

# How to write a paper in T<sub>E</sub>X

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## Abstract

In this brief paper we illustrate some simple T<sub>E</sub>X and L<sup>A</sup>T<sub>E</sub>X commands which facilitate writing a mathematics paper. All you have to do is supply the mathematics! Start with this document, change my name to your name and my title to your title, and you're off and running.<sup>1</sup>

## 1 Introduction

The best way to learn T<sub>E</sub>X is by imitation. This paper illustrates the basic steps for typesetting mathematics in T<sub>E</sub>X, and a few of the most important “document-managing” commands provided in L<sup>A</sup>T<sub>E</sub>X. There is much more to be learned, but very little else you *must* learn to do a satisfactory job. L<sup>A</sup>T<sub>E</sub>X is a system which “sits on top of” T<sub>E</sub>X, and makes its features easier to use. T<sub>E</sub>Xnically this document is showing you how to use L<sup>A</sup>T<sub>E</sub>X rather than T<sub>E</sub>X, but it's not too important to understand the distinction.

## 2 Workflow

Running T<sub>E</sub>X (or L<sup>A</sup>T<sub>E</sub>X) requires a text-editor (any one will do) for creating a source file and a T<sub>E</sub>X “engine” for compiling the source into typeset output. There exist many nice integrated systems that facilitate combining these two steps, e.g. viewing the source in one window and the typeset output in another. Examples are WinEdT or WinShell (combined with MiKTeX) for Windows machines and TeXShop for the Mac. All provide a single button called “PDFLaTeX” which allows you to produce a nice pdf file with a single click. This workflow is highly recommended.

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<sup>1</sup>Early versions of this document were written almost 25 years ago. It has been updated many times to keep pace with improvements in TeX. This is the 2010 edition, with updates by Curtis Greene and David Lippel.

### 3 Advice: How to Use This Paper

Find a  $\text{\TeX}$  system that allows you to view the source and output simultaneously. Compare each item in the source with the output it produces. Experiment by making small changes. To learn new tricks, ask a friend who knows  $\text{\TeX}$  slightly better than you do<sup>2</sup>.

### 4 Definitions and Terminology

This section doesn't have any mathematical definitions, but if you have some, they might look like this.

**Definition 4.1.** *A definition is a concise explanation of the meaning of a word or phrase or symbol.*

### 5 Typesetting Simple Mathematics

It's a general rule in  $\text{\TeX}$  that anything preceded by a backslash (for example `\section` or `\item`) does not appear as written, but rather is a "command" instructing  $\text{\TeX}$  to do something else. In addition, anything you type between dollar signs `$. . . . $` is treated as "mathematics", and given very special treatment as to spacing, type size, etc. Expressions typed as  `$\alpha$`  and  `$X_i^2$`  (for example) appear as  $\alpha$  and  $X_i^2$ . Material between double dollar signs  `$$ . . . . . $$`  appears as "displayed mathematics", for example:

$$\sum_0^{\infty} x^i = \frac{1}{1-x}$$

If you want to have displayed equations numbered, replace the double dollar signs by  `\begin{equation} . . . . . \end{equation}` :

$$f(x) = \int_0^x e^{-t} dt \tag{1}$$

### 6 Lists and Numbered Environments

$\text{\LaTeX}$  provides especially nice features for making lists, with automatic numbers and cross-referencing. This might be used for example in making up questions on an exam. The commands to produce a numbered list are

```
\begin{enumerate}
.
.
\end{enumerate}
```

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<sup>2</sup>This is the single most effective technique for building up your  $\text{\TeX}$  skills.

Individual items on the list are preceded by the command `\item`. The following illustrates problems on a math exam. Extra space can be added between problems using commands like `\bigskip` and `\vspace{1in}`.

