

# L<sup>A</sup>T<sub>E</sub>X Workshop

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# 1 Introduction

“ $\text{\LaTeX}$  is a high-quality typesetting system; it includes features designed for the production of technical and scientific documentation.  $\text{\LaTeX}$  is the de facto standard for the communication and publication of scientific documents.  $\text{\LaTeX}$  is available as free software”. [1]

One of the key differences in  $\text{\LaTeX}$  when compared to more common word processors such as MS Word, LibreOffice etc., is the separation of content and presentation. In  $\text{\LaTeX}$ , the author describes the general structure of the document (i.e., section headings, paragraphs, equations, figures), and the layout and typesetting is handled by  $\text{\LaTeX}$  (or rather the underlying  $\text{\TeX}$  backend).

There are several advantages to this:

- The author can focus on the actual content without worrying about layout and presentation
- The presentation can be modified without introducing major changes to the document
- $\text{\LaTeX}$ ’s standard format allows authors to easily conform to styles provided by external publishers

$\text{\LaTeX}$  is written in plaintext and processed by an external program to generate output files (usually PDFs).

## 1.1 Pronunciation and Spelling

$\text{\LaTeX}$  is pronounced *lah-tech* or *lay-tech*, but  $\text{\TeX}$  is never pronounced *tecks*. It is typeset using the `\LaTeX{}` macro or with the capitalisation “LaTeX”.

## 1.2 Language Structures

There are two major language structures that you will encounter when using  $\text{\LaTeX}$ ; macros and environments.

### 1.2.1 Macros

Macros tell  $\text{\LaTeX}$  how to do things. They use the following syntax

---

```
1 \commandname
2 % or
3 \commandname[optional args]{required args}
```

---

Macros provide functionality for layouts, symbols, styles, etc. Common font styles include

**Bold face** `\textbf{Text}` — **Text**

**Italics** `\textit{Text}` — *Text*

**Emphasis** `\emph{Text}` — *Text* (either upright or italics depending on surrounding text)

**Underline** `\underline{Text}` — Text

We can also define custom macros that combine other macros or simplify repetitive instructions.

### 1.2.2 Environments

Environments are how we write larger sections of the document which often contain many lines or macros. Environments begin with a `\begin{environmentname}` macro, and end with a `\end{environmentname}` macro. Common environments include `figure`, `equation`, `itemize` (these will be discussed later).

## 2 Basic Structure

### 2.1 Sections

Sections are used to divide the document into parts. A new section is started with the `\section{sectionname}` macro. Section titles are formatted to be bigger, bolded, and automatically numbered.

The table of contents (`\tableofcontents`) is generated from the section headings. All the page numbers and section numbers are set automatically.

### 2.2 Subsections

We can also split sections into smaller `\subsection{subsectionname}`

#### 2.2.1 Subsubsection

... and `\subsubsection{subsubsectionname}`

### Unnumbered sections

Sections and subsections can be unnumbered if they are declared with an asterisk. e.g. `\section*{section name}`. The current subsection is unnumbered in this way

### 2.3 Lists

Dot point lists are created with the `itemize` environment

- Each item begins with the `\item` macro
- another item
  - You can also do nested lists by just starting a new `itemize` environment
    - \* And the marker changes for each level you are on
      - List markers and spacing and spacing can be customised with the `enumitem` package

Numbered lists are created with the `enumerate` environment

1. Each item begins with the `\item` macro
2. another item
  - (a) You can also do nested lists by just starting a new `enumerate` environment
    - i. And the marker changes for each level you are on
      - A. List markers and spacing and spacing can be customised with the `enumitem` package

## 3 Maths

One of  $\text{\LaTeX}$ 's strengths is the formatting of maths. The easiest way to layout maths is with the inline maths mode, which is used by surrounding expressions with `$`s. e.g.  $a + b = c$ .  $\text{\LaTeX}$  automatically handles spacing and formatting of maths.

