# More Math Into LATEX 4th Edition

George Grätzer

# More Math Into LATEX

4th Edition

Foreword by
Rainer Schöpf
LATEX3 team



George Grätzer
Department of Mathematics
University of Manitoba
Winnipeg, MB R3T 2N2
Canada
gratzer@mas.umanitoba.ca

Cover design by Mary Burgess. Typeset by the author in LATEX.

Library of Congress Control Number: 2007923503

ISBN-13: 978-0-387-32289-6 e-ISBN-13: 978-0-387-68852-7

Printed on acid-free paper.

©2007 Springer Science+Business Media, LLC

All rights reserved. This work may not be translated or copied in whole or in part without the written permission of the publisher (Springer Science+Business Media LLC, 233 Spring Street, New York, NY 10013, USA) and the author, except for brief excerpts in connection with reviews or scholarly analysis. Use in connection with any form of information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed is forbidden.

The use in this publication of trade names, trademarks, service marks and similar terms, even if they are not identified as such, is not to be taken as an expression of opinion as to whether or not they are subject to proprietary rights.

987654321

springer.com (HP)

#### To the **Volunteers**

without whose dedication over 15 years, this book could not have been done

and to my four grandchildren

**Danny** (11),

**Anna** (8),

**Emma** (2),

and Kate (0)

# Short Contents

Fo	preword	XXI				
Pr	eface to the Fourth Edition xx					
In	troduction	xxix				
I	Short Course	1				
1	Your IATEX	3				
2	Typing text	7				
3	Typing math	17				
4	Your first article and presentation	35				
II	Text and Math	59				
5	Typing text	61				
6	Text environments	117				
7	Typing math	151				
8	More math	187				
0	Multiling math displays	207				

viii Short Contents

III Document Structure	245
10 IATEX documents	247
11 The AMS article document class	271
12 Legacy document classes	303
IV Presentations and PDF Documents	315
13 PDF documents	317
14 Presentations	325
V Customization	361
15 Customizing IATEX	363
VI Long Documents	419
16 BibTeX	421
17 MakeIndex	449
18 Books in LATEX	465
A Installation	489
B Math symbol tables	501
C Text symbol tables	515
D Some background	521
E IATEX and the Internet	537
F PostScript fonts	543
G IATEX localized	547
H Final thoughts	551
Bibliography	557
Index	561

# **Contents**

Fo	rewo	rd	xxi					
Pr		to the Fourth Edition	XXV					
	Ack	nowledgments	xxvii					
In	trodu	action	xxix					
	Is th	is book for you?	xxix					
I	Sho	ort Course	1					
1	Your LATEX							
	1.1	Your computer	3					
	1.2	Sample files	4					
	1.3	Editing cycle	4					
	1.4	Three productivity tools	5					
2	Тур	ing text	7					
	2.1	The keyboard	8					
	2.2	Your first note	9					
	2.3	Lines too wide	12					
	2.4	More text features	13					
3	Тур	ing math	17					
	3.1	A note with math	17					
	3.2	Errors in math	19					
	3.3	Building blocks of a formula	22					
	3.4	Displayed formulas	27					
		3.4.1 Equations	27					

X Contents

		3.4.2	Aligned formulas	30
		3.4.3	Cases	33
4	You	r first a	rticle and presentation	35
	4.1	The an	natomy of an article	35
		4.1.1	The typeset sample article	41
	4.2	An art	icle template	44
		4.2.1	Editing the top matter	44
		4.2.2	Sectioning	46
		4.2.3	Invoking proclamations	46
		4.2.4	Inserting references	47
	4.3	On usi	ing LATEX	48
		4.3.1	LATEX error messages	48
		4.3.2	Logical and visual design	52
	4.4	Conve	erting an article to a presentation	53
		4.4.1	Preliminary changes	53
		4.4.2	Making the pages	55
		4.4.3	Fine tuning	55
П	То	vt and	l Math	59
11	10	At allu	Matii	39
5	Typi	ing text		61
	5.1	The ke	eyboard	62
		5.1.1	Basic keys	62
		5.1.2	Special keys	63
		5.1.3	Prohibited keys	63
	5.2	Words	s, sentences, and paragraphs	64
		5.2.1	Spacing rules	64
		5.2.2	Periods	66
	5.3	Comm	nanding LATEX	67
		5.3.1	Commands and environments	68
		5.3.2	Scope	71
		5.3.3	Types of commands	73
	5.4	Symbo	ols not on the keyboard	74
		5.4.1	Quotation marks	75
		5.4.2	Dashes	75
		5.4.3	Ties or nonbreakable spaces	76
		5.4.4	Special characters	76
		5.4.5	Ellipses	78
		5.4.6	Ligatures	79
		5.4.7	Accents and symbols in text	79
		5.4.8	Logos and dates	80

*Contents* xi

		5.4.9	Hyphenation	82
	5.5	Commo	ents and footnotes	85
		5.5.1	Comments	85
		5.5.2	Footnotes	87
	5.6	Changi	ing font characteristics	88
		5.6.1	Basic font characteristics	88
		5.6.2	Document font families	89
		5.6.3	Shape commands	90
		5.6.4	Italic corrections	91
		5.6.5	Series	93
		5.6.6	Size changes	93
		5.6.7	Orthogonality	94
		5.6.8	Obsolete two-letter commands	94
		5.6.9	Low-level commands	95
	5.7	Lines,	paragraphs, and pages	95
		5.7.1	Lines	96
		5.7.2	Paragraphs	99
		5.7.3		00
		5.7.4	_	01
	5.8	Spaces		02
		5.8.1		02
		5.8.2	_	04
		5.8.3		05
		5.8.4		06
	5.9	Boxes		07
		5.9.1		07
		5.9.2		09
		5.9.3		10
		5.9.4		12
		5.9.5		13
		5.9.6		15
6	Toyt	environ	amonts 1	17
U	6.1			118
	6.2		1 7	18
	0.2	6.2.1		19
		6.2.2		19
		6.2.3		20
		6.2.4	1	
	6.2			20 23
	6.3 6.4	•		123 124
	0.4		,	
		6.4.1	The full syntax	28

xii Contents

		6.4.2	Proclamations with style	129
	6.5	Proof 6	environments	131
	6.6	Tabula	r environments	133
		6.6.1	Table styles	140
	6.7	Tabbin	ng environments	141
	6.8	Miscel	llaneous displayed text environments	143
7	Typi	ing mat	h	151
	7.1	Math e	environments	152
	7.2	Spacin	ng rules	154
	7.3	Equati	ons	156
	7.4	Basic o	constructs	157
		7.4.1	Arithmetic operations	157
		7.4.2	Binomial coefficients	159
		7.4.3	Ellipses	160
		7.4.4	Integrals	161
		7.4.5	Roots	161
		7.4.6	Text in math	162
		7.4.7	Building a formula step-by-step	164
	7.5	Delimi	iters	166
		7.5.1	Stretching delimiters	167
		7.5.2	Delimiters that do not stretch	168
		7.5.3	Limitations of stretching	169
		7.5.4	Delimiters as binary relations	170
	7.6	Operat	tors	170
		7.6.1	Operator tables	171
		7.6.2	Defining operators	173
		7.6.3	Congruences	173
		7.6.4	Large operators	174
		7.6.5	Multiline subscripts and superscripts	176
	7.7	Math a	accents	176
	7.8	Stretch	nable horizontal lines	178
		7.8.1	Horizontal braces	178
		7.8.2	Overlines and underlines	179
		7.8.3		179
	7.9	Formu	ıla Gallery	180
8	Mor	e math		187
	8.1	Spacin	ng of symbols	187
		8.1.1		188
		8.1.2		188
		8.1.3	•	190
		8.1.4		190

Contents

		8.1.5	The phantom command	191
	8.2	Buildir	ng new symbols	192
		8.2.1	Stacking symbols	192
		8.2.2	Negating and side-setting symbols	194
		8.2.3	Changing the type of a symbol	195
	8.3	Math a	alphabets and symbols	195
		8.3.1	Math alphabets	196
		8.3.2	Math symbol alphabets	197
		8.3.3	Bold math symbols	197
		8.3.4	Size changes	199
		8.3.5	Continued fractions	200
	8.4	Vertica	d spacing	200
	8.5		g and grouping	201
	8.6		laneous	204
		8.6.1	Generalized fractions	204
		8.6.2	Boxed formulas	205
9			ath displays	207
	9.1		Guide	207
		9.1.1	Columns	209
		9.1.2	Subsidiary math environments	209
		9.1.3	Adjusted columns	210
		9.1.4	Aligned columns	210
		9.1.5	Touring the Visual Guide	210
	9.2		ing formulas	211
	9.3		ng long formulas	212
	9.4	Some g	general rules	215
		9.4.1	General rules	215
		9.4.2	Subformula rules	215
		9.4.3	Breaking and aligning formulas	217
		9.4.4	Numbering groups of formulas	218
	9.5	Aligne	d columns	219
		9.5.1	An align variant	221
		9.5.2	eqnarray, the ancestor of align	222
		9.5.3	The subformula rule revisited	223
		9.5.4	The alignat environment	224
		9.5.5	Inserting text	226
	9.6	Aligne	d subsidiary math environments	227
		9.6.1	Subsidiary variants	227
		9.6.2	Split	230
	9.7		ed columns	231
		9.7.1		232

xiv Contents

		9.7.2 Arrays	236
		9.7.3 Cases	239
	9.8	Commutative diagrams	240
	9.9	Adjusting the display	242
III	D	ocument Structure	245
10	LATE.	X documents	247
	10.1	The structure of a document	248
	10.2	The preamble	249
	10.3	Top matter	251
		10.3.1 Abstract	251
	10.4	Main matter	251
		10.4.1 Sectioning	252
		10.4.2 Cross-referencing	255
		10.4.3 Floating tables and illustrations	258
	10.5	Back matter	261
		10.5.1 Bibliographies in articles	261
		10.5.2 Simple indexes	267
	10.6	Visual design	268
11	The	AMS article document class	271
			271
		•	271
			272
			272
			273
	11.2		273
			273
			275
			279
			281
		1	282
			285
	11.3		285
		•	294
			297
			300

Contents

12	Lega	cy doci	ument classes	303
	12.1	Article	s and reports	303
		12.1.1	Top matter	304
		12.1.2	Options	306
	12.2	Letters		308
	12.3	The LAT	T <sub>E</sub> X distribution	310
		12.3.1	Tools	312
IV	<b>P</b> 1	resenta	ations and PDF Documents	315
13		docume		317
	13.1		ript and PDF	317
			PostScript	317
			PDF	318
			Hyperlinks	319
	13.2		inks for LATEX	319
			Using hyperref	320
		13.2.2		320
			Bookmarks	321
		13.2.4	Additional commands	322
14	Pres	entation	ns	325
	14.1	Quick	and dirty beamer	326
			First changes	326
			Changes in the body	327
			Making things prettier	328
			Adjusting the navigation	328
	14.2		peamers	333
		14.2.1	Overlays	333
		14.2.2	Understanding overlays	335
			More on the \only and \onslide commands	337
		14.2.4	Lists as overlays	339
			Out of sequence overlays	341
		14.2.6	Blocks and overlays	343
			Links	343
		14.2.8	Columns	347
		14.2.9	Coloring	348
	14.3	The str	ructure of a presentation	350
			Longer presentations	354
		14.3.2	Navigation symbols	354
	14.4	Notes		355
	14.5	Theme	s	356

xvi Contents

	14.6 Plann	ing your presentation	358
	14.7 What	did I leave out?	358
V	Custom	ization	361
15	Customizir	ng IATeX	363
		defined commands	
		Examples and rules	
		2 Arguments	
		Short arguments	
		Optional arguments	
		Redefining commands	
		Redefining names	
	15.1.7		
	15.1.8	B Delimited commands	378
	15.2 User-	defined environments	380
	15.2.1	Modifying existing environments	380
	15.2.2		
	15.2.3	3 Optional arguments with default values	384
	15.2.4	Short contents	385
	15.2.5	5 Brand-new environments	385
	15.3 A cus	tom command file	386
	15.4 The sa	ample article with user-defined commands	392
		pering and measuring	
	15.5.1	Counters	399
	15.5.2	Length commands	403
	15.6 Custo	m lists	406
		Length commands for the list environment	
		The list environment	
		3 Two complete examples	
		The trivlist environment	
	15.7 The d	angers of customization	415
V	I Long D	<b>Documents</b>	419
16	ВівТеХ		421
	16.1 The d		
		Entry types	
		2 Typing fields	
	16.1.3	3 Articles	428
	16.1.4	4 Books	429

