

NORTHWESTERN UNIVERSITY

How to Write a Doctoral Dissertation  
with L<sup>A</sup>T<sub>E</sub>X

A DISSERTATION

SUBMITTED TO THE GRADUATE SCHOOL  
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

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DOCTOR OF PHILOSOPHY

Field of Mathematics

By

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## ABSTRACT

How to Write a Doctoral Dissertation  
with L<sup>A</sup>T<sub>E</sub>X

Miguel A. Lerma

This document has the form of a “fake” doctoral dissertation in order to provide an example of such. Here we examine how to write a Doctoral Dissertation using L<sup>A</sup>T<sub>E</sub>X, and in particular how to use the nuthesis document class.

## **Acknowledgements**

Text for Acknowledgments (optional).

## Preface

This is the preface (optional).

## **List of abbreviations**

This is the list of abbreviations (optional).

## Glossary

This is the glossary (optional).

## Nomenclature

This is the nomenclature (optional).

## Dedication

This is the dedication (optional).

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## CHAPTER 1

**Introduction**

This document deals with how to write a doctoral dissertation using  $\text{\LaTeX}$ , and how to use the `nuthesis` document class. For further information about using  $\text{\TeX}$  and  $\text{\LaTeX}$  see [2, 3, 4].

Note that in spite of the effort to accommodate this work to the requirements of the University, it is not possible to guarantee that it will always work, and the author of the dissertation remains responsible for checking that such requirements are actually fulfilled by his/her final work.

In case of any problem with `nuthesis`, e-mail me to:

`malerma@math.northwestern.edu`.

## **Part 1**

# **General Instructions**

## CHAPTER 2

**Instructions for preparing doctoral dissertations**

We are not going to look at the complete set of instructions, which can be obtained in the Office of Graduate Studies. Here we will look at a few instructions related to the arrangement of the dissertation and a few other “technical” details. The booklet of instructions I am using has date of September, 1993 (by now obsolete, but I am using this document only for testing purposes, and the accuracy of its content is not really essential at this point.)

Always remember that this “fake” dissertation is neither a dissertation, nor a set of instructions, but just some information to take better advantage of computers to write a dissertation. So, you should get the real booklet of instructions from the Office of Graduate Studies and check everything by yourself.<sup>1</sup>

The following are just a couple of tests for the “quote” and “quotation” environments:

This is a quote.

Always remember that this “fake” dissertation is neither a dissertation, nor a set of instructions, but just some information to take better advantage of computers to write a dissertation. So, you should get the

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<sup>1</sup>This is a footnote to remind you that this “fake” dissertation is neither a dissertation, nor a set of instructions, but just some information to take better advantage of computers to write a dissertation. So, you should get the real booklet of instructions from the Office of Graduate Studies and check everything by yourself.

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This is a quotation.

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### **2.1. Arrangement of dissertation**

Arrange your dissertation as follows.

- (1) Title Page. This page is counted, but there should not be a page number on this page. Begin counting pretext pages here.
- (2) Copyright Page. Begin showing pretext page numbers with lower case Roman numerals at bottom of page.
- (3) Abstract.
- (4) Optional Prefatory Pages (optional): Acknowledgment page, preface, list of abbreviations, glossary, nomenclature, and dedication.
- (5) Table of contents.
- (6) List of Tables, Illustrations, Figures or Graphs (optional).

- (7) Text body. The text may include an introduction. Tables, illustrations, figures, and graphs may be included in the main body of the text, or they should immediately follow the text. They should not be placed at the end of chapters. Every page in a dissertation is numbered, except the title page. Page numbering will begin on the second page with Arabic numeral 2.
- (8) References. Consult your supervisor about the style.
- (9) Appendix or Appendices (optional).
- (10) Vita (optional).

## **2.2. Other requirements**

### **2.2.1. Margins**

There should be one inch margins on all sides, including page numbers. Typing or print should be within these measurements.

Page numbers should conform to margin requirements and be placed at least 1 inch from the top and right sides of the page.

### **2.2.2. Spacing and page arrangement**

The preliminary pages (abstract, dedication, acknowledgments, table of contents) and main body text must be double spaced.

Quotations, captions, items in tables, lists, graphs and charts may be single spaced.

Every page in a dissertation is numbered, except the title page.

Page numbering will begin on the second page with Arabic numeral 2.

There should be no blank pages.

On pages of the dissertation that are formatted with landscape orientation, the page number must appear in lower right - hand corner if the page, so that it would appear in the correct location if the page were rotated to portrait orientation.

## CHAPTER 3

**How to use the nuthesis document class**

The nuthesis class is a slightly modified amsbook class.

**3.1. Preamble**

The preamble of your document should start like this:

```
\documentclass[12pt]{nuthesis}
```

The first line declares “**nuthesis**” as document class, with an option of 12pt for the character size, which is slightly greater than usual (the default is 10pt). You may include other options, as in any other L<sup>A</sup>T<sub>E</sub>X document.

You may include other packages, for instance:

```
\usepackage{amscd}
```

The default spacing for both texts and quoted texts is doublespaced. That can be changed with the following self-explanatory commands:

```
\onehalfspacing
```

```
\singlespacing
```

```
\onehalfspacequote
```

```
\singlespacequote
```

Next commands, are required in the preamble. Replace the dots in the commands with the appropriate information:

`\author{...}`

% Replace the dots in the command by your full name.

% Make it combination of lower and uppercases

% e.g., `\author{Dorothy Kay Shoemaker}`

`\title{...}`

% Replace the dots in the above command

% by your thesis title,

% e.g., `'\title{A Take of Gnus, Gnats and \\ Armadillos}'`.

% If the title consists of more than one line,

% it should be in inverted pyramid form. You have to

% specify the line breakings by `\\` commands.

Next commands are optional:

`\degree{...}`

% The degree sought as given in the Graduate Catalogue.

% Capital letters are recommended.

% e.g., `'\degree{DOCTOR OF BUSINESS ADMINISTRATION}'`

% The default value is `'DOCTOR OF PHILOSOPHY'`

% for dissertation.

`\graduationmonth{...}`

% Graduation month, in the form as

% `'\graduationmonth{May}'`.

% The default value (either May, August, or December)

% is guessed according to the time of running LaTeX

```

% Do not abbreviate.

% Note: either May, August, or December
\graduationyear{...}

% Graduation year, in the form as '\graduationyear{1991}'.
% The default value is guessed according to the time of
% running LaTeX.
% 4 (not 2) digit number

```

### 3.2. Document

Next, the body of your thesis starts and some stuff is generated:

```

\begin{document}

\frontmatter          % Pretext settings.
\titlepage            % Produces the title page.
\copyrightpage        % Creates the copyright page.
\abstract

% Place your abstract here. The abstract heading will be
% generated automatically.

\acknowledgments

% Place the text of your acknowledgments here.
% Your name and graduation date will appear
% automatically.
% If this is the preface instead of acknowledgments,
% use \preface.

```

```

\tableofcontents % Table of Contents will be automatically
                 % generated and placed here.

\listoftables    % List of Tables and List of
                 % Figures will be placed

\listoffigures  % here, if applicable.

```

Next, the actual text comes. It could be a sequence of chapters divided into sections, subsections, etc:

```

\mainmatter      % Main settings.

\chapter{...}    % The first chapter.
                 % \chapter command is of the form
                 % \chapter[...]{...} or \chapter{...} where
... text ...    % {chapter heading} and [entry in table of
                 % contents].

\section{...}    %
                 % IMPORTANT: If your chapter heading consists
                 % of more than one lines, it will be auto-
... text ...    % matically broken into separate lines.
                 % However, if you don't like the way LaTeX
                 % breaks the chapter heading into lines, use

\section{...}    % '\newheadline' command to break lines.

... text ...

\chapter{...}    % It is Chapter 2.

```

```

    ... text ...
\section{...}
    ... text...
\subsection{...}
    ... more text ...
\appendix      % Appendix begins here
% \appendices  % If more than one appendix chapters,
                % use \appendices instead of \appendix
\chapter{...}  % First appendix chapter, i.e., Appendix A.
\section{...}  % This is appendix section A.1.
.....

```

Also, the chapters can be written in different files, say `chap1.tex`, `chap2.tex`, `chap3.tex`, etc, and be loaded by `\include` commands:

```

\include{chap1}
\include{chap2}
\include{chap3}
.....
\include{appen1}
\include{appen2}
.....

```

Then the bibliography comes. It can be made by hand like this:

```

\begin{thebibliography}{foo}
\bibitem ...

```

```
\end{thebibliography}
```

It can also be generated with BiB<sub>T</sub>E<sub>X</sub>, which is explained in chapter 4.

