Formatting a Thesis with LaTeX

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Abstract

This report describes the use of LaTeX to format a thesis. A number of topics are covered: content and organization of the thesis, LaTeX macros for controlling the thesis layout, formatting mathematical expressions, generating bibliographic references, importing figures and graphs, generating graphs in MATLAB, and formatting tables. The LaTeX macros used to format a thesis (and this document) are described. As well, MATLAB procedures are shown to illustrate methods that can be used to format graphs in a form suitable for inclusion in a LaTeX document.

Sommaire

For McGill theses, the French language version of the abstract goes here.

Acknowledgments

Thesis regulations require that contributions by others in the collection of materials and data, the design and construction of apparatus, the performance of experiments, the analysis of data, and the preparation of the thesis be acknowledged.

Contents

List of Figures

List of Tables

List of Acronyms

16-QAM	16-point Quadrature Amplitude Modulation
3GPP	Third Generation Partnership Project
3GPP2	Third Generation Partnership Project 2
64-QAM	64-point Quadrature Amplitude Modulation
ADSL	Asymmetric Digital Subscriber Line
ARQ	Automatic Repeat Request
WPAN	Wireless Personal Area Network

Chapter 1

Thesis Organization

A thesis should present results in a scholarly fashion. The following discusses the organization of a thesis, such as would be appropriate to presenting research results pertaining to Electrical & Computer Engineering.

1.1 Scope of a Thesis

The terms of reference differ for a Master's Thesis and a Doctoral Thesis. For the Master's Thesis, the Faculty of Graduate Studies and Research at McGill University [1] gives the following guidelines.

> A thesis for a Master's degree must show familiarity with previous work in the field and must demonstrate the ability to carry out research and to organize results. The thesis must be expressed in good literate style. An exhaustive review of work in the particular field of study is not necessarily required, nor is original scholarship necessarily expected.

The terms of reference state that "In most disciplines, Master's theses will not exceed 100 pages."

For a Doctoral thesis, the terms of reference are as follows.

> A thesis for the doctoral degree must display original scholarship, expressed in good literate style, and must be a distinct contribution to knowledge.

For McGill University, the first page should include the declaration "Submitted to McGill University in partial fulfillment of the requirements for the degree of Master of Engineering" (or "Doctor of Philosophy") is required.

1.2 Audience

A thesis is not a paper. It provides the opportunity to present results with more background than would be normally appear in a journal or conference paper. Specifically, in the introduction it should describe the importance of the problem in terms that a non-specialist can understand. In other words, the thesis should be written at several levels. The outer layer is for educated non-specialists. The innermost layer is for specialists in the research area.

1.3 Chapter Contents

Many contemporary theses mix analytic and experimental results. This experimental component might consist of computer simulations to verify analytic conjectures. It is such analytic/experimental thesis that will serve as an example for the organization that I suggest below.

1. The introduction should clearly state the rationale and objectives of the study. Describe the problem and its context in terms that a non-specialist can understand. It is my opinion that the introduction should normally *not* have any equations. The introduction should also give a short overview of past work. In the case of a Ph.D. thesis, the introductory chapter should list the original contributions of the research.

   Finally, the introduction should give an overview of the organization of the thesis, briefly listing what appears in each chapter of the remainder of the thesis.

2. The second chapter in the thesis introduces the problem area with more detail and now more formally with mathematics. This chapter would usually not present new results.

3. The third chapter gets more specific and presents old and new results for the problem at hand. Depending on the scope of the problem solved, this presentation might spread over additional chapters.

4. The next chapters would present experimental or simulation results, drawing conclusions from the results.

5. The last chapter is the Summary and Conclusions. This chapter should summarize the work done and should restate the conclusions that were drawn from the results. Sometimes, this chapter also contains suggestions for future work.

Be aware that some readers will read only the introduction, while some others will read only the introduction and the conclusions. It is very important that these chapters be written with extra care and be precise as to language.

1.4 Appendices

A thesis can and should make use of appendices. Appendices offer an opportunity to make the flow of ideas in the main text of uniform depth. It is disruptive to see detailed proofs in the main text. Furthermore, appendices offer the opportunity to use simpler self-standing notation. They can be used in much the same way as sub-procedures are used in programming languages. The appendices should be largely self-contained. The reader will be annoyed if he/she has to constantly turn back to the main text.

In the past, appendices were often used to give computer program listings. With the ability to distribute programs electronically on the Internet, program listings should probably not take up space in the thesis. Moreover, were program listings to appear, I feel they should be subject to the same "good literate style" criteria as the main body of the thesis, that is they should be properly formatted and fully commented.

1.5 Text Format

The format of the text (margins, type size, spacing) in the thesis is governed by Thesis Office rules. With modern typesetting such as LaTeX in the present document, these formatting rules are easily satisfied. While spell-checking can root out some egregious errors, careful proof-reading is still necessary to make sure that meaning is conveyed in a grammatical fashion.

Chapter 2

LaTeX Formatting

The LaTeX document formatting system is described in [2]. LaTeX is itself built on top of TeX. As such most of the plain TeX macros are still available. These are described in *The TeXbook* [3]. The book *A Guide to LaTeX 2ε* [4] provides additional information on LaTeX. Additional resources are *The LaTeX Companion* [5] and *The LaTeX Graphics Companion* [6] which describe common macro packages for use with LaTeX.

2.1 LaTeX Package for Theses

This document was set using the `McECEThesis` style. This style sets up the LaTeX page format parameters to be appropriate for a thesis.

2.1.1 Title page

The preamble for the LaTeX document to format the title page consists of the following commands.

```
\documentclass [12pt,letterpaper]{report}
\usepackage {McECEThesis}
... other preamble commands
\begin{document}
\title{Thesis Title}
\author{Thesis Author}
\organization{%
  Department of Electrical \& Computer Engineering\\
  McGill University\\
```

```
  Montreal, Canada}
\note{%
  {\hrule height 0.4ex}
  \vskip 3ex
  A thesis submitted to McGill University
  in partial fulfilment of the requirements of the degree of
  Doctor of Philosophy.
  \vskip 3ex
  \copyright\ \the\year\ Thesis Author
}
\maketitle
...
```

These commands set up the thesis to use 12 pt font on letter paper (8.5 inches by 11 inches) for the main text and define commands to format the title page. An optional `twoside` option formats the document for two-sided printing. When `two-side` is in effect, the `openright` option can be used to force chapters to start on a right-hand page, i.e., one with an odd page number. If the `twoside` and `openright` options are omitted, the document will be typeset for a one-sided layout in which there is no difference between the margins and headers for odd and even pages.

The present document uses the `McECEThesis` style, but adds some flair to this setup by adding a University crest to the title page, using coloured lines (that will not be obvious on a black and white printout) on the top of each page. The commands for adding these options are shown in Appendix A.

2.1.2 Text spacing

An appropriate spacing for a thesis is one-and-a-half spacing. To get one-and-a-half spacing, use the `setspace` package. This is a standard LaTeX package that sets the spacing for the text but restores single spacing for figures, tables and footnotes. This package is invoked as follows.

```
\usepackage {setspace}
...
\onehalfspacing
...
```

The examples, such as the ones in this document, are set in single spacing with a smaller font. Single spacing within the document invoked with a `\begin{singlespace}` environ-

ment.

2.1.3 Page headers

The present document is typeset using the `fancyhdr` package. These header are the default when the `McECEThesis` package is used. To revert to the normal LaTeX page headers, use the `plainhdr` option to the `McECEThesis` package.

For the `two-side` option, the default page header has the current chapter title in the header for left-sided pages and the current section title in the header for right-sided pages. For one-sided printing, the header contains the current chapter title.

An optional `datestamp` package places a date stamp in the footer. This date stamp is useful while the thesis is being written to help keep track of when different parts were printed.

As a side note, it is very prudent and useful to use a revision control system to maintain the LaTeX source files for a thesis. An example of such a system available under Unix is the `rcs` package. It allows you to keep a working copy of a document with the past history of changes kept in a change file.

2.1.4 Headers and captions

Section headers

Section headers are invoked with the `\section`, `\subsection` and `\subsubsection` macros. It is rare to use the lowest level header. Since a thesis is already organized into chapters, a `\subsection` is already two levels below a chapter.

Diminished sections

Sometimes it is useful to have a lower level header which is not numbered as shown in the header immediately above. This header has text in italics with no section numbering,

```
\def\dsssection #1{\subsubsection*{\it #1}}
...
\dsssection{Diminished subsubsection heading}
...
```

Always use the standard sectioning commands rather than typesetting the header manually. The sectioning commands insert proper spacing before and after the header, and ensure that a page break does not occur immediately after the header.