Contents xvii

		16.1.5	Conference proceedings and collections	430
		16.1.6	Theses	433
		16.1.7	Technical reports	434
		16.1.8	Manuscripts and other entry types	435
		16.1.9	Abbreviations	436
	16.2	Using l	ВівТ <sub>Е</sub> Х	437
		16.2.1	Sample files	437
		16.2.2	Setup	439
		16.2.3	Four steps of BIBTEXing	440
		16.2.4	BIBTEX rules and messages	443
		16.2.5	Submitting an article	446
	16.3	Conclu	ding comments	446
17	Mak	eIndex		449
			ing the document	449
		-	commands	453
			sing the index entries	459
				462
			le indexes	463
		_	ry	464
			ding comments	464
18	Rook	ks in IAT	Γ- <b>Y</b>	465
10			locument classes	466
	10.1		Sectioning	466
			Division of the body	467
			Document class options	468
			Title pages	469
			Springer's document class for monographs	469
	18.2		of contents, lists of tables and figures	473
	10.2		Tables of contents	473
			Lists of tables and figures	475
			Exercises	476
	18 3		zing the files for a book	476
	10.5	18.3.1	-	477
		18.3.2	Inclusion and selective inclusion	478
			Organizing your files	479
	18 /		l design	479
			reparations for the publisher	482
			create the PDF file for your book	484
	10.0	TI VOII (	CICARC UIC FIJE HIG IOL VOULDOOK	404

xviii Contents

A	Insta	allation	489
	A.1	LaTeX on a PC	490
		A.1.1 Installing MiKTeX	490
		A.1.2 Installing WinEdt	490
		A.1.3 The editing cycle	491
		A.1.4 Making a mistake	491
		A.1.5 Three productivity tools	494
		A.1.6 An important folder	494
	A.2	LaTeX on a Mac	495
		A.2.1 Installations	495
		A.2.2 Working with TeXShop	496
		A.2.3 The editing cycle	498
		A.2.4 Making a mistake	498
		A.2.5 Three productivity tools	498
		A.2.6 An important folder	499
В	Mat	h symbol tables	501
	B.1	Hebrew and Greek letters	501
	B.2	Binary relations	503
	B.3	Binary operations	506
	B.4	Arrows	507
	B.5	Miscellaneous symbols	508
	B.6	Delimiters	509
	B.7	Operators	510
		B.7.1 Large operators	511
	B.8	Math accents and fonts	512
	B.9	Math spacing commands	513
C	Text	symbol tables	515
	C.1	Some European characters	515
	C.2	Text accents	516
	C.3	Text font commands	516
		C.3.1 Text font family commands	516
		C.3.2 Text font size changes	517
	C.4	Additional text symbols	518
	C.5	Additional text symbols with T1 encoding	519
	C.6	Text spacing commands	520
D	Som	e background	521
	D.1	A short history	521
		D.1.1 T <sub>E</sub> X	521
		D.1.2 LATEX 2.09 and AMS-TEX	522
		D.1.3 LATEX3	523

Contents

		D.1.4 More recent developments	524
	D.2	Structure	525
		D.2.1 Using LATEX	525
		D.2.2 AMS packages revisited	528
	D.3	How LATEX works	528
		D.3.1 The layers	528
		D.3.2 Typesetting	529
		D.3.3 Viewing and printing	530
		D.3.4 LATEX's files	531
	D.4	Interactive LATEX	534
	D.5	Separating form and content	535
E	ĿΤΕ	X and the Internet	537
	E.1	Obtaining files from the Internet	537
	E.2	The TEX Users Group	541
	E.3	Some useful sources of LATeX information $\dots \dots \dots \dots$ .	542
F	Post	Script fonts	543
	F.1	The Times font and MathTime	544
	F.2	Lucida Bright fonts	546
	F.3	More PostScript fonts	546
G	LATE	X localized	547
Н	Fina	l thoughts	551
	H.1	What was left out?	551
		H.1.1 LATEX omissions	551
		H.1.2 T <sub>E</sub> X omissions	552
	H.2	Further reading	553
	H.3	What's coming	554
Bibliography			557
Index			

## **Foreword**

It was the autumn of 1989—a few weeks before the Berlin wall came down, President George H. W. Bush was president, and the American Mathematical Society decided to outsource TFX programming to Frank Mittelbach and me.

Why did the AMS outsource TEX programming to us? This was, after all, a decade before the words "outsourcing" and "off-shore" entered the lexicon. There were many American TEX experts. Why turn elsewhere?

For a number of years, the AMS tried to port the mathematical typesetting features of  $\mathcal{A}_{\mathcal{M}}\mathcal{S}$ -TeX to LaTeX, but they made little progress with the AMSFonts. Frank and I had just published the New Font Selection Scheme for LaTeX, which went a long way to satisfy what they wanted to accomplish. So it was logical that the AMS turned to us to add AMSFonts to LaTeX. Being young and enthusiastic, we convinced the AMS that the  $\mathcal{A}_{\mathcal{M}}\mathcal{S}$ -TeX commands should be changed to conform to the LaTeX standards. Michael Downes was assigned as our AMS contact; his insight was a tremendous help.

We already had LaTeX-NFSS, which could be run in two modes: compatible with the old LaTeX or enabled with the new font features. We added the reworked  $\mathcal{AMS}$ -TeX code to LaTeX-NFSS, thus giving birth to  $\mathcal{AMS}$ -LaTeX, released by the AMS at the August 1990 meeting of the International Mathematical Union in Kyoto.

 $\mathcal{A}_{\mathcal{M}}\mathcal{S}$ -LeTeX was another variant of LeTeX. Many installations had several LeTeX variants to satisfy the needs of their users: with old and new font changing commands, with and without  $\mathcal{A}_{\mathcal{M}}\mathcal{S}$ -LeTeX, a single and a multi-language version. We decided to develop a Standard LeTeX that would reconcile all the variants. Out of a group of interested people grew what was later called the LeTeX3 team—and the LeTeX3 project got underway. The team's first major accomplishment was the release of LeTeX  $2_{\mathcal{E}}$  in June 1994. This standard LeTeX incorporates all the improvements we wanted back in 1989. It is now very stable and it is uniformly used.

Under the direction of Michael Downes, our AMS-LATEX code was turned into AMS packages that run under LATEX just like other packages. Of course, the LATEX3

xxii Foreword

team recognizes that these are special; we call them "required packages" because they are part and parcel of a mathematician's standard toolbox.

Since then a lot has been achieved to make an author's task easier. A tremendous number of additional packages are available today. The LATEX Companion, 2nd edition, describes many of my favorite packages.

George Grätzer got involved with these developments in 1990, when he got his copy of AMS-LATEX in Kyoto. The documentation he received explained that AMS-LATEX is a LATEX variant—read Lamport's LATEX book to get the proper background. AMS-LATEX is not AMS-TEX either—read Spivak's AMS-TEX book to get the proper background. The rest of the document explained in what way AMS-LATEX differs from LATEX and AMS-TEX. Talk about a steep learning curve ...

Luckily, George's frustration working through this nightmare was eased by a lengthy e-mail correspondence with Frank and lots of telephone calls to Michael. Three years of labor turned into his first book on  $\LaTeX$ , providing a "simple introduction to  $\LaTeX$ .".

This fourth edition is more mature, but preserves what made his first book such a success. Just as in the first book, Part I is a short introduction for the beginner, dramatically reducing the steep learning curve of a few weeks to a few hours. The rest of the book is a detailed presentation of what you may need to know. George "teaches by example". You find in this book many illustrations of even the simplest concepts. For articles, he presents the LATEX source file and the typeset result side-by-side. For formulas, he discusses the building blocks with examples, presents a *Formula Gallery*, and a *Visual Guide* to multiline formulas.

Going forth and creating "masterpieces of the typesetting art"—as Donald Knuth put it at the end of the *TeXbook*—requires a fair bit of initiation. This is the book for the LaTeX beginner as well as for the advanced user. You just start at a different point.

The topics covered include everything you need for mathematical publishing.

- Starting from scratch, by installing and running LATEX on your own computer
- Instructions on creating articles, from the simple to the complex
- Converting an article to a presentation
- Customize LATEX to your own needs
- The secrets of writing a book
- Where to turn to get more information or to download updates

The many examples are complemented by a number of easily recognizable features:

Rules which you must follow

**Tips** on how to achieve some specific results

Experiments to show what happens when you make mistakes—sometimes, it can be difficult to understand what went wrong when all you see is an obscure LATEX error message

Foreword xxiii

This book teaches you how to convert your mathematical masterpieces into typographical ones, giving you a lot of useful advice on the way. How to avoid the traps for the unwary and how to make your editor happy. And hopefully, you'll experience the fascination of doing it right. Using good typography to better express your ideas.

If you want to learn LaTeX, buy this book and start with the *Short Course*. If you can have only one book on LaTeX next to your computer, this is the one to have. And if you want to learn about the world of LaTeX packages, also buy a second book, the LaTeX Companion, 2nd edition.

Rainer Schöpf

Painer Schopf

LATEX3 team

# Preface to the Fourth Edition

This is my fourth full-sized book on LATEX.

The first book, *Math into T<sub>E</sub>X: A Simple Introduction to A<sub>M</sub>S-L<sup>A</sup>T<sub>E</sub>X* [19], written in 1991 and 1992, introduced the brand new  $\mathcal{A}_{\mathcal{M}}S$ -L<sup>A</sup>T<sub>E</sub>X, a L<sup>A</sup>T<sub>E</sub>X variant not compatible with the L<sup>A</sup>T<sub>E</sub>X of the time, L<sup>A</sup>T<sub>E</sub>X 2.09. It brought together the features of L<sup>A</sup>T<sub>E</sub>X and the math typesetting abilities of  $\mathcal{A}_{\mathcal{M}}S$ -T<sub>E</sub>X, the AMS typesetting language.

The second book, *Math into LATEX: An Introduction to LATEX and AMS-LATEX* [27], written in 1995, describes the new LATEX introduced by the LATEX3 team and the AMS typesetting features implemented as extensions of LATEX, called packages.

The third book, *Math into LaTeX*, 3rd edition [30], published in 2000, reports on the same system. By 2000, both the "new" LaTeX and the AMS packages were quite mature. The feverish debugging of the new LaTeX every six months bore fruit. LaTeX became very stable. It has changed little since 2000. Version 2.0 of the AMS packages was released and it also became very stable. The third book reports on a rock solid typesetting system.

