A TEMPLATE USING LATEX FOR DISSERTATIONS

IN MATHEMATICS VERSION 10/28/2005

A DISSERTATION IN
Mathematics
and
"Co-Discipline"

Presented to the Faculty of the University
of Missouri-Kansas City in partial fulfillment of
the requirements for the degree

DOCTOR OF PHILOSOPHY

by
LARRY QUIN EIFLER

B.S., University of Missouri-Kansas City, 1964
M.S., Purdue University, 1966

Kansas City, Missouri
2005

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Larry Quin Eifler, Candidate for the Doctor of Philosophy Degree

University of Missouri-Kansas City, 2005

ABSTRACT

The user of this template must understand that it is the responsibility of the student to meet the formatting requirements set down in the "University of Missouri-Kansas City Guide to Formatting Theses and Dissertations." Following this template does not guarantee acceptance by the School of Graduate Studies.

When preparing the abstract, follow carefully the directions in the "Guide to Formatting Graduate Theses and Dissertations." In addition, use the form illustrated in this sample. The type of information shown at the top of the page and at the end of the abstract is included in all abstracts. The spacing and capitalization must be observed.

Center horizontally the information at the top: (1) the title; (2) the author's name and the degree to be received; (3) University of Missouri-Kansas City, year; and (4) ABSTRACT. Begin typing the title on the 12th line. The title, in all capitals, is set in two lines (or more) if it is longer than 48 spaces; use inverted pyramid style and double-space. Triple-space between the title and the author's name. Initial letters only are capitalized in typing the author's name and the degree. Double-space

before adding the "University of Missouri-Kansas City." Triple-space before and after "ABSTRACT."

Triple-space following the text of the abstract. Then add the sentence exactly as show below, except, of course, change, the 000 to the approximate number of words in the abstract. The final information is the name and signature of the professor in charge of the thesis (dissertation). Type the name of the professor below the signature line.

This abstract of 000 words is approved as to form and content.

_____

Your Major Professor, Ph.D.
Professor
Department of Mathematics and Statistics

The undersigned, appointed by the Dean of the School of Graduate Studies, have examined a dissertation titled "Your Exact Thesis Title Goes Here," presented by Your Full Name, candidate for the Doctor of Philosophy degree, and hereby certify that in their opinion it is worthy of acceptance.

First Professor, Ph.D. Department of Mathematics and Statistics	Date
Second Professor, Ph.D. Department of Mathematics and Statistics	Date
Third Professor, Ph.D. Department of Mathematics and Statistics	Date
Fourth Professor, Ph.D. Another Department or Unit	Date
Fifth Professor, Ph.D. Another Department or Unit	Date

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ACKNOWLEDGMENTS

This thesis template was typeset using LATEX. The 12-point book style was used as a basis for the style file used to produce this template. I would like to thank Elizabeth Smock for her help in checking the format of an earlier version. If you are using the style file provided with this template and you have any questions or problems, then feel free to contact Larry Eifler in the Department of Mathematics and Statistics.

DEDICATION

To my parents with love and appreciation

Though nothing can bring back the hour
Of splendour in the grass,
of glory in the flower;
We will grieve not, rather find
Strength in what remains behind;

William Wordsworth

CHAPTER 1

A BRIEF DESCRIPTION OF TEX

The TEX[1] formatting program is the creation of Donald Knuth of Stanford University and has been implemented on a wide variety of computers. From an input source file, TEX produces as output a device independent file (DVI file). Given a DVI file, appropriate printer drivers produce, within the inherent capabilities of the print devices, exactly the same printed output.

In producing this template, single line spacing was interpreted as a rigid length of 12 points between baselines. Double line spacing was interpreted as a rigid length of 24 points between baselines and similarly for a triple line space. You should expect that a special formatting problem will have to be handled as a one-off item and that some vertical spacing problems may require special handling. Final adjustments in vertical spacing and in handling widow and orphan lines should done at the very end of your manuscript preparation.