1. Solve:  $y'' + xy' + y = \sin(x)$ , if  $y(0) = y'(0) = 0$ .
2. Compute the indefinite integral:

$$\int \frac{1}{\sqrt{1-t^2}} dt$$

3. Find the maximum value of  $f(x) = x(x-1)(x-2)$  over the interval  $0 \leq x \leq 3$ .

## 7 More Complicated Mathematics

This section is included to indicate how much more complex mathematical expressions are composed. The source text may look formidable at first, but one gets used to it.

$$\int_0^\infty \frac{dx}{(1+x^2)(1+r^2x^2)(1+r^4x^4)\dots} = \frac{\pi}{2(1+r+r^3+r^6+r^{10}+\dots)}$$

The next equation is numbered:

$$\sum_{n \geq 0} \frac{q^{n^2}}{(1-q)(1-q^2)\dots(1-q^n)} = \prod_{n \geq 0} \frac{1}{(1-q^{5n+1})(1-q^{5n+4})} \quad (2)$$

Another numbered equation:

$$\lim_{x \rightarrow \infty} \left(1 + \frac{\alpha}{x}\right)^x = e^\alpha \quad (3)$$

And another:

$$\zeta(s) = \sum_{n \geq 0} \frac{1}{n^s} = \prod_{p \text{ prime}} \frac{1}{1-p^s} \quad (4)$$

And I'll bet you didn't know this one:

$$\sum_{0 \leq k \leq n-1} \binom{n-1}{k} n^{n-1-k} (k+1)! = n^n \quad (5)$$

Even expert `TEX`ers often work with a manual beside them, to look up obscure math commands if necessary. The manuals are good, and easy to use for this purpose.

## 8 Theorems

There is a really nice way to have theorems typeset automatically, with numbers and labels, which can be referenced symbolically<sup>3</sup>. For example.

**Theorem 8.1.**  *$\pi$  is irrational.*

*Proof.* Left to the reader. □

**Definition 8.2.** *An integer  $n$  is odd if  $n = 2k + 1$  for some integer  $k$ .*

The main result of this section was Theorem 8.1, although Definition 8.2 has nothing to do with it. A very interesting but completely unrelated reference is [2].

## 9 Other Tricks

It's absolutely irrelevant how you break lines within paragraphs of your source text: TeX takes over and fills lines into well-spaced paragraphs at the compiling stage. (You can override line- and page-breaking using the `\newline` and `\newpage` commands if absolutely necessary.) A paragraph is simply defined as whatever occurs between two successive blank lines of the source text. One secret to efficient TeXing is not to worry at all about how the source text looks — cut and copy fragments to suit your convenience, and don't bother to clean things up.

If you find yourself typing something frequently, it is possible to define a “macro” which lets you type an abbreviation instead. Macros are defined at the beginning of the document, with a statement like

```
\newcommand{\phat}{\hat{p}}
```

Now typing `phat` is equivalent to typing `\hat{p}` (and the result is  $\hat{p}$ ). Some other examples appear at the top of this source document. For example `\REF` is used instead of `\ref` to put brackets around the reference.

One can create diagrams using programs such as Mathematica or Photoshop and include them in a document. For more information on including figures in your paper, look at the “figureshell” template available on math department webpage.

## 10 Including Graphics in your Document

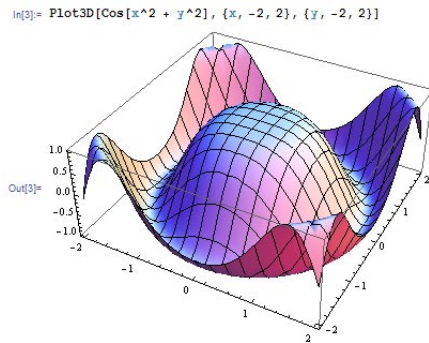
Including graphics in a TeX document used to be very complicated, but now it is extremely easy: anything you can save as a pdf file can be “included”, using a command like

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<sup>3</sup>For technical reasons, if your document contains numbered theorems, equations, definitions, etc., you have to run PDFLaTeX *twice* in order to have the numbers appear correctly.

```
\includegraphics[scale=.4]{myfile.pdf}
```

The example shown here is a little rough, because it was saved as a screenshot and then converted to pdf. It could be tweaked in a variety of ways to produce nicer output. But it illustrates that *anything* you can save as a screenshot can be included in your T<sub>E</sub>X document. In Mathematica you can generate pdf output directly, and the results are nice and sharp. But the file sizes are sometimes quite large.



## References

- [1] L. Chihara, On the zeroes of Askey-Wilson polynomials, with applications to coding theory, S.I.A.M. Jour. Math. Anal. **18** (1987) 183-207.
- [2] P. Diaconis, *Group Representations in Probability and Statistics*, Inst. Math. Statistics, Hayward CA, 1988.
- [3] P. Diaconis and R.L. Graham, The Radon transform on  $Z_2^k$ , Pacific Journal of Math. **118** (1985), 323-345.