What also changed between 1995 and 2000 is the widespread use of the Internet. Several chapters of the third book deal with the impact of the Internet on mathematical publications.

Now, seven years later, we can still report that LateX—no longer new—and the AMS packages have changed very little. However, the impact of the Internet became even more important. Computers also changed. They are now much more powerful. When I started typesetting math with LateX, it took two and a half minutes to typeset a page. This book takes 1.8 seconds to typeset on my computer, a Mac desktop from 2006. As a result, we do not have to be very selective in what we load into memory; we can load everything we may possibly need.

xxvi Preface

#### Circumincession

So this is the first big change compared to the previous books. In this book, we roll TEX, LATEX, and the AMS packages into one, and we call it simply LATEX. This results in a great simplification in the exposition and makes the learning curve a little less steep.

I am sure with some advanced users this will prove to be a controversial decision. They want to know where a command is defined. For the beginner and the non-expert user this does not make any difference. What matters is that the command they need be available when they need it.

From the beginner's point of view, this approach is very beneficial. Take as an example the \text command. In all three of my books, we first introduce the LaTeX command \mbox for typing text in math formulas. After half a page of discussion comes the sentence: "It is better to enter text in formulas with the \text command provided by the amsmath package." Then another half page discusses the command \text. In this book, we ignore \mbox and go right-away to \text. You do not have to do anything to access the command, the amsmath package is always loaded for you.

And what to do if you want to find out where a command is defined. Now for both the PC and the Mac, you can easily search for contents of files. Do you want to know where a command is defined? Search for it and it is easy to find the file in which it is introduced.

#### **Presentations**

The second big change is the widespread acceptance of the Adobe PDF format. As a result, the majority of the lectures today at math meetings are given as *presentations*, PDF files projected to screens using computers. Blackboards and whiteboards have largely disappeared and computer projections are overtaking projectors. So this book takes up presentations as a major topic, introducing it in Part I and discussing it in detail in Chapter 14.

#### Installations

In the third book, I report a recurring question that comes up from my readers again and again:

Can you help me get started from scratch, covering everything from installing a working LATEX system to the rudiments of text editing?

And here is the third big change that has happened in the last few years. While earlier there were dozens of different LaTeX implementations and hundreds of text editors, today most PC users use MikTeX with the text editor/front end WinEdt and most Mac users use TeX Live with the text editor/front end TeXShop. So if you want help to

Preface xxvii

install LATEX, it is easy for me to help you. Appendix A provides instructions on how to install these systems.

## Acknowledgments

This book is based, of course, on the three previous books. I would like to thank the many people who read and reread those earlier manuscripts.

**The editors** Richard Ribstein, Thomas R. Scavo, Claire M. Connelly.

The professionals Michael Downes (the project leader for the AMS), Frank Mittelbach and David Carlisle (of the LATEX3 team) read and criticized some or all of the three books.

Oren Patashnik (the author of BIBTeX) carefully corrected the BIBTeX chapter for two editions.

Sebastian Rahtz (the author of the hyperref package and coauthor of *The LATEX Web Companion* [18]) read the chapter on the Web in the third book.

Last but not least, Barbara Beeton of the AMS read all three books with incredible insight.

**The volunteers** for the second book alone, there were 29—listed there. The volunteer readers made tremendous contributions and offered hundreds of pages of corrections. No expert can substitute for the diverse points of view I got from them.

**My colleagues** especially Michael Doob, Harry Lakser, and Craig Platt, who have been very generous with their time.

**The publishers** Edwin Beschler, who believed in the project from the very beginning and guided it through a decade and Ann Kostant who continued Edwin's work.

For this book, I have had the most talented and thorough group of readers ever: Andrew Adler of the University of British Columbia, Canada, Joseph Maria Font of the University of Barcelona, Spain, and Alan Litchfield, of the Auckland University of Technology, New Zealand. Chapter 14 was read by David Derbes, Adam Goldstein, Mark Eli Kalderon, Michael Kubovy, Matthieu Masquelet, and Charilaos Skiadas—and Chapter 15 by Ross Moore. Interestingly, only half of them are mathematicians, the rest are philosophers, linguists, and so on. Appendix A.1 was read by Brian Davey and Appendix A.2 by Richard Koch (the author of TeXShop).

The fourth edition was edited by Barbara Beeton, Edwin Beschler, and Clay Martin with Ann Kostant as the Springer editor. The roles of Edwin and Ann have changed, but not the importance of their contributions. The index was compiled with painstaking precision by Laura Kirkland. Barbara Beeton also provided a number of intriguing illustrations of quaint commands. My indebtedness to her cannot be overstated.

## Introduction

### Is this book for you?

This book is for the mathematician, physicist, engineer, scientist, linguist, or technical typist who has to learn how to typeset articles containing mathematical formulas or diacritical marks. It teaches you how to use LaTeX, a typesetting markup language based on Donald E. Knuth's typesetting language TeX, designed and implemented by Leslie Lamport, and greatly improved by the AMS.

Part I provides a quick introduction to LATeX, from typing examples of text and math to typing your first article (such as the sample article on pages 42–43) and creating your first presentation (such as the sample presentation on pages 57–58) in a very short time. The rest of the book provides a detailed exposition of LATeX.

LATEX has a huge collection of rules and commands. While the basics in Part I should serve you well in all your writings, most articles and presentations also require you to look up special topics. Learn Part I well and become passingly familiar enough with the rest of the book, so when the need arises you know where to turn with your problems.

You can find specific topics in one or more of the following sources: the Short Contents, the detailed Contents, and the Index.

## What is document markup?

When you work with a word processor, you see your document on the computer monitor more or less as it looks when printed, with its various fonts, font sizes, font shapes (e.g., roman, italic) and weights (e.g., normal, boldface), interline spacing, indentation, and so on.

Working with a *markup language* is different. You type the *source file* of your article in a *text editor*, in which all characters appear in the same font. To indicate changes in the typeset text, you must add *text markup commands* to the source file.

xxx Introduction

For instance, to emphasize the phrase detailed description in a LATEX source file, type

\emph{detailed description}

The \emph command is a markup command. The marked-up text yields the typeset output

```
\left| egin{array}{l} detailed \ description \end{array} 
ight|
```

In order to typeset math, you need *math markup commands*. As a simple example, you may need the formula  $\int \sqrt{\alpha^2 + x^2} \, dx$  in an article you are writing. To mark up this formula in LaTeX, type

```
\int \sqrt{\alpha} \frac{2} + x^{2}}\,dx
```

You do not have to worry about determining the size of the integral symbol or how to construct the square root symbol that covers  $\alpha^2 + x^2$ . LATEX does it all for you.

On pages 290–293, I juxtapose the source file for a sample article with the typeset version. The markup in the source file may appear somewhat challenging at first, but I think you agree that the typeset article is a pleasing rendering of the original input.

### The three layers

The markup language we shall discuss comes in three layers: TeX, LaTeX, and the AMS packages, described in detail in Appendix D. Most LaTeX installations—including the two covered in Appendix A—automatically place all three on your computer. You do not have to know what comes from which layer, so we consider the three together and call it LaTeX.

### The three platforms

Most of you run LATEX on one of the following three computer types:

- A PC, a computer running Microsoft Windows
- A Mac<sup>1</sup>, a Macintosh computer running OS X
- A computer running a UNIX variant such as Solaris or Linux

The LaTeX source file and the typeset version both look the same independent of what computer you have. However, the way you type your source file, the way you typeset it, and the way you look at the typeset version depends on the computer and on the LaTeX implementation you use. In Appendix A, we show you how to install LaTeX for a PC and a Mac. Many UNIX systems come with LaTeX installed.

 $<sup>^{1}</sup>$ In the old days, I used to run Textures under OS 9. Unfortunately, Textures does not run on new Intel Macs.

*Introduction* xxxi

#### What's in the book?

Part I is the *Short Course*; it helps you to get started quickly with LaTeX, to type your first articles, to prepare your first presentations, and it prepares you to tackle LaTeX in more depth in the subsequent parts. We assume here that LaTeX is installed on your computer. If it is not, jump to Appendix A.

Chapter 1 introduces the *terminology* we need to talk about your LATEX implementations. Chapter 2 introduces how LATEX uses the *keyboard* and how to *type text*. You do not need to learn much to understand the basics. Text markup is quite easy. You learn math markup—which is not so straightforward—in Chapter 3. Several sections in this chapter ease you into *mathematical typesetting*. There is a section on the basic building blocks of math formulas. Another one discusses equations. Finally, we present the two simplest multiline formulas, which, however, cover most of your everyday needs.

In **Chapter 4**, you start writing your *first article* and prepare your *first presentation*. A LATEX article is introduced with the sample article intrart.tex. We analyze in detail its structure and its source file, and we look at the typeset version. Based on this, we prepare an article template, and you are ready for your first article. A quick conversion of the article intrart.tex to a presentation introduces this important topic.

**Part II** introduces the two most basic skills for writing with LaTeX in depth, *typing text* and *typing math*.

**Chapters 5** and **6** introduce *text* and *displayed text*. Chapter 5 is especially important because, when you type a LATEX document, most of your time is spent typing text. The topics covered include special characters and accents, hyphenation, fonts, and spacing. Chapter 6 covers displayed text, including *lists* and *tables*, and for the mathematician, *proclamations* (theorem-like structures) and *proofs*.

Typing math is the heart of any mathematical typesetting system. **Chapter 7** discusses inline formulas in detail, including basic constructs, delimiters, operators, math accents, and horizontally stretchable lines. The chapter concludes with the *Formula Gallery*.

Math symbols are covered in three sections in **Chapter 8**. How to space them, how to build new ones. We also look at the closely related subjects of math alphabets and fonts. Then we discuss tagging and grouping equations.

LATEX knows a lot about typesetting an inline formula, but not much about how to display a multiline formula. **Chapter 9** presents the numerous tools LATEX offers to help you do that. We start with a *Visual Guide* to help you get oriented.

Part III discusses the parts of a LATEX document. In Chapter 10, you learn about the *structure* of a LATEX document. The most important topics are *sectioning* and *cross-referencing*. In Chapter 11, we discuss the amsart *document class* for articles. In particular, I present the title page information. Chapter 11 also features sampart.tex, a sample article for amsart, first in typeset form, then in mixed form, juxtaposing the source file and the typeset article. You can learn a lot about LATEX just by reading the source file one paragraph at a time and seeing how that paragraph is typeset. We con-

xxxii Introduction

clude this chapter with a brief description of the AMS distribution, the packages and document classes, of which amsart is a part.

In **Chapter 12** the most commonly used *legacy document classes* are presented, article, report, and letter (the book class is discussed in Chapter 18), along with a description of the standard LATEX distribution. Although article is not as sophisticated as amsart, it is commonly used for articles not meant for publication.

In **Part IV**, we start with **Chapter 13**, discussing PDF *files, hyperlinks*, and the hyperref package. This prepares you for *presentations*, which are PDF files with hyperlinks. In **Chapter 14** we utilize the beamer *package* for making LATEX presentations.

**Part V** (**Chapter 15**) introduces techniques to *customize* LaTeX: user-defined commands, user-defined environments, and command files. We present a sample command file, newlattice.sty, and a version of the sample article utilizing this command file. You learn how parameters that affect LaTeX's behavior are stored in counters and length commands, how to change them, and how to design your own custom lists. A final section discusses the pitfalls of customization.