A Programmable Formatting System

TEX is a programmable formatting system for typesetting. LATEX is a macro extension of the underlying TEX system. TEX especially facilitates the typesetting of mathematical formulas. A document's format is controlled by generic commands

[1]TEX is a trademark of the American Mathematical Society. TEX is pronounced "tech" while Leslie Lamport suggests that the pronounciation of LATEX will be determined by usage, not fiat. I use "lay-tecks" which is one of many reasonable choices.

embedded in its text. This gives a uniform treatment to the formatting of the text to be typeset as opposed to a strictly WYSIWYG system in which essentially identical text might be formatted differently. The primary reference for LATEX is Lamport [4]. Also, Diller [2] and Hahn [3] are excellent introductions to LATEX.

The text to be typeset using TEX consists of ordinary text and control sequences to control the formatting of a document. These control sequences are usually words or groups of letters prefaced with the backslash character (\). For example, the control sequence "\chapter" instructs TEX to start a new chapter, print the title, and make an entry in the table of contents. For non-technical typesetting, TEX simply builds paragraphs from text in the input files. Only a very few control sequences are needed for non-technical typing. New paragraphs are indicated by a blank line in the input file. Line adjustment and hyphenation are performed automatically.

Names and Words with Accents

Here is a small catalog of names and words with accent marks: Pál Erdős, naïve, pǔtōnghuà, sì ge nǚ xuésheng, Sergeĭ I͡ur'ev, Guillaume François Antoine l'Hôpital, Möbius strip, Rouché's theorem, Española, Gabor Szegö, Ernesto Cesáro, Kurt Gödel, Øystein Ore, Radon-Nikodým, Carathéodory, Stone-Čech, George Pólya, Muhammad ibn Mûsâ al-Khwârizmî and Jan Łukasiewicz.

Symbolic Referencing

Symbolic referencing of figures, tables, equations and bibliographic references use the "\cite", "\ref", "\pageref", "\label" and "\bibitem" commands. This capability is useful in referring to tables, figures, equations, thgeorems, lemmas, corollaries

and entries in the bibliography. This facility is especially usefule for equations and citations.

Bibliography Format

A sample bibliography using the AMS-Plain style is given in the pamphlet "Guidelines for preparing electronic manuscripts — AMS-LATEX" which is available from the American Mathematical Society [1, pp. 24–25]. This sample may be donwloaded from the website for the AMS.

Warnings and Omissions

Do not footnote chapter or section headings, captions, labels, etc. Multiline headings for chapters and sections are not handled. Also, multiline captions for figures and tables should be avoided.

In producing this template, single line spacing was interpreted as a rigid length of 12 points between baselines. Double line spacing was interpreted as a rigid length of 24 points between baselines and similarly for a triple line space. You should expect that a special formatting problem will have to be handled as a one-off item and that some vertical spacing problems may require special handling. Final adjustments in vertical spacing and in handling widow and orphan lines should done at the very end of your manuscript preparation. Remember to check the log file produced by LATEX. If there is a margin violation, then log file will have a warning even if the violation is a fraction of a point.

CHAPTER 2

MATHEMATICAL TYPESETTING

One of the most powerful features of TEX is ability to create mathematical formulas and display them properly. LATEX will automatically number your equations and you may refer to them by means of symbolic reference.

Mathematical Formulas

Assume that

$$F(t) = \sum_{n=0}^{\infty} f_n(t) \quad \text{for} \quad 0 \le t \le x. \tag{2.1}$$

Using equation 2.1, we find that

$$\begin{aligned} \int_0^x F(t)\,dt &= \int_0^x \sum_{n=0}^{\infty} f_n(t)\,dt \\ &= \sum_{n=0}^{\infty} \int_0^x f_n(t)\,dt. \end{aligned} \tag{2.2}$$

We can also display an equation array without numbers.

$$\begin{aligned} \int_0^x F(t)\,dt &= \int_0^x \sum_{n=0}^{\infty} f_n(t)\,dt \\ &= \sum_{n=0}^{\infty} \int_0^x f_n(t)\,dt. \end{aligned}$$

We next demonstrate the creation of some formulas. At the same time, this tests the "\subsection" macro.