## **Part 2**

# **Further Instructions**

## CHAPTER 4

**Making the bibliography with BiB<sub>T</sub>E<sub>X</sub>**

BiB<sub>T</sub>E<sub>X</sub> allows one to generate automatically the bibliography from a database of bibliographic items. You need to do the following:

- (1) Create the bibliographic database, which is a file whose name ends in `.bib`. Let us call it `diss.bib`. Entries in this file are like this:

```
@BOOK{knuth:tb,  
  author = "Donald K. Knuth",  
  title = "The \TeX book",  
  publisher = "Addison-Wesley",  
  year = "1984",  
}  
  
@TECHREPORT{poorten:sp,  
  author = "Alf~J.~van der Poorten",  
  title = "Some problems of recurrent interest",  
  institution = "School of Mathematics and Physics,  
                Macquarie University",  
  address = "North Ryde, Australia 2113",  
  number = "81-0037",
```

```

    month = "August",
    year = "1981",
}

```

```

@ARTICLE{erdos:oap,
  author = "Paul Erd{\o}s and Paul Turan",
  title = "On a problem in the theory of uniform
          distribution, {I}",
  journal = "Indag. Math.",
  volume = "10",
  year = "1948",
  pages = "370--378",
}

```

- (2) Include a `\bibliographystyle` command in your  $\LaTeX$  file, say

```
\bibliographystyle{plain}
```

and a `\bibliography` command to load the bibliography, in this case `\bibliography{diss}`,

at the point of your document where the bibliography should be inserted. The document at this point will look like this:

```
\bibliographystyle{plain}
```

```
\bibliography{diss}
```

- (3) Run  $\LaTeX$  on your main file, say `foo.tex`: `latex foo`. This generates an auxiliary file `foo.aux` with a list of `\cite` references.

- (4) Run BiBTeX on your file: `bibtex foo`. BiBTeX reads the auxiliary file, looks up the bibliographic database (`diss.bib`), and writes a `.bbl` file with the bibliographic information formatted according to the bibliographic style file (`.bst`, say `plain.bst`) specified. Error messages are written to a `.blg` file.
- (5) Run L<sup>A</sup>T<sub>E</sub>X again: `latex foo`, which now reads the `.bbl` reference file.
- (6) Run L<sup>A</sup>T<sub>E</sub>X for a third time: `latex foo`, resolving all references.

This includes all bibliographic items that have been cited in the document with a `\cite` command. In order to include non cited items in the bibliography, use the command `\nocite`. For instance, `\nocite{knuth:tb}` anywhere in the document (after `\begin{document}`) would include in the bibliography the item with label `knuth:tb`. In order to include *all* items of the bibliographic database, use the command `\nocite{*}`.

## CHAPTER 5

**Tables and Figures**

The *tabular* environment allows us to create complex tables and figures, and draw boundaries around and within it. The following example illustrates this:

Table 5.1. An example of table.

<i>presente</i>		<i>pasado perfecto</i>		
yo	soy	yo	he	sido
tú	eres	tú	has	sido
él	es	él	ha	sido
nosotros	somos	nosotros	hemos	sido
vosotros	sois	vosotros	habéis	sido
ellos	son	ellos	han	sido

That table was created with the following sequence of commands:

```
\begin{table}[h]
\begin{center}
\caption{An example of table.}
\vskip 10pt
\begin{tabular}{|l|l|l|l|} \cline{1-2} \cline{4-6}
\multicolumn{2}{|c|} {\textsl{presente}} & \hspace{7mm} &
\multicolumn{3}{|c|} {\textsl{pasado perfecto}} \\ \
\cline{1-2} \cline{4-6}
yo & soy & & yo & he & sido \\ \
```

```

t\'u & eres & & t\'u & has & sido \\
\'el & es & & \'el & ha & sido \\
nosotros & somos & & nosotros & hemos & sido \\
vosotros & sois & & vosotros & hab\'eis & sido \\
ellos & son & & ellos & han & sido \\
\cline{1-2} \cline{4-6}
\end{tabular}
\end{center}
\end{table}

```

The argument `h` indicates the position for the table, in this case “here if possible”. Other values of this argument are: `t` (top of the page), `b` (bottom of the page), `p` (page of floats) and `H` (here always). It is possible to combine several arguments, such as `ht` (“here if possible, otherwise on top of the page”).

Figure 5.1 is a typical example of inclusion of a figure contained in a file with encapsulated PostScript. In order to use it, it is necessary to include the command `\usepackage{psfig}` at the beginning of the document.



Figure 5.1. An example of imported eps file with a long caption requiring two lines of text.

It has been generated with the following commands:

```
\begin{center}
\ \includegraphics[height=1.5in,width=1.2in]{myfile}
\caption[An example of imported eps file.]{An example of imported eps
file with a long caption requiring two lines of text.}
\label{f:ex}
\end{center}
\end{figure}
```

The command that imports the file is `\psfig`, and it also controls its size (`height` and `width`), and can rotate the figure (`angle`).

Figures can also be drawn by using  $\text{\LaTeX}$  commands. Figure 5.2 is an example (taken from [4]).

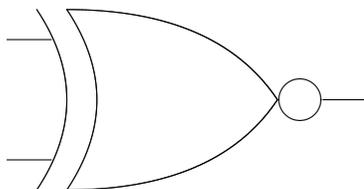


Figure 5.2. An example of picture

It has been generated with the following set of commands:

```
\begin{figure}[htb]
\begin{center}
\setlength{\unitlength}{4mm}
```

```

\begin{picture}(12,10)(-2,0)
  \linethickness{0.4pt}
  \qBezier(2.00,6.00)(7.00,6.00)(9.00,3.00)
  \qBezier(2.00,0.00)(7.00,0.00)(9.00,3.00)
  \qBezier(2.00,6.00)(4.00,3.00)(2.00,0.00)
  \qBezier(1.00,6.00)(3.00,3.00)(1.00,0.00)
  \put(9.75,3.00){\circle{1.50}}
  \put(10.50,3.00){\line(1,0){1.50}}
  \put(0.00,5.00){\line(1,0){1.50}}
  \put(0.00,1.00){\line(1,0){1.50}}
\end{picture}

\caption{An example of picture}

\label{f:cir}

\end{center}

\end{figure}

```

Those commands have rather obvious meanings. In particular, the command `\qBezier` draws a quadratic Bezier curve, defined by its two ending points, and a third point (whose coordinates are in the middle) that is used as control point. Figure 5.3 illustrates the effect of the control point:

That figure has been generated with the following commands:

```

\begin{figure}[htb]
\begin{center}
  \setlength{\unitlength}{.8mm}

```

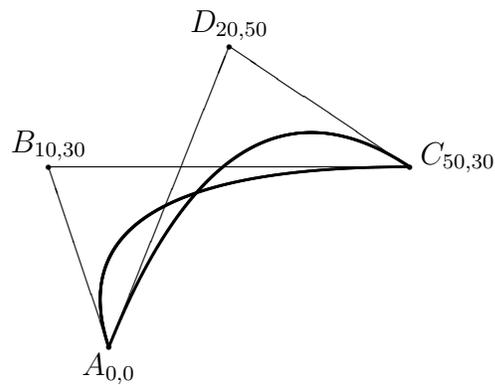


Figure 5.3. Bezier curves

```

\begin{picture}(55,55)(-15,0)
  \linethickness{1pt}
  \qBezier(0,0)(-10,30)(50,30)
  \qBezier(0,0)(20,50)(50,30)
  \thinlines
  \put(0,0){\line(-1,3){10}}
  \put(50,30){\line(-1,0){60}}
  \put(0,0){\line(2,5){20}}
  \put(50,30){\line(-3,2){30}}
  \put(0,0){\circle*{1}}
  \put(0,-1){\makebox(0,0)[t]{$A_{0,0}$}}
  \put(-10,30){\circle*{1}}
  \put(-10,31){\makebox(0,0)[b]{$B_{10,30}$}}
  \put(50,30){\circle*{1}}
  \put(58,29){\makebox(0,0)[b]{$C_{50,30}$}}
  \put(20,50){\circle*{1}}

```

```

\put(20,51){\makebox(0,0)[b]{$D_{20,50}$}}
\end{picture}
\caption{Bezier curves}
\label{f:qb}
\end{center}
\end{figure}

```

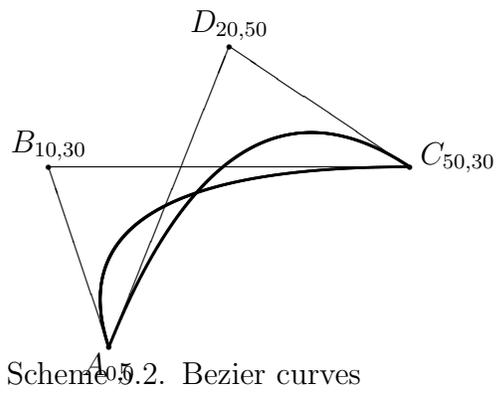
Next, a couple of examples of schemes:

Scheme 5.1 is a typical example of inclusion of a figure contained in a file with encapsulated PostScript. In order to use it, it is necessary to include the command `\usepackage{psfig}` at the beginning of the document.