In **Part VI** (**Chapters 16** and **17**), we discuss the special needs of longer documents. Two applications, contained in the standard LaTeX distribution, BIBTeX and *MakeIndex*, make compiling *large bibliographies* and *indexes* much easier.

LATEX provides the book and the amsbook document classes to serve as foundations for well-designed books. We discuss these in **Chapter 18**. Better quality books have to use document classes designed by professionals. We provide some sample pages from a book using Springer's symono.cls document class.

Detailed instructions are given in **Appendix A** on how to install LaTeX on a PC and a Mac. On a PC we install WinEdt and MiKTeX. On a Mac, we install MacTeX, which consists of TeX Live and TeXShop. For both installations, we describe the editing cycle and three productivity tools in sufficient detail so that you be able to handle the tasks on the sample files of the *Short Course*.

You will probably find yourself referring to **Appendices B** and **C** time and again. They contain the *math and text symbol tables*.

**Appendix D** relates some historical background material on LATEX. It gives you some insight into how LATEX developed and how it works. **Appendix E** discusses the many ways we can find LATEX material on the *Internet*.

**Appendix F** is a brief introduction to the use of *PostScript fonts* in a LATEX document. **Appendix G** briefly describes the use of LATEX for languages other than American English.

Finally, **Appendix H** discusses what we left out and points you towards some areas for further reading.

Introduction xxxiii

#### Mission statement

This book is a guide for typesetting mathematical documents within the constraints imposed by LaTeX, an elaborate system with hundreds of rules. LaTeX allows you to perform almost any mathematical typesetting task through the appropriate application of its rules. You can customize LaTeX by introducing user-defined commands and environments and by changing LaTeX parameters. You can also extend LaTeX by invoking packages that accomplish special tasks.

It is not my goal

- to survey the hundreds of LaTeX packages you can utilize to enhance LaTeX
- to teach how to write TEX code and to create your own packages
- to discuss how to design beautiful documents by writing document classes

The definitive book on the first topic is Frank Mittelbach and Michel Goosens's *The LATEX Companion*, 2nd edition [46] (with Johannes Braams, David Carlisle, and Chris Rowley). The second and third topics still await authoritative treatment.

#### **Conventions**

To make this book easy to read, I use some simple conventions:

- Explanatory text is set in this typeface: Times.
- Computer Modern typewriter is used to show what you should type, as well as messages from LaTeX. All the characters in this typeface have the same width, making it easy to recognize.
- I also use Computer Modern typewriter to indicate
  - Commands (\parbox)
  - Environments (\align)
  - Documents (intrart.tex)
  - Document classes (amsart)
  - Document class options (draft)
  - Folders or directories (work)
  - The names of packages, which are extensions of LATEX (verbatim)
- When I show you how something looks when typeset, I use Computer Modern, TEX's standard typeface:

xxxiv Introduction

I think you find this typeface sufficiently different from the other typefaces I have used. The strokes are much lighter so that you should not have much difficulty recognizing typeset IATEX material. When the typeset material is a separate paragraph or paragraphs, corner brackets in the margin set it off from the rest of the text—unless it is a displayed formula.

• For explanations in the text, such as

Compare iff with iff, typed as iff and if{f}, respectively.

the same typefaces are used. Because they are not set off spatially, it may be a little more difficult to see that iff is set in Computer Modern roman (in Times, it looks like this: iff), whereas iff is set in the Computer Modern typewriter typeface.

I usually introduce commands with examples, such as

\\[22pt]

However, it is sometimes necessary to define the syntax of a command more formally. For instance,

 $\[ [length] \]$ 

where *length*, typeset in Computer Modern typewriter italic font, represents the value you have to supply.

Good luck and have fun.

George Gratzer

E-mail:

gratzer@ms.umanitoba.ca

Home page:

http://www.maths.umanitoba.ca/homepages/gratzer.html

CHAPTER

# Your LATEX

Are you sitting in front of your computer, your LaTeX implementation up and running? In this chapter we get you ready to tackle this *Short Course*. When you are done with Part I, you will be ready to start writing your articles in LaTeX.

If you do not have a LaTeX implementation up and running, go to Appendix A. There you find precise and detailed instructions how to set up LaTeX on a PC or a Mac. There is enough in the appendix for you to be able to handle the tasks in this *Short Course*. You will be pleasantly surprised at how little time it takes to set LaTeX up. If you use some variant of UNIX, turn to a UNIX guru who can help you set up LaTeX on your computer and guide you through the basics. If all else fails, read the documentation for your UNIX system.

## 1.1 Your computer

We assume very little, only that you are familiar with your keyboard and with the operating system on your computer. You should know standard PC and Mac menus, pull down menus, buttons, tabs, the menu items, such as Edit>Paste, the menu item Paste on the menu Edit. You should understand folders (we use this terminology regardless of the platform, with apologies to our UNIX readers), and you need to know how to save a file and copy a file from one folder to another.

On a PC, work\test refers to the subfolder test of the folder work. On a Mac, work/test designates this subfolder. To avoid having to write every subfolder twice, we use work/test, with apologies to our PC readers.

## 1.2 Sample files

We work with a few sample documents in this *Short Course*. You can type the sample documents as presented in the text, or you can download them from the Internet (see Section E.1). The samples folder also contains a copy of SymbolTables.pdf, a PDF version of Appendices B and C, the symbol tables.

I suggest you create a folder on your computer named samples, to store the downloaded sample files, and another folder called work, where you will keep your working files. Copy the documents from the samples to the work folder as needed. *In this book, the* samples *and* work *folders refer to the folders you have created.* 

If you Save As... a sample file under a different name, remember the naming rule.

#### **Rule** ■ Naming of source files

The name of a LaTeX source file should be *one word* (no spaces, no special characters), and end with .tex.

So first art.tex is bad, but art1.tex and FirstArt.tex are good.

#### 1.3 Editing cycle

Watch a friend type a mathematical article in LATEX and you learn some basic steps.

1. A text editor is used to create a LATEX source file. A source file might look like the top window in Figure 1.1:

```
\documentclass{amsart}
\begin{document}
The hypotenuse: $\sqrt{a^{2} + b^{2}}$. I can type math!
\end{document}
```

Note that the source file is different from a typical word processor file. All characters are displayed in the same font and size.

2. Your friend "typesets" the source file (tells the application to produce a typeset version) and views the result on the monitor (the two corners indicate material typeset by LaTeX):

```
The hypotenuse: \sqrt{a^2+b^2}. I can type math!
```

as in the middle window in Figure 1.1.

- 3. *The editing cycle continues*. Your friend goes back and forth between the source file and the typeset version, making changes and observing the results of these changes.
- 4. *The file is printed.* Once the typeset version is satisfactory, it is printed, creating a paper version of the typeset article. Alternatively, your friend creates a PDF file of the typeset version (see Chapter 13.1.2).

If LaTeX finds a mistake when typesetting the source file, it opens a new window, the *log window*, illustrated as the bottom window in Figure 1.1, and displays an error message. The same message is saved into a file, called the *log file*. Look at the figures in Appendix A, depicting a variety of editing windows, windows for the typeset article, and log windows for the two LaTeX implementations discussed there.

Various LaTeX implementations have different names for the source file, the text editor, the typeset file, the typeset window, the log window, and the log file. Become familiar with these names for the LaTeX implementation you use, so you can follow along with our discussions. In Appendix A, we bring you up to speed for the LaTeX implementations discussed therein.

## 1.4 Three productivity tools

Most LATEX implementations have these important productivity tools:

**Synchronization** To move quickly between the source file and the typeset file, most LATEX implementations offer *synchronization*, the ability to jump from the typeset

Figure 1.1: Windows for the source and typeset files and the log window.

file to the corresponding place in the source file and from the source file to the corresponding place in the typeset file.

#### **Block comment** Block comments are very useful:

- 1. When looking for a LaTeX error, you may want LaTeX to ignore a block of text in the source file (see page 51).
- 2. Often you may want to make comments about your project but not have them printed or you may want to keep text on hand while you try a different option. To accomplish this, insert a comment character, %, at the start of each line where the text appears. These lines are ignored when the LaTeX file is processed.

Select a number of lines in a source document, then by choosing a menu option all the lines (the whole block) are commented out (a % sign is placed at the beginning of each line). This is *block comment*. The reverse is *block uncomment*.

**Jump to a line** This is specified by the line number in the source file. To find an error, LATEX suggests that you jump to a line.

Find out how your LaTeX implements these features. In Appendix A, we discuss how these features are implemented for the LaTeX we install.

Pay careful attention how your L<sup>A</sup>T<sub>E</sub>X implementation works. This enables you to rapidly perform the editing cycle and utilize the productivity tools when necessary.

2

# Typing text

In this chapter, I introduce you to typesetting text by working through examples. More details are provided throughout the book, in particular, in Chapters 5 and 6.

A source file is made up of *text, math* (*formulas*), and *instructions* (*commands*) to LATEX. For instance, consider the following variant of the first sentence of this paragraph:

is math

), and

is text again. Finally,

\emph{instructions to} \LaTeX.

are instructions. The instruction \emph is a *command with an argument*, while the instruction \LaTeX is a *command without an argument*.

Commands, as a rule, start with a backslash (\) and tell LaTeX to do something special. In this case, the command \emph emphasizes its *argument* (the text between the braces). Another kind of instruction to LaTeX is called an *environment*. For instance, the commands

\begin{flushright}

and

\end{flushright}

enclose a flushright environment; the *content*, that is, the text that is typed between these two commands, is right justified (lined up against the right margin) when typeset. (The flushleft environment creates left justified text; the center environment creates text that is centered horizontally on the page.)

In practice, text, math, and instructions (commands) are mixed. For example,

```
My first integral: \int x \sin^2 2(x) \, dx.
```

is a mixture of all three; it typesets as

My first integral:  $\int \zeta^2(x) dx$ .

Creating a document in LaTeX requires that we type the text and math in the source file. So we start with the keyboard, proceed to type a short note, and learn some simple rules for typing text in LaTeX.

#### 2.1 The keyboard

The following keys are used to type text in a source file:

$$a-z$$
  $A-Z$  0-9 + = \* / ( ) [ ]

You may also use the following punctuation marks:

, ; . ? ! : ' ' -

and the space bar, the Tab key, and the Return (or Enter) key.

Since TEX source files are "pure text" (ASCII files), they are very portable. There is one possible problem limiting this portability, the line endings used in the source file. When you press the Return key, your text editor writes an invisible code into your source file that indicates where the line ends. Since this code may be different on different platforms (PC, Mac, and UNIX), you may have problems reading a source file created on a different platform. Luckily, many text editors include the ability to switch end-of-line codes and some, including the editors in WinEdt and TeXShop, do so automatically.

Finally, there are thirteen special keys that are mostly used in LATEX commands:

# \$ % & ~ \_ ^ \ { } @ " |

If you need to have these characters typeset in your document, there are commands to produce them. For instance, \$ is typed as \\$, the underscore, \_, is typed as \\_, and % is typed as \%. Only @ requires no special command, type @ to print @. There are also commands to produce composite characters, such as accented characters, for example ä, which is typed as \"{a}. See Section 5.4.4 for a complete discussion of symbols not available directly from the keyboard and Appendix C for the text symbol tables. Appendices B and C are reproduced in the samples folder as a PDF file, SymbolTables.pdf.

