Very Short Introduction to LaTeX

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2015

1 Motivation

The computer scientist Donald Knuth developed the program TeX [1] in the late 70s to facilitate typesetting texts containing mathematical formulas. This used to be a slow and error-prone process in the traditional publishing industry. Knuth also developed the program Metafont [2] for defining non-proprietary and freely available fonts.

Working in plain TeX is possible but the learning curve is somewhat steep. Leslie Lamport started the Latex [3] project which uses TeX but provides improved support for end users. Subsequently a number of auxiliary programs were developed for scientific publishing, such as BibTeX for maintaining consistent citations.

TeX and LaTeX are free and open source software. TeX documents can be transferred among different operating systems without any change while still resulting in the same professional quality output. Due to their free availability, high quality results and platform-independence TeX and LaTeX have become standard for publishing in many scientific fields, especially mathematics and related disciplines.

LaTeX can be used on the command line, and there are good reasons to do so, e.g. automated file generation. However, for the novice user one of the development environments is probably a better choice. In this text the free software `texmaker` is described.

2 Small Sample Document

LaTeX does not employ a WYSIWYG approach (What You See Is What You Get). Instead, there are several steps:

1. A text editor (such as nano or gedit in Linux, or the built-in text editor of texmaker) is used to edit the TEX file containing the document content and formatting instructions. This file is saved with the extension .tex.

2. The program latex is run; it reads the TEX file and generates a DVI file. Alternatively, pdflatex generates a PDF file.

3. The DVI or PDF file is viewed with a preview program (such as evince in Linux) and finally printed.

This process is facilitated with texmaker which integrates everything in a single application. Start texmaker (on the command line or via a menu, if available). You are presented with an empty document window. Enter the following text:

```
\documentclass{article}
\title{A LaTeX Document}
\author{Your Name}
\date{November 2014}
\begin{document}
\maketitle

\section{Introduction}

LaTeX is very much recommended for scientific
publishing.

However, it will work well with other types of publications,
such as novels or poetry.
\end{document}
```

Save the file e.g. as sample.tex and go to menu Options/Configure Texmaker/Quick Build tab: PdfLatex + View PDF should be selected. This works for simple documents like this one (no cross-references or bibliography). Click on the Quick Build arrow (or press F1) and you should see the preview window with your typeset text. Errors are displayed at the bottom of the window, together with line numbers. Common errors are:

- Forgetting to close braces

- \begin{..} without corresponding \end{..}

- misspelled names of LaTeX commands

The sample document contains a number of LaTeX instructions:

\documentclass{article} This defines the type of document which determines a large number of layout options.

- *article* is usually a good starting point for short to medium length texts where *section* is the highest heading level.
- *report* provides an additional *chapter* level for longer texts.
- *book* sets different margins on odd and even pages for binding.

\title, \author, \date These are part of the preamble. At this point they do not yet produce any text.

\begin{document} This concludes the preamble and starts the document content.

\maketitle Data from \title, \author, and \date is used to generate a title. The title layout depends on the document class.

\section{Introduction} Section and subsection are used in article. These are numbered and if desired a table of contents with page numbers can be generated with `\tableofcontents`, but this is usually better suited for longer texts such as reports.

\end{document} This concludes the TEX document.

An empty line starts a new paragraph. TeX will fill the current text width and introduce line breaks within paragraphs. Hyphenation is used if needed, but spaces between words are the primary positions for line breaks. Sometimes a line break occurs at an inconvenient spot. Use a tilde ~ instead of space to avoid a line break at this point. The `\footnote{...}` command creates a numbered footnote.[1]

TeX and LaTeX have a large set of font types. Here are some of the more commonly used ones:

{\it ...} *italics*
{\bf ...} **bold face**
{\tt ...} `teletype`
{\sf ...} sans serif

Font sizes can be changed with `\large`, `\Large`, `\LARGE`, and `\small`, `\footnotesize`, `\tiny`, and back to `\normalsize`. These should be used sparingly and for small pieces of text only; for the whole document use an option for the document class:

`\documentclass[12pt]{article}`

The margins are somewhat generous in the article class i.e. a lot of paper is wasted. Add `\usepackage{fullpage}` to the preamble to decrease the left, right, top, and bottom margins. Here are some other options to change the spacing; these should also go into the preamble:

---

[1]Don't use footnotes.

`\parindent0mm` – set the first line indent to 0 i.e. no indent
`\parskip2mm` – add vertical space between paragraphs

Some characters have special meaning in TeX and must be escaped with a backslash:

`\$` $ `\%` % `\_` _ `\&` & `\#` #

There are many other commands that produce various symbols. Some symbols require certain packages in the preamble, such as `\usepackage{eurosym}` for `\euro`.