Section heads stand out from the normal text by having bold text and/or by having a larger font size. Capitalization of the text can also be used to differentiate different header levels. A suggested scheme for capitalization is shown in Table 2.1.[1] With this scheme, the each word in a `\section` header has an initial uppercase letter, while only the first word in a `subsection` will be be capitalized. As suggested above, an unnumbered `\subsubsection` command using an italic font might be used instead of the lowest level section header.

Table 2.1 Capitalization for section heads

Section Type	Font Size	Capitalization	Example
`\section`	large bold	Capitals	**Section Header**
`\subsection`	bold	Lowercase	**Subsection header**
`\subsubsection`	bold	Lowercase	**Subsubsection header**

Table captions

Table headers are usually placed above the table. The table caption can be quite long and as such the words are not usually capitalized. The `\caption` command has an optional argument which can be used to specify a shorter version of the caption which will appear in the List of Tables.

The default setup in LaTeX inserts space above a caption (`\abovecaptionskip`) and zero space below the caption (`\belowcaptionskip`). The `McECEThesis` style offers a `\Tcaption` command for captions which appear above, for instance, a table. This command leaves no space above the caption, but inserts space below the caption.

Figure captions

Figure captions are usually placed below the figure. As with tables, the words in the captions are not capitalized. If the figure caption is long or contains a citation, the optional argument for the caption can be used so that a shorter version (without citations) will appear in the List of Figures.

[1] The section font sizes in the table are those as modified by the `McECEThesis` style. See Section 2.3.

2.2 Document Source

LaTeX is flexible as to the spacing in the source file. One can take advantage of this to make finding text and moving text around in the source file easier. Consider starting a new sentence on a new line. For long sentences may span several lines in the source file, indent the second and subsequent lines with a single space. This convention allows you to easily find and move individual sentences around in the source file.

TeX recognizes an empty line as a paragraph break. You should use empty lines rather than inserting an explicit `\par` command. In fact, it is useful to liberally use blank lines in the input source. For instance if one places `\section` commands on separate lines, the section boundaries are much easier to find in the source file.

Break up a chapter oriented document into separate files. For example, the present document has a main file which sets up the title page and preamble, and then inputs each chapter as a separate file using the `\include` command.

2.3 Changes to the Report Class

The `McECEThesis` style file makes a number of changes to the default layout of the `report` class.

1. Section and subsection headers are printed in a slightly smaller font than is the default for LaTeX. In addition, these headers are printed without right justification. This looks better than having the first lines of long titles stretched to fill the line.

2. The default placement of tables and figures is changed so that the "here" placement is attempted before other placements. The captions for tables and figures have been modified to have the table and figure numbers in bold. The figure and table captions are set in a smaller font to 80% of the width of the text. This indentation and change of font size helps make them stand out from the surrounding text.

3. The bibliography command generates a chapter title of "References". The table of contents uses the same title. This name can be changed by redefining the macro `\bibname`.

2.4 Page Margins

The `McECEThesis` style file defines a number of dimensions that can be changed to alter the page margins. Change the appropriate dimensions before the `\begin{document}` command. The four offsets and their defaults are as follows.

```
\insidemargin = 1.3in
\outsidemargin = 0.8in
\abovemargin = 1.1in
\belowmargin = 0.75in
```

When one-sided printing is in effect, the inside margin is the left margin. For two-sided printing, the inside margin is the margin at the binding.

2.5 PostScript Printing and Fonts

2.5.1 Bitmap Fonts and Resolution Dependency

The default Computer Modern fonts used by LaTeX are distributed or generated as bitmap fonts generated for a particular printer resolution. Proper printing of requires that the fonts be appropriate to the resolution of the printer in use.

2.5.2 PostScript fonts

There are standard macro packages that allow for the text to be typeset using PostScript fonts such as Times or Palatino. The drawback is that such fonts do not have all of the math symbols needed to typeset general TeX math expressions. This means math characters are typeset using the Computer Modern fonts and are not fully compatible with the appearance of the PostScript fonts [6, pages 354–357].

2.5.3 Outline fonts

An alternate to the standard bitmap TeX fonts, are the PostScript outline versions of the TeX fonts that are now freely available. The resulting PostScript file generates good looking output on any PostScript printer or viewer. Moreover conversion from PostScript to pdf results in a much smaller pdf file for the outline fonts than for the bitmap fonts.

The LaTeX part of the document processing is unaffected by using outline fonts. Only the printer driver need be concerned with the font details. To use outline fonts, one needs to install or modify a setup file which describes the available PostScript fonts and the locations of PostScript fonts. For the `dvips` printer driver, the driver is informed of the location of these files with the following commands in the `.dvipsrc` file,

```
% Postscript type 1 fonts
p +<path>/fonts/cmpsfonts/psfonts.cmz
H <path>/fonts/cmpsfonts/pfb:
```

2.6 Hyphens, Dashes, and Minus Signs

Some typographical conventions are worth noting as they contribute to the readability of a document. There are several kinds of "dashes", each used for a specific purpose.

1. Ordinary hyphens as they appear in compound words such as "non-specialist".
2. En-dashes which are used to denote a range of numbers. In TeX these are entered as two consecutive dashes, `--`, and give results such as "see pages II-3–I-4 for the years 1992–1995". The difference between hyphens and en-dashes should be evident in the first part of the example.[2].
3. Em-dashes are long dashes, entered as three consecutive dashes, `---`, used to separate parenthetical expressions—such as this one.
4. Minus signs are used for negative numbers. These are used in math mode. This means that negative numbers even in plain text should be entered in math mode, for example: "takes on the value is -1", with the negative value written in TeX as `$-1$`. The minus sign takes up a full digit position, while a hyphen in its place is much shorter.

2.7 Labels and References

LaTeX allows for equations, sections and other entities to be labelled with a symbolic reference. Thus an equation can be labelled with `\label{`*xxx*`}` and later referred to with

[2]The amsmath package supplies a `\nobreakdash` macro to control and/or prevent line breaks immediately after a dash

`\Eq.~(\ref{`*xxx*`})`.[3] Since labels are used for several different types of objects, I suggest the adoption of a convention for labels such that the label contains a component which specifies the type of object being labelled (see Table 2.2).

Table 2.2 Label conventions

Object	Label	Reference	Appearance
figure	`\label{F:`*xxx*`}`	`Fig.~\ref{F:`*xxx*`}`	Fig. 1
table	`\label{T:`*xxx*`}`	`Table~\ref{T:`*xxx*`}`	Table 2
equation	`\label{E:`*xxx*`}`	`Eq.~(\ref{E:`*xxx*`})`	Eq. (3.1)
chapter	`\label{C:`*xxx*`}`	`Chapter~\ref{C:`*xxx*`}`	Chapter 1
section	`\label{S:`*xxx*`}`	`Section~\ref{S:`*xxx*`}`	Section 2.1
appendix	`\label{A:`*xxx*`}`	`Appendix~\ref{A:`*xxx*`}`	Appendix A

2.8 List of Terms

Theses with many technical terms can benefit from a list of acronyms or terms. This list appears after the list of figures and tables. The `\longtable` package allows for long tables that span more than one page. The setup for a list of terms can be as follows.

```
\usepackage {longtable}
...
\listof tables
...
\newpage
\chapter*{List of Acronyms}\markright{List of Terms}

\begin{longtable}{ll}
  16-QAM   &  16-point Quadrature Amplitude Modulation\\
  3GPP     &  Third Generation Partnership Project\\
  3GPP2    &  Third Generation Partnership Project 2\\
  64-QAM   &  64-point Quadrature Amplitude Modulation\\
  ADSL     &  Asymmetric Digital Subscriber Line\\
  ARQ      &  Automatic Repeat Request\\
  WPAN     &  Wireless Personal Area Network
\end{longtable}
```

[3] The tilde (`~`) represents an unbreakable space used to prevent a line break at that point.

Chapter 3

Mathematical Layout Styles

TEX does a marvelous job of setting mathematical formulas, most often choosing pleasing spacing. However, on occasion one should intercede to improve the layout. This chapter defines a few such occasions. In addition, this chapter documents some features of the `amsmath` package which overcome difficulties in typesetting some mathematical forms. The `amsmath` package is documented in the file `amsldoc.tex` and in *The LaTeX Companion* [6].