LATEX prohibits the use of other keys on your keyboard—unless you are using a version of LATEX that is set up to work with non-English languages (see Appendix G). When trying to typeset a source file that contains a prohibited character, LATEX displays an error message similar to the following:

- ! Text line contains an invalid character.
- 1.222 completely irreducible^^?

^^?

In this message, 1.222 means line 222 of your source file. You must edit that line to remove the character that LaTeX cannot understand. The log file (see Section D.3.4) also contains this message. For more about LaTeX error messages, see Sections 3.2 and 4.3.1.

## 2.2 Your first note

We start our discussion on how to type a note in LaTeX with a simple example. Suppose you want to use LaTeX to produce the following:

It is of some concern to me that the terminology used in multi-section math courses is not uniform.

In several sections of the course on matrix theory, the term "hamiltonian-reduced" is used. I, personally, would rather call these "hyper-simple". I invite others to comment on this problem.

Of special concern to me is the terminology in the course by Prof. Rudi Hochschwabauer. Since his field is new, there is no accepted terminology. It is imperative that we arrive at a satisfactory solution.

To produce this typeset document, create a new file in your work folder with the name note1.tex. Type the following, including the spacing and linebreaks shown, but not the line numbers:

```
1
    % Sample file: note1.tex
 2
    \documentclass{sample}
 3
 4
    \begin{document}
    It is of some concern to me
 5
    the terminology used in multi-section
 6
 7
     math courses is not uniform.
 8
 9
     In several sections of the course on
    matrix theory, the term
10
11
      "hamiltonian-reduced" is used.
      I, personally, would rather call these
12
     "hyper-simple". I invite others
13
14
     to comment on this problem.
15
16
    Of special concern to me is the terminology
     in the course by Prof.~Rudi Hochschwabauer.
17
18
    Since his field is new, there is no accepted
19
                    It is imperative
     terminology.
20
     that we arrive at a satisfactory solution.
21
     \end{document}
```

Alternatively, copy the note1.tex file from the samples folder (see page 4). Make sure that sample.cls is in your work folder.

The first line of note1.tex starts with %. Such lines are called *comments* and are ignored by LaTeX. Commenting is very useful. For example, if you want to add some notes to your source file and you do not want those notes to appear in the typeset version of your article, you can begin those lines with a %. You can also comment out part of a line:

simply put, we believe % actually, it's not so simple

Everything on the line after the % character is ignored by LATEX.

Line 2 specifies the *document class* (in our case, sample)<sup>1</sup> that controls how the document is formatted.

The text of the note is typed within the document environment, that is, between the lines

\begin{document}

and

\end{document}

Now typeset note1.tex. If you use WinEdt, click on the TeXify icon. If you use TeXShop, click the Typeset button. You should get the typeset document as shown on page 10. As you can see from this example, LaTeX is different from a word processor. It disregards the way you input and position the text, and follows only the formatting instructions given by the markup commands. LaTeX notices when you put a blank space in the text, but it ignores how many blank spaces have been inserted. LaTeX does not distinguish between a blank space (hitting the space bar), a tab (hitting the Tab key), and a single carriage return (hitting Return once). However, hitting Return twice gives a blank line; one or more blank lines mark the end of a paragraph.

Let  $ET_EX$ , by default, fully justifies text by placing a flexible amount of space between words—the *interword space*—and a somewhat larger space between sentences—the *intersentence space*. If you have to force an interword space, you can use the  $L_EX$  books, we use the symbol  $L_EX$  to mean a blank space). See Section 5.2.2 for a full discussion.

The ~ (tilde) command also forces an interword space, but with a difference; it keeps the words on the same line. This command is called a *tie* or *nonbreakable space* (see Section 5.4.3).

Note that on lines 11 and 13, the left double quotes are typed as '' (two left single quotes) and the right double quotes are typed as '' (two right single quotes or apostrophes). The left single quote key is not always easy to find. On an American keyboard,<sup>2</sup> it is usually hidden in the upper-left or upper-right corner of the keyboard, and shares a key with the tilde (~).

<sup>&</sup>lt;sup>1</sup>I know you have never heard of the sample document class. It is a special class created for these exercises. You can find it in the samples folder (see page 4). If you have not yet copied it over to the work folder, do so now.

<sup>&</sup>lt;sup>2</sup>The location of special keys on the keyboard depends on the country where the computer was sold. It also depends on whether the computer is a PC or a Mac. In addition, notebooks tend to have fewer keys than desktop computers. Fun assignment: Find the tilde (~) on a Spanish and on a Hungarian keyboard.

# 2.3 Lines too wide

LATEX reads the text in the source file one line at a time and when the end of a paragraph is reached, LATEX typesets the entire paragraph. Occasionally, LATEX gets into trouble when trying to split the paragraph into typeset lines. To illustrate this situation, modify note1.tex. In the second sentence, replace term by strange term and in the fourth sentence, delete Rudi, including the blank space following Rudi. Now save this modified file in your work folder using the name note1b.tex. You can also find note1b.tex in the samples folder (see page 4).

Typesetting note1b.tex, you obtain the following:

It is of some concern to me that the terminology used in multi-section math courses is not uniform.

In several sections of the course on matrix theory, the strange term "hamiltonian-reduced" is used. I, personally, would rather call these "hyper-simple". I invite others to comment on this problem.

Of special concern to me is the terminology in the course by Prof. Hochschwabauer. Since his field is new, there is no accepted terminology. It is imperative that we arrive at a satisfactory solution.

The first line of paragraph two is about 1/4 inch too wide. The first line of paragraph three is even wider. In the log window, LATEX displays the following messages:

```
Overfull \hbox (15.38948pt too wide) in paragraph at lines 9--15 []\OT1/cmr/m/n/10 In sev-eral sec-tions of the course on ma-trix the-ory, the strange term ''hamiltonian-
```

```
Overfull \hbox (23.27834pt too wide) in paragraph at lines 16--21 []\OT1/cmr/m/n/10 Of spe-cial con-cern to me is the ter-mi-nol-ogy in the course by Prof. Hochschwabauer.
```

You will find the same messages in the log file (see Sections 1.3 and D.2.1).

The first message,

```
Overfull \hbox (15.38948pt too wide) in paragraph at lines 9--15
```

refers to the second paragraph (lines 9–15 in the source file—its location in the typeset document is not specified). The typeset version of this paragraph has a line that is 15.38948 points too wide. LATEX uses *points* (pt) to measure distances; there are about 72 points in 1 inch (or about 28 points in 1 cm).

The next two lines.

[]\OT1/cmr/m/n/10 In sev-eral sec-tions of the course on ma-trix

the-ory, the strange term 'hamiltonian-

identify the source of the problem: LATEX did not properly hyphenate the word

hamiltonian-reduced

because it (automatically) hyphenates a hyphenated word *only at the hyphen*. The second reference.

```
Overfull \hbox (23.27834pt too wide) in paragraph at lines 16--21
```

is to the third paragraph (lines 16–21 of the source file). There is a problem with the word Hochschwabauer; LaTeX's standard hyphenation routine cannot handle it (a German hyphenation routine would have no difficulty hyphenating this name—see Appendix G). If you encounter such a problem, you can either try to reword the sentence or insert one or more *optional* (or discretionary) hyphen commands (\-), which tell LaTeX where it may hyphenate the word. In this case, you can rewrite Hochschwabauer as Hoch\-schwa\-bauer and the second hyphenation problem disappears. You can also utilize the \hyphenation command (see Section 5.4.9).

Sometimes a small horizontal overflow can be difficult to spot. The draft document class option may help (see Sections 11.5, 12.1.2, and 18.1 for more about document class options). LaTeX places a black box (or *slug*) in the margin to mark an overfull line. You can invoke this option by changing the \documentclass line to

\documentclass[draft]{sample}

A version of note1b.tex with this option can be found in the samples folder under the name noteslug.tex. Typeset it to see the "slugs".

# 2.4 More text features

Next, we produce the following note:

September 12, 2006

From the desk of George Grätzer

October 7–21 please use my temporary e-mail address:

George\_Gratzer@yahoo.com

Type in the source file, without the line numbers. Save it as note2.tex in your work folder (note2.tex can be found in the samples folder—see page 4):

```
% Sample file: note2.tex
 2
     \documentclass{sample}
 3
 4
     \begin{document}
     \begin{flushright}
 5
 6
        \today
 7
     \end{flushright}
 8
     \textbf{From the desk of George Gr\"{a}tzer}\\[22pt]
 9
     October~7--21 \emph{please} use my
10
     temporary e-mail address:
11
     \begin{center}
12
        \texttt{George\_Gratzer@yahoo.com}
13
     \end{center}
14
     \end{document}
```

This note introduces several additional text features of LATEX:

- The \today command (in line 6) to display the date on which the document is typeset (so you will see a date different from the date shown above in your own typeset document).
- The environments to *right justify* (lines 5–7) and *center* (lines 11-13) text.
- The commands to change the text style, including the \emph command (line 8) to *emphasize* text, the \textbf command (line 9) for **bold** text, and the \texttt command (line 12) to produce typewriter style text.

These are *commands with arguments*. In each case, the argument of the command follows the name of the command and is typed between braces, that is, between { and }.

- The form of the LaTeX commands: Almost all LaTeX commands start with a backslash (\) followed by the command name. For instance, \textbf is a command and textbf is the command name. The command name is terminated by the first non-alphabetic character, that is, by any character other than a-z or A-Z. So textbf1 is not a command name, in fact, \textbf1 typesets as 1. (Let us look at this a bit more closely. \textbf is a valid command. If a command needs an argument and is not followed by braces, then it takes the next character as its argument. So \textbf1 is the command \textbf with the argument 1, which typesets as bold 1: 1.) Note that command names are case sensitive. Typing \Textbf or \TEXTBF generates an error message.
- The multiple role of hyphens: Double hyphens are used for number ranges. For example, 7--21 (in line 9) typesets as 7-21. The punctuation mark is called an *en*

15

*dash*. Use triple hyphens for the *em dash* punctuation mark—such as the one in this sentence.

- The *new line* command, \\ (or \newline): To create additional space between lines (as in the last note, under the line **From the desk...**), you can use the \\ command and specify an appropriate amount of vertical space: \\[22pt]. Note that this command uses *square brackets* rather than braces because the argument is *optional*. The distance may be given in points (pt), centimeters (cm), or inches (in). (There is an analogous *new page* command, \newpage, not used in this short note.)
- Special rules for special characters (see Section 2.1), for accented characters and for some European characters. For instance, the accented character \(\text{\tilde{a}}\) is typed as \"{a}. Accents are explained in Section 5.4.7 (see also the tables in Section C.2).

When you need to know more about typing text than we have discussed here, see Chapters 5 and 6. See also Appendix C, where all text symbols are organized into tables. Recall that we also have the SymbolTables.pdf in the samples folder.

# Typing math

While marking up text in LaTeX is easy, marking up math is less intuitive because math formulas are two-dimensional constructs and we have to mark them up with a one-dimensional string of characters. However, even the most complicated two-dimensional formula is made up of fairly simple building blocks. So by concentrating on the building blocks—selectively, just learn the ones you need—you can get started with math quickly.

# 3.1 A note with math

In addition to the regular text keys and the 13 special keys discussed in Section 2.1, two more keys are used to type math:

< >

The formula 2 < |x| > y (typed as \$2 < |x| > y\$) uses both. Note that such math formulas, called *inline*, are enclosed by \$ symbols. We discuss shortly another kind of math formula called *displayed*.

