{array} \right)$$

References

- Make a label by `\label{sec:intro}` and such, then refer to `\ref{sec:intro}` and `\pageref{sec:intro}`
- Implemented through `.aux` file; two runs needed
- Warnings on undefined references and duplicate labels

Contents

- Table of contents formed automatically
- insert with `\tableofcontents`
- star-commands (`\section*` and such) not in table of contents;
- manual additions: `\addcontentsline` and more

Index

- `\usepackage{makeidx}`
- Create entries by `\index{Keyword}`, `\index{Key!subkey}` and more.
- `\printindex` to include index;
- run external program `makeindex`
- external file `.ind`

Bibliography

- Refer to books, articles with `\cite{Dongarra:1992a}`
- `\bibliographystyle{plain}`
  `\bibliography{cs}`
- Run external program `bibtex <mytexfile>`, giving `.bbl` file

```
@book{tbt,
author = {Victor Eijkhout},
title = {{\TeX} by Topic},
publisher = {Addison-Wesley UK},
year = {1991},
note = {out of print;
  available online at \url{http://www.eijkhout.net/tbt/
}
```

Customizing LaTeX

Parameter changes

- Layout parameters are 'lengths'

```
\setlength{\textwidth}{10in}
\addtolength{\oddsidemargin}{-1cm}
```

- Some lengths are 'rubber length'

```
\setlength{\parskip}{10pt plus 3pt minus 2pp}
```

Layout options and parameters

- Document class choice, class options: `twoside`, `a4paper`, `letterpaper`
- Parameters: `\textheight`, `\textwidth`, `\topmargin`

Page styles

- Use `\pagestyle{plain}` or `empty` or `headings`
- More flexible: use package `fancyhdr`, page style `fancy`
- Fancy: six ingredients `{lcr}{head,foot}`

  `\lhead{<text>}` `\chead{<text>}` `\rhead{<text>}`

Fancy running heads

- Use `lhead{text}` (also `c`, `r`; `foot`)
- Combined

```
\fancyhead[LE,OR]{\rightmark}
\fancyfoot[LE,OR]{\thepage}
```

Automatic running heads

- Commands `\markright{head}` and `\markboth{left}{right}`
- Fancy style uses `\rightmark` and `\leftmark` by default
- TeX searches back for last left and right mark
- Marks are set automatically by sectioning commands

Multicolumn text

Load

```
\usepackage{multicol}
```

and write

```
\begin{multicol}{3}
text in three column mode
\end{multicol}
```

Can start/end anywhere.

Just a bit about device drivers

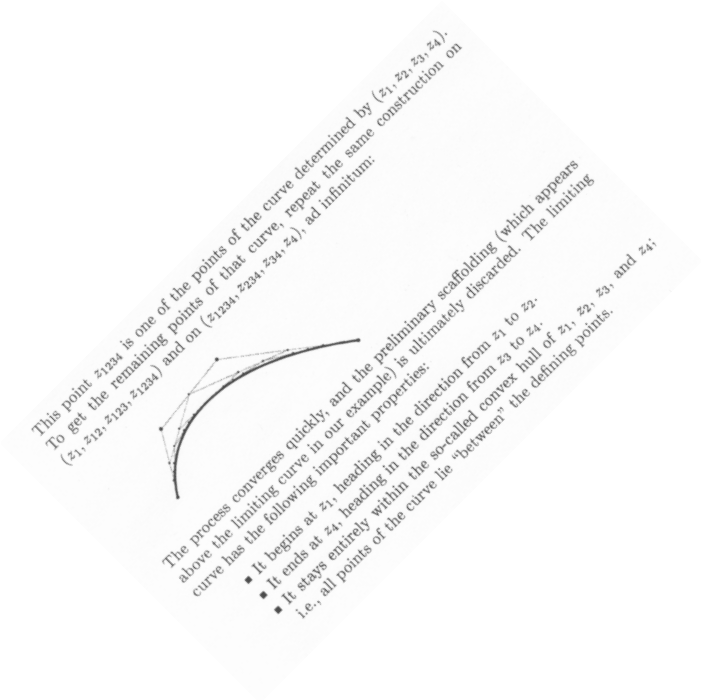
- TeX does not support graphics
- Extension mechanism: 'specials'
- Arbitrary text in the `dvi` output, interpreted by device driver
- $\Rightarrow$ TeX has to know about device driver
- specific LaTeX graphics extensions: `psfig`, `epsf`, `graphics`
- `pdflatex` has device driver built in

Included pictures

- Use package `graphicx`

  `\includegraphics[scale=.3,angle=45]{spline-pic}`

  Output:



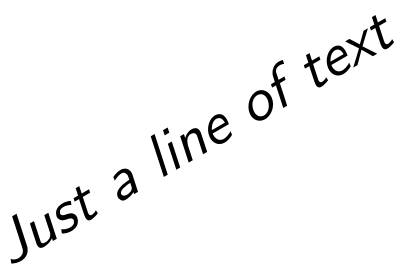
- good idea to put this in a float

Text manipulation

```
\usepackage{rotating}

\begin{turn}{30}
Just a line of text
\end{turn}
```

Output:



Counters

- Use existing counters `section`, `footnote`, `enumi`

```
\setcounter{subsection}{3}
\addtocounter{enumii}{-1}
\refstepcounter{footnote}
\arabic{section} \Roman{subsection}
```

- Define new counters:

```
\newcounter{exercise}[chapter]
```

Commands

```
\newcommand{\IncrByOne}{increased by~$1$}
\dots and $n$~\IncrByOne.
\newcommand{\IncrDecrBy}[2]{#1creased by~$#2$}
\dots and $n$~\IncrDecrBy{de}{5}.
```

Output:

. . . and n increased by 1. *. . . and n decreased by* 5.

(\renewcommand)

Commands, optional arguments

```
\newcommand{\IncrDecrBy}[2][in]{#1creased by~$#2$}
\dots and $x$~\IncrDecrBy{1}.
\dots and $y$~\IncrDecrBy[de]{5}.
```

Output:

. . . and x increased by 1. *. . . and y decreased by* 5.

New environments

```
\renewenvironment{example}%
  {\begin{quote}\tiny\textbf{Example.}}%
  {\end{quote}}
\dots and text.
\begin{example} Blah blah. \end{example}
```

Output:

. . . and text.

Example. *Blah blah.*

Arguments and optional args as before.