The Bernoulli Polynomials

The Bernoulli polynomials may be defined by means of a generating function. Namely, define $B_n(x)$ for $n = 0, 1, \ldots$ by

$$\frac{te^{xt}}{e^t - 1} = \sum_{n=0}^{\infty} B_n(x)\frac{t^n}{n!}. \tag{2.3}$$

Note that $B_0(x) = 1$. One can show that

$$\int_0^1 B_n(x)\,dx = 0 \quad \text{for} \quad n = 1, 2, \ldots \tag{2.4}$$

and

$$B_n'(x) = nB_{n-1}(x) \quad \text{for} \quad n = 1, 2, \ldots. \tag{2.5}$$

One can show that $B_{2n+1}(0) = 0$ for $n = 1, 2, 3, \ldots$.

The Gamma Function

The gamma function may be defined by a limit. Namely, define $\Gamma(x)$ by

$$\Gamma(x) = \lim_{n\to\infty} \frac{n!n^x}{x(x+1)\cdots(x+n)} \quad \text{for} \quad x > 0. \tag{2.6}$$

One can show that

$$\Gamma(x+1) = x\Gamma(x) \quad \text{for} \quad x > 0 \tag{2.7}$$

and

$$\Gamma(x)\Gamma(x+\tfrac{1}{2}) = \Gamma(\tfrac{1}{2})\Gamma(2x)2^{1-2x}. \tag{2.8}$$

Matrices

Consider the $m \times n$ matrix defined below. It is well-known that the row space of A and the column space of A have the same dimension.

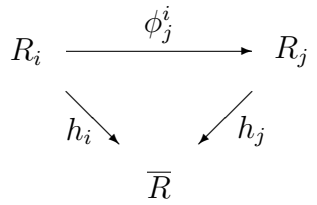
$$A = \begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{pmatrix} \tag{2.9}$$

Commutative Diagrams

If your dissertation is in pure mathematics, you may well wonder why graphics and pictures are of concern to you. Diagrams involving mappings can be made using arrays or using the picture facility of LATEX.

$$\begin{array}{ccc} A & \xrightarrow{\phi} & B \\ \downarrow{\scriptstyle \pi_A} & & \downarrow{\scriptstyle \pi_B} \\ \overline{A} & \xrightarrow{\overline{\phi}} & \overline{B} \end{array} \tag{2.10}$$

Even quite complicated diagrams are possible using the picture facility. After one has coded some simple examples of diagrams, the simple examples can be used as templates for ever more complex diagrams. When coding a new diagram pattern, first draw the diagram on graph paper. Then label the various parts with coordinates. I prefer to work with units measured in points so that fine adjustments do not lead to fractional units.



(2.11)

Theorem-like Structures and Lists

Theorem-like structures such as definitions, lemmas, propositions, corollaries, conjectures, axioms, postulates and schemata are used in mathematical text. Some examples of theorem-like structures are given below.

DEFINITION 2.1. Let P be a set and let σ be a function of P into P. We say that (P, σ, x_0) is a Peano system provided that

(P1) $x_0 \in X$ and $x_0 \neq \sigma(x)$ for each $x \in X$,

(P2) $\sigma(x) = \sigma(y) \Rightarrow x = y$ for each $x, y \in P$ and

(P3) $x_0 \in Q$ and $\sigma(Q) \subseteq Q$ implies $Q = P$ for each subset Q of P.

DEFINITION 2.2. Let $a, b \in \mathbb{N}$. We write $a \mid b$ if there exists $c \in \mathbb{N}$ such that $b = ac$.

LEMMA 2.3. Let $a, b, c \in \mathbb{N}$. If $a \mid b$ and $a \mid c$, then $a \mid b + c$.

PROOF. Choose $m, n \in \mathbb{N}$ such that $b = ma$ and $c = na$. Then

$$b + c = ma + na = (m + n)a.$$

Hence, $a \mid b + c$. □

THEOREM 2.4. Let $x > 0$. Then $\Gamma(x+1) = x\Gamma(x)$.