We begin typesetting math with the following note:

In first-year calculus, we define intervals such as (u, v) and  $(u, \infty)$ . Such an interval is a *neighborhood* of a if a is in the interval. Students should realize that  $\infty$  is only a symbol, not a number. This is important since we soon introduce concepts such as  $\lim_{x\to\infty} f(x)$ .

When we introduce the derivative

$$\lim_{x \to a} \frac{f(x) - f(a)}{x - a},$$

we assume that the function is defined and continuous in a neighborhood of a.

To create the source file for this mixed text and math note, create a new document with your text editor. Name it math.tex, place it in the work folder, and type in the following source file—without the line numbers—or simply copy math.tex from the samples folder (see page 4):

```
% Sample file: math.tex
 1
 2
     \documentclass{sample}
 3
    \begin{document}
 4
    In first-year calculus, we
 5
                                  define intervals such
 6
    as (u, v) and (u, \inf ty). Such an interval
 7
     is a \emph{neighborhood} of $a$
 8
     if $a$ is in the interval. Students should
    realize that $\infty$ is only a
9
     symbol, not a number. This is important since
10
     we soon introduce concepts
11
      such as \lim_{x \to \infty} f(x) .
12
13
14
    When we introduce the derivative
15
        \lim_{x \to a} \frac{f(x) - f(a)}{x - a}
16
17
18
    we assume that the function is defined and
19
     continuous in a neighborhood of
20
     \end{document}
```

This note introduces several basic concepts of math in L<sup>A</sup>T<sub>E</sub>X:

- There are two kinds of math formulas and environments in math.tex:
  - Inline math environments open and close with \$ (as seen throughout this book) or open with \( (and close with \).
  - *Displayed* math environments open with \[ and close with \].

3.2 Errors in math

• Within math environments, LATEX uses its own spacing rules and completely ignores the white space you type, with two exceptions:

- Spaces that terminate commands. So in \$\infty a\$ the space is not ignored, \$\inftya\$ produces an error.
- Spaces in the arguments of commands that temporarily revert to regular text. \text is such a command (see Sections 3.3 and 7.4.6).

The white space that you add when typing math is important only for the readability of the source file. We summarize with a simple rule.

# Rule ■ Spacing in text and math

Many spaces equal one space in text, whereas your spacing is ignored in math, unless the space terminates a command.

- A math symbol is invoked by a command. For example, the command for ∞ is \infty and the command for → is \to. The math symbols are organized into tables in Appendix B (see also SymbolTables.pdf in the samples folder).
- Some commands, such as \sqrt, need *arguments* enclosed by { and }. To typeset  $\sqrt{5}$ , type \$\sqrt{5}\$, where \sqrt is the command and 5 is the argument. Some commands need more than one argument. To get

$$\frac{3+x}{5}$$

```
type
\[
   \frac{3+x}{5}
\]
```

where \frac is the command, 3+x and 5 are the arguments—we indent for readability.

# 3.2 Errors in math

Even in such a simple note there are opportunities for errors. To help familiarize yourself with some of the most commonly seen LATEX math errors and their causes, we deliberately introduce mistakes into math.tex. The version of math.tex with mistakes is mathb.tex. By inserting and deleting % signs, you make the mistakes visible to LATEX one at a time—recall that lines starting with % are comments and are therefore ignored by LATEX.

Type the following source file, and save it under the name mathb.tex in the work folder or copy the file mathb.tex from the samples folder (see page 4). Do not type the line numbers—they are shown here to help you with the experiments.

```
1
    % Sample file: mathb.tex
 2
    \documentclass{sample}
 3
 4
    \begin{document}
 5
    In first-year calculus, we define intervals such
 6
    % as (u, v) and (u, \inf ty). Such an interval
    as (u, v) and (u, \inf v). Such an interval
 7
8
    is a \emph{neighborhood} of $a$
    if $a$ is in the interval. Students should
10
    realize that $\infty$ is only a
11
     symbol, not a number. This is important since
12
    we soon introduce concepts
      such as \lim_{x \to \infty} f(x).
13
14
    such as <math>\lim_{x \to \infty} f(x) .
15
16
    When we introduce the derivative
17
    1/
18
        \lim_{x \to a} \frac{f(x) - f(a)}{x - a}
19
        \lim_{x \to a} \frac{f(x) - f(a) x - a}
    %
20
    \1
21
    we assume that the function is defined and
22
     continuous in a neighborhood of
23
     \end{document}
```

**Experiment 1** In line 7, the \$ before the (u is missing. Typeset the mathb.tex source file. LATEX generates the following error message:

Since the \$ was omitted, LaTeX reads (u, \infty) as text; but the \infty command instructs LaTeX to typeset a math symbol, which can only be done in a math formula. So LaTeX offers to put a \$ in front of \infty while typesetting the source file—it does not put the \$ in the source file itself. LaTeX attempts a cure, but in this example it comes too late, because the math formula should start just before (u.

3.2 Errors in math

Whenever you see the ? prompt, you may press Return to ignore the error and continue typesetting the document. Section D.4 lists a number of other options and prompts.

**Experiment 2** Uncomment line 6 by deleting the % at the beginning of line 6 and comment out line 7 by inserting a % at the beginning of line 7. This eliminates the previous error. Uncomment line 14 and comment out line 13. This introduces a new error, the closing brace of the subscript is missing. Now typeset the note. You get the error message

LATEX reports that a closing brace (}) is missing, but it is not sure where the brace should be. LATEX noticed that a subscript (see page 23) started with {, but LATEX reached the end of the math formula before finding a closing brace }. To remedy this, you must look in the formula for an opening brace { that is not balanced, and insert the missing closing brace }. Make the necessary change and typeset again to view the difference.

**Experiment 3** Uncomment line 13 and comment out line 14, removing the previous error. Delete the % at the beginning of line 19 and insert a % at the beginning of line 18, introducing our final error, omitting the closing brace of the first argument and the opening brace of the second argument of \frac Save and typeset the file. You get the error message

```
! Too many }'s.
\frac #1#2->{\begingroup #1\endgroup \@@over #2}
```

1.20 \]

LATEX got confused. The second line of the message explains that \frac has two arguments and it is not working out, but the error is incorrectly identified.

If the typo on line 19 is  $\frac{f(x)-f(a)}{x-a}g$ , then LATEX produces

$$\frac{f(x) - f(a)x - a}{g}$$

and no error message is generated.

**Experiment 4** Make sure all the errors are commented out. Typeset mathb.tex, testing that there are no errors. Now delete the two \$ signs in line 22, that is, replace \$a\$ by a. Typeset the file. It typesets with no errors. Here is the last line of the typeset file you get:

we assume that the function is defined and continuous in a neighborhood of a. instead of  $\ \ \ \ \ \$  we assume that the function is defined and continuous in a neighborhood of a.

This is probably the error most often made by beginners. There is no error message by LATEX and the typeset version looks good. You need sharp eyes to catch such an error

See Section 4.3.1 for more information about finding and fixing problems in your LATEX source files.

# 3.3 Building blocks of a formula

A formula is built from a large collection of components. We group them as follows:

- Arithmetic
  - Subscripts and superscripts
- Binomial coefficients
- Congruences
- Delimiters
- Ellipses
- Integrals
- Math accents
- Matrices
- Operators
  - Large operators
- Roots
- Text

In this section, I describe each of these groups, and provide examples illustrating their use.

**Arithmetic** The arithmetic operations a + b, a - b, -a, a/b, and ab are typed in the natural way (the spaces are typed only for readability, others may type fewer spaces):

$$a + b$$
,  $a - b$ ,  $-a$ ,  $a / b$ ,  $a b$ 

If you wish to use  $\cdot$  or  $\times$  for multiplication, as in  $a \cdot b$  or  $a \times b$ , use \cdot or \times, respectively. The expressions  $a \cdot b$  and  $a \times b$  are typed as follows:

\$a \cdot b\$ \$a \times b\$

Displayed fractions, such as

$$\frac{1+2x}{x+y+xy}$$

are typed with \frac:

The \frac command is seldom used inline because it can disrupt the interline spacing of the paragraph.

**Subscripts and superscripts** Subscripts are typed with \_ (underscore) and superscripts with ^ (caret). Subscripts and superscripts should be enclosed in braces, that is, typed between { and }. To get  $a_1$ , type  $a_{10}$ . Omitting the braces in this example causes no harm, but to get  $a_{10}$ , you *must* type  $a_{10}$ . Indeed,  $a_{10}$  is typeset as  $a_{10}$ . Further examples,  $a_{i1}$ ,  $a_{$ 

$$a_{i_{1}}$$
,  $a^{2}$ ,  $a^{i_{1}}$ ,  $a_{n}^{2}$ 

There is one symbol, the prime ('), that is automatically superscripted in math. To get f'(x), just type f'(x).

**Binomial coefficients** Binomial coefficients are typeset with the \binom command. For example,  $\binom{a}{b+c}$  is typed inline as

$$\infty {binom{a}{b + c}}$$

whereas a displayed version,

$$\binom{\frac{n^2-1}{2}}{n+1}$$

is typed as

**Congruences** The two most important forms are

$$a \equiv v \pmod{\theta}$$
 typed as \$a \equiv v \pmod{\theta}\$  $a \equiv v \pmod{\theta}$  typed as \$a \equiv v \pod{\theta}\$

**Delimiters** Parentheses and square brackets are examples of delimiters. They are used to delimit some subformulas, as in  $(a*b)+(c*d)^{2}$ , which typesets as  $[(a*b)+(c*d)]^{2}$ . Let  $(a*b)+(c*d)^{2}$ . Let  $(a*b)+(c*d)^{2}$  can be instructed to expand them vertically to enclose a formula such as

$$\left(\frac{1+x}{2+y^2}\right)^2$$

which is typed as

The \left( and \right) commands tell LaTeX to size the parentheses correctly, relative to the size of the symbols inside the parentheses. Two further examples,

$$\left|\frac{a+b}{2}\right|, \quad \left\|A^2\right\|$$

would be typed as

where \quad is a spacing command (see Sections 8.1 and B.9).

Additional delimiters are listed in Sections 7.5 and B.6.

**Ellipses** The *ellipsis* (...) in text is provided by the \dots command:

In formulas, the ellipsis is printed either as *low* (or *on-the-line*) *dots*:

$$F(x_1,\ldots,x_n)$$
 is typed as  $F(x_{1}, \ldots, x_n)$ 

or as centered dots:

$$x_1 + \cdots + x_n$$
 is typed as  $x_{1} + \cdot \cdot + x_n$  is typed as

The command \dots typesets the correct ellipsis with the correct spacing in most cases. If it does not, see Section 7.4.3 on how to specify the appropriate ellipsis from the four types available.

**Integrals** The command for an integral is \int. The lower limit is specified as a subscript and the upper limit is specified as a superscript. For example, the formula  $\int_0^{\pi} \sin x \, dx = 2$  is typed as

$$\int_{0}^{\pi} \sin x , dx = 2$$

where  $\setminus$ , is a spacing command (see Sections 8.1 and B.9).

Math accents The four most frequently used math accents are:

- $\bar{a}$  typed as  $\alpha$
- $\hat{a}$  typed as  $\hat{a}$
- $\tilde{a}$  typed as  $\star \tilde{a}$
- $\vec{a}$  typed as  $\c {a}$

See Sections 7.7 and B.8 for complete lists.