3.1 Fractions

For displayed equations, the mode for mathematical expressions is `\displaystyle`. Yet the numerators and denominators of fractions are set in `\textstyle`, a more cramped style. Consider the following formula, entered as

```
H(z) = \frac {1 + \sum_{i=1}^q b_k z^{-i}}{1 - \sum_{k=1}^p a_k z^{-k}}
```

$$H(z) = \frac{1 + \sum_{i=1}^{q} b_k z^{-i}}{1 - \sum_{k=1}^{p} a_k z^{-k}} \tag{3.1}$$

Note the cramped style of the summations. We can force the numerator and denominator to remain in `\displaystyle` using a macro `\Dfrac` to do this. Using this macro,

```
\newcommand\Dfrac[2]{\dfrac{\displaystyle #1}{\displaystyle #2}}
H(z) = \Dfrac {1 + \sum_{i=1}^q b_k z^{-i}}{1 - \sum_{k=1}^p a_k z^{-k}}
```

results in the following displayed equation with a more open layout.

$$H(z) = \frac{1 + \sum_{i=1}^{q} b_k z^{-i}}{1 - \sum_{k=1}^{p} a_k z^{-k}} \tag{3.2}$$

3.2 Cases

Similar cramped equations occur when the `array` environment is used to display cases. Consider the following formula,

```
G(z) = \left\{ \begin{array}{ll}
                 \frac {P(z)}{1+z^{-1}}   & \mbox{for $p$ even}, \\
                 P(z)                     & \mbox{for $p$ odd}.
               \end{array}
       \right.
```

which is typeset as

$$G(z) = \begin{cases} \frac{P(z)}{1+z^{-1}} & \text{for } p \text{ even}, \\ P(z) & \text{for } p \text{ odd}. \end{cases} \tag{3.3}$$

Note the difference in the rendition of the quantity $P(z)$ on the two lines. Using `\Dfrac` will help, but we also need to add some spacing between the lines.

The `amsmath` package provides a `cases` environment and a `\text` macro. The modified setup is then

```
G(z) = \begin{cases}
         \Dfrac {P(z)}{1+z^{-1}} & \text{for $p$ even}, \\[1ex]
         P(z)                    & \text{for $p$ odd}.
       \end{cases}
```

which is typeset as

$$G(z) = \begin{cases} \dfrac{P(z)}{1+z^{-1}} & \text{for } p \text{ even}, \\ P(z) & \text{for } p \text{ odd}. \end{cases} \tag{3.4}$$

3.3 Parentheses

The LaTeX book [2] only describes a subset of the choices available for parentheses, brackets and other delimiters. It suggests using the `\left` and `\right` operators to choose the size of the delimiters.

Consider the following equation,

```
R_p(\theta) = \frac{T_c}{2} \cos \left(\pi {\theta \over T_c} \right)
```

giving the following typeset equation

$$R_p(\theta) = \frac{T_c}{2} \cos \left(\pi \frac{\theta}{T_c}\right) \tag{3.5}$$

The size of the parentheses has been chosen to match the height and depth of the enclosed formula. I find that this gives parentheses which are too large.

TeX offers a number of delimiter sizes which can be explicitly chosen. The left (opening) delimiter operators, in order of increasing size, are `\bigl`, `\Bigl`, `\biggl`, and `\Biggl`. For a middle delimiter, use `\bigm`, etc. For a right (closing) delimiter, use `\bigr`, etc. Unfortunately plain TeX offers these in fixed sizes, not relative to the current size. The `amsmath` package redefines the delimiter sizes in terms of the size of a normal parenthesis. The `\bigl`, `\Bigl`, `\biggl` and `\Biggl` delimiters are respectively 1.2, 1.8, 2.4 and 3 times the size of an ordinary parenthesis.

Using these definitions, here is the same formula as above, but now using an explicitly selected delimiter size,

```
R_p(\theta) = {T_c \over 2} \cos \bigl(\pi {\theta \over T_c} \bigr)
```

giving the following typeset equation

$$R_p(\theta) = \frac{T_c}{2} \cos\bigl(\pi \frac{\theta}{T_c}\bigr) \tag{3.6}$$

Changes in delimiter size can help group nested expressions. For instance, here we use two sizes of parentheses,

```
z(t) = \bigl(x_1(t)-y_2(t)\bigr) \bigl(x_2(t)-y_2(t)\bigr)
```

giving the following typeset equation

$$z(t) = \big(x_1(t) - y_2(t)\big)\big(x_2(t) - y_2(t)\big) \tag{3.7}$$

3.4 Aligning Equations

Equations aligned using the method suggested in the LaTeX book have too much space near the alignment point. For instance, using the format suggested

```
\begin{eqnarray}
  \hat A(z) & = & 1 - \sum_{k=1}^{N_p} c_k \, z^{-k}\\
            & = & 1 - P(z)
\end{eqnarray}
```

results in

$$\begin{aligned} \hat{A}(z) &= 1 - \sum_{k=1}^{N_p} c_k \, z^{-k} && (3.8)\\ &= 1 - P(z) && (3.9) \end{aligned}$$

The `amsmath` package offers many different alignment options for equations. The same equation is better typeset as

```
\begin{align}
  \hat A(z) &= 1 - \sum_{k=1}^{N_p} c_k \, z^{-k}\\
            &= 1 - P(z)
\end{align}
```

These commands give the following printed equation.

$$\begin{aligned} \hat{A}(z) &= 1 - \sum_{k=1}^{N_p} c_k \, z^{-k} && (3.10)\\ &= 1 - P(z) && (3.11) \end{aligned}$$

Notice that the `align` environment replaces the `equation` environment and that both equations are numbered.

The `amsmath` environment `split` works *inside* an `equation` environment without numbering the individual lines. The equation can be typeset using `split` as

```
\begin{equation}
\begin{split}
  \hat A(z) &= 1 - \sum_{k=1}^{N_p} c_k \, z^{-k}\\
            &= 1 - P(z)
\end{split}
\end{equation}
```

These commands give the following printed equation.

$$\begin{aligned}\hat{A}(z) &= 1 - \sum_{k=1}^{N_p} c_k \, z^{-k} \\ &= 1 - P(z)\end{aligned} \tag{3.12}$$

The following alignment using has both math expressions and text expressions. It uses the `alignat` macro to allow for explicit specification of the space before the text expression.

```
\newcommand{\mRx}{\mathbf{R}_\mathbf{x}}
\newcommand{\vrx}{\mathbf{r}_\mathbf{x}}
\begin{alignat}{2}
  {\mRx}_{ij} &= r_{xx}(i,j),    &&\qquad\text {for $1 \le i,j \le N_p$}\\
     {\vrx}_i &= r_{xx}(0,i),    &&\qquad\text {for $1 \le j \le N_p$}.
\end{alignat}
```

The elements within an `alignat` environment are alternately right and left justified. By supplying the empty column, the text expression becomes left justified. The typeset equation appears as follows.

$$\mathbf{R}_{\mathbf{x}ij} = r_{xx}(i,j), \qquad \text{for } 1 \le i,j \le N_p \tag{3.13}$$

$$\mathbf{r}_{\mathbf{x}i} = r_{xx}(0,i), \qquad \text{for } 1 \le j \le N_p. \tag{3.14}$$

3.5 Sub-equations

In some cases it is useful to be able to refer to a multi-line equation as a whole or to its parts. Consider the following equation using the `subequations` environment provided by `amsmath`.

```
\begin{subequations}
\label{E:eqn}
```

```
\begin{align}
  a &= b \label{E:eqnA} \\
  c &= c
\end{align}
\end{subequations}
```

This equation appears as

$$a = b \tag{3.15a}$$

$$c = c \tag{3.15b}$$

with the label `E:eqn` being defined as 3.15 and the label `E:eqnA` being defined as 3.15a.

3.6 Vectors and Matrices

It is common to represent scalars as lowercase (math italic) symbols, vectors as lowercase bold symbols, and matrices as uppercase bold symbols. LaTeX has two boldface fonts that can be used in equations. One, `\boldmath`, gives italic (slanted) characters and the other, `\mathbf`, gives upright characters.[1] Textbooks are divided as to whether matrices are represented by slanted or upright bold characters.

It is useful to provide definitions at the top of the TeX source file for the vectors and matrices that you will use. This way if you choose to change the representational form, this can be done with a change in a single place. Consider the following definitions

```
\newcommand{\mathBF}[1]{\mbox{\boldmath $#1$}}
\renewcommand{\V}[1]{\mathBF{#1}}
\newcommand{\M}[1]{\mathBF{#1}}
\newcommand{\va}{\V{a}}
\newcommand{\vb}{\V{b}}
\newcommand{\vc}{\V{c}}
\newcommand{\vx}{\V{x}}
\newcommand{\MA}{\M{A}}
...
\begin{equation}
  \MA \vx = \vb, \qquad \va = \vc
\end{equation}
```

[1] The `amsmath` package provides a `\boldsymbol` command to get bold versions of symbols. For example a bold infinity ($\boldsymbol{\infty}$) is obtained in math mode with `\boldsymbol{\infty}`.