PROOF. Let $x > 0$. Using 2.6, we have

$$\begin{aligned}
\Gamma(x+1) &= \lim_{n\to\infty} \frac{n!n^{x+1}}{(x+1)(x+2)\cdots(x+1+n)} \\
&= \lim_{n\to\infty} \frac{n!n^{x}}{x(x+1)\cdots(x+n)} \frac{nx}{x+1+n} \\
&= x\Gamma(x).
\end{aligned}$$

□

CHAPTER 3

TABLES AND FIGURES

The placement of tables and figures presents special problems since a table or figure should be placed near the point where it is referenced. In LATEX, tables and figures are examples of floating bodies. There placement is controlled by LATEX using a variety of commands and style paramenters. The subtle interplay of the style parameters lead many to the belief that LATEX puts tables and figures wherever it pleases. Note the use of "\protect" in the source code for the caption of Figure1.

Formatting of Tables

The value of special mathematical constants has always been important and fascinating to mathematicians. Table 1 presents the decimal values of some square roots.

Table 1. Decimal values for $\sqrt{n}$

n	$\sqrt{n}$
2	1.4142 13562 37309 50488
3	1.7320 50807 56887 72935

Table 2 presents the decimal values of π, e and $\ln 2$. One can adjust the spacing of the rows and columns to improve readability. There should be consistent

formatting throughout the dissertation.

Table 2. Mathematical constants

π	3.1415 92653 58979 32384 62643
e	2.7182 81828 45904 52353 60287
$\ln 2$	0.6931 47180 55994 53094 17232

The placement of tables and figures presents special problems since a table or figure should be placed near the point where it is referenced. In LATEX, tables and figures are examples of floating bodies. The placement of floating bodies is difficult to control at times.

Diagrams, Graphs and the Picture Environment

Most implementations of LATEX have facilities for including encapsulated PostScript code or files as figures. I wrote the PostScript code to produce Figure 1 for Noah Rhee. Graphics can be printed by converting the dvi output from LATEX to a PostScript file. If you use a software package to produce your graphics, be sure to save the output as an encapsulated PostScript file so that a bounding box will be computed. Often the font used by a graphics package will not precisely match the main font used in the dissertation. If the graphic is scaled, then the text part of the graphic may be too small.

LATEX has a picture facility which can be used to produce simple diagrams. Several informative examples are given in Diller's book [2, pp. 149–164]. A simple

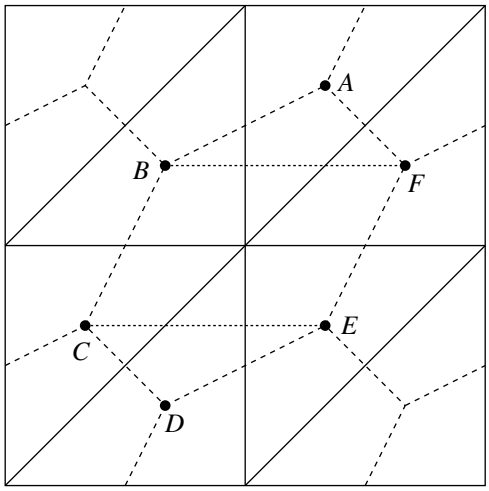


Figure 1. Interior case for hexagonal overlay

one-dimensional spring mass system with damping is depicted in Figure 2. I initially wrote the code for the spring mass system for my Math 345 class.

