

# Writing Articles with L<sup>A</sup>T<sub>E</sub>X

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March 2010

## Abstract

This is an educational article addressing students of the Applied Physics School at TEDA, Tianjin, PR of China. We describe how to compose an article with L<sup>A</sup>T<sub>E</sub>X, a *document preparation system*, as it calls itself. We explain the coarse structure of such an article and discuss how to enter text, typeset mathematical formulas, include graphics and provide for a bibliography. You should print the source code `article.tex` of this document in order to follow the discussion.

## 1 Coarse structure

A L<sup>A</sup>T<sub>E</sub>X document consists of a preamble and the document proper. The preamble consists of instructions only, they affect the entire document. The document proper is wrapped into a `\begin{document}... \end{document}` environment. `\end{document}` normally is the last line of your document. What follows is ignored. You may use this feature for an extended comment or for placing computer code.

`\documentclass` must be the first instruction of the preamble, in our case it reads `\documentclass[fleqn]{article}`. Besides `article` (the argument in curly brackets) there are classes for a report, a book, a presentation (beamer), for Springer Verlag monographs (svmono), and so on. Here we discuss the article document class only. The argument in square brackets is optional. We have specified `[fleqn]` which means that equations are flushed left, and not centered (default).

The following preamble instructions load additional packages which regulate how source code characters are mapped to locations in fonts, which fonts are to be used, how graphics is to be included and how computer code listings are printed. You probably may not need the `moreverb` package.

Now the document proper.

`\title` specifies the title. The `\bf` command<sup>1</sup> says that the following text

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<sup>1</sup>All commands begin with a backslash. The following sequence of letters is the command name. The first non-letter character terminates the command name.

should be printed in bold face.

`\author` specifies the author. Note that `\\` stands for a line break.

`\date` specifies a date. When working on your document, you should say `\date{\today}`. If your document is finished, say `\date{August 12, 2010}`, for example. If you want to suppress the date, say `\date{}`.

`\maketitle` produces the title section of your article.

Now comes the abstract, embedded in a `\begin{abstract}... \end{abstract}` environment. We will explain the `\noindent` here and the `\setlength` instructions in the preamble when we talk about paragraphs.

A normal article consists of its title (specifying the title proper, the authors, and the date), the abstract, a few sections, and a bibliography.

A new section is introduced by `\section{section name}`. This command does more than printing a large fat section title. It arranges that this section is associated with a number which changes if preceding sections are removed or added.

Sections may, but must not, contain subsections which are introduced by the command `\subsection{subsection name}`.

Although there are deeper section levels, such as `\subsubsection`, you should not use this feature for short articles of less than 50 pages or so.

If a section is divided into subsections<sup>2</sup>, there should be a short summary. Put otherwise, a `\section` command should not be followed immediately by a `\subsection` command. The following section may serve as an example.

## 2 How to type text

We discuss how to organize the text into paragraphs, how they can be formatted and some subtleties of typing.

### 2.1 Paragraphs

Sentences are grouped into paragraphs. Each paragraph describes an idea. LaTeX breaks a paragraph into lines where the last one need not fit the page-width. When reading a text you will easily recognize its paragraphs.

One or more empty lines separate paragraphs. `\par` does the same, however, it should be used in macro definitions only.

By default, a new paragraph is marked by indenting the first line. This is fine for text only documents, but if there are many displayed mathematical formulas you should not indent paragraphs. It looks better to separate paragraphs by extra space.

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<sup>2</sup>One subsection only does not make sense.

```
\setlength{\parindent}{0mm}
\setlength{\parskip}{1mm}
```

in the preamble achieves this. These are the settings for this article.

## 2.2 Subtleties

Normally, text is reproduced just as you type it. There are, however, some exceptions.

A group of letters forms a word. A word can be terminated by a line break in the source code, by one or more spaces or by a punctuation mark.

```
ends here. This    is
fine.
```

produces ends here. This is fine.

A piece of text may be distinguished from the rest by *emphasizing* it. We have achieved this by `\emph{emphasizing}`.

A word may be underlined by writing `\underline{underlined}`.

When  $\text{\LaTeX}$  tries to break a paragraph into lines, a space is a preferred position since it separates words. If a space should not be used for line breaking, mark it with a tilde, such as in `12.3~mm` or `4321~EUR`.

There are three kinds of dashes. `Electro-optic` is written as `Electro-optic`. `pages 38--51` reads pages 38–51. Three minus signs yield a very long dash, such as in `As always---but not yesterday---the weather was fine`. This produces `As always—but not yesterday—the weather was fine`.

## 3 Mathematical formulas

Setting mathematical expressions<sup>3</sup> used to be expensive, therefore Donald Knuth<sup>4</sup> choose `$` for toggling between text mode and math mode. You say `$E=mc^2$` and you get  $E = mc^2$ . Therewith you include mathematical expressions into the running text.

Note that `^` indicates a superscript. A subscript is denoted by an underscore, such as `$F_{ij}$` which produces  $F_{ij}$ .