In order to print an equation on its own line, you can use the `equation` environment. To make things super script, `^` is used, and to make things subscript, `_` is used. Fractions are formatted with the `\frac{numerator}{denominator}` macro

$$a_2^2 + b_2^2 = \frac{r}{c} \quad (1)$$

$$a_2^2 + b_2^2 = \frac{r}{c} \quad (2)$$

$$a_{33}^{22} + (b_2)^2 = \frac{r}{c} \quad (3)$$

$$a_{33}^{22} + b_2^2 = \frac{r}{c} \quad (4)$$

$$\sum_{i=1}^n x_i^2 = 5 \quad (5)$$

$$\lim_{x \rightarrow \infty} sdfjsdf \quad (6)$$

The `equation` environment only allows for a single line of maths, if multiple lines are required, the `align` environment can be used. In addition to allowing multiple lines, `align` also allows you to align each line at a point specified by an `&`. Below, each line is aligned on the `=` sign.

$$\begin{aligned} 0 &= ax^2 + bx + c \\ 0 &= a\left(x^2 + \frac{b}{a}x\right) + c \\ a\left(\frac{b}{2a}\right)^2 &= a\left(x^2 + \frac{b}{a}x + \left(\frac{b}{2a}\right)^2\right) + c \\ \frac{b^2 - 4ac}{4a^2} &= \left(x + \frac{b}{2a}\right)^2 \\ x &= \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \end{aligned} \quad (7)$$

If you want to write normal text in maths mode, you need to use the `\text` macro

$$\text{this text is written in text mode} \quad (8)$$

$$thistextiswritteninmathmode \quad (9)$$

L<sup>A</sup>T<sub>E</sub>X provides a lot of different symbols that can be used in math mode including the greek alphabet (shown below). A more extensive list can be found at The Great, Big List of L<sup>A</sup>T<sub>E</sub>X Symbols [2]

$$\alpha\beta\gamma\delta\epsilon\zeta\eta\theta\vartheta\iota\kappa\lambda\mu\nu\xi\pi\varpi\rho\sigma\tau\upsilon\phi\chi\psi\omega \quad (10)$$

$$\Gamma\Delta\Theta\Lambda\Xi\Pi\Sigma\Upsilon\Phi\Psi\Omega \quad (11)$$

Bringing all of these together can give pretty equations like:

$$v = \frac{2}{L} \sum_{n=1}^{\infty} e^{-(\kappa\beta_n^2 + \nu)t} \cos(\beta_n x) \left( \kappa\beta_n (-1)^n \int_0^t e^{(\kappa\beta_n^2 + \nu)\lambda} \phi(\lambda) d\lambda + \int_0^L f(x') \cos(\beta_n x') dx' \right)$$

$$v = T - T_f, \quad \kappa = \frac{k}{\rho c}, \quad \nu = \frac{hp}{\rho c A}, \quad \beta_n = \frac{\pi}{2L}(2n + 1)$$

## 4 Figures, Tables, and Code

Figures and tables can be added to the document either raw or by using floats. Floats let  $\text{\LaTeX}$  algorithmically place the figures in the document to look good. The float environment for figures is `figure` and for tables is `table` (suprise suprise). Floats are containers for objects which can't be displayed over multiple pages. Floats should always have a caption to describe them (with `\caption`), as they do not always appear where they appear in the source code. This cat below here is in Figure 1 and Figure 3b.



