A quick intro to LaTeX

LaTeX (LAH-tek) is an enhanced version of the mathematical typesetting software TeX, developed by Donald Knuth during the late 1070's and 1980's. Today, it is freely available in many forms, with enhancements for almost any kind of document preparation. It requires a certain initial investment of time and effort to learn, but the time invested is very well repaid. Nothing else comes close to the freedom and power that even the occasional user of LaTeX can draw upon.

The best way to get started is looking at some examples, as we do in the first section below. In the second section, we will give a bigger picture of what LaTeX is and does, sufficient, we hope, to get the reader going on any of the many fine introductory books.

1. Some examples

In this section we give a sequence of examples. Each is given twice. The first version, in `this font`, is what appears in the file that you write and feed to the LaTeX software. The second time, in the regular font we are using now, shows how it will appear in the final document.

The first example is just ordinary text. Note how LaTeX ignores much of the spacing and line breaking in the input. Note also the way that it ignores any comments that appear on a line after a percent sign %. If you actually want a percent sign to appear in the final document, it is entered with a preceding backslash as "`\%`".

```
The authors are grateful to many sources of support during the lengthy
preparation of this work. These
include the Australian % putting a percent sign % tells
     % LaTeX to ignore everything that comes after it on the same line
Research Council, the
Korea Research     Foundation, the Basic Science
                        Research Center of Korea
University, Saint Louis University, the U. S. National Science Foundation,
the Mathematical Sciences  Research Institute, the University of Oklahoma
Vice President for Research, and the University of Oklahoma College of Arts
and Sciences. We also thank the referees of versions of this work for
occasional corrections and
many helpful suggestions.
```

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Text given between two dollar signs is treated in "math mode". In math mode, fonts are selected differently, spacing is different and adapted to formulas, and certain commands become available, such as \pi to produce a letter π (commands usuallly start with a backslash \\). Note that to use ordinary Roman font in math mode, the \text command is used.

```
The elliptic 3-manifolds were completely classified long ago. They are
exactly the 3-manifolds whose universal cover can be uniformized as the
unit sphere $S^3$ in $\mathbb{R}^4$ so that $\pi_1(M)$ acts freely as
a subgroup
of $\text{Isom}_+(S^3)=\text{SO}(4)$. The subgroups of $\text{SO}(4)$ that
act freely were first determined by Hopf and Seifert-Threlfall, and
reformulated using quaternions by Hattori.
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The next example shows a little more math mode. Note also the way that quotes work in ordinary text, with opening and closing quotes both available.

```
We interpret $K_U$ as the ''upper'' knot, contained in $T\times (3/4,1]$,
and $K_L$ as the ''lower'' knot, contained in $T\times [0,1/4)$.  The
vertical $1$-handle with cocore $\sigma$ is assumed to run between $T\times
\{1/4\}$ and $T\times \{3/4\}$, with the separating disk $\sigma$ being its
intersection with~$T\times \{1/2\}$.
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More complicated commands often use the begin-end structure, as in the `pmatrix` command in the next example. The \[-\] pair is like the dollar signs, but escapes to mathematics "display" mode. The main difference from ordinary math mode is there is that the text is centered on the page, but there are a number of other differences as well. You can also use double dollar signs for displyed text, as in $$\alpha$$, and can use a \(-\) enclosure equivalently to single dollar signs, as in \(\alpha\)

```
The notations here indicate the underlying algebra.
Assume that $T_{p,q}$ is normalized, with $p+r\geq q+s>0$; as mentioned
above, all other cases can be reduced to this one. Write $(p+r)/(q+s)$ as
a continued fraction $[n_1,\ldots,n_k]$ with all $n_i$ positive.  Write
$U=\begin{pmatrix}1&1\\0&1\end{pmatrix}$ and
$L=\begin{pmatrix}1&0\\1&1\end{pmatrix}$. We call the matrix
\[M_{p+r,q+s}=(U\text{ or }L)^{n_k-1}\cdots U^{n_2}L^{n_1} =
\begin{pmatrix}p&q\\r&s\end{pmatrix}\]
the matrix \textit{associated to $T_{p+r,q+s}$.}
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$$M_{p+r,q+s} = (U \text{ or } L)^{n_k-1} \cdots U^{n_2} L^{n_1} = \begin{pmatrix} p & q \\ r & s \end{pmatrix}$$

the matrix *associated to $T_{p+r,q+s}$*.

The next example features definitions using the \newcommand command, that allows you to define your own LATEX commands. Note also the cross-referencing commands \label, which associates its argument (the "label" you give it) to the local environment (in this case, a definition environment). Later, the \ref command is given, using as its argument the given label. LATEX inserts the correct reference number in the final document, allowing you to add and take out references without worrying about cross-referencing.