### 3.1 Displayed formula

Within a `\begin{displaymath}...\end{displaymath}` environment you may say

$$\Phi(\omega) = \int_{-\infty}^{\infty} dt e^{-i\omega t} F(t)$$

---

<sup>3</sup>or formulae, formulæ, or formulas

<sup>4</sup>the author of  $\text{\TeX}$ , see [1]

This formula was produced by

```
\begin{displaymath}
\Phi(\omega)=\int_{-\infty}^{\infty} dt e^{-i\omega t} F(t)
\end{displaymath}
```

It is far from being perfect.

First, the Greek letter  $\omega$  appears with different size on both sides of the equation. Second, the letter  $e$  (Euler's number) is not a variable, it should be printed upright, and not slanted. We correct this:

```
\Phi(\omega)=\int_{-\infty}^{\infty} dt \,
\text{e}^{-i\omega t} F(t)
```

which produces

$$\Phi(\omega) = \int_{-\infty}^{\infty} dt e^{-i\omega t} F(t)$$

Now, it is rather cumbersome to write this complicated expression again and again, we therefore construct a macro.

### 3.2 Macros

`\newcommand{\name}[1]{expression}` defines a new command with one argument. Here is an example:

```
\newcommand{\EXP}[1]{\text{e}^{-\displaystyle #1}}
```

The first (here: the only) argument is denoted by `#1` in the replacement text. You now may say

```
\Phi(\omega)=\int_{-\infty}^{\infty} dt \, \EXP{-i\omega t} F(t)
```

in order to obtain the above formula. Make sure that the macro is defined in the preamble.

Let us define another macro for unnumbered equations. It shall have two arguments, the formula and the punctuation mark after it:

```
\newcommand{\UEQ}[2]{\begin{displaymath}#1\;#2\end{displaymath}}
```

`\;` inserts three small spaces `\.`. You may now write

```
\UEQ{
\Phi(\omega)=\int_{-\infty}^{\infty} dt \, \EXP{-i\omega t} F(t)
}{.}
```

which results in

$$\Phi(\omega) = \int_{-\infty}^{\infty} dt e^{-i\omega t} F(t) .$$

You can also number your formulas if you wish to refer to them. For this you need a label. Therefore the macro for numbered formulas has three arguments, the label, the formula, and the punctuation mark:

```

\newcommand{\NEQ[3]\begin{equation}#2\;#3\label{#1}\end{equation}}
\NEQ{ft-F}{
\Phi(\omega)=\int_{-\infty}^{\infty} dt\,\EXP{-i\omega t}\,F(t)
}{.}

```

generates

$$\Phi(\omega) = \int_{-\infty}^{\infty} dt e^{-i\omega t} F(t). \quad (1)$$

You may now speak about formula (1). This output was generated by typing `formula~(\ref{ft-F})`. Never say formula 1. This value will change if another numbered formula is inserted before. However, the symbolic reference `ft-F` will always provide the associated formula number.

### 3.3 More about mathematics

We have learned that Greek letters are called by their name, from `\alpha` to `\Omega`, from  $\alpha$  to  $\Omega$ . `\int` is the integral, `\infty` denotes infinity. The square root  $c = \sqrt{a^2 + b^2}$  is invoked by `\$c=\sqrt{a^2+b^2}\$`. LaTeX knows all common functions like `\sin`, `\cos` or `\log`. `\frac` has two arguments, it is the fraction of the denominator divided by the nominator. Try to reproduce

$$\alpha(t) = \frac{e^{-\Gamma t}}{1 + \cosh(\kappa t)}.$$

Brackets may be adjusted to the required size. For this you use the `\left` and `\right` macros. Here is an example:

$$R(t) = \left\{ \frac{1 + \sin^2 \Omega t}{1 + \cos^2 \Omega t} \right\}^2.$$

This formula was typeset as

```

\UEQ{
R(t)=\left\{\frac{1+\sin^2\Omega t}{1+\cos^2\Omega t}\right\}^2
}{.}

```

Note that curly brackets must be typed as `\{` and `\}` since the brackets pure have a special meaning.

`<` means less than, as in  $a < b$ .  $a \leq b$  is produced by saying `\$a\le b\$`. Note the space after `\le`, it terminates the macro name.

`\to` produces a right arrow, as in  $f_n \rightarrow f$ .

`\dots` is used for defining a range, such as `\$n=1,2,\dots,N\$` which reads  $n = 1, 2, \dots, N$ .

$E = \hbar\omega$  is typed `\$E=\hbar\omega\$`. `\$E= \hbar \omega\$` does the same. Note that in the first case the macro name `\hbar` is terminated by the backslash, the first non-letter.

You find more about mathematical formulas in [2] which is the ultimate reference. [3] is a freely available Internet book of 140 pages which is a very good substitute.

## 4 Including graphics

You must say `\usepackage[pdftex]{graphicx}` in the preamble if you want to include pictures. `graphicx` is not mis-spelled, it denotes an improved version of the `graphics` package. `[pdftex]` says that you aim at a PDF representation of your document.