Scheme 5.1. An example of imported eps file with a long caption requiring two lines of text.

Another scheme:



## CHAPTER 6

## An example of Mathematical writing

## 6.1. Generalized Fatou's Lemma

Here we show an application of the following lemma:

**Lemma 6.1** (Generalized Fatou's Lemma). *Let  $A$  be a Dedekind ring and  $F$  a rational series in  $A[[X]]$ , i.e.,  $F = p/q$  for some  $p, q \in A[X]$ . Then there exist two polynomials  $P, Q \in A[X]$  such that  $F = P/Q$ , where  $P$  and  $Q$  are relatively prime and  $Q(0) = 1$ .*

**Proof.** See [1], p. 15, theorem 1.3. □

**Theorem 6.2.** *Let  $\{c_n\}_{n=-\infty}^{\infty}$  a set of elements from  $K$  such that  $c_n \in k'$  for every  $n \geq n_0$ , and verifying the following recurrence relation of order  $M$ :*

$$(6.1) \quad c_n = r_1 c_{n-1} + r_2 c_{n-2} + \cdots + r_M c_{n-M}$$

for every  $n \in \mathbb{Z}$ , where  $r_1, r_2, \dots, r_M$  are in  $K$ ,  $r_M \neq 0$ . Then:

- (i) *The coefficients  $r_1, r_2, \dots, r_M$  are in  $k'$ , and for every  $n \in \mathbb{Z}$ ,  $c_n \in k'$ .*
- (ii) *If  $c_n \in \mathcal{O}_{k',v}$  for every  $n \geq n_0$ , then the coefficients  $r_1, r_2, \dots, r_M$  are all in  $\mathcal{O}_{k',v}$ .*

**Proof.**

- (i) Let  $C_n$  and  $R$  be the matrices:

$$(6.2) \quad C_n = \begin{pmatrix} c_n & c_{n+1} & \cdots & c_{n+M-1} \\ c_{n+1} & c_{n+2} & \cdots & c_{n+M} \\ \vdots & \vdots & \ddots & \vdots \\ c_{n+M-1} & c_{n+M} & \cdots & c_{n+2M-2} \end{pmatrix}$$

and

$$(6.3) \quad R = \begin{pmatrix} 0 & 1 & 0 & \cdots & 0 \\ 0 & 0 & 1 & \cdots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \cdots & 1 \\ r_M & r_{M-1} & r_{M-2} & \cdots & r_1 \end{pmatrix}$$

We have that  $C_{n+1} = RC_n$ . Since the recurrence relation is of order  $M$ ,  $C_n$  is non singular. On the other hand,  $R = C_{n+1} C_n^{-1}$ . Since the elements of  $C_n$  are in  $k'$  for  $n \geq n_0$ , the entries of  $R$ , and those of  $R^{-1}$ , will be in  $k'$ . Since  $C_{n-1} = R^{-1} C_n$ , we get that the entries of  $C_n$  will be in  $k'$  also for  $n < n_0$ .

(ii) For each  $t \geq n_0$  define the formal power series

$$(6.4) \quad F_t(X) = \sum_{n=0}^{\infty} c_{t+n} X^n$$

which is in  $\mathcal{O}_{k',v}[[X]]$ . We have  $F_t(X) = p_t(X)/q(X)$ , where  $p_t(X), q(X) \in k'[X]$  are the following:

$$(6.5) \quad p_t(X) = \sum_{j=0}^{M-1} \left( c_{t+j} - \sum_{i=1}^j r_i c_{t+j-i} \right) X^j$$

$$(6.6) \quad q(X) = 1 - r_1 X - r_2 X^2 - \dots - r_M X^M$$

This can be checked by multiplying  $F_t(X)$  by  $q_t(X)$  and using the recurrence relation, which gives  $F_t(X) q(X) = p_t(X)$  (see [6]).

Now we will prove that  $p_t(X)$  and  $q(X)$  are relatively prime. To do so, we will see that they cannot have any common root (in  $\overline{k'}$ ). In fact, assume that  $\alpha$  is a common root of  $p_{t_0}(X)$  and  $q(X)$  for some  $t_0 \geq n_0$ , i.e.:  $p_{t_0}(\alpha) = q(\alpha) = 0$ . Since  $q(0) = 1$ , then  $\alpha \neq 0$ . Now we have:

$$(6.7) \quad X F_{t_0+1}(X) = F_{t_0}(X) - c_{t_0}$$

so:

$$(6.8) \quad \begin{aligned} X p_{t_0+1}(X) &= X q(X) F_{t_0+1}(X) \\ &= q(X) (F_{t_0}(X) - c_{t_0}) = p_{t_0}(X) - c_{t_0} q(X) \end{aligned}$$

Hence  $p_{t_0+1}(\alpha) = 0$ , which means that  $\alpha$  is also a root of  $p_{t_0+1}(X)$ . By induction we get that  $p_t(\alpha) = 0$  for every  $t \geq t_0$ . Grouping the terms of  $p_t(X)$  with respect to

$c_t, c_{t+1}, \dots, c_{t+M-1}$ , we get:

$$(6.9) \quad p_t(X) = \sum_{j=0}^{M-1} a_j(X) c_{t+j}$$

where

$$(6.10) \quad a_j(X) = X^j \left( 1 - \sum_{i=1}^{M-j-1} r_i X^i \right)$$

Note that  $a_0(X), a_1(X), \dots, a_{M-1}(X)$  do not depend on  $t$ . On the other hand  $p_t(\alpha) = 0$  implies

$$(6.11) \quad \sum_{j=0}^{M-1} a_j(\alpha) c_{t+j} = 0$$

for every  $t \geq t_0$ . Note that  $a_{M-1}(\alpha) = \alpha^{M-1} \neq 0$ , so  $a_0(\alpha), a_1(\alpha), \dots, a_{M-1}(\alpha)$  are not all zero, and (6.11) means that the columns of the matrix  $C_{t_0}$  are linearly dependent, so  $\det C_{t_0} = 0$ , which contradicts the fact that  $C_{t_0}$  is non singular. Hence, the hypothesis that  $p_t(X)$  and  $q(X)$  have a common root has to be false. This proves that  $p_t(X)$  and  $q(X)$  are relatively prime.

By (generalized Fatou's) lemma 6.1, and taking into account that  $\mathcal{O}_{k',v}$  is a Dedekind ring, we get that there exist two relatively prime polynomials  $P_t(X)$  and  $Q_t(X)$  in  $\mathcal{O}_{k',v}[X]$  such that  $F_t(X) = P_t(X)/Q_t(X)$  and  $Q_t(0) = 1$ . Hence:  $p_t(X) Q_t(X) = q(X) P_t(X)$ . By unique factorization of polynomials in  $k'[X]$ , there is a  $u \in k'$  such that  $P_t(X) = u p_t(X)$  and  $Q_t(X) = u q_t(X)$ . Since  $Q_t(0) = q(0) = 1$ , we get that  $u = 1$ , so  $P_t(X) = p_t(X)$  and  $Q_t(X) = q(X)$ . Hence, the coefficients of  $q(X)$  are in  $\mathcal{O}_{k',v}$ .

□

## 6.2. Other examples of Mathematical writing

### 6.2.1. An example of commutative diagram

The following is an example of commutative diagram. It requires the `amscd` package.

$$\begin{array}{ccc}
 S^{\mathcal{W}_\Lambda} \otimes T & \xrightarrow{j} & T \\
 \downarrow & & \downarrow \text{End } P \\
 (S \otimes T)/I & \xlongequal{\quad} & (Z \otimes T)/J
 \end{array}$$

That diagram has been made with the following commands:

```

\newcommand{\End}{\operatorname{End}}
\begin{CD}
S^{\{\mathcal{W}\}_\Lambda} \otimes T @>j>> T \\
@VVV @VV{\text{End } P}V \\
(S \otimes T)/I @= (Z \otimes T)/J
\end{CD}

```

Here we include another graphic file to test spacing in the list of figures.



Figure 6.1. Another example of imported eps file.