**Matrices** You type the matrix

$$a+b+c$$
  $uv$   $x-y$  27  
 $a+b$   $u+v$   $z$  134

with the \matrix command

```
\[
   \begin{matrix}
    a + b + c & uv & x - y & 27\\
    a + b & u + v & z & 134
   \end{matrix}
\]
```

The matrix environment separates adjacent matrix elements within a row with ampersands (&). Rows are *separated* by new line commands (\\). Do not end the last row with a new line command!

The matrix environment has to appear within a math environment, as in the example. As a rule, it is in a displayed math environment, since inline it appears too large. It can be used in the align environment discussed in Section 3.4.2.

The matrix environment does not provide delimiters. Several variants do, including pmatrix and vmatrix. For example,

$$\mathbf{A} = \begin{pmatrix} a+b+c & uv \\ a+b & u+v \end{pmatrix} \begin{vmatrix} 30 & 7 \\ 3 & 17 \end{vmatrix}$$

is typed as follows:

```
\[
\mathbf{A} =
\begin{pmatrix}
    a + b + c & uv\\
    a + b & u + v
\end{pmatrix}
\begin{vmatrix}
    30 & 7\\
    3 & 17
\end{vmatrix}
\]
```

As you can see, pmatrix typesets as a matrix between a pair of \left( and \right) commands, while vmatrix typesets as a matrix between a pair of \left| and \right| commands. See Section 9.7.1 for a listing of all the matrix variants.

**Operators** To typeset the sine function,  $\sin x$ , type  $\sin x$ .

Note that sin x would be typeset as sin x because LaTeX interprets this expression as the product of four variables.

LATEX calls \sin an *operator*. Sections 7.6.1 and B.7 list a number of operators. See Section 7.6.2 for user-defined operators. Some are just like \sin. Others produce a more complex display, for example,

$$\lim_{x \to 0} f(x) = 0$$

is typed as

**Large operators** The command for *sum* is \sum and for *product* is \prod. The following examples,

$$\sum_{i=1}^{n} x_i^2 \qquad \prod_{i=1}^{n} x_i^2$$

are typed as

where \qquad is a spacing command (see Sections 8.1 and B.9) used to separate the two formulas, yielding twice the space produced by \quad.

Sums and products are examples of *large operators*. They are typeset bigger when displayed than inline. They are listed in Sections 7.6.4 and B.7.1.

**Roots** \sqrt produces a square root. For instance,  $\sqrt{a+2b}$  is typed as

$$\frac{a + 2b}$$

The *n*-th root,  $\sqrt[n]{5}$ , requires the use of an *optional argument*, which is specified using brackets (see Section 5.3.1):  $\sqrt[n]{5}$ .

**Text** You can include text in a formula with a \text command. For instance,

$$a = b$$
, by assumption

is typed as

Note the spacing command \qquad in the argument of \text. You could also type

because \qquad works in math as well as in text (see Sections 8.1 and B.9).

# 3.4 Displayed formulas

# 3.4.1 Equations

The equation environment creates a displayed math formula and automatically generates an equation number. The equation

$$\int_0^\pi \sin x \, dx = 2$$

is typed as

```
\begin{equation}\label{E:firstInt}
\int_{0}^{\pi} \sin x \, dx = 2
\end{equation}
```

The equation number, which is automatically generated, depends on how many other numbered equations occur before the given equation.

To reference this formula without having to remember a number—which may change when you edit your document—give the equation a symbolic label by using the \label command and refer to the equation in your document by using the symbolic label, the argument of the \label command. In this example, I have called the first equation firstInt (first integral), and used the convention that the label of an equation starts with E:, so that the complete \label command is

```
\label{E:firstInt}
```

The number of this formula is referenced with the \ref command. Its page is referenced using the \pageref command. For example, to get

```
see (1) on page 27
type
see~(\ref{E:firstInt}) on page~\pageref{E:firstInt}
```

The \eqref command provides the reference number in parentheses. So the last example could be typed

```
see~\eqref{E:firstInt} on page~\pageref{E:firstInt}
```

The \eqref command is smart. Even if the equation number is referenced in emphasized or italicized text, the reference typesets upright (in roman type).

Note the use of the nonbreakable space (~) to ensure that when typeset the equation number is on the same line as the word see. (See the footnote on page 11.) You should always use a nonbreakable space to link a \ref command to the name of its part, for instance, equation, page, section, chapter. Use two nonbreakable spaces in

```
Sections \ref{S:main} and \ref{S:subsidiary}.
```

The main advantage of this cross-referencing system is that when you add, delete, or rearrange equations, LaTeX automatically renumbers the equations and adjusts the references that appear in your typeset document. You can split a long article into two or move a section to the end, and LaTeX takes care of the renumbering. This significantly reduces the amount of time you need to spend working on your document. It also reduces the potential for errors in the finished project.

#### Rule ■ Typeset twice

For renumbering to work, you have to typeset the source file twice.

The first run creates a list of references that need to be linked. The second creates the cross references and inserts the relevant text throughout the document (see Sections 18.2 and D.3.4). LATEX issues a warning if you forget. Such warnings do not interrupt the typesetting, you only see them in the log window—if the window is visible—and in the log file. It is a good idea to check for warnings periodically.

An equation is numbered whether or not there is a \label command attached to it. Of course, if there is no \label command, the number generated for the equation by Label command \ref or \eqref.

The system described here is called *symbolic referencing*. The symbol for the number is the argument of the \label command, and that symbol can be referenced with \ref, \eqref, or \pageref commands. LaTeX uses the same mechanism for all of the generated numbering systems: sections, subsections, subsubsections, equations, theorems, lemmas, and bibliographic references—except that for bibliographic references, LaTeX uses the \bibitem command to define a bibliographic item and the \cite command to cite a bibliographic item (see Section 4.2.4 and Chapter 16).

What happens if you misspell a reference, e.g., typing \ref{E:firstint} instead of \ref{E:firstInt}? LaTeX typesets ??. There are two warnings in the log file:

```
LaTeX Warning: Reference 'E:firstint' on page 39 undefined on input line 475.
```

for the typeset page and the other one close to the end:

LaTeX Warning: There were undefined references.

If a \cite is misspelled, you get [?] and similar warnings.

Equations can also be *tagged* by attaching a name to the formula with the \tag command. The tag replaces the equation number.

For example,

(Int) 
$$\int_0^{\pi} \sin x \, dx = 2$$

is typed as

```
\begin{equation}
\int_{0}^{\pi} \sin x \, dx = 2 \tag{Int}
\end{equation}
```

Tags (of the type discussed here) are *absolute*. This equation is *always* referred to as (Int). Equation numbers, on the other hand, are *relative*, they may change when equations are added, deleted, or rearranged.

# 3.4.2 Aligned formulas

LATEX has many ways to typeset multiline formulas. We discuss three constructs in this section: *simple alignment, annotated alignment,* and *cases*. See Chapter 9 for many others.

For simple and annotated alignment we use the align environment. Each line in the align environment is a separate equation, which LATEX automatically numbers.

#### Simple alignment

Simple alignment is used to align two or more formulas. To obtain the formulas

(2) 
$$r^2 = s^2 + t^2,$$

$$(3) 2u + 1 = v + w^{\alpha},$$

$$(4) x = \frac{y+z}{\sqrt{s+2u}};$$

type the following, using \\ as the *line separator* and & as the *alignment point*:

Note that you should not have a \\ to terminate the last line.

Figure 3.1 displays the source and the typeset versions of formulas (2)–(4), emphasizing the alignment points of the source and the typeset formula. Of course, in the source, the alignment points do not have to line up.

These formulas are numbered (2), (3), and (4) because they are preceded by one numbered equation earlier in this section.

The align environment can also be used to break a long formula into two or more parts. Since numbering both lines in such a case would be undesirable, you can prevent the numbering of the second line by using the \notag command in the second part of the formula.

For example,

(5) 
$$h(x) = \int \left( \frac{f(x) + g(x)}{1 + f^2(x)} + \frac{1 + f(x)g(x)}{\sqrt{1 - \sin x}} \right) dx$$
$$= \int \frac{1 + f(x)}{1 + g(x)} dx - 2\tan^{-1}(x - 2)$$

is typed as follows:

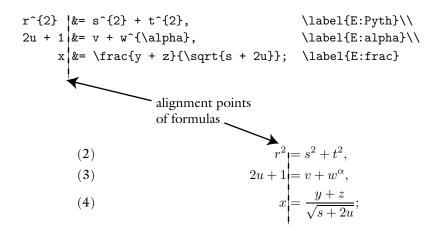


Figure 3.1: Simple alignment: source and typeset.

```
+ \frac{1+ f(x)g(x)}{\sqrt{1 - \sin x}}
    \right) \, dx\label{E:longInt}\\
&= \int \frac{1 + f(x)}{1 + g(x) } \, dx
    - 2 \tan^{-1}(x-2)\notag
\end{align}
```

The rules for simple alignment are easy to remember.

#### Rule Simple alignments

- Use the align environment.
- Separate the lines with \\.
- In each line, indicate the alignment point with &, one & per line. If the alignment point is adjacent to an =, +, and so on, place it *before* to ensure proper spacing.
- Place a \notag command in each line that you do not wish numbered.
- If no line should be numbered, use the align\* environment.
- Place a \label command in each numbered line you may want to reference with \ref, \eqref, or \pageref.

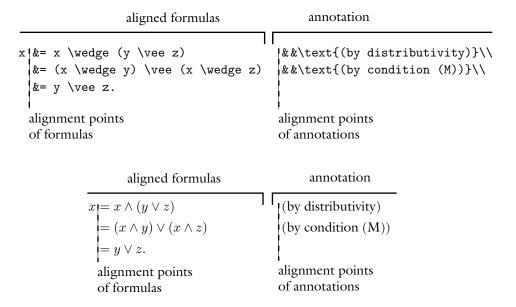


Figure 3.2: Annotated alignment: source and typeset.

#### Annotated alignment

Annotated alignment allows you to align formulas and their annotations, that is, explanatory text, separately (see Figure 3.2):

(6) 
$$x = x \land (y \lor z)$$
 (by distributivity)  
=  $(x \land y) \lor (x \land z)$  (by condition (M))  
=  $y \lor z$ .

This example is typed as

```
\begin{align}
    x &= x \wedge (y \vee z)
    &&\text{(by distributivity)}\label{E:DoAlign}\\
    &= (x \wedge y) \vee (x \wedge z)
    &&\text{(by condition (M))} \notag\\
    &= y \vee z. \notag
\end{align}
```

The rules for annotated alignment are similar to the rules of simple alignment. In each line, in addition to the alignment point marked by &, there is also a mark for the start of the annotation: &&.

33

### 3.4.3 Cases

The cases construct is a specialized matrix. It has to appear within a math environment such as the equation environment (see Section 3.4.1) or the align environment (see Section 3.4.2). Here is a typical example:

$$f(x) = \begin{cases} -x^2, & \text{if } x < 0; \\ \alpha + x, & \text{if } 0 \le x \le 1; \\ x^2, & \text{otherwise.} \end{cases}$$

is typed as follows:

Notice how you can put inline math, opened and closed with \$, inside the argument of a \text command.

The rules for using the cases environment are the same as for matrices. Separate the lines with  $\$  and indicate the annotation with &.

# Your first article and presentation

# 4.1 The anatomy of an article

To begin, we use the sample article intrart.tex (in the samples folder) to examine the anatomy of an article. Copy it over to the work folder or type it, and save it in the work folder as we discuss the parts of an article.