There are two kinds of pictures: pixel graphic or line graphics.

A pixel picture is a rectangular matrix of picture elements, or pixels. Normally, each pixel is described by eight bits for its red content, by eight bits for green and eight bits for blue. This information will be compressed by this or another scheme. Most digital cameras produce `.jpg` pictures which can be included into your article.

Line graphics is something else. It consists of instruction like: draw a line with a circular pen of diameter  $d$  with color  $c$  from location  $(x_1, x_2)$  to location  $(y_1, y_2)$  or: shade the region... with color  $c$ , and so forth. The most widely spread line graphics format is EPS<sup>5</sup>. MATLAB graphics may be exported in EPS format and can be compressed to PDF by

```
>> epstopdf filename.eps
```

This command generates a PDF file `filename.pdf` which may be included into your article.

Now, inserting a picture at a definite place is not a good idea. If your article is broken into pages, the picture must be either on this or the next page. Let LaTeX itself look for the best place! You achieve this with a `figure` environment.

The following macro requires two arguments, the picture filename and the figure caption text.

```
1 \newcommand{\FIG}[2]{
2   \begin{figure}[!hbt]
3     \begin{center}
4       \begin{minipage}{0.85\textwidth}
5         \centering{\includegraphics[width=90mm]{#1}}
6         \caption{\label{#1}\small{#2}}
7       \end{minipage}
8     \end{center}
9   \end{figure}
10 }
```

We will not explain this macro in detail, simply copy and use it. You may adjust

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<sup>5</sup>Encapsulated PostScript

it to your needs.

At this place we include Fig. 1:

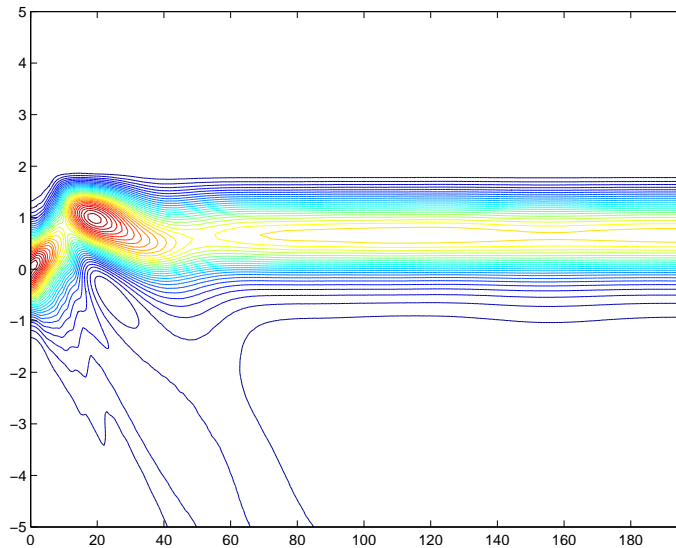


Figure 1: Propagation of a Gaussian beam in a slab waveguide. The beam center is at the interface between film and substrate.

In the source file we wrote

```
\FIG{prp_swg3.pdf}{  
Propagation of a Gaussian beam in a slab waveguide. The beam center  
is at the interface between film and substrate.}  
This figure is labeled by its file name. Above we have written  
At this place we include Fig.-\ref{prp_swg3.pdf}:
```

## 5 Citing literature

At the end of your article you should collect all bibliographical references. Here is an example:

```
1 \begin{thebibliography}{9}  
2 \bibitem{Knuth}  
3 Donald Knuth, \emph{The TeXbook}, Addison-Wesley,  
4 1984. ISBN 0-201-13448-9  
5 \bibitem{Lamport}  
6 Leslie Lamport, \emph{LaTeX: A document preparation  
7 system: User's guide and
```

```

8  reference}, Addison-Wesley, 1994. ISBN 0-201-52983-1.
9  \bibitem{Oetiker}
10 Tobias Oetiker et al., \emph{The not so short introduction
11 to {LaTeX}~2$_\epsilon$}, \\\
12 \verb!http://www.ctan.org/.../english/lshort.pdf!
13 \end{thebibliography}

```

The `bibliography` environment has an argument which specifies whether you expect up to 9, or 99, or 999 entries. It determines the amount of indention. `\bibitem{Knuth}` says that the following bibliographical reference gets the label Knuth. At any place in the text you may say `\cite{Knuth}` which produces [1]. That is all. You can also work with a literature database from which the BibTeX program extracts and formats the bibliography entries, but this would be overkill for simple articles like this.

## References

- [1] Donald Knuth, *The TeXbook*, Addison-Wesley, 1984. ISBN 0-201-13448-9
- [2] Leslie Lamport, *LaTeX: A document preparation system: User's guide and reference*, Addison-Wesley, 1994. ISBN 0-201-52983-1.
- [3] Tobias Oetiker et al., *The not so short introduction to LaTeX 2<sub>ε</sub>*, <http://www.ctan.org/tex-archive/info/lshort/english/lshort.pdf>