### 6.2.2. Using AMS fonts

To use AMS fonts it is necessary to choose from an assortment of  $\text{\LaTeX}$  packages. For instance the command `\usepackage{amsmath}` calls in the *amsmath* package, which provides blackboard bold letters (e.g.  $\mathbb{R}$ ) and some math symbols.<sup>1</sup> A superset of that package is *amssymb*. Other packages are *eufrak* for Frankfurt letters (e.g.  $\mathfrak{R}$ ) and *euca1* for Euler script (e.g.  $\mathcal{R}$ ). Consult the  $\text{\LaTeX}$  documentation about this subject for additional information.

---

<sup>1</sup>The *amsbook* class, hence the *nuthesis* class, includes the *amsmath* package automatically

## References

- [1] M. J. Bertin et al. *Pisot and Salem Numbers*. user Verlag, Berlin, 1992.
- [2] Donald K. Knuth. *The T<sub>E</sub>Xbook*. Addison-Wesley, 1984.
- [3] Leslie Lamport. *ΛT<sub>E</sub>X: A document preparation system*. Addison-Wesley, 2nd edition, 1994.
- [4] F Mittelbach M Goosens and A Samarin. *The ΛT<sub>E</sub>XCompanion*. Addison-Wesley, 1994.
- [5] Michael Spivak. *The joy of T<sub>E</sub>X*. American Mathematical Society, Providence, R.I., 2nd edition, 1990.
- [6] Alf J. van der Poorten. Some problems of recurrent interest. Technical Report 81-0037, School of Mathematics and Physics, Macquarie University, North Ryde, Australia 2113, August 1981.

## APPENDIX A

**The source  $\LaTeX$  file for this document**

This is a first appendix.

## APPENDIX B

**The source  $\LaTeX$  file for this document**

Second appendix, with the full source of this file. Look near its end if you are curious about how a  $\LaTeX$  file can include its own source.

```

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% nuthesis-sample.tex, to be texed with latex.
%% MAL (6/16/1999)
%% updated MAL - 7/11/2016 (update margin requirements)
%% updated MAL - 4/18/2017 (make table of contents appear in left PDF sidebar)
%% updated MAL - 4/27/2017 (testing spacing in lists of figures and tables)
%% updated MAL - 4/23/2018 (fixing problem with \appendices)
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%
%% How to Write a Doctoral Dissertation with LaTeX
%%
%% (Find a ‘template’ in the file nuthesis-template.tex)
%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%\documentclass[12pt,reqno]{nuthesis}
\documentclass[12pt]{nuthesis}

\usepackage{amscd}          % For writing commutative diagrams.

\usepackage{eucal}         % Euler fonts.

\usepackage{verbatim}     % I need the verbatim package here.

\usepackage{graphicx}     % This is to include graphic files.

%\renewcommand\advspace[1]{}

\author{Miguel A. Lerma}

\title{How to Write a Doctoral Dissertation\\ with \LaTeX{}}

\degree{DOCTOR OF PHILOSOPHY}

\field{Mathematics}

\graduationmonth{June}

\graduationyear{2012}

```

```

%%%%%%%%%%%%%% Some optional commands to be tested %%%%%%%%%%%%%%%

%\degree{...}
%\graduationmonth{...}
%\graduationyear{...}

%%%%%%%%%%%%%% Some Math support %%%%%%%%%%%%%%%

%      Theorem environments (they need the amsthm package)

%% \theoremstyle{plain} %% This is the default
\newtheorem{thm}{Theorem}[chapter]
\newtheorem{cor}[thm]{Corollary}
\newtheorem{lem}[thm]{Lemma}
\newtheorem{prop}[thm]{Proposition}
\newtheorem{ax}{Axiom}

\theoremstyle{definition}
\newtheorem{defn}{Definition}[section]

\theoremstyle{remark}
\newtheorem{rem}{Remark}[section]
\newtheorem*{notation}{Notation}

%%%%%%%%%%%%%% Macros %%%%%%%%%%%%%%%

%      Here some macros that I need in this document

\newcommand{\latexe}{\LaTeX\kern.125em2%
               \lower.5ex\hbox{\$\varepsilon$}}

\newcommand{\amslatex}{\AmS-\LaTeX{}}

\chardef\bslchar='\ \ % p. 424, TeXbook

\newcommand{\cn}[1]{\texttt{\bslchar #1}}

\makeatletter

```

```
\def\square{\RIfM@\bgroup\else$\bgroup\aftergroup$\fi
  \vcenter{\hrule\hbox{\vrule\@height.6em\kern.6em\vrule}%
            \hrule}\egroup}
```

```
\makeatother
```

```
\makeindex      % Make the index
```

```
%%%%%%%%%% The document starts here %%%%%%%%%%
```

```
\begin{document}
```

```
%\frontmatter          % Preliminary pages start here.
```

```
\maketitle            % Produces the title page.
```

```
\copyrightpage        % Creates the copyright page.
```

```
\abstract
```

```
\index{Abstract}%
```

This document has the form of a ‘‘fake’’ doctoral dissertation in order to provide an example of such. Here we examine how to write a Doctoral Dissertation using `\LaTeX{}`, and in particular how to use the `nuthesis` document class.

```
\acknowledgements
```

```
\index{Acknowledgments@\emph{Acknowledgments}}%
```

Text for Acknowledgments (optional).

```
\preface              % Preface (optional).
```

This is the preface (optional).

```
\listofabbreviations
```

This is the list of abbreviations (optional).

`\glossary`

This is the glossary (optional).

`\nomenclature`

This is the nomenclature (optional).

`\dedication{This is the dedication (optional).}`

`%\setcounter{tocdepth}{3} % MAL - 3/26/2007`

`\clearpage\phantomsection`  
`\tableofcontents % Table of contents`

`\clearpage\phantomsection`  
`\listoftables % List of Tables`

`\clearpage\phantomsection`  
`\listoffigures % List of Figures`

`\clearpage\phantomsection`  
`\listofschemes % List of Schemes`

%%%

`%\mainmatter`

`% Actual text starts here %`

`\chapter{Introduction}`  
`\index{Introduction@\emph{Introduction}}%`

This document deals with how to write a doctoral dissertation using `\LaTeX{}`, and how to use the `\texttt{nuthesis}` document class. `\index{nuthesis class@{\texttt{nuthesis} class}}%`  
 For further information about using `\TeX{}` and `\LaTeX{}` see `\cite{knuth:tb,leslie:dps,gms:tlc}`.

Note that in spite of the effort to accommodate this work to the requirements of the University, it is not possible to guarantee that it will always work, and the author of the dissertation remains responsible for checking that such requirements are actually fulfilled by his/her final work.

In case of any problem with `\texttt{nuthesis}`, e-mail me to:  
`\begin{quotation}`  
`\texttt{malerma@math.northwestern.edu}`.  
`\end{quotation}`

`\part{General Instructions}`

`\chapter{Instructions for preparing doctoral dissertations}`  
`\index{Instructions for preparing doctoral dissertations%`  
`@\emph{Instructions for preparing doctoral dissertations}}%`

We are not going to look at the complete set of instructions, which can be obtained in the Office of Graduate Studies. `\index{Office of Graduate Studies}%`

Here we will look at a few instructions related to the arrangement of the dissertation and a few other ‘‘technical’’ details. The booklet of instructions I am using has date of September, 1993 (by now obsolete, but I am using this document only for testing purposes, and the accuracy of its content is not really essential at this point.)

Always remember that this ‘‘fake’’ dissertation `\index{fake dissertation}%`  
 is neither a dissertation, nor a set of instructions, but just some information to take better advantage of computers to write a dissertation. So, you should get the real booklet of instructions from the Office of Graduate Studies and check everything by

yourself.\footnote{This is a footnote to remind you that this ‘‘fake’’ dissertation is neither a dissertation, nor a set of instructions, but just some information to take better advantage of computers to write a dissertation. So, you should get the real booklet of instructions from the Office of Graduate Studies and check everything by yourself.}

The following are just a couple of tests for the ‘‘quote’’ and ‘‘quotation’’ environments:

```
\begin{quote}
\index{quote}%
This is a quote.
```

Always remember that this ‘‘fake’’ dissertation is neither a dissertation, nor a set of instructions, but just some information to take better advantage of computers to write a dissertation. So, you should get the real booklet of instructions from the Office of Graduate Studies and check everything by yourself.

```
\end{quote}
```

Next, a quotation:

```
\begin{quotation}
\index{quotation}%
This is a quotation.
```

Always remember that this ‘‘fake’’ dissertation is neither a dissertation, nor a set of instructions, but just some information to take better advantage of computers to write a dissertation. So, you should get the real booklet of instructions from the Office of Graduate Studies and check everything by yourself.

```
\end{quotation}
```

```
\section{Arrangement of dissertation}
\index{Arrangement of dissertation%
\emph{Arrangement of dissertation}}%
```