A peculiarity is that `\boldmath` cannot be used directly in math equations, it must be declared outside of math mode. In the example, this is accomplished by defining a new macro `\mathBF` which puts the expression inside a `\mbox`. The preamble commands also define macros `\V` and `\M` which are used to define the representational forms for vectors and matrices. These definitions result in the following typeset equation (using slanted bold characters),

$$\boldsymbol{A}\boldsymbol{x} = \boldsymbol{b}, \qquad \boldsymbol{a} = \boldsymbol{c} \tag{3.16}$$

If we repeat the example, this time using upright bold characters,

```
\newcommand{\V}[1]{\mathbf{#1}}
\newcommand{\M}[1]{\mathbf{#1}}
...
\begin{equation}
  \MA \vx = \vb, \qquad \va = \vc
\end{equation}
```

we get the following

$$\mathbf{A}\mathbf{x} = \mathbf{b}, \qquad \mathbf{a} = \mathbf{c} \tag{3.17}$$

Note that some letters (for example $\boldsymbol{a}$ and $\mathbf{a}$) change in shape when the font switches from slant to upright. In some sense, using slanted bold characters is more in keeping with the slanted (non-bold) math characters. However, upright bold is very common for vectors and matrices in textbooks.

Here is a longer example using upright bold characters.

```
\newcommand{\ve}{\V{e}}
\newcommand{\vx}{\V{x}}
\newcommand{\vv}{\V{v}}
\newcommand{\MA}{\M{A}}
\newcommand{\MQ}{\M{Q}}
...
\begin{equation}
\begin{split}
  \ve^T \ve &= \vx^T \MA^T \MA \vx - 2 \vv^T \MA \vx + \vv^T \vv \\
            &= \vx^T \MQ \vx - \vx^T \vb + \vv^T \vv,
\end{split}
\end{equation}
```

This example is typeset as follows.

$$\begin{aligned}\mathbf{e}^T\mathbf{e} &= \mathbf{x}^T\mathbf{A}^T\mathbf{A}\mathbf{x} - 2\mathbf{v}^T\mathbf{A}\mathbf{x} + \mathbf{v}^T\mathbf{v} \\ &= \mathbf{x}^T\mathbf{Q}\mathbf{x} - \mathbf{x}^T\mathbf{b} + \mathbf{v}^T\mathbf{v},\end{aligned} \tag{3.18}$$

The following example uses a mix of upright and slanted bold symbols.

```
\newcommand{\C}[1]{\mathBF{#1}}
\newcommand{\cRh}{\C{R}_{\C{h}}}
\newcommand{\cW}{\C{W}}
\newcommand{\ce}[1]{\C{e}_{\V{#1}}}
\newcommand{\cRx}{\C{R}_{\V{x}}}
...
\begin{equation}
  (\cRh^T \cRh)^{-1} \cRh^T \cW' \ce0 =
      (\cRx^T \cW \cRx)^{-1} \cRx^T \cW \ce0.
\end{equation}
```

This results in the following.

$$(\boldsymbol{R}_{\mathbf{h}}^T\boldsymbol{R}_{\mathbf{h}})^{-1}\boldsymbol{R}_{\mathbf{h}}^T\boldsymbol{W}'\boldsymbol{e}_{\mathbf{0}} = (\boldsymbol{R}_{\mathbf{x}}^T\boldsymbol{W}\boldsymbol{R}_{\mathbf{x}})^{-1}\boldsymbol{R}_{\mathbf{x}}^T\boldsymbol{W}\boldsymbol{e}_{\mathbf{0}}. \tag{3.19}$$

3.7 Tildes, Hats and Superscripts

Complex mathematical notation can involve symbols with superimposed tildes, circumflexes and the like. There can then be problems when these composite symbols take on superscripts. LaTeX sees the composite symbols as large entity and places the superscripts too high. For example consider the following equation.

```
\def\hC#1{\C{\hat{#1}}}           % hat vector
\def\htC#1{\C{\hat{\tilde{#1}}}}  % hat, tilde vector
\def\tC#1{\C{\tilde{#1}}}         % tilde vector
...
\begin{equation}
\begin{split}
  \C{d}^{(i)} &= \hC{v}^{(i)} - \htC{v}^{(i)} \\
  \C{n}^{(i)} &= \C{u}^{(i)} - \tC{v}^{(i)}
\end{split}
\end{equation}
```

With these definitions we get the following equation.

$$\begin{aligned} \boldsymbol{d}^{(i)} &= \hat{\boldsymbol{v}}^{(i)} - \hat{\tilde{\boldsymbol{v}}}^{(i)} \\ \boldsymbol{n}^{(i)} &= \boldsymbol{u}^{(i)} - \tilde{\boldsymbol{v}}^{(i)} \end{aligned} \tag{3.20}$$

Note that the superscript is placed at different levels depending on whether the composite symbol has a tilde and/or a hat. The fix to this problem is to use the `\vphantom` macro. The `\vphantom` command creates an empty box of zero width but with a height and depth equal to its argument. By placing the `\vphantom` at the end of the definition of the composite symbol, the following superscript is applied to this empty box and is placed at the same height as it would for a symbol without a hat and/or tilde. With the new definitions, the result is more pleasing.

```
\def\hC#1{\C{\hat{#1}}\vphantom{\C{#1}}}           % hat vector
\def\htC#1{\C{\hat{\tilde{#1}}}\vphantom{\C{#1}}} % hat, tilde vector
\def\tC#1{\C{\tilde{#1}}\vphantom{\C{#1}}}         % tilde vector
...
\begin{equation}
\begin{split}
  \C{d}^{(i)} &= \hV{v}^{(i)} - \htV{v}^{(i)} \\
  \C{n}^{(i)} &= \V{u}^{(i)} - \tV{v}^{(i)}
\end{split}
\end{equation}
```

With the modified definitions, we get the following.

$$\begin{aligned} \boldsymbol{d}^{(i)} &= \hat{\boldsymbol{v}}^{(i)} - \hat{\tilde{\boldsymbol{v}}}^{(i)} \\ \boldsymbol{n}^{(i)} &= \boldsymbol{u}^{(i)} - \tilde{\boldsymbol{v}}^{(i)} \end{aligned} \tag{3.21}$$

3.8 Defining New Mathematical Functions

LaTeX does not define certain mathematical functions that can be useful. Just to choose one example, consider a definition of a `\argmin` function. Macros such as `\cos` cause the function name to be typeset in an upright font while the rest of the equation is typeset by default in an italic font. In addition spacing before and after the function name is important. TeX has builtin commands to help define these. Appendix B of the TeXbook [3] gives the definitions for the basic control sequences in TeX. We just need define `\argmin`

to be similar to the definition of `\limsup` for instance.

Consider the following definition and use of `argmin`

```
\def\argmin{\mathop{\rm arg\,min}}
t_{\rm min} = \argmin_t f(t)
```

This appears as,

$$t_{\rm min} = \arg\min_t f(t) \tag{3.22}$$

3.9 Words in Mathematical Expressions

It is not uncommon to use a short-form of a word for a subscript. For instance the minimum value of a variable might be designated as $x_{\rm min}$. Note that use of a roman font for the subscript to indicate that it is a word or short-form rather than a mathematical symbol. TEX typesets an arbitrary collection of letters in math mode as if it were a product of variables. The difference in appearance can be illustrated between three variables which are entered as follows

```
x_{diff} \qquad x_{\it diff} \qquad x_{\rm diff}
```

and which appear as follows.

$$x_{diff} \qquad x_{\it diff} \qquad x_{\rm diff} \tag{3.23}$$

Note the difference between the first and second forms, both of which use an italic subscript. However, the second form treats "diff" as a word and looks much better for it.

On occasion, computer-like variables creep into mathematical expressions. These can look odd in a typeset document. Consider the following two variables

$$q_i^{(previous)} \qquad exc_e(n). \tag{3.24}$$

My advice is not to use such constructs, but instead use a more mathematical variable. The examples can easily be written in a more standard form, say

$$q_i^{(k-1)} \qquad x_e(n). \tag{3.25}$$

Another related problem is the appearance of uppercase subscripts on lowercase symbols. Consider the examples,

$$u_{ZI}(n), \qquad u_{ZS}(n), \qquad U_{ZI}(z), \qquad U_{ZS}(z) \tag{3.26}$$

The uppercase subscript appears too big as a subscript to the lowercase letter "u", but is not out of place on the uppercase letter "U". We can change the appearance by forcing the uppercase subscripts into a smaller size with the `\scriptscriptstyle` macro,

```
\def\ss#1{{\scriptscriptstyle \it #1}}
\begin{equation}
  u_{\ss{ZI}}(n), \qquad u_{\ss{ZS}}(n), \qquad
  U_{\ss{ZI}}(z), \qquad U_{\ss{ZS}}(z)
\end{equation}
```

With the smaller subscripts, the variables appear as follows.

$$u_{\scriptscriptstyle ZI}(n), \qquad u_{\scriptscriptstyle ZS}(n), \qquad U_{\scriptscriptstyle ZI}(z), \qquad U_{\scriptscriptstyle ZS}(z) \tag{3.27}$$

With this version, the uppercase subscripts now better match the lowercase letters, but perhaps are too small relative to the uppercase letters.