Figure 1: This is a caption for the figure. The figure numbering is automatic



Figure 2: test

Figure 4: An example listing

---

```

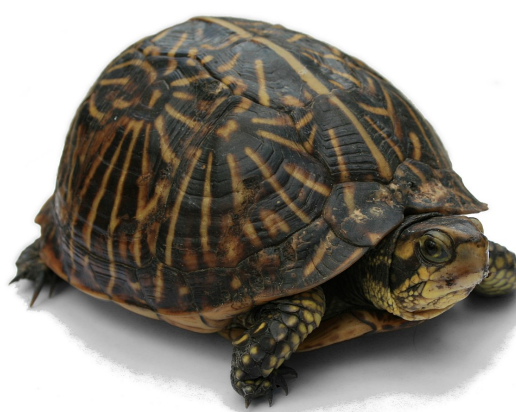
1 #include <iostream>
2
3 int main() {
4     std::cout << "Hello World!" << std::endl;
5     return 0;
6 }
7

```

---



(a) The first subfigure



(b) The second subfigure

Figure 3: A caption for both subfigures

Table 1: An example table. This generally goes above the table

	Column 1	Column 2
Row 1	7	2
Row 2	8	9
Row 3	2	0
Row 4	4	1

Lists of figures and tables can be printed similarly to a table of contents with `\listoffigures` and `\listoftables`

Source code can also be included with the `listing` environment. In addition to the environment, code can also be included with the `\lstinline` macro (this is what I have been doing for all the macros in this document)

## 4.1 References & Labels

Throughout this document you may have noticed that everything is numbered (e.g. equations, sections, figures, tables). It is incredibly easy to refer to these things with the label and reference system in  $\text{\LaTeX}$ . Everything that is numbered (and some things that are not) can have a label attached with the `\label{labelname}` macro. The number can then be later referred to with the `\ref{labelname}` macro. This means that if you go back and add a figure, all your reference to later figures will be automatically updated to reflect the new figure names.

Even better, when the `hyperref` package is included (by `\usepackage{hyperref}` in the preamble), all of these references are turned into hyperlinks to the item. This means that you can click on a reference and go straight to the related equation, figure, or table. This package

Table 2: Placement specifiers for floats. Multiple of these can be specified

Spec.	Location
h	Place <i>approximately</i> here
t	Place at top of page
b	Place at bottom of page
p	Place on page for only floats
!	Override internal placement parameters (force placement)

also turns all the entries in the table of contents and table of figures into a link, to allow for easy navigation of the document

If you want to reference the page that a label is on, you can do that with the `\pageref{labelname}` macro. Below are some examples of references.

- Reference to a figure – Figure 1
- Reference to a subfigure – Figure 3b
- Reference to table – Table 2
- Reference to a section (with pageref) – Section 2.3 on page 1

## 4.2 L<sup>A</sup>T<sub>E</sub>X (usually) knows better than you

A mistake many people new to L<sup>A</sup>T<sub>E</sub>X make is trying to force images to go in particular places. This is often very hard and not necessary. L<sup>A</sup>T<sub>E</sub>X is very good at placing floats in places that look good, and do not break the flow or layout of the document too much.

There are several placement specifiers that we can provide to the float commands in order to give L<sup>A</sup>T<sub>E</sub>X hints on where we want the float to go. These go right after begin float macro. e.g. `\begin{figure}[placement specifier] ... \end{figure}`. Table 2 shows all of the available placement specifiers.

## 5 Citations

There are many ways to manage bibliographies, citations, and reference lists in L<sup>A</sup>T<sub>E</sub>X, and many of them are outdated or have been superseded by newer alternatives. The method that I use is with a combination of BibLaTeX and Biber. BibLaTeX is the frontend in L<sup>A</sup>T<sub>E</sub>X that handles citations and printing the bibliography. Biber is the backend which manages the database of all the references. The `biblatex` package needs to be included with `\usepackage[style=ieee]{biblatex}` in the preamble. The IEEE style can be replaced with others, such as APA. This changes both the citation and bibliography style.

References are stored in a database file with a `.bib` extension. An example database file for the sources used in this document is shown below. Each entry in the database file refers to an source, with the necessary fields filled. In the preamble, the database file needs to be added with `\addbibresource{references.bib}`.

These sources can be cited with `\cite{referencename}` (no parentheses) or `\parencite{referencename}` (with parentheses). For example [3] **smit54**

At the end of the document, the bibliography can be printed with `\printbibliography`. It will only print sources that are actually cited in the document.