3   Labels and References

Set labels with the `\label{here}` command and refer to the corresponding section with `\ref{here}` which in this document results in section 3. If you want the page number instead of the section number use `\pageref{here}` resulting in page 4. Note that LaTeX needs to run at least twice for all references to be set correctly. Undefined references such as `\pageref{undefined}` produce a warning in texmaker's log window and are shown as double question marks in the typeset text: **??**.

A label is set with the counter in the current context. Sections, figures, tables, and equations all receive counters which can be used in `\label` and `\ref`.

Add `\usepackage{hyperref}` to the preamble to get Hypertext references in the PDF output.

4   Math

TeX and LaTeX allow for typesetting mathematics in very high quality. The syntax is more or less intuitive; here is an example for displayed formulae i.e. they are put into a separate centered paragraph:

```
\begin{equation}\label{cov}
cov(X,Y) = \sum_{i=1}^N \frac{(x_i-\bar{x}) (y_i-\bar{y})}{N}
\end{equation}
```

```
\begin{equation}\label{cor}
\rho_{x,y} = \frac{cov(x,y)}{\sigma_x \sigma_y}
\end{equation}
```

$$cov(X,Y) = \sum_{i=1}^N \frac{(x_i - \bar{x})(y_i - \bar{y})}{N} \tag{1}$$

$$\rho_{X,Y} = \frac{cov(X,Y)}{\sigma_X \sigma_Y} \tag{2}$$

The `\ref` command can be used to refer to the numbered equation, in this case e.g. equation 2 by using `\ref{cor}`. In math mode spaces are not printed; use tilde characters ~ for blank (space).

Single Dollar signs $ switch math mode within the paragraph: `$ \rho_{x,y} = ... $` which results in $\rho_{x,y} = cov(x,y)/(\sigma_x \sigma_y)$. This saves space, but it should only be used for simple and short expressions.

LaTeX has a very long list of predefined mathematical symbols covering almost every conceivable need. However, you can easily define your own symbols by constructing from available building blocks, e.g. if you want an epsilon with a bar you can use `$\bar{\epsilon}$` for $\bar{\epsilon}$.

5   Tables

The tabular environment is used to produce tables. Tables are usually centred. Note the alignment specification for the individual columns (l for left, r for right, c for centred); numbers should be aligned on the right.

```
\begin{center}
\begin{tabular}{lr}
Apples  &  25 \\
Oranges & 150 \\
\hline
Total   &  75 \\
\end{tabular}
\end{center}
```

Apples	25
Oranges	150
Total	175

6   Graphics

LaTeX can be used to produced very neat graphics, but usually other applications such as statistics software are used to generate diagrams. Most common formats such as JPG work fine, but Postscript graphics should be converted to PDF if pdflatex is used; on the Linux command line the `convert` program can be used, e.g. convert diagram.eps diagram.pdf.

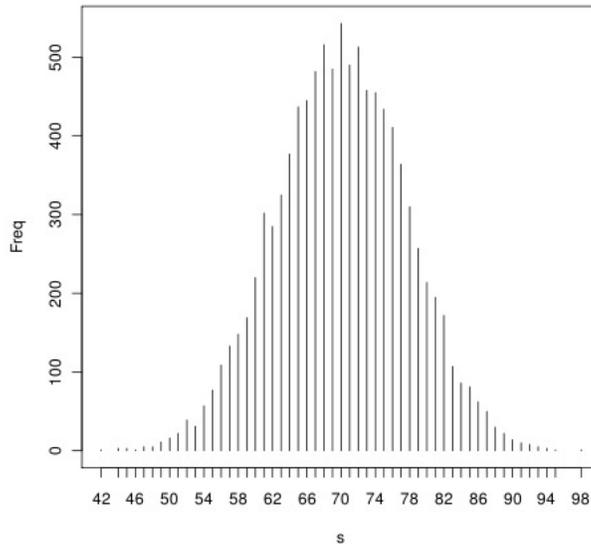Figure 1: Histogram of the sum of 20 dice cast 10000 times.

Add \usepackage{graphicx} to the preamble. Assume that there is a file dice.jpg in the current directory; that file can be included with the code below. Usually this happens inside a figure environment which places that figure at the top of the current page, if that space is available. Figure placement can be forced to the top, bottom, or current page, e.g. \begin{figure}[t]. However, since there can be several figures even in a short text it is best to leave figure placement to LaTeX, if at all feasible. The caption is numbered and can be labeled e.g. as \label{dice} command and referred to with \ref{dice}. In this document this results in figure 1.

```
\begin{figure}
\begin{center}
\includegraphics[scale=0.5]{dice.jpg}
\end{center}
\caption{Histogram of the sum of 20 dice cast 10000 times.}
\label{dice}
\end{figure}
```

The figure counter used in the captions and references is incremented automatically. There is a similar environment for tables used with \begin{table} and \end{table}.