3.10 Punctuation in Mathematical Expressions

A question that comes up often is how to punctuate a displayed equation. The easiest rule is that if it reads as part of a sentence, then punctuate the expression that way. For instance, if the expression ends a sentence, the equation should be terminated by a period. If the sentence continues after the equation, a comma is often appropriate. One can look at standard journals, such as the IEEE Transactions for examples of punctuation.

Chapter 4

Graphics

In this chapter, we discuss some aspects of including graphics in a technical document. Specific examples are shown for graphics produced by TEX, `xfig` and MATLAB. The term graphics encompasses a number of different forms. Here we refer mainly to graphs.

4.1 Graphics Packages

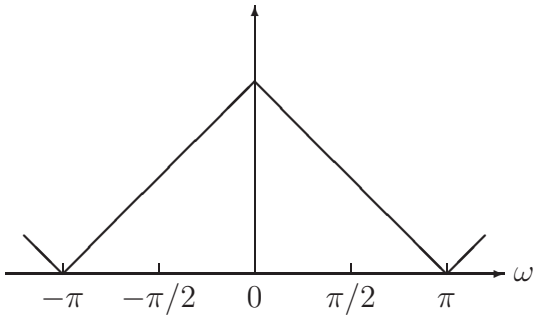
Graphics can be produced using a number of different programs, even from within LATEX itself. As an example consider a graph of a stylized frequency response. The result is shown in Fig. 4.1 as drawn several different ways: using the `picture` environment in LATEX, using `xfig` and using MATLAB.

4.1.1 LATEX `picture` environment

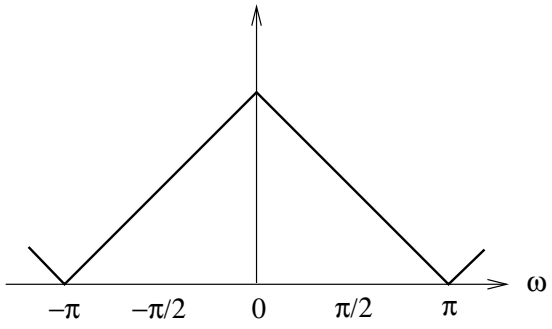
LATEX has a `picture` environment that can be used for drawing figures. This environment is quite restricting but adequate for the present job[1]. It can only draw lines at a small number of different slopes, and with only two possible line thicknesses for sloped lines. The lines for the function to be plotted were chosen to be exactly at 45 deg and are rendered well using the `picture` environment. The commands to draw the figure are shown below.

```
\setlength{\unitlength}{1in}
\def\Btext(#1,#2)#3{\put(#1,#2){%
\begin{picture}(0,0)(0,0)
```

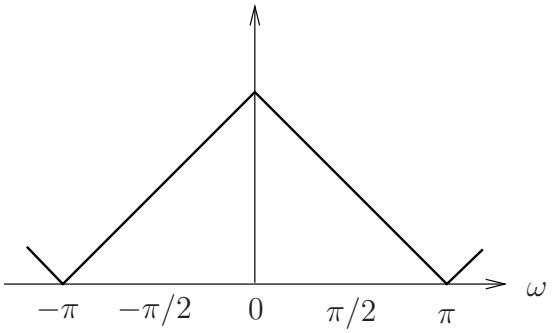
[1]The `pict2e` package promised in the LATEX book [2] is not available as of this writing.



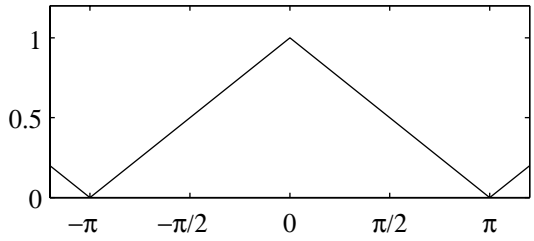
(a) Drawing using the LaTeX `picture` environment



(b) Drawing using `xfig` and PostScript fonts



(c) Drawing using `xfig` and LaTeX fonts



(d) Drawing using MATLAB

Fig. 4.1 A simple graph drawn using different plot packages

```
  \put(0,0){\line(0,1){0.05}}
  \put(0,-0.05){\makebox(0,0)[t]{#3}}
\end{picture}}}
\def\S{\vphantom{$/$}}
\begin{picture}(2.6,1.6)(-1.2,-0.2)
% Axes
  \put(0,0){\vector(0,1){1.4}}
  \put(-1.3,0){\vector(1,0){2.6}}
  \put(1.35,0){\makebox(0,0)[l]{$\omega$}}
  \Btext(-1,0){\S$-\pi$} \Btext(-0.5,0){\S$-\pi/2$}
  \Btext(0,0){\S$0$}     \Btext(0.5,0){\S$\pi/2$}
  \Btext(1,0){\S$\pi$}
% Function
  \thicklines
  \put(-1.2,0.2){\line(1,-1){0.2}}
  \put(-1,0){\line(1,1){1}}
  \put(0,1){\line(1,-1){1}}
  \put(1,0){\line(1,1){0.2}}
\end{picture}
```

4.1.2 `xfig` drawings

`xfig` is a drawing package available for Unix workstations running X-windows display software. It can be used to generate a pure PostScript output using PostScript fonts, or to generate a combination of PostScript for the lines and LaTeX for the text.

4.1.3 MATLAB drawings

MATLAB has powerful computational and graphics abilities. However for such simple drawings as in the example, it has shortcomings. For instance, MATLAB does not have the built-in capability to draw lines with arrows. We have to be content with axes labelled in a box. The graph in 4.1(d) was produced with the following commands.

```
figure ('DefaultTextFontName', 'Times', ...
        'DefaultTextFontSize', 10, ...
        'DefaultAxesFontName', 'Times', ...
        'DefaultAxesFontSize', 10);

SetPlotSize ([2.5, 1], 'inches');

xvalues = [-2 -1 0 1 2 ];
```

```
yvalues = [1 0 1 0 1];
plot (xvalues, yvalues);

axis ([-1.2, 1.2 0, 1.2]);

set (gca, 'XTick', [-1 -0.5 0 0.5 1]);
set (gca, 'XTickLabel', '-p|-p/2|0|p/2|p');
set (gca, 'Fontname', 'Symbol');
set (gca, 'YTick', [0 .5 1]);

set (gcf, 'PaperPositionMode', 'auto');
print -deps Spec1.ps;
```

Producing graphics with MATLAB is discussed in more detail later.

4.2 Including Graphics in a LaTeX Document

A PostScript drawing which needs no further scaling can be included into a document with the following commands.

```
\begin{figure}
  \centering
  \includegraphics{Plot.ps}%
  \caption {Sample plot}
\end{figure}
```

In the case of the multipart figure shown earlier, the `subfigure` package was used. The basic framework used to get two plots to a row was as follows.

```
\begin{figure}
\centering
  \subfigure[First drawing]{\includegraphics {plot1}}%
  \hspace {2em}%
  \subfigure[Second drawing]{\includegraphics {plot2}}%
  \\
  \subfigure[Third drawing]{\includegraphics {plot3}}%
  \hspace{2em}%
  \subfigure[Fourth drawing]{\includegraphics {plot4}}%
}%
\caption{Main caption}
\end{figure}
```

The actual form used in the earlier figure differed in that some plots were generated by LaTeX commands and others were PostScript figures. In addition, since not all plots were precisely the same size, additional `\hspace` commands were used to even out the spacing.

4.3 Data Graphs

Graphs serve as a visual means to convey information. There is in fact a visual "language" for doing so. The author of a technical document should make every effort to present graphical information in such a way as to make assimilation of the information easy.

4.3.1 Aspect ratio

Consider a plot of a segment of a signal, say a speech signal. This type of information has traditionally been plotted as if it were produced by a strip chart recorder, i.e. the plot is wide but not very high. This is natural as we are seldom interested in the exact amplitudes, but we are interested in the time of occurrence of events. There are other graphs that are traditionally plotted high and narrow. For instance a plot of probability of error (log scale) versus signal-to-noise ratio (in dB) is usually plotted in this form.