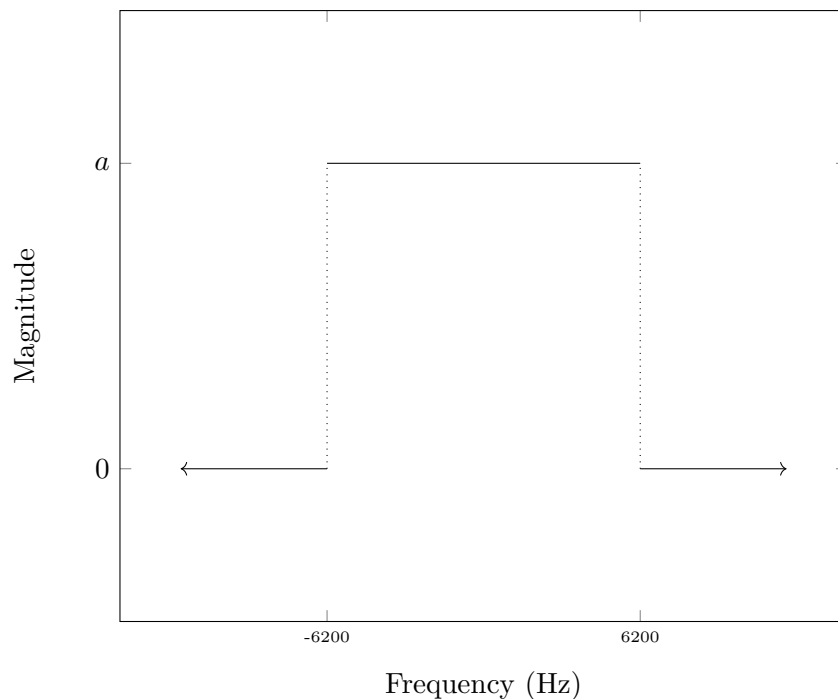


Figure 5: Frequency Plot from EGB242

## 6 Other Use Cases

### 6.1 In-Place Diagrams

In cases where it may be convenient/elegant to draw simple plots/diagrams with LaTeX itself, the `tikz` package provides support for this. In addition, the plots shown in Figures 5 and 6 also require the `pgfplots` package.

### 6.2 Circuit Diagrams

It may be useful at some point to be able to construct circuit diagrams in LaTeX, and so the `circuitikz` package can be used in order to implement this functionality. Shown below in Figure 7 is an example of a circuit diagram one might construct.

### 6.3 Matrices/Vectors

It may also be convenient at some point to be able to express matrices and vectors in MATLAB. These have their own environments which come from the `amsmath` package, and can be used to produce the following:

$$\begin{bmatrix} x_1'(t) \\ x_2'(t) \\ x_3'(t) \\ x_4'(t) \end{bmatrix} = \begin{bmatrix} -0.1 & 0.05 & 0 & 0 \\ 0.05 & -0.2 & 0.05 & 0.05 \\ 0.05 & 0.05 & -0.2 & 0.05 \\ 0 & 0 & 0.05 & -0.1 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \\ x_3(t) \\ x_4(t) \end{bmatrix} + \begin{bmatrix} 500 \\ 250 \\ 100 \\ 10 \end{bmatrix}$$