```
\newcommand{\Diff}{\text{Diff}}
\newcommand{\Imb}{\text{Emb}}
\newcommand{\I}{\text{I}}
\newcommand{\rel}{\text{rel}}


Throughout this chapter, all Riemannian metrics are assumed to be products
near the boundary, or near the horizontal boundary for total spaces of
bundles, such that any submanifolds under consideration meet the collars
in $\I$-fibers. Let $V$ be a submanifold of $M$. The notation
$\mathcal{X}(V,TM)$ means the Fr\'echet space of sections from $V$ to the
restriction of the tangent bundle of $M$ to $V$ that are tangent to
$\partial M$ at all points of $V\cap \partial M$. We also utilize various
kinds of control, as indicated in the following definitions.
\begin{definition}\label{def:diffcontrol}
The notations $\Diff(M\rel X)$ and $\Diff^{M-X}(M)$ mean the space of
diffeomorphisms which restrict to the identity map on each point of the
subset $X$ of $M$.  These notations may be combined, for example
$\Diff^L(M\rel X)$ is the space of diffeomorphisms that are the identity
on $X\cup (M-L)$. \end{definition}$\cdots$

For a neighborhood $K$ of $V$, the superscript notation of
Definition~\ref{def:diffcontrol} may be used, as in $\Imb^K(V,M\rel S)$.
```

Throughout this chapter, all Riemannian metrics are assumed to be products near the boundary, or near the horizontal boundary for total spaces of bundles, such that any submanifolds under consideration meet the collars in I-fibers. Let V be a submanifold of M. The notation $\mathcal{X}(V,TM)$ means the Fréchet space of sections from V to the restriction of the tangent bundle of M to V that are tangent to ∂M at all points of $V \cap \partial M$. We also utilize various kinds of control, as indicated in the following definitions.

Definition 0.1 *The notations* $\mathrm{Diff}(M \operatorname{rel} X)$ *and* $\mathrm{Diff}^{M-X}(M)$ *mean the space of diffeomorphisms which restrict to the identity map on each point of the subset X of M. These notations may be combined, for example* $\mathrm{Diff}^L(M \operatorname{rel} X)$ *is the space of diffeomorphisms that are the identity on* $X \cup (M - L)$.

. . .

For a neighborhood K of V, the superscript notation of Definition 0.1 may be used, as in $\mathrm{Emb}^K(V, M \operatorname{rel} S)$.

A very useful LATEX environment is the "enumerate" environment:

```
\begin{enumerate}
\item For $m$ odd, $\Diff(L(m,1))\approx P_2 \times S^1 \times S^3 \times
\mathbb{R}^\infty$.
\item For $m$ even, $\Diff(L(m,1))\approx P_2 \times S^1 \times
\text{SO}(3) \times \mathbb{R}^\infty$.
\end{enumerate}
or this
\begin{enumerate}
\item[(a)] For $m$ odd, $\Diff(L(m,1))\approx P_2
\times S^1 \times S^3 \times \mathbb{R}^\infty$.
\item[(b)] For $m$ even, $\Diff(L(m,1))\approx P_2 \times S^1 \times
\text{SO}(3) \times \mathbb{R}^\infty$.
\end{enumerate}
Notice that the \texttt{item} command takes an ``optional'' parameter,
allowing you to specify the numbering of the items, which defaults to 1, 2,
and so on if you do not specify anything.

The enumerate environment can be customized to your stylistic needs. It
also has many cousins that are environments suited to different kinds of
listings.
```

1. For m odd, $\mathrm{Diff}(L(m,1)) \approx P_2 \times S^1 \times S^3 \times \mathbb{R}^\infty$.

2. For m even, $\mathrm{Diff}(L(m,1)) \approx P_2 \times S^1 \times \mathrm{SO}(3) \times \mathbb{R}^\infty$.

or this

(a) For m odd, $\mathrm{Diff}(L(m,1)) \approx P_2 \times S^1 \times S^3 \times \mathbb{R}^\infty$.

(b) For m even, $\mathrm{Diff}(L(m,1)) \approx P_2 \times S^1 \times \mathrm{SO}(3) \times \mathbb{R}^\infty$.

Notice that the \item command takes an "optional" parameter, allowing you to specify the numbering of the items, which defaults to 1, 2, and so on if you do not specify anything.

The enumerate environment can be customized to many stylistic needs. It also has many cousins that are environments suited to different kinds of listings.

The \tabular command allows you to define the format of a table, then enter the lines of the table with each item separated by a & symbol.