4.3.2 Scales

Choosing the scale for a graph is important, particularly if several graphs display similar information. It then important that the scales of the graphs be chosen to be the same, so that meaningful comparisons can be carried out.

4.3.3 Plot sizes

Consider including PostScript graphics generated by a MATLAB script. The size of the plot can be controlled at several points. MATLAB can be used to set the axis sizes or the plot can be resized when it is included into the LaTeX document. However, these different methods give different results. In MATLAB, changing the axis size does not affect the size of text such as axis labels, while when resizing a complete PostScript figure both text and other graphics change size.

I strongly suggest the following: *Generate the plot in MATLAB in the actual size and with the desired font sizes.* With this convention, the plot can be incorporated into the

LaTeX document with no further scaling.

4.4 Graphics Using MATLAB

Some notes on this MATLAB script shown earlier are as follows.

1. The font size is set to 10 pt when the figure is created. This font size should be compatible with the document being produced. For instance for a thesis, the main text font size is 12 pt. In the thesis style file, figure captions are set with `\small` font. Figures with font size 10 pt are then appropriate.

2. The font for text and axes is chosen to be `Times`. For many LaTeX documents, the main text font is Computer Modern Roman. The most compatible MATLAB font is `Times`.

3. The size of the plot on the screen is set to be 2.5 in by 1 in. The MATLAB procedure `SetPlotSize` is shown in Appendix B.

4. The tick locations and the plot limits are set explicitly. This ensures that we have full control of scaling. This control is especially important when two graphs need to be compared. It is then important to make sure that they have compatible and comparable scaling.

5. The X-axis ticks are labelled manually with strings. The letter π is produced by switching to the `Symbol` font. The letter "p" in that font gets rendered as "π".

6. To prevent scaling when the MATLAB figure is "printed" to a PostScript file, the `PaperPositionMode` is set to `auto`.

Chapter 5

Tables

5.1 Tables in LaTeX

Tables of many different sorts can be made with LaTeX. This chapter gives suggestions on producing tables, along with a number of examples.

5.2 Table Formatting

Here are some general suggestions for tables.

- In general, do not put vertical lines in tables. A look newer textbooks, will reveal that modern typographical layouts for tables almost never incorporate vertical lines. These tables tend to be simple and clean, with perhaps a horizontal line above the column titles, a single or double horizontal line below the column titles and finally a single horizontal line below the table. Heed the advice of Lamport in the LaTeX book [2, p. 63], "Lines usually just add clutter to a table; they are seldom helpful."
- Numerical tables often look better set in a small font.
- Align numbers at the decimal place.
- Keep numerical results in a table to a reasonable number of significant digits. Rarely is it important to see more than 3 or 4 significant digits.
- Adopt an open look, with adequate space between rows. The `arraystretch` command can be used to spread the rows of a table.

To illustrate these rules, here is a table and the LaTeX input which was used to generate it.

Table 5.1 Filter specifications

Taps (N)	Transition Band	Stopband Weighting (α)	Passband Ripple dB	Stop-band Rejection dB	Ultimate Stop Band dB
8	A	1	0.06	31	31
12			0.025	48	50
16			0.008	60	75
12	B	1	0.04	33	36
16			0.02	44	48
24			0.008	60	78
16	C	1	0.07	30	36
24		1	0.02	44	49
32		2	0.009	51	60
48		2	0.006	50	66
24	D	1	0.1	30	38
48		2	0.006	50	66
64		5	0.002	65	80
48	E	2	0.07	32	46
64		5	0.025	40	51

Transition Code Letter	Normalized Transition Band
A	0.14
B	0.10
C	0.0625
D	0.043
E	0.023

The normalized transition band is the width of the transition band normalized to 2π; that is, $(\omega_s - \pi/2)/(2\pi)$.

```
\begin{table}
  \centering
  \Tcaption {Filter specifications}
  \label {T:FSpec}
  \small
  \renewcommand\arraystretch{1.1}
```

```
\def~{\phantom{0}}
\def\ExSp#1{\noalign{\vskip #1}}
\begin{tabular}{cccccc}
  \hline\hline \ExSp{0.4ex}
  Taps  & Transition & Stopband   & Passband & Stop-band & Ultimate \\
  ($N$) & Band       & Weighting  & Ripple   & Rejection & Stop Band \\
        &            & ($\alpha$) & dB       & dB        & dB \\
  \ExSp{0.4ex} \hline \ExSp{0.4ex}
  ~8 &   &   &  0.06~ & 31 & 31 \\
  12 & A & 1 &  0.025 & 48 & 50 \\
  16 &   &   &  0.008 & 60 & 75 \\[1.2ex]
  12 &   &   &  0.04~ & 33 & 36 \\
  16 & B & 1 &  0.02~ & 44 & 48 \\
  24 &   &   &  0.008 & 60 & 78 \\[1.2ex]
  16 &   & 1 &  0.07~ & 30 & 36 \\
  24 &   & 1 &  0.02~ & 44 & 49 \\
  32 & \raisebox{1.5ex}[0pt]{C}
         & 2 &  0.009 & 51 & 60 \\
  48 &   & 2 &  0.006 & 50 & 66 \\[1.2ex]
  24 &   & 1 &  0.1~~ & 30 & 38 \\
  48 &   & 2 &  0.006 & 50 & 66 \\
  64 &   & 5 &  0.002 & 65 & 80 \\[1.2ex]
  48 &   & 2 &  0.07~ & 32 & 46 \\
  64 & \raisebox{1.5ex}[0pt]{E}
         & 5 &  0.025 & 40 & 51 \\
  \ExSp{0.4ex} \hline
\end{tabular}
\vskip 1ex
\begin{tabular}{cc}
  Transition  & Normalized \\
  Code Letter & Transition Band \\
  \ExSp{0.4ex} \hline \ExSp{0.4ex}
  A  & 0.14~~ \\
  B  & 0.10~~ \\
  C  & 0.0625 \\
  D  & 0.043~ \\
  E  & 0.023~ \\
  \ExSp{0.4ex} \hline
\end{tabular}
\qquad
\begin{minipage}[c]{2.1 in}
  \sloppy
  The normalized transition band is the width of the transition band
```

```
    normalized to $2\pi$; that is, $(\omega_s - \pi/2) / (2\pi)$.
  \end{minipage}
\end{table}
```

We can see a number of "tricks" that were used for typesetting this table.

- The caption is typeset using the `\Tcaption` which provides the correct spacing for captions which are placed above the table.

- The tilde character is redefined (locally since it is inside the table environment) to be `phantom{0}`. This macro prints nothing, but leaves a space equal to the size of a digit `0`. Since in the standard LaTeX fonts, all digits are equal space, this then can be used as a place holder to help align numbers. Using the `~` placeholder, we can make all numeric columns equal in width, and then center the result. The widths of the columns for this example are primarily determined by the width of the column headers. If we left or right justify the numbers within these columns, they will be well off-center. Using equal width fields allows us to center the numbers in the columns.

- The spacing between rows is determined by a invisible strut that is placed in each row of the table. The height of the strut is `0.7\baselineskip` and the depth is `0.3\baselineskip`, where `\baselineskip` is the base line skip parameter for the current font. For instance when using twelve point fonts, the `baselineskip` is 14.5 pt. As long as the text in a row has a height less than the height of the strut and a depth (due to character descenders) less than the depth of the strut, the spacing between rows is uniform.

  The `\arraystretch` macro can be used to scale the strut and thus change the spacing between rows. In the example, the `\arraystretch` is set to 1.1, giving 10% more space between rows.

- The default spacing works well except when horizontal lines are present. The spacing between two rows without an intervening horizontal line seems bigger because the white space below the upper row and the white space above the lower row add. When a horizontal line is added, it is useful to add a little extra space before and after the line. To provide the extra space, we define a new macro based on the builtin TeX macro `\noalign`.

```
\def\ExSp#1{\noalign{\vskip #1}}
```

We use this macro to insert extra space (0.4 ex) around horizontal lines. The extra space is given in units of `ex`, where 1 ex is approximately equal to the height of a lowercase x in the current font. Using a font-specific unit like this ensures that if changes in font are made, the spacing is modified accordingly.

Each row ends with a `\\` macro. This macro can take an extra argument which is an amount of extra space to be inserted. This provides another mechanism to insert space between lines in the table.

- This table also has some entries in the first column which are centered between rows of the subsequent columns. This is achieved by using a `\raisebox` command to raise the entry above its normal position.