Arrange your dissertation as follows.

```

\begin{enumerate}

\item Title Page.
\index{Title Page}%
This page is counted, but there should not
be a page number on this page.
Begin counting pretext pages here.

\item Copyright Page.
\index{Copyright Legend}%
Begin showing pretext page numbers with lower case Roman numerals at
bottom of page.

\item Abstract.
\index{Abstract}%

\item Optional Prefatory Pages
\index{Prefatory Pages}%
(optional):
Acknowledgment page, preface, list of abbreviations, glossary,
nomenclature, and dedication.

\item Table of contents.
\index{Table of contents}%

\item List of Tables,
\index{List of Tables}%
Illustrations,
\index{List of Illustrations}%
Figures
\index{List of Figures}%
or Graphs
\index{List of Graphs}%
(optional).

\item Text body. \index{Text}%
The text may include an introduction. Tables, illustrations,
figures, and graphs may be included in the main body of the text, or
they should immediately follow the text. They should not be placed
at the end of chapters. Every page in a dissertation is numbered,
except the title page. Page numbering will begin on the second page

```

with Arabic numeral 2.

```
\item References.
\index{References}%
Consult your supervisor about the style.
```

```
\item Appendix or Appendices
\index{Appendix}%
\index{Appendices}%
(optional).
```

```
\item Vita (optional).
```

```
\end{enumerate}
```

```
\section{Other requirements}
\index{Other requirements%
@\emph{Other requirements}}%
```

```
\subsection{Margins}
\index{Margins@\emph{Margins}}%
There should be one inch margins on all sides, including page
numbers. Typing or print should be within these measurements.
```

Page numbers should conform to margin requirements and be placed at least 1~inch from the top and right sides of the page.

```
\subsection{Spacing and page arrangement}
\index{Spacing and page arrangement%
@\emph{Spacing and page arrangement}}
\index{Spacing}%
\index{page arrangement}%
```

The preliminary pages (abstract, dedication, acknowledgments, table of contents) and main body text must be double spaced.

Quotations, captions, items in tables, lists, graphs and charts may be single spaced.

Every page in a dissertation is numbered, except the title page.

Page numbering will begin on the second page with Arabic numeral 2.

There should be no blank pages.

On pages of the dissertation that are formatted with landscape orientation, the page number must appear in lower right - hand corner if the page, so that it would appear in the correct location if the page were rotated to portrait orientation.

```
\chapter{How to use the nuthesis document class}
\index{How to use the nuthesis document class%
@\emph{How to use the nuthesis document class}}%
```

The nuthesis class is a slightly modified amsbook class.

```
\section{Preamble}
\index{Preamble@\emph{Preamble}}%
```

The preamble of your document should start like this:

```
\begin{verbatim}
  \documentclass[12pt]{nuthesis}
\end{verbatim}
\index{commands!documentclass@\cn{documentclass}}%
\index{commands!usepackage@\cn{usepackage}}%
```

The first line declares ‘‘\texttt{nuthesis}’’ as document class,

```
\index{document class}%
```

with an option of 12pt for the character size, which is slightly greater than usual (the default is 10pt).

You may include other options, as in any other `\LaTeX{}` document.

You may include other packages, for instance:

```
\begin{verbatim}
  \usepackage{amscd}
\end{verbatim}
```

The default spacing for both texts and quoted texts is doublespaced. That can be changed with the following self-explanatory commands:

```
\begin{verbatim}
\onehalfspacing
\singlespacing
\onehalfspacequote
\singlespacequote
\end{verbatim}
\index{commands!onehalfspacing@\cn{onehalfspacing}}%
\index{commands!singlespacing@\cn{singlespacing}}%
\index{commands!onehalfspacequote@\cn{onehalfspacequote}}%
\index{commands!singlespacequote@\cn{singlespacequote}}%
```

Next commands, are required in the preamble. Replace the dots in the commands with the appropriate information:

```
\begin{verbatim}
\author{...}
    % Replace the dots in the command by your full name.
    % Make it combination of lower and uppercases
    % e.g., \author{Dorothy Kay Shoemaker}
\title{...}
    % Replace the dots in the above command
    % by your thesis title,
    % e.g., '\title{A Take of Gnus, Gnats and \\ Armadillos}'.
    % If the title consists of more than one line,
    % it should be in inverted pyramid form. You have to
    % specify the line breakings by \\ commands.
\end{verbatim}
\index{commands!author@\cn{author}}%
\index{commands!title@\cn{title}}%
```

Next commands are optional:

```
\begin{verbatim}
\degree{...}
```

```

% The degree sought as given in the Graduate Catalogue.
% Capital letters are recommended.
% e.g., '\degree{DOCTOR OF BUSINESS ADMINISTRATION}'
% The default value is 'DOCTOR OF PHILOSOPHY'
% for dissertation.
\graduationmonth{...}
% Graduation month, in the form as
% '\graduationmonth{May}'.
% The default value (either May, August, or December)
% is guessed according to the time of running LaTeX
% Do not abbreviate.
% Note: either May, August, or December
\graduationyear{...}
% Graduation year, in the form as '\graduationyear{1991}'.
% The default value is guessed according to the time of
% running LaTeX.
% 4 (not 2) digit number
\end{verbatim}
\index{commands!degree@\cn{degree}}%
\index{commands!graduationmonth@\cn{graduationmonth}}%
\index{commands!graduationyear@\cn{graduationyear}}%

```

```

\section{Document}
\index{Document@\emph{Document}}%

```

Next, the body of your thesis starts and some stuff is generated:

```

\begin{verbatim}
\begin{document}
\frontmatter           % Pretext settings.
\titlepage             % Produces the title page.
\copyrightpage         % Creates the copyright page.
\abstract
% Place your abstract here. The abstract heading will be
% generated automatically.
\acknowledgments
% Place the text of your acknowledgments here.
% Your name and graduation date will appear
% automatically.

```

```

    % If this is the preface instead of acknowledgments,
    % use \preface.
\tableofcontents    % Table of Contents will be automatically
                    % generated and placed here.
\listoftables      % List of Tables and List of
                    % Figures will be placed
\listoffigures     % here, if applicable.
\end{verbatim}
\index{commands!titlepage@\cn{titlepage}}%
\index{commands!copyrightpage@\cn{copyrightpage}}%
\index{commands!environments!acknowledgments}%
\index{commands!abstract@\cn{abstract}}%
\index{commands!tableofcontents@\cn{tableofcontents}}%
\index{commands!listoftables@\cn{listoftables}}%
\index{commands!listoffigures@\cn{listoffigures}}%

Next, the actual text comes. It could be a sequence of
chapters divided into sections, subsections, etc:
\begin{verbatim}
\mainmatter        % Main settings.
\chapter{...}      % The first chapter.
                    % \chapter command is of the form
                    % \chapter[...]{..} or \chapter{..} where
    ... text ...   % {chapter heading} and [entry in table of
                    % contents].
\section{...}      %
                    % IMPORTANT: If your chapter heading consists
                    % of more than one lines, it will be auto-
    ... text ...   % matically broken into separate lines.
                    % However, if you don't like the way LaTeX
                    % breaks the chapter heading into lines, use
\section{...}      % '\newheadline' command to break lines.

    ... text ...
\chapter{...}      % It is Chapter 2.
    ... text ...
\section{...}
    ... text...
\subsection{...}
    ... more text ...

```

```

\appendix           % Appendix begins here
% \appendices       % If more than one appendix chapters,
                    % use \appendices instead of \appendix
\chapter{...}       % First appendix chapter, i.e., Appendix A.
\section{...}       % This is appendix section A.1.
    .....
\end{verbatim}
\index{commands!chapter@\cn{chapter}}%
\index{commands!section@\cn{section}}%
\index{commands!subsection@\cn{subsection}}%
\index{commands!appendix@\cn{appendix}}%
\index{commands!appendices@\cn{appendices}}%

```

Also, the chapters can be written in different files, say `\texttt{chap1.tex}`, `\texttt{chap2.tex}`, `\texttt{chap3.tex}`, etc, and be loaded by `\cn{include}` commands:

```

\begin{verbatim}
\include{chap1}
\include{chap2}
\include{chap3}
    .....
\include{appen1}
\include{appen2}
    .....
\end{verbatim}
\index{commands!include@\cn{include}}%

```

Then the bibliography `\index{bibliography}%` comes. It can be made by hand like this:

```

\begin{verbatim}
\begin{thebibliography}{foo}
\bibitem ...
\end{thebibliography}
\end{verbatim}
\index{commands!environments!thebibliography}%