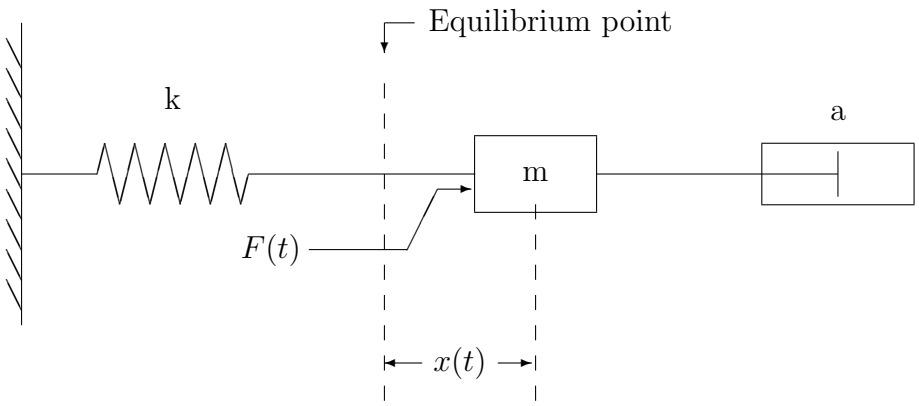


Figure 2. Spring mass system

APPENDIX A

A USER'S GUIDE FOR THE TEMPLATE

For the most part, the user should be able to modify the sources files which come with this template so as to obtain a properly formatted dissertation. Figure 3 gives a listing of the main control file `Main-LQE.tex`.

```
\documentclass{kcmath2e}

\usepackage{graphics}
\input{Defns-LQE}          % Required
\input{Format-LQE}         % Required

\begin{document}

\include{TitlePage-LQE}
\include{Abstract-LQE}
\include{Acceptance-LQE}
\include{Contents-LQE}
\include{Acknow-LQE}
\include{Dedication-LQE}   % optional
\include{EndFront-LQE}
\include{Chap1-LQE}
\include{Chap2-LQE}
\include{Chap3-LQE}
\include{Appendix-A-LQE}
\include{Appendix-B-LQE}
\include{Biblio-LQE}
\include{Vita-LQE}

\end{document}
```

Figure 3. Main control file for template

A brief description of each of the source files as well as the style file used to produce this template is presented below.

1. **Main-LQE.tex -** This file selects the document style and inputs a sequence of files which generate the template. It contains no text of its own.
2. **Kcmath2e.cls -** The 12-point book style was used as a basis for this style file. The `\chapter` and `\section` macros are defined so as to satisfy the format for dissertations at UMKC. Several other details concerned with the format requirements specifed in the "Guide" are handled by this style file.
3. **Format-LQE.tex -** The margins, spacing and various parameters are defined in this file. One may select the depth of the listing for the table of contents. One may select if a list of figures or a list of tables is to be printed.
4. **Defns-LQE.tex -** The theorem-like environments are defined here. Also, macros for starting and ending a proof are defined. The blackboard font is defined in this part.
5. **TitlePage-LQE.tex -** This generates the title page. The optional copyright page is also generated.
6. **Abstract-LQE.tex -** This generates the abstract.
7. **Acceptance-LQE.tex -** This generates the acceptance page.
8. **Contents.tex -** This file gives commands for generating the table of contents. If appropriate, a list of figures and/or a list of tables is generated.
9. **Acknow-LQE.tex -** This generates an acknowledgment page.
10. **Dedication-LQE.tex -** This generates a dedication page. This page is not numbered and is not counted.

11. **EndFront.tex** - This file generates headings within the table of contents, list of figures and list of tables. Also, the numbering of the pages is reset to 1 and set to arabic style.
12. **Chap1-LQE.tex** - This contains Chapter 1 of the template.
13. **Chap2-LQE.tex** - This contains Chapter 2 of the template. The `\input` command can be used to input sections or portions of a chapter. Be careful to distinguish between the commands `\input` and `\include`.
14. **Spring-Mass.tex** - This contains the picture of a spring mass system.
15. **Commut-Diagram.tex** - This contains two commutative diagrams and a short discussion of how they were created.
16. **Appendix-A-LQE.tex** - This contains Appendix A. You are reading it now!
17. **Appendix-B-LQE.tex** - This contains Appendix B.
18. **Biblio-LQE.tex** - This file contains the bibliography for the template.
19. **SampleBiblio.tex** - This document illustrates the AMS-Plain style for a bibliography.
20. **Vita-LQE.tex** - This file contains the vita page.
21. **NRheeHex2b.eps** - This is an EPS file.
22. **YinYang.eps** - This is an EPS file.