Another example of a table appears as Table 5.2. This table uses multi-column headers. It also employs two dummy columns for spacing. The commands to produce this table are shown below.

Table 5.2 Comparison of the underlying pitch pulse estimation using the SVD and the weighted average for different values of the error weight ω.

	SVD				Weighted Average			
ω	$\sum \sigma_k^2$	$\sum \alpha_k^2$	G_E	Iter.	$\sum \sigma_k^2$	$\sum \alpha_k^2$	G_E	Iter.
0.1	6.54	0.00	0.14	2	4.89	0.11	1.30	3
0.2	5.75	0.03	0.67	2	3.61	0.37	2.30	4
0.3	4.37	0.19	1.70	2	2.69	0.79	2.99	5
0.4	2.77	0.67	2.93	4	2.00	1.10	3.38	5
0.5	1.48	1.53	3.51	6	1.47	1.54	3.51	6
0.6	0.70	2.68	3.01	7	1.05	2.04	3.39	7
0.7	0.36	3.82	2.08	6	0.72	2.64	3.03	10
0.8	0.23	4.78	1.30	7	0.44	3.41	2.44	14
0.9	0.13	5.85	0.53	12	0.21	4.58	1.49	24

```
\begin{table}
  \centering
  \Tcaption[%
Comparison of pitch pulse estimation using the SVD and weighted
```

```
 average]{%
Comparison of the underlying pitch pulse estimation using the SVD and the
 weighted average for different values of the error weight $\omega$.}
  \label{T:MultiC}
  \def~{\phantom{0}}
  \def\Hline{\noalign{\hrule height 2\arrayrulewidth}}
  \begin{tabular}{cccccccccc}
    \Hline \ExSp{1ex}
      & ~~ & \multicolumn{4}{c}{SVD}
      & ~~ & \multicolumn{4}{c}{Weighted Average} \\
    \ExSp{0.2ex} \cline{3-6} \cline{8-11} \ExSp{1ex}
    $\omega$ & & $\sum \sigma_k^2$ & $\sum \alpha_k^2$ & $G_E$ & Iter.
             & & $\sum \sigma_k^2$ & $\sum \alpha_k^2$ & $G_E$ & Iter. \\
    \ExSp{0.8ex} \hline \ExSp{1ex}
    0.1 & & 6.54 & 0.00 & 0.14 & ~2 & & 4.89 & 0.11 & 1.30 & ~3 \\
    0.2 & & 5.75 & 0.03 & 0.67 & ~2 & & 3.61 & 0.37 & 2.30 & ~4 \\
    ...
    0.8 & & 0.23 & 4.78 & 1.30 & ~7 & & 0.44 & 3.41 & 2.44 & 14 \\
    0.9 & & 0.13 & 5.85 & 0.53 & 12 & & 0.21 & 4.58 & 1.49 & 24 \\
    \ExSp{1ex} \hline
  \end{tabular}
\end{table}
```

- This table uses a thick line to separate the caption from the table itself.
- Extra spacing is provided before and after horizontal lines.
- This table has a long caption which appears above the table. A shorter caption is provided within square brackets; this short caption will appear in the list of tables at the beginning of the document.

Chapter 6

Bibliographies

There are many different standardized formats for use bibliographies. For Electrical Engineering, the IEEE journals provide a model for formatting bibliographic entries. Some features of the IEEE format are

1. The references appear in the order in which they are cited in the text.
2. Authors are identified by initial and last name.
3. Paper titles are set in lowercase.

6.1 BibTeX

Rather than be drawn into the minutiae of the formatting, use BIBTEX. The BIBTEX database is entered in a canonical format, but its output can be coerced to into one of many formats for the references as they appear in a LATEX document. In addition, BIBTEX can be used to form a database of references. Only those references that are actually cited are extracted from the database.

In the document text, citations are invoked with a symbolic key that matches a key in the database. For instance, one can cite a work as `\cite{Kabal:1996b}`, which appears in the text as "[5]". In the example, the key is the last name of the first author, and date. In addition, the key can include a letter to indicate the type of reference if it is not a journal paper, i.e. "C" for conference, "T" for thesis, etc. Thus a thesis might have the key `Loo:T1996`.

The BIBTEX entries themselves are in a file with a `.bib` extension, such as `Ref.bib`. The main document has two statements which control how the bibliography is generated. For BIBTEX entries in a file `Ref.bib` and using an IEEE style bibliography (`ieeetr`), the following commands are used.

```
\bibliographystyle{ieeetr}
\bibliography{Ref}
```

The `\bibliography` command generates the list of reference in the text. For documents with double or one-and-a-half spacing, I prefer to use single spacing for the list of references, viz,

```
\begin{singlespace}
  \bibliographystyle{ieeetr}
  \bibliography{Ref}
\end{singlespace}
```

The `bib` file (`Ref.bib` in the example) is one that you create and put in a directory such that LATEX can find it. As LATEX processes the document, it creates an `aux` file which specifies the bibliography style and the `bst` file, along with a list of citations. BIBTEX is then invoked with the `aux` file as input. BIBTEX processes the citations in the `aux` file, looking for the corresponding keys in the `bib` file and formatting the output according to the bibliographic style specification. The output is a `bbl` file which LATEX can process when it is invoked again.

```
% latex Ref
% bibtex Ref
```

6.2 BIBTEX Database

BIBTEX allows for the definition of strings in the database file (the `bib` file). Defining strings for journal names and the like, not only saves typing but ensures consistency for the entries. Other strings such as short forms for the month names are defined by BIBTEX itself. For example, use `nov` for the month name, rather than spelling it out. This way, the style can determine the rendition of the month name.

These conventions are perhaps best illustrated by example. Here is a part of a database of publications.

```
===== definitions
@string{INRS = "INRS-Tele\-com\-mu\-ni\-ca\-tions"}
@string{IEEE-COM = "IEEE Trans. Communications"}
@string{IEEE-IT = "IEEE Trans. Inform. Theory"}
@string{IEEE-SP = "IEEE Trans. Signal Processing"}
@string{IEEE-ASSP = "IEEE Trans. Acoustics, Speech, Signal
        Processing"}
@string{SpeechCom = "Speech Communication"}
@string{SigProc = "Signal Processing"}
@string{IEEE-Globecom = "Proc. IEEE Globecom Conf."}
@string{IEEE-ICC = "Proc. IEEE Int. Conf. Communications"}
@string{IEEE-ICASSP = "Proc. IEEE Int. Conf. on Acoustics, Speech,
        Signal Processing"}
@string{IEEE-ISCAS = "Proc. IEEE Int. Symposium on Circuits and
        Systems"}
@string{IEEE-ISIT = "Proc. IEEE Int. Symposium on Information Theory"}
@string{EUSIPCO-7 = "Proc. VII European Signal Processing Conf."}
@string{ICSLP = "Proc. Int. Conf. on Spoken Language Processing"}
@string{CJECE = "Canadian J. Electrical and Computer Engineering"}
@string{SP-SSAP-6 = "Proc. Sixth IEEE SP Workshop on Statistical
        Signal \& Array Processing"}

@preamble{"\def\hyph{-} "}

========== journal papers
@article{Valaee:96,
author = "Shahrokh Valaee and Peter Kabal",
title = "An Optimal Focusing Subspace for {C}oherent {S}ignal {S}ubspace
         Processing",
journal = IEEE-SP,
volume = 44,
pages = "752-756",
month = mar,
year = 1996
}
@article{De:95,
author = "Aloknath De and Peter Kabal",
title = "Auditory distortion measure for speech coder evaluation ---
        {H}idden {M}arkovian approach",
journal = SpeechCom,
volume = 17,
pages = "39-57",
month = aug,
```

```
year = 1995
}

========== papers submitted
@article{Valaee:S95,
author = "Shahrokh Valaee and Benoit Champagne and Peter Kabal",
title = "Localization of Wideband Signals Using Least-Squares and
         Total Least-Squares Approaches",
journal = IEEE-SP,
note = "(submitted Aug. 1995)"
}

========== book chapters
@incollection{Grass:B92,
author = "John Grass and Peter Kabal and Majid Foodeei and
          Paul Mermelstein",
title = "High quality low-delay speech coding at 12 kb/s",
booktitle = "Speech and Audio Coding for Wireless and Network
             Applications",
pages = "3-9",
publisher = "Kluwer Academic",
year = 1993
}

========== conference papers
@conference{Loo:C96,
author = "James H. Y. Loo and Wai-Yip Chan and Peter Kabal",
title = "Classified Nonlinear Predictive Vector Quantization of Speech
         Spectral Parameters",
booktitle = IEEE-ICASSP,
address = "Atlanta, GA",
pages ="761-764",
month = may,
year = 1996
}
@conference{Valaee:C94b,
author = "Shahrokh Valaee and Peter Kabal and Benoit Champagne",
title = "A Parametric Approach to Extended Source Localization",
booktitle = EUSIPCO-7,
address = "Edinburgh, Scotland",
pages ="764-767",
month = sep,
year = 1994
```

```
}
@conference{Qian:C93,
author = "Yasheng Qian and Peter Kabal",
title = "Pseudo-three-tap Pitch Prediction Filters",
booktitle = IEEE-ICASSP,
address = "Minneapolis, MN",
pages ="{II\hyph523}-{II\hyph526}",
month = apr,
year = 1993
}

========== theses
@mastersthesis{Zlobec:T95,
author = "Sanro Zlobec",
title = "Linear Predictive Spectral Shaping for Acoustical Echo
         Cancellation",
type = "{M.Eng.} thesis",
school = "McGill University",
address = "Department of Electrical Engineering",
month = nov,
year = 1995,
}
@phdthesis{Valaee:T94,
author = "Shahrokh Valaee",
title = "Array Processing for Detection and Localization of Narrowband,
         Wideband and Distributed Sources",
type = "{Ph.D.} thesis",
school = "McGill University",
address = "Department of Electrical Engineering",
month = may,
year = 1994
}

========== technical reports
@techreport{Champagne:R92,
author = "Benoit Champagne and Arthur Lobo and Peter Kabal",
title = "A Low-cost Autodirective Microphone Array for
         Audio-Teleconferencing Applications",
institution = INRS,
number = "92-05",
month = feb,
year = 1992
}
```