```

It can also be generated with `BiB\TeX{}`,

```
\index{BiBTeX@BiB\TeX{}}%
which is explained in chapter \ref{c:bib}.
```

```
\part{Further Instructions}
```

```
\chapter{Making the bibliography with BiB\TeX{}}\label{c:bib}
\index{Making the bibliography with BiBTeX%
@}\emph{Making the bibliography with BiB\TeX{}}%
```

```
BiB\TeX{}
\index{BiBTeX@BiB\TeX{}}%
allows one to generate automatically the bibliography
from a database of bibliographic
items. You need to do the following:
```

```
\begin{enumerate}
```

```
\item Create the bibliographic database,
```

```
\index{bibliographic database}%
```

```
which is a file
```

```
whose name ends in \texttt{.bib}.
```

```
\index{.bib@\texttt{.bib}}%
```

```
Let us call
```

```
it \texttt{diss.bib}. Entries in this file are like this:
```

```
\begin{verbatim}
```

```
@BOOK{knuth:tb,
```

```
  author = "Donald K. Knuth",
```

```
  title = "The \TeX book",
```

```
  publisher = "Addison-Wesley",
```

```
  year = "1984",
```

```
}
```

```
@TECHREPORT{poorten:sp,
```

```
  author = "Alf~J.~van der Poorten",
```

```
  title = "Some problems of recurrent interest",
```

```
  institution = "School of Mathematics and Physics,  
Macquarie University",
```

```
  address = "North Ryde, Australia 2113",
```

```
  number = "81-0037",
```

```

    month = "August",
    year = "1981",
}

```

```

@ARTICLE{erdos:oap,
  author = "Paul Erd{\o}s and Paul Turan",
  title = "On a problem in the theory of uniform
          distribution, {I}",
  journal = "Indag. Math.",
  volume = "10",
  year = "1948",
  pages = "370--378",
}

```

\end{verbatim}

\item Include a \cn{bibliographystyle}  
 \index{commands!bibliographystyle@\cn{bibliographystyle}}%  
 command in your \LaTeX{} file, say

```
\cn{bibliographystyle}\{plain\}}
```

and a \cn{bibliography}  
 \index{commands!bibliography@\cn{bibliography}}%  
 command to load the bibliography,  
 in this case \cn{bibliography}\{diss\}, at the point of your  
 document where the bibliography should be inserted.  
 The document at this point will look like this:

```

\begin{verbatim}
\bibliographystyle{plain}
\bibliography{diss}
\end{verbatim}

```

\item Run \LaTeX{} on your main file, say \texttt{foo.tex}:  
 \texttt{latex foo}. This generates an auxiliary file  
 \texttt{foo.aux} with a list of \cn{cite}  
 \index{commands!cite@\cn{cite}}  
 references.

\item Run BiB\TeX{} on your file: \texttt{bibtex foo}.  
 BiB\TeX{} reads the auxiliary file, looks up the

```

bibliographic database (\texttt{diss.bib}),
and writes a \texttt{.bbl}
\index{.bbl@\texttt{.bbl}}%
file with the bibliographic
information formatted according to the bibliographic style
file (\texttt{.bst}),
\index{.bst@\texttt{.bst}}%
say \texttt{plain.bst})
\index{.bst@\texttt{.bst}}%
specified.
Error messages are written to a \texttt{.blg}
\index{.blg@\texttt{.blg}}%
file.

```

```

\item Run \LaTeX{} again: \texttt{latex foo}, which now
reads the \texttt{.bbl}
\index{.bbl@\texttt{.bbl}}%
reference file.

```

```

\item Run \LaTeX{} for a third time: \texttt{latex foo},
resolving all references.

```

```

\end{enumerate}

```

This includes all bibliographic items that have been cited in the document with a `\cn{cite}` `\index{commands!cite@\cn{cite}}%` command. In order to include non cited items in the bibliography, use the command `\cn{nocite}`. For instance, `\cn{nocite}\{knuth:tb\}` anywhere in the document (after `\cn{begin}\{document\}`) would include in the bibliography the item with label `\texttt{knuth:tb}`. In order to include *all* items of the bibliographic database, use the command `\cn{nocite}\{*}`. `\index{commands!nocite@\cn{nocite}}%`

```

\chapter{Tables and Figures}
\index{Tables and Figures@\emph{Tables and Figures}}%

```

The `\emph{tabular}`

`\index{commands!environments!tabular}%`  
 environment allows us to create complex tables and figures, and draw boundaries around and within it. The following example illustrates this:

```
\begin{table}[h]
\begin{center}
\caption{An example of table.}
\vskip 10pt
\begin{tabular}{|l|l|l|l|} \cline{1-2} \cline{4-6}
\multicolumn{2}{|c|} {\textsl{presente}} & \hspace{7mm} &
\multicolumn{3}{|c|} {\textsl{pasado perfecto}} \\ \cline{1-2} \cline{4-6}
yo & soy & & yo & he & sido \\
t'u & eres & & t'u & has & sido \\
'el & es & & 'el & ha & sido \\
nosotros & somos & & nosotros & hemos & sido \\
vosotros & sois & & vosotros & hab'eis & sido \\
ellos & son & & ellos & han & sido \\ \cline{1-2} \cline{4-6}
\end{tabular}
\end{center}
\end{table}
\index{commands!environments!table}%
```

That table was created with the following sequence of commands:

```
\begin{verbatim}
\begin{table}[h]
\begin{center}
\caption{An example of table.}
\vskip 10pt
\begin{tabular}{|l|l|l|l|} \cline{1-2} \cline{4-6}
\multicolumn{2}{|c|} {\textsl{presente}} & \hspace{7mm} &
\multicolumn{3}{|c|} {\textsl{pasado perfecto}} \\ \cline{1-2} \cline{4-6}
yo & soy & & yo & he & sido \\
t'u & eres & & t'u & has & sido \\
'el & es & & 'el & ha & sido \\
nosotros & somos & & nosotros & hemos & sido \\
vosotros & sois & & vosotros & hab'eis & sido \\
\end{tabular}
\end{center}
\end{table}
\end{verbatim}
```

```
ellos & son & & ellos & han & sido \\
\cline{1-2} \cline{4-6}
\end{tabular}
\end{center}
\end{table}
\end{verbatim}
```

The argument `\texttt{h}` indicates the position for the table, in this case ‘‘here if possible’’.

Other values of this argument

are: `\texttt{t}` (top of the page), `\texttt{b}` (bottom of the page), `\texttt{p}` (page of floats) and `\texttt{H}` (here always). It is possible to combine several arguments, such as `\texttt{ht}` (‘‘here if possible, otherwise on top of the page’’).

Figure `\ref{f:ex}` is a typical example of inclusion of a figure contained in a file with encapsulated PostScript.

```
\index{PostScript}%
```

```
\index{encapsulated PostScript}%
```

In order to use it, it is necessary to include the command `\break`

```
\cn{usepackage\{psfig\}}
```

```
\index{psfig}%
```

at the beginning of the document.

```
\begin{figure}[htb]
```

```
\begin{center}
```

```
\ \includegraphics[height=1.5in,width=1.2in]{myfile}
```

```
\caption[An example of imported eps file.]{An example of imported eps
file with a long caption requiring two lines of text.}
```

```
\label{f:ex}
```

```
\end{center}
```

```
\end{figure}
```

```
\index{commands!environments!figure}%
```

It has been generated with the following commands:

```
\begin{verbatim}
```

```
\begin{center}
```

```
\ \includegraphics[height=1.5in,width=1.2in]{myfile}
```

```

\caption[An example of imported eps file.]{An example of imported eps
file with a long caption requiring two lines of text.}
\label{f:ex}
\end{center}
\end{figure}
\end{verbatim}

```

The command that imports the file is `\cn{psfig}`, and it also controls its size (`\texttt{height}` and `\texttt{width}`), and can rotate the figure (`\texttt{angle}`).