APPENDIX B

EXAMPLES OF POSTSCRIPT CODING

The PostScript code for a modified yīnyáng or tàijítú drawing is presented in Figure 4. This code produced the drawing in Figure 5.

```
%!PS-Adobe-3.0 EPSF-3.0
%%BoundingBox: 149 249 471 571
%%Title:
%%Creator: Larry Eifler
%%CreationDate:(1/5/94)
%%EndComments

%   -- Procedures --
/Lines{
40 20 120 { 20 moveto 0 120 rlineto } for
30 20 130 { 20 exch moveto 120 0 rlineto } for
}def
%   -- Main Program --
150 250 translate      2 2 scale
1 setlinewidth  0.5 setgray
0 0 moveto
160 0  lineto 160 160 lineto 0 160 lineto
closepath fill
0 setgray  80 80 60 0 360 arc clip fill
1 setgray Lines stroke
80 50 10 0 360 arc fill
80 110  30  90 270 arc
80  50  30  90 270 arcn
80  80  60 270  90 arc clip fill
0 setgray Lines stroke
80 110 10 0 360 arc fill
showpage
%%EOF
```

Figure 4. PostScript code for a yin/yang drawing

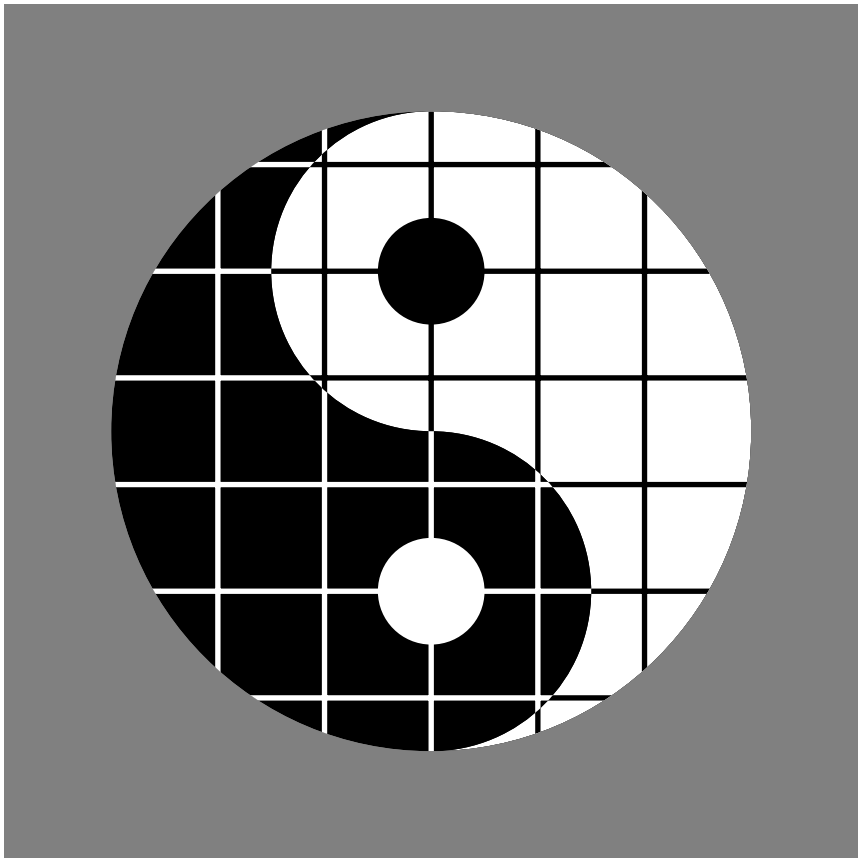


Figure 5. A whimsical yin/yang

REFERENCES

1. *Guidelines for preparing electronic manuscripts — AMS-LATEX*, Amer. Math. Soc., Providence, R. I., 1991.
2. A. Diller, *LATEX line by line*, Wiley, New York, 1993.
3. J. Hahn, *LATEX for everyone*, 2nd ed., Personal TEX, Mill Valley, CA, 1991.
4. L. Lamport, *LATEX: A document preparation system*, 2nd ed., Addison-Wesley, New York, 1994.

VITA

Larry Quin Eifler was born on March 13, 1943, in Independence, Kansas. In 1960 he graduated from Paseo High School in Kansas City, Missouri. He received a B.S. degree from the University of Missouri-Kansas City in 1964.