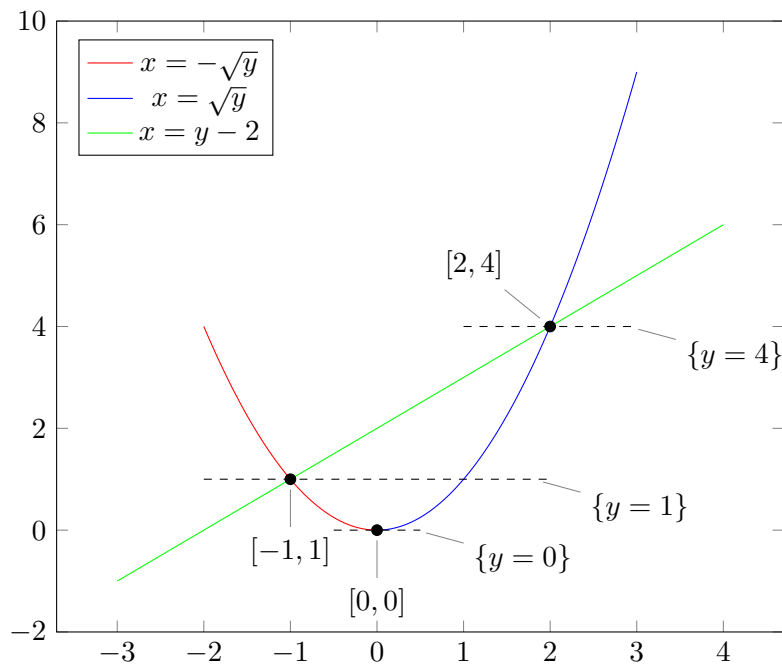


Figure 6: Graph Plot from MXB105

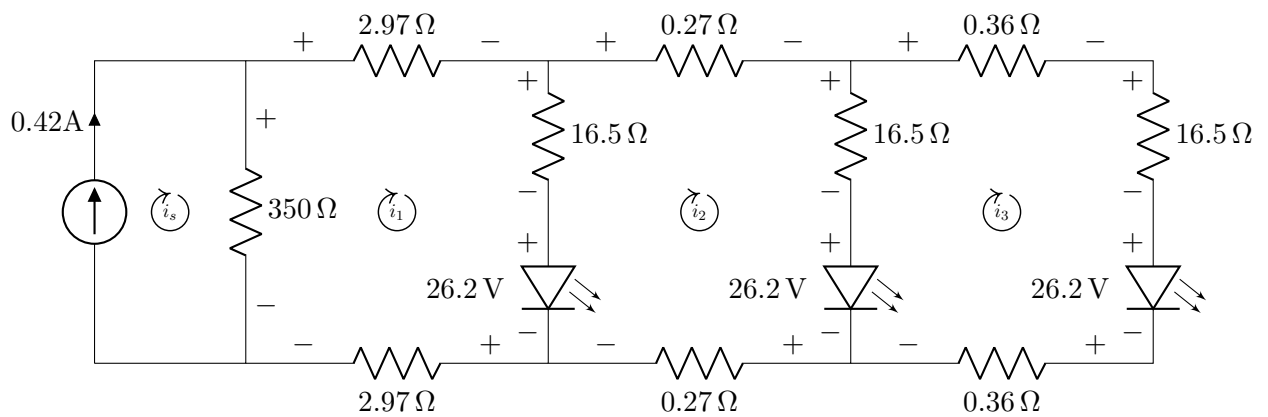


Figure 7: Circuit Diagram from EGB120

## 7 Other Resources

- The  $\text{\LaTeX}$  Wikibook – Good reference documentation and guides – <https://en.wikibooks.org/wiki/LaTeX>
- The  $\text{\TeX}$  Stack Exchange – Answers to most of your questions – <https://tex.stackexchange.com/>
- Comprehensive  $\text{\TeX}$  Archive Network (CTAN) – Package database – <https://ctan.org/>

## References

- [1] L. Project. “LaTeX - a document preparation system.” (2018), [Online]. Available: <https://www.latex-project.org/> (visited on 03/19/2018).
- [2] D. Carlisle, S. Pakin, and A. Holt. “The great, big list of LaTeX symbols.” (Feb. 7, 2001), [Online]. Available: [https://www.rpi.edu/dept/arc/training/latex/LaTeX\\_symbols.pdf](https://www.rpi.edu/dept/arc/training/latex/LaTeX_symbols.pdf).
- [3] C. Columbus, *How I Discovered America*. Barcelona: Hispanic Press, 1492.