Figures can also be drawn by using `\LaTeX{}` commands. Figure `\ref{f:circuit}` is an example (taken from `\cite{gms:tlc}`).

```

\begin{figure}[htb]
\begin{center}
\setlength{\unitlength}{4mm}
\begin{picture}(12,10)(-2,0)
\linethickness{0.4pt}
\qbezier(2.00,6.00)(7.00,6.00)(9.00,3.00)
\qbezier(2.00,0.00)(7.00,0.00)(9.00,3.00)
\qbezier(2.00,6.00)(4.00,3.00)(2.00,0.00)
\qbezier(1.00,6.00)(3.00,3.00)(1.00,0.00)
\put(9.75,3.00){\circle{1.50}}
\put(10.50,3.00){\line(1,0){1.50}}
\put(0.00,5.00){\line(1,0){1.50}}
\put(0.00,1.00){\line(1,0){1.50}}
\end{picture}
\caption{An example of picture}
\label{f:circuit}
\end{center}
\end{figure}
\index{picture}%

```

It has been generated with the following set of commands:

```

\begin{verbatim}
\begin{figure}[htb]
\begin{center}
\setlength{\unitlength}{4mm}
\begin{picture}(12,10)(-2,0)

```

```

\linethickness{0.4pt}
\qbezier(2.00,6.00)(7.00,6.00)(9.00,3.00)
\qbezier(2.00,0.00)(7.00,0.00)(9.00,3.00)
\qbezier(2.00,6.00)(4.00,3.00)(2.00,0.00)
\qbezier(1.00,6.00)(3.00,3.00)(1.00,0.00)
\put(9.75,3.00){\circle{1.50}}
\put(10.50,3.00){\line(1,0){1.50}}
\put(0.00,5.00){\line(1,0){1.50}}
\put(0.00,1.00){\line(1,0){1.50}}
\end{picture}
\caption{An example of picture}
\label{f:cir}
\end{center}
\end{figure}
\end{verbatim}

```

Those commands have rather obvious meanings. In particular, the command `\cn{qbezier}`  
`\index{commands!qbezier@\cn{qbezier}}%`  
draws a quadratic Bezier curve, defined by its two ending points, and a third point (whose coordinates are in the middle) that is used as control point. Figure `\ref{f:qb}` illustrates the effect of the control point:

```

\begin{figure}[htb]
\begin{center}
\setlength{\unitlength}{.8mm}
\begin{picture}(55,55)(-15,0)
\linethickness{1pt}
\qbezier(0,0)(-10,30)(50,30)
\qbezier(0,0)(20,50)(50,30)
\thinlines
\put(0,0){\line(-1,3){10}}
\put(50,30){\line(-1,0){60}}
\put(0,0){\line(2,5){20}}
\put(50,30){\line(-3,2){30}}
\put(0,0){\circle*{1}}
\put(0,-1){\makebox(0,0)[t]{$A_{0,0}$}}
\put(-10,30){\circle*{1}}
\put(-10,31){\makebox(0,0)[b]{$B_{10,30}$}}
\put(50,30){\circle*{1}}

```

```

        \put(58,29){\makebox(0,0)[b]{$C_{50,30}$}}
        \put(20,50){\circle*{1}}
        \put(20,51){\makebox(0,0)[b]{$D_{20,50}$}}
    \end{picture}
\caption{Bezier curves}
\label{f:qb}
\end{center}
\end{figure}
\index{Bezier curves}%

```

That figure has been generated with the following commands:

```

\begin{verbatim}
\begin{figure}[htb]
\begin{center}
    \setlength{\unitlength}{.8mm}
    \begin{picture}(55,55)(-15,0)
        \linethickness{1pt}
        \q bezier(0,0)(-10,30)(50,30)
        \q bezier(0,0)(20,50)(50,30)
        \thinlines
        \put(0,0){\line(-1,3){10}}
        \put(50,30){\line(-1,0){60}}
        \put(0,0){\line(2,5){20}}
        \put(50,30){\line(-3,2){30}}
        \put(0,0){\circle*{1}}
        \put(0,-1){\makebox(0,0)[t]{$A_{0,0}$}}
        \put(-10,30){\circle*{1}}
        \put(-10,31){\makebox(0,0)[b]{$B_{10,30}$}}
        \put(50,30){\circle*{1}}
        \put(58,29){\makebox(0,0)[b]{$C_{50,30}$}}
        \put(20,50){\circle*{1}}
        \put(20,51){\makebox(0,0)[b]{$D_{20,50}$}}
    \end{picture}
\caption{Bezier curves}
\label{f:qb}
\end{center}
\end{figure}
\end{verbatim}

```

Next, a couple of examples of schemes:

Scheme `\ref{s:ex}` is a typical example of inclusion of a figure contained in a file with encapsulated PostScript.

```
\index{PostScript}%
```

```
\index{encapsulated PostScript}%
```

In order to use it, it is necessary to include the command `\break`

```
\cn{usepackage}{psfig\}
```

```
\index{psfig}%
```

at the beginning of the document.

```
\begin{scheme}[htb]
```

```
\begin{center}
```

```
\ \includegraphics[height=1.5in,width=1.2in]{myfile}
```

```
\caption[An example of imported eps file.]{An example of imported eps file with a long caption requiring two lines of text.}
```

```
\label{s:ex}
```

```
\end{center}
```

```
\end{scheme}
```

```
\index{commands!environments!scheme}%
```

Another scheme:

```
\begin{scheme}[htb]
```

```
\begin{center}
```

```
\setlength{\unitlength}{.8mm}
```

```
\begin{picture}(55,55)(-15,0)
```

```
\linethickness{1pt}
```

```
\qbezier(0,0)(-10,30)(50,30)
```

```
\qbezier(0,0)(20,50)(50,30)
```

```
\thinlines
```

```
\put(0,0){\line(-1,3){10}}
```

```
\put(50,30){\line(-1,0){60}}
```

```

\put(0,0){\line(2,5){20}}
\put(50,30){\line(-3,2){30}}
\put(0,0){\circle*{1}}
\put(0,-1){\makebox(0,0)[t]{$A_{0,0}$}}
\put(-10,30){\circle*{1}}
\put(-10,31){\makebox(0,0)[b]{$B_{10,30}$}}
\put(50,30){\circle*{1}}
\put(58,29){\makebox(0,0)[b]{$C_{50,30}$}}
\put(20,50){\circle*{1}}
\put(20,51){\makebox(0,0)[b]{$D_{20,50}$}}
\end{picture}
\caption{Bezier curves}
\label{s:qb}
\end{center}
\end{scheme}

```

```

\chapter{An example of Mathematical writing}
\index{An example of Mathematical writing%
@\emph{An example of Mathematical writing}}%

```

```

\section{Generalized Fatou's Lemma}
\index{Generalized Fatou's Lemma%
@\emph{Generalized Fatou's Lemma}}%

```

Here we show an application of the following lemma:

```

\begin{lem}[Generalized Fatou's Lemma] \label{1:fatou}

```

Let  $A$  be a Dedekind ring and  $F$  a rational series in  $A[[X]]$ , i.e.,  $F = p/q$  for some  $p, q \in A[X]$ . Then there exist two polynomials  $P, Q \in A[X]$  such that  $F = P/Q$ , where  $P$  and  $Q$  are relatively prime and  $Q(0) = 1$ .

`\end{lem}`

`\proof`

See `\cite{bertin:psn}`, p.~15, theorem~1.3.

`\endproof`

`\begin{thm} \label{1:req}`

Let  $\{c_n\}_{n=-\infty}^{\infty}$  a set of elements from  $K$  such that  $c_n \in k'$  for every  $n \geq n_0$ , and verifying the following recurrence relation of order  $M$ :

`\begin{equation}`

$c_n = r_1 c_{n-1} + r_2 c_{n-2} + \dots + r_M c_{n-M}$

`\end{equation}`

for every  $n \in \mathbb{Z}$ , where  $r_1, r_2, \dots, r_M$  are in  $K$ ,  $r_M \neq 0$ .

Then:

`\item{(i)}` The coefficients  $r_1, r_2, \dots, r_M$  are in  $k'$ , and for every  $n \in \mathbb{Z}$ ,  $c_n \in k'$ .

`\item{(ii)}` If  $c_n \in \mathcal{O}_{k',v}$  for every  $n \geq n_0$ , then the coefficients  $r_1, r_2, \dots, r_M$  are all in  $\mathcal{O}_{k',v}$ .

`\end{thm}`

`\proof`

`\item{(i)}` Let  $C_n$  and  $R$  be the matrices:

`\begin{equation}`

$C_n =$

`\ \left(`

`\begin{array}{lllll}`

$c_n & c_{n+1} & \dots & c_{n+M-1} & \backslash \backslash$

$c_{n+1} & c_{n+2} & \dots & c_{n+M} & \backslash \backslash$

$\vdots & \vdots & \ddots & \vdots & \backslash \backslash$

$$\begin{array}{ccccccc}
 & & c_{n+M-1} & & c_{n+M} & & \dots & & c_{n+2M-2} \\
 \end{array}$$

$$R = \begin{pmatrix} 0 & 1 & 0 & \dots & 0 \\ 0 & 0 & 1 & \dots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \dots & 1 \\ r_M & r_{M-1} & r_{M-2} & \dots & r_1 \end{pmatrix}$$

We have that  $C_{n+1} = R \cdot C_n$ . Since the recurrence relation is of order  $M$ ,  $C_n$  is non singular. On the other hand,  $R = C_{n+1} \cdot C_n^{-1}$ . Since the elements of  $C_n$  are in  $k'$  for  $n \geq n_0$ , the entries of  $R$ , and those of  $R^{-1}$ , will be in  $k'$ . Since  $C_{n-1} = R^{-1} \cdot C_n$ , we get that the entries of  $C_n$  will be in  $k'$  also for  $n < n_0$ .