```
Here is a simple table, to illustrate the ``tabular'' environment:
\begin{center}
\begin{tabular}{c|c}
Quantified statement&Negation\\
\hline %\noalign{\hrule height 0.25 pt}
$\exists x\in S, P(x)$ & $\forall x \in S, \neg P(x)$ \\
$\forall x\in S, P(x)$ & $\exists x \in S, \neg P(x)$ \\
\end{tabular}
\end{center}

\bigskip

\noindent and here is a more elaborate one:
\begin{small}
\setlength{\fboxsep}{0pt}
\setlength{\fboxrule}{0.5pt}
\begin{center}
\fbox{%
\begin{tabular}{c|c|c|c|c}
$C_i$&$L_1$&$R_1$&$L_2$&$R_2$\\
\hline
$M_i$&$\begin{pmatrix}1 & 0\\ 1 & 1 \end{pmatrix}$
&$\begin{pmatrix}1 & 1\\ 0 & 1 \end{pmatrix}$
&$\begin{pmatrix}1 & 0\\ 1 & 0 \end{pmatrix}$
&$\begin{pmatrix}0 & 1\\ 0 & 1 \end{pmatrix}$\\
\end{tabular}}
\end{center}
\end{small}
```

Here is a simple table, to illustrate the "tabular" environment:

Quantified statement	Negation
$\exists x \in S, P(x)$	$\forall x \in S, \neg P(x)$
$\forall x \in S, P(x)$	$\exists x \in S, \neg P(x)$

and here is a more elaborate one:

C_i	L_1	R_1	L_2	R_2
M_i	$\begin{pmatrix}1 & 0\\ 1 & 1 \end{pmatrix}$	$\begin{pmatrix}1 & 1\\ 0 & 1 \end{pmatrix}$	$\begin{pmatrix}1 & 0\\ 1 & 0 \end{pmatrix}$	$\begin{pmatrix}0 & 1\\ 0 & 1 \end{pmatrix}$

2. The bigger picture

Question: What is LaTeX?

Answer No. 1: LaTeX is a programming language.

In this way of looking at it, what you write is actually a sequence of commands telling LaTeX what to put in your final document and how to format it. For example, putting

```
f(x)-g(x)
```

in your file is a command telling LaTeX to typeset the letters f(x)-g(x), using the ordinary Roman font, while putting

```
\textit{f(x)-g(x)}
```

is a command telling LaTeX to typeset the letters *f(x)-g(x)*, using italic font, and putting

```
$f(x)-g(x)$
```

tells it to enter math mode, typeset the math mode letters $f(x) - g(x)$, and exit math mode. Note how in math mode, the letters are in italic font, but the hyphen is interpreted as a subtraction symbol and the spacing is much better for formulas.

Answer No. 2: LaTeX is a computer program that accepts your input file as data, and outputs certain other files.

The input file that you prepare should carry a `.tex` suffix, as in `root.tex`. When you enter

```
latex root.tex
```

on the command line, LaTeX will read root.tex and check it for errors. If there are errors, it will describe the to you. If not (or if there are few enough errors that it can still process the document), it will write out several files:

1. root.dvi – A "device-independent" file that encodes the information necessary to produce the typset output. The dvi file can be viewed on an appropriate reader, or changed to a postscript file root.ps (printable on a standard printer) using another program whose name is dvips). There are also versions of LaTeX that produce pdf files as output.

2. root.log – A copy of the output that LaTeX feeds to the command line as it runds.

3. root.aux – Some technical stuff that you don't need to worry about until you are fairly expert in LaTeX.

There are many enhancements of LaTeX available. For example, there are ways to draw pictures or to import graphics files into your document. Many people have written "packages" that you can import into your document just by putting

```
\usepackage{packagename1,packagename2,etc.}
```

in the "preamble" of your document (more on this coming up shortly).

Question: What appears in the LaTeX "source" file?

Here is a short example:

```
\documentclass[11pt]{article}

\usepackage{fullpage}

\newcommand{\R}{{\mathbb R}}
\newcommand{\Z}{{\mathbb Z}}
\renewcommand{\P}{{\mathbb P}}

\begin{document}

The stuff that is supposed to be typset goes here. Only this part will be
seen directly in the final document.

\end{document}
```

The part before the `\begindocument` line is the "preamble", where you can define commands to be used anywhere in your document, and give LaTeX many other kinds of special instructions about how to format your document, There are ways to define sophisticated commands that take parameters, and so on. Note the use of `\renewcommand`. It is needed because `\P` is already a built-in command in LaTeX, and this definition will override that. It's usually not a good idea to redefine a built-in command, but this one is OK.

The file root.dvi produced from root.tex by LaTeXwould print out as:

The stuff that is supposed to be typset goes here. Only this part will be seen directly in the final document.

There are also many user-friendly interfaces and implementations of LaTeX that help you prepare the source file, so that you don't have to learn much about LaTeX to use it for many purposes. If you start using it more, though, it's worth your time to read a book about it and learn how to control it much more precisely than is possible using the point and click setups. You can also find many tutorials online, and can get help and references on most any aspect of LaTeX, say by googling `latex math symbols` or whatever you want to look up.