7 BibTeX

Citations are managed with BibTeX. This program reads bib files containing definitions of sources to be cited and generates a formatted bibliography according to a predefined style. Texmaker includes bibtex, but it has to be configured in the Quickbuild tab in Options/Configure Texmaker: pdflatex + bibtex + pdflatex (x2) + view pdf. Set that option, then open a new file and enter the following:

```
@book{Knuth84,
title = {The TeXbook},
author = {Donald E. Knuth},
publisher = {Addison-Wesley},
year = 1984
}
```

Save the file as intro.bib and cite the source anywhere within your TEX file: `\cite{Knuth84}`. To produce the bibliography containing only the sources actually cited add the following to the end of your TEX file, just before `\end{document}`:

```
\bibliographystyle{plain}
\bibliography{intro}
```

Since the bibliography style is plain the source is now cited simply as [1]. Missing sources are displayed as error messages during processing. The output shows a question mark for such cases. There are many predefined bibliography styles, such as alpha which results in citations of the form [Knu84]. To change to a different style only the `\bibliographystyle{}` command has to be updated. Bibtex supports various entry types with different required and optional fields, e.g.

	required	optional
article	author, title, journal, year	volume, number, pages, month, ..
book	author or editor, title, publisher, year	volume, series, address, edition, ..
inproceedings	author, title, booktitle, year	editor, pages, organization, ..
techreport	author, title, institution, year	type, number, address, month, ..

8 Encodings and Non-ASCII Characters

The **ASCII** code (American Standard Code for Information Interchange) has dominated information processing for several decades. It contains the characters used in the English language and various punctuation characters, as well as a set of control characters. Files

containing only ASCII characters are highly portable across different hard- and software platforms. For documents in English the ASCII encoding is perfectly suitable.

LaTeX authors writing in other languages need to find some workaround or use another encoding; you probably also need to install additional Tex and Latex packages; see section 9. There are three alternatives:

1. The **UTF-8** encoding should (!) be supported in current operating systems and applications, and it should allow for direct input of non-ASCII characters such as German umlauts via the keyboard. The byte encoding for the ASCII characters is identical in both ASCII and UTF-8. Characters not present in the ASCII code are encoded in two, three, or four bytes. The following modified preamble is needed to support UTF-8 and German:

   ```
   \documentclass[12pt,ngerman]{article}
   \usepackage[utf8]{inputenc}
   \usepackage[]{babel}
   ```

   Similar options are available for other languages. Note that the text editor must also support UTF-8. This is the case for texmaker, and other reasonably current software. However, problems with non-ASCII characters still occur in some configurations.

2. There is another option using the following preamble:

   ```
   \documentclass{article}
   \usepackage{german}
   ```

   The German Umlaut ö is entered as `"o` e.g. in the word `k"onnte`. This method was standard for decades, and consequently it is well supported and reliable. While being a little inconvenient it has one big advantage: the TEX file contains only ASCII characters and does not need any special encoding such as UTF-8. When transferring files across different operating systems or applications this can avoid a *lot* of trouble. This author continues to use this method, just like many other Latex users in German-speaking countries.

3. There is yet another option for entering non-ASCII characters such as the German umlauts: `\"o` i.e. the Latex command that produces the character ö in the output. No additional packages for UTF-8 or German are needed. This makes sense when typing only a few umlauts in an otherwise English text (use `\ss` for ß).

9 Installation

In Linux the installation of LaTeX and texmaker is easily done via the package manager, e.g. apt-get or the GUI program Software Manager in Debian/Ubuntu/Mint. The package manager will also install the dependencies, e.g. the basic tex packages.

texlive-latex-base Commonly used LaTeX modules

texlive-latex-extra A large number of useful additional modules, e.g. fullpage.sty

texlive-lang-german Umlauts and other German adaptations

texlive-fonts-recommended Additional fonts used in various applications

Unfortunately, some Linux distributions use slightly different package names, e.g. in Fedora the list is: texlive-collection-latexextra, texlive-german, texlive-hyphen-german, texlive-babel-german, texlive-collection-fontsrecommended.

Texmaker is free software and available for all major operating systems. It can be downloaded from www.xm1math.net/texmaker. Texmaker needs a LaTeX distribution; this is available at http://latex-project.org which contains a lot of further documentation and tutorials on specialized TeX and LaTeX packages. The community forums at tex.stackexchange.com are another good place to find help on all kinds of tex-related problems.

References

[1] Donald E. Knuth. *The TeXbook*. Addison-Wesley, Reading, Massachusetts, 1984.

[2] Donald E. Knuth. *The METAFONTbook*. Addison-Wesley, Reading, Massachusetts, 1986.

[3] Leslie Lamport. *LaTeX: A Document Preparation System*. Addison-Wesley, 2nd edition, 1994.