(ii) For each  $t \geq n_0$  define the formal power series

$$F_t(X) = \sum_{n=0}^{\infty} c_{t+n} X^n$$

which is in  $\mathcal{O}_{k',v}[[X]]$ .

We have  $F_t(X) = p_t(X)/q(X)$ ,

where  $p_t(X), q(X) \in k'[X]$  are the following:

$$p_t(X) = \sum_{j=0}^{M-1} \text{Bigl}( c_{t+j} - \sum_{i=1}^j r_i \cdot c_{t+j-i} \text{Bigr) } X^j$$

$$q(X) = 1 - r_1 X - r_2 X^2 - \dots - r_M X^M$$

`\end{equation}`

This can be checked by multiplying  $F_t(X)$  by  $q_t(X)$  and using the recurrence relation, which gives  $F_t(X)q_t(X) = p_t(X)$  (see `\cite{poorten:sp}`).

Now we will prove that  $p_t(X)$  and  $q(X)$  are relatively prime. To do so, we will see that they cannot have any common root (in  $\overline{k}$ ). In fact, assume that  $\alpha$  is a common root of  $p_{t_0}(X)$  and  $q(X)$  for some  $t_0 \geq n_0$ , i.e.:

$$p_{t_0}(\alpha) = q(\alpha) = 0.$$

Since  $q(0)=1$ , then  $\alpha \neq 0$ . Now we have:

`\begin{equation}`

$$X F_{t_0+1}(X) = F_{t_0}(X) - c_{t_0}$$

`\end{equation}`

so:

`\begin{multline}`

$$\begin{aligned} X p_{t_0+1}(X) &= X q(X) F_{t_0+1}(X) \\ &= q(X) (F_{t_0}(X) - c_{t_0}) = p_{t_0}(X) - c_{t_0} q(X) \end{aligned}$$

`\end{multline}`

Hence  $p_{t_0+1}(\alpha) = 0$ , which means that  $\alpha$  is also a root of  $p_{t_0+1}(X)$ . By induction we get that  $p_t(\alpha) = 0$  for every  $t \geq t_0$ . Grouping the terms of  $p_t(X)$  with respect to  $c_t, c_{t+1}, \dots, c_{t+M-1}$ , we get:

`\begin{equation}`

$$p_t(X) = \sum_{j=0}^{M-1} a_j(X) c_{t+j}$$

`\end{equation}`

where

`\begin{equation}`

$$a_j(X) = X^j \operatorname{Bigl}( 1 - \sum_{i=1}^{M-j-1} r_i X^i \operatorname{Bigr}$$

`\end{equation}`

Note that  $a_0(X), a_1(X), \dots, a_{M-1}(X)$  do not depend on  $t$ .

On the other hand  $p_t(\alpha)=0$  implies

`\begin{equation}`

`\label{e:coldep}`

$$\sum_{j=0}^{M-1} a_j(\alpha) c_{t+j} = 0$$

`\end{equation}`

for every  $t \geq t_0$ . Note that  $a_{M-1}(\alpha) = \alpha^{M-1}$

$\neq 0$ , so  $a_0(\alpha), a_1(\alpha), \dots, a_{M-1}(\alpha)$

are not all zero, and `(\ref{e:coldep})` means that the columns

of the matrix  $C_{\{t_0\}}$  are linearly dependent, so  $\det C_{\{t_0\}}=0$ , which contradicts the fact that  $C_{\{t_0\}}$  is non singular. Hence, the hypothesis that  $p_t(X)$  and  $q(X)$  have a common root has to be false. This proves that  $p_t(X)$  and  $q(X)$  are relatively prime.

By (generalized Fatou's) lemma<sup>~\ref{1:fatou}</sup>, and taking into account that  $\mathcal{O}_{\{k',v\}}$  is a Dedekind ring, we get that there exist two relatively prime polynomials  $P_t(X)$  and  $Q_t(X)$  in  $\mathcal{O}_{\{k',v\}}[X]$  such that  $F_t(X) = P_t(X)/Q_t(X)$  and  $Q_t(0)=1$ . Hence:  $p_t(X)\backslash, Q_t(X) = q(X)\backslash, P_t(X)$ . By unique factorization of polynomials in  $k'[X]$ , there is a  $u \in k'$  such that  $P_t(X) = u\backslash, p_t(X)$  and  $Q_t(X) = u\backslash, q_t(X)$ . Since  $Q_t(0)=q(0)=1$ , we get that  $u=1$ , so  $P_t(X) = p_t(X)$  and  $Q_t(X) = q(X)$ . Hence, the coefficients of  $q(X)$  are in  $\mathcal{O}_{\{k',v\}}$ .

\endproof

\section{Other examples of Mathematical writing}

\subsection{An example of commutative diagram}

\index{An example of commutative diagram%

@{An example of commutative diagram}}%

The following is an example of commutative diagram.

\index{commutative diagram}%

It requires the \texttt{amscd} package.

\index{amscd package@{\texttt{amscd} package}}

\begin{equation\*}

\newcommand{\End}{\operatorname{End}}

\begin{CD}

$S^{\{\mathcal{W}\}}_{\Lambda} \otimes T \quad @>j>> \quad T \backslash$

$@VVV \quad \quad \quad @VV{\text{End } P}V \backslash$

$(S \otimes T)/I \quad \quad \quad @= \quad \quad \quad (Z \otimes T)/J$

```
\end{CD}
\end{equation*}
```

That diagram has been made with the following commands:

```
\begin{verbatim}
\newcommand{\End}{\operatorname{End}}
\begin{CD}
S^{\{\mathcal{W}\}}_{\Lambda} \otimes T @>j>> T \backslash
@VVV @VV{\End P}V \backslash
(S \otimes T) / I @= (Z \otimes T) / J
\end{CD}
\end{verbatim}
```

Here we include another graphic file to test spacing in the list of figures.

```
\begin{figure}[htb]
\begin{center}
\includegraphics[height=1.5in,width=1.2in]{myfile}
\caption[Another example of imported eps file.]{Another example of
imported eps file.}
\label{f:ex2}
\end{center}
\end{figure}
```

```
\subsection{Using AMS fonts}
\index{Using AMS fonts@{Using AMS fonts}}
```

To use AMS fonts it is necessary to choose from an assortment of  $\LaTeX$  packages. For instance the command `\cn{usepackage\{amsfonts\}}` calls in the `\emph{amsfonts}` package, which provides blackboard bold letters (e.g.  $\mathbb{R}$ ) and some math symbols. `\footnote{The \emph{amsbook} class, hence the \emph{nuthesis} class, includes the \emph{amsfonts} package automatically}`

A superset of that package is `\emph{amssymb}`. Other packages are `\emph{eufrak}` for Frankfurt letters (e.g.  $\mathfrak{R}$ ) and `\emph{eucal}` for Euler script (e.g.  $\mathcal{R}$ ). Consult the  $\LaTeX$  documentation about this subject for additional information.

```

\begin{singlespace}
%\bibsep 12pt
\bibliographystyle{plain} % Here the bibliography
%\bibliographystyle{elsart-num} % Here the bibliography
\clearpage\phantomsection
\bibliography{diss} % is inserted.
\index{Bibliography@\emph{Bibliography}}%

```

```

\nocite{*} % This command causes all items in the
           % bibliographic database to be added to
           % the bibliography, even if they are not
           % explicitly cited in the text.
\end{singlespace}

```

% Appendix or Appendices

```
\appendix
```

```

\chapter{The source \LaTeX{} file for this document}
\index{Appendix@\emph{Appendix A}}%

```

This is a first appendix.

```

\chapter{The source \LaTeX{} file for this document}
\index{Appendix@\emph{Appendix B}}%

```

Second appendix, with the full source of this file. Look near its end if you are curious about how a \LaTeX{} file can include its own source.

```
\clearpage
```

```
\begin{singlespace}
```

```

\verbatiminput{\jobname} % Command to include the source
                          % of this document.

```

```
\end{singlespace}
```

```
\begin{vita}                                % Vita (optional).

\begin{doublespace}

Miguel A. Lerma
\index{Miguel A. Lerma}%
was born in [\dots]

\end{doublespace}

\end{vita}

% Index
\clearpage%
\let\chaptername\relax% to avoid the word "appendix" appearing in the TOC
\phantomsection%
\begin{singlespace}

\index{Index@\emph{Index}}%
\printindex%    % Include the index here.

\end{singlespace}

\end{document}
```

## Vita

Miguel A. Lerma was born in [...]

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