Some notes on this database.

1. Author names are separated by the word `and`. It is a common mistake for new users of BIBTEX to use commas between names.

2. Since the final output will be TEX commands, certain concessions must be made. Hyphenation is supplied for the definition of the string `INRS` so that TEX will hyphenate this long string. In the string `SP-SSAP-6`, an ampersand has to be escaped: `\&`.

3. In some styles, notably the IEEE style, titles will be converted to lowercase. However, certain words should remain capitalized. Thus in several paper titles, we see initial letters in braces. This prevents them from being converted to lowercase if the style calls for that conversion.

4. In the `pages` entries, the page ranges have the `-` converted to an en-dash (`--`). There is however one case where we do not want hyphens to be converted to en-dashes. To prevent conversion, we define the `\hyph` command to produce a plain hyphen.

5. Note the use of standard short forms for the month names (for example `feb` for February). This allows the bibliography style to choose whether the name should be given in short form or in full.

After processing by BIBTEX using the `ieeetr` style, these references (if cited in order) would appear as follows.

[1] S. Valaee and P. Kabal, "An optimal focusing subspace for Coherent Signal Subspace processing," *IEEE Trans. Signal Processing*, vol. 44, pp. 752–756, Mar. 1996.

[2] A. De and P. Kabal, "Auditory distortion measure for speech coder evaluation — Hidden Markovian approach," *Speech Communication*, vol. 17, pp. 39–57, Aug. 1995.

[3] S. Valaee, B. Champagne, and P. Kabal, "Localization of wideband signals using least-squares and total least-squares approaches," *IEEE Trans. Signal Processing.* (submitted Aug. 1995).

[4] J. Grass, P. Kabal, M. Foodeei, and P. Mermelstein, "High quality low-delay speech coding at 12 kb/s," in *Speech and Audio Coding for Wireless and Network Applications*, pp. 3–9, Kluwer Academic, 1993.

[5] J. H. Y. Loo, W.-Y. Chan, and P. Kabal, "Classified nonlinear predictive vector quantization of speech spectral parameters," *Proc. IEEE Int. Conf. on Acoustics, Speech, Signal Processing* (Atlanta, GA), pp. 761–764, May 1996.

[6] S. Valaee, P. Kabal, and B. Champagne, "A parametric approach to extended source localization," *Proc. VII European Signal Processing Conf.* (Edinburgh, Scotland), pp. 764–767, Sept. 1994.

[7] Y. Qian and P. Kabal, "Pseudo-three-tap pitch prediction filters," *Proc. IEEE Int. Conf. on Acoustics, Speech, Signal Processing* (Minneapolis, MN), pp. II-523–II-526, Apr. 1993.

[8] S. Zlobec, "Linear predictive spectral shaping for acoustical echo cancellation," M.Eng. thesis, McGill University, Department of Electrical Engineering, Nov. 1995.

[9] S. Valaee, *Array Processing for Detection and Localization of Narrowband, Wideband and Distributed Sources*. Ph.D. thesis, McGill University, Department of Electrical Engineering, May 1994.

[10] B. Champagne, A. Lobo, and P. Kabal, "A low-cost autodirective microphone array for audio-teleconferencing applications," Tech. Rep. 92-05, INRS-Telecommunications, Feb. 1992.

Appendix A

LaTeX Macros

The LaTeX commands and macros used in formatting the title page for this document are shown in this appendix.

A.1 Thesis Preamble

The commands used to create the title page for a thesis are shown below. The McGill University crest is brought in via a macro `McGillCrest` which allows for setting the size and colour of an imported PostScript file which contains the actual crest. The title page also includes a red separator line.

```
\title{My Thesis}
\author{The Author}
\organization{%
  \\[0.2in]
  \McGillCrest {!}{1in}\\
  \\[0.1in]
  Department of Electrical \& Computer Engineering\\
  McGill University\\
  Montreal, Canada}
\note{%
  {\color{red} \hrule height 0.4ex}
  \vskip 3ex
  A thesis submitted to the Faculty of Graduate Studies and Research
  in partial fulfillment of the requirements for the degree of
  Master of Engineering.
  \vskip 3ex
```

```
  \copyright\ \the\year\ The Author
}

\maketitle
```

Appendix B

MATLAB Script

The MATLAB procedure used to set the size of a MATLAB plot is shown below.

B.1 SetPlotSize

```
function SetPlotSize (pos, units)
% SetPlotSize  Set the size of the current plot
%   SetPlotSize(pos,units)
%     or
%   SetPlotSize(pos)        % default units "inches" assumed
%
% pos   - axes position [xsize, ysize] or
%                       [xleft, ybottom, xsize, ysize]
% units - units for the dimensions, default 'inches'.  The choices
%         are 'centimeters', 'pixels', 'inches', 'points', and
%         'normalized'.
% Note: The 'Units' for the current axes are set to the units
%       specified.  If the units are absolute measurements
%       (i.e. not 'normalized'), then figure can be resized on
%       the screen using the mouse.  This feature can be used to
%       "crop" white space above and to the left of the axes.

% SetPlotSize 2000-02-08

% Notes:
% - The default axes position for Matlab is given in normalized
%   units as [0.130 0.110 0.775 0.815].  These values are used
%   to determine the space around the axes.
```

```
if (nargin <= 1)
  units = 'inches';
end

Np = length(pos);
if (Np ~= 2 & Np ~= 4)
  error ('SetPlotSize: pos must have 2 or 4 elements');
end

posnorm = [0.130 0.110 0.775 0.815];
if (Np == 2)
  figsize = pos ./ posnorm(3:4);
  axespos = [(posnorm(1:2) .* figsize) pos];
else
  figsize = (pos(1:2) + pos(3:4)) ./ (posnorm(1:2) + posnorm(3:4));
  axespos = pos;
end

% Set the figure
saveunits = get (gcf, 'Units');
set (gcf, 'Units', units);
figpos = get (gcf, 'Position');
set (gcf, 'Position', [figpos(1:2) figsize]);
set (gcf, 'Units', saveunits);

% Set the axes
set (gca, 'Units', units);
set (gca, 'Position', axespos);

Figno = get(0, 'CurrentFigure');
disp (sprintf ('SetPlotSize: Figure %d, size: %g x %g', Figno, figsize));
```

References

[1] Faculty of Graduate Studies and Research, McGill University, "Guidelines for thesis preparation," Sept. 1994.

[2] L. Lamport, *LaTeX A Document Preparation System*. Addison-Wesley, second ed., 1994.

[3] D. E. Knuth, *The TeXbook*. Addison-Wesley, 1986.

[4] H. Kopka and P. W. Daly, *A Guide to LaTeX 2ε*. Addison-Wesley, second ed., 1995.

[5] M. Goossens, F. Mittelbach, and A. Samarin, *The LaTeX Companion*. Addison-Wesley, 1994.

[6] M. Goossens, S. Rahtz, and F. Mittelbach, *The LaTeX Graphics Companion*. Addison-Wesley Longman, 1997.