Every Larticle has two parts, the preamble and the body. The *preamble* of an article is everything from the first line of the source file down to the line

\begin{document}

For a schematic view of an article, see Figure 4.1.

The preamble contains instructions affecting the entire document. The *only* required command in the preamble is the \documentclass command. There are other commands (such as the \usepackage commands) that must be placed in the preamble if they are used, but these commands do not have to be present in every document.

Here is the preamble of the introductory sample article:

```
% Introductory sample article: intrart.tex
\documentclass{amsart}
\usepackage{amssymb,latexsym}
\usepackage{graphicx}
\newtheorem{theorem}{Theorem}
\newtheorem{lemma}{Lemma}
\newtheorem{definition}{Definition}
\newtheorem{notation}{Notation}
```

The preamble specifies the *document class* and then the LATEX enhancements, or *packages*, used in the article. The preamble can also specify additional commands that are used throughout the document, such as proclamation definitions, user-defined commands, and so on.

intrart.tex specifies the amsart document class. This class defines the format used by the AMS journals—and many others—for articles. LATEX then loads two pack-

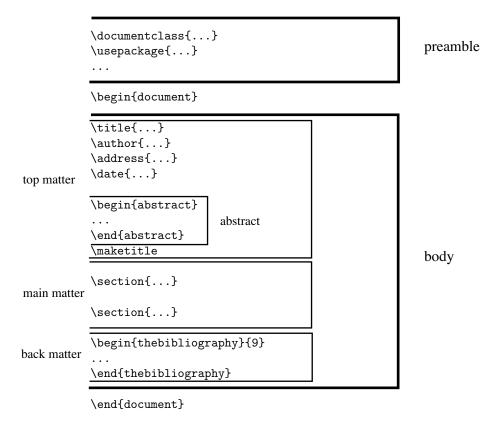


Figure 4.1: A schematic view of an article.

ages, latexsym and amssymb, that provide the names of some mathematical symbols. Finally, LATEX loads the graphicx package, which we need because of the illustration.

The preamble concludes with the *proclamations*. A proclamation is a theorem, lemma, definition, corollary, note, or other similar construct. The intrart.tex article defines four proclamations. The first of these,

```
\newtheorem{theorem}{Theorem}
```

defines the theorem environment, which then can be used in the body of the article, as explained in Section 4.2.3. The other three are similar. LATEX automatically numbers and formats proclamations.

The article proper, called the *body*, is the content of the document environment—it is between the lines

```
\begin{document}
and
\end{document}
```

as illustrated in Figure 4.1. The body of an article is split into several parts, starting with the *top matter* containing title page information and the abstract. The top matter follows the line

```
\begin{document}
and concludes with the line
\maketitle
Here is the top matter of the introductory sample article:
\title{A construction of complete-simple\\
       distributive lattices}
\author{George~A. Menuhin}
\address{Computer Science Department\\
         University of Winnebago\\
         Winnebago, MN 53714}
\date{March 15, 2006}
\begin{abstract}
In this note, we prove that there exist
\emph{complete-simple distributive lattices,}
that is, complete distributive lattices
with only two complete congruences.
```

\maketitle

\end{abstract}

And here is the rest of the body of the introductory sample article with some commentary, exclusive of the bibliography:

```
\section{Introduction}\label{S:intro}
In this note, we prove the following result:
\begin{theorem}
There exists an infinite complete distributive
lattice~$K$ with only the two trivial complete
congruence relations.
\end{theorem}
\section{The $\Pi^{*}$ construction}\label{S:P*}
The following construction is crucial in the proof
of our Theorem (see Figure \ref{Fi:products}):
\begin{definition}\label{D:P*}
Let D_{i}\, for i \in I, be complete distributive
lattices satisfying condition \textup{(J)}. Their
$\Pi^{*}$ product is defined as follows:
١/
  \pi^{*} (D_{i} \in I) =
  \Phi (D_{i}^{-} \in I) + 1;
\1
that is, \Phi^* ( D_{i} \mid i \in I )$ is
\Phi (D_{i}^{-} \in I)  with a new
unit element.
\end{definition}
\begin{notation}
If i \in I and d \in D_{i}^{-}, then
1/
  \langle \dots, 0, \dots, d, \dots, 0, \dots \rangle
\1
is the element of \pi^{*} (D_{i} \in I)  whose
$i$-th component is $d$ and all the other components
are $0$.
\end{notation}
See also Ernest~T. Moynahan~\cite{eM57a}.
Next we verify the following result:
```

```
\begin{theorem}\label{T:P*}
Let $D_{i}$, $i \in I$, be complete distributive
lattices satisfying condition~\textup{(J)}.
Let $\Theta$ be a complete congruence relation on
$\Pi^{*} ( D_{i} \mid i \in I )$.
If there exist $i \in I$ and $d \in D_{i}$ with
$d < 1_{i}$ such that, for all $d \leq c < 1_{i}$,
\begin{equation}\label{E:cong1}
\langle \dots, d, \dots, 0, \dots \rangle \equiv \langle \dots, c, \dots, 0, \dots \rangle
\pod{\Theta},
\end{equation}
then $\Theta = \iota$.
\end{theorem}</pre>
```

We include an illustration, products.eps or products.pdf (in your samples folder). We copy them over to the work folder and load the graphicx package. We name the illustration in the figure environment. The illustration must be in the graphic image file formats EPS or PDF (see Chapter 13.1.2). We left the argument of the \caption command empty—it normally contains the name or a description of the figure. The illustration is centered with the \centering command (see Section 6.3).

```
\begin{figure}[hbt]
\centering\includegraphics{products}
\caption{}\label{Fi:products}
\end{figure}
```

The figure environment *floats*, that is, LaTeX decides where to place the typeset figure. We can influence LaTeX's choice (see Section 10.4.3).

Then we place a proof in a proof environment.

```
\begin{proof}
Since
\begin{equation}\label{E:cong2}
\langle \dots, d, \dots, 0, \dots \rangle \equiv
\langle \dots, c, \dots, 0, \dots \rangle
\pod{\Theta},
\end{equation}
and $\Theta$ is a complete congruence relation,
it follows from condition~(J) that
\begin{equation}\label{E:cong}
\langle \dots, d, \dots, 0, \dots \rangle \equiv
\bigvee ( \langle \dots, c, \dots, 0, \dots \rangle
\mid d \leq c < 1 ) \pod{\Theta}.</pre>
```

```
\end{equation}
Let j \in I, j \in I, and let a \in D_{j}^{-}.
Meeting both sides of the congruence \eqref{E:cong2}
with $\langle \dots, a, \dots, 0, \dots \rangle$,
we obtain that
\begin{equation}\label{E:comp}
   0 = \langle \dots, a, \dots, 0, \dots \rangle
     \pod{\Theta},
\end{equation}
Using the completeness of $\Theta$ and \eqref{E:comp},
we get:
\[
   0 \equiv \bigvee ( \langle \dots, a, \dots, 0,
     \dots \rangle \mid a \in D_{\{j\}}^{-} ) = 1
     \pod{\Theta},
\1
hence \frac{1}{100} hence \frac{1}{100} hence \frac{1}{100} hence \frac{1}{100}
\end{proof}
At the end of the body, the bibliographic entries are typed between the lines
\begin{thebibliography}{9}
and
\end{thebibliography}
```

There are fewer than 10 references in this article, so we tell LATEX to make room for single-digit numbering by providing the argument 9 to the thebibliography environment. We use 99 if the number of references is between 10 and 99. The typeset bibliography is titled References.

The bibliography of intrart.tex is structured as follows:

\begin{thebibliography}{9}

```
\bibitem{sF90}
Soo-Key Foo,
\emph{Lattice Constructions},
Ph.D. thesis,
University of Winnebago, Winnebago, MN, December, 1990.
\bibitem{gM68}
George~A. Menuhin,
```

```
\emph{Universal algebra}.
D.~Van Nostrand, Princeton, 1968.
\bibitem{eM57}
Ernest~T. Moynahan,
\emph{On a problem of M. Stone},
Acta Math. Acad. Sci. Hungar. \textbf{8} (1957),
455--460.
\bibitem{eM57a}
Ernest~T. Moynahan,
\emph{Ideals and congruence relations in
lattices}. II,
Magyar Tud. Akad. Mat. Fiz. Oszt. K\"{o}zl.
\text{textbf}{9} (1957), 417--434.
\end{thebibliography}
The body and the article end when the document environment is closed with
\end{document}
```

# 4.1.1 The typeset sample article

On the next two pages, you find the typeset intrart.tex, the introductory sample article.

# A CONSTRUCTION OF COMPLETE-SIMPLE DISTRIBUTIVE LATTICES

#### GEORGE A. MENUHIN

ABSTRACT. In this note, we prove that there exist complete-simple distributive lattices, that is, complete distributive lattices with only two complete congruences.

#### 1. Introduction

In this note, we prove the following result:

**Theorem 1.** There exists an infinite complete distributive lattice K with only the two trivial complete congruence relations.

#### 2. The $\Pi^*$ construction

The following construction is crucial in the proof of our Theorem (see Figure 1):

**Definition 1.** Let  $D_i$ , for  $i \in I$ , be complete distributive lattices satisfying condition (J). Their  $\Pi^*$  product is defined as follows:

$$\Pi^*(D_i \mid i \in I) = \Pi(D_i^- \mid i \in I) + 1;$$

that is,  $\Pi^*(D_i \mid i \in I)$  is  $\Pi(D_i^- \mid i \in I)$  with a new unit element.

**Notation 1.** If  $i \in I$  and  $d \in D_i^-$ , then

$$\langle \dots, 0, \dots, d, \dots, 0, \dots \rangle$$

is the element of  $\Pi^*(D_i \mid i \in I)$  whose i-th component is d and all the other components are 0.

See also Ernest T. Moynahan [4].

Next we verify the following result:

**Theorem 2.** Let  $D_i$ ,  $i \in I$ , be complete distributive lattices satisfying condition (J). Let  $\Theta$  be a complete congruence relation on  $\Pi^*(D_i \mid i \in I)$ . If there exist  $i \in I$  and  $d \in D_i$  with  $d < 1_i$  such that, for all  $d \le c < 1_i$ ,

(1) 
$$\langle \dots, d, \dots, 0, \dots \rangle \equiv \langle \dots, c, \dots, 0, \dots \rangle$$
 ( $\Theta$ ),

then  $\Theta = \iota$ .

Proof. Since

(2) 
$$\langle \dots, d, \dots, 0, \dots \rangle \equiv \langle \dots, c, \dots, 0, \dots \rangle$$
 ( $\Theta$ ),

and  $\Theta$  is a complete congruence relation, it follows from condition (J) that

(3) 
$$\langle \dots, d, \dots, 0, \dots \rangle \equiv \bigvee (\langle \dots, c, \dots, 0, \dots \rangle \mid d \le c < 1)$$
 ( $\Theta$ ).

Date: March 15, 2006.

1

#### GEORGE A. MENUHIN

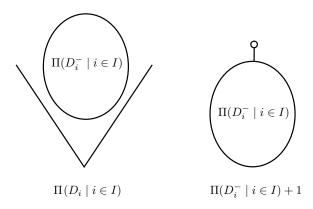


Figure 1

Let  $j \in I$ ,  $j \neq i$ , and let  $a \in D_j^-$ . Meeting both sides of the congruence (2) with  $\langle \dots, a, \dots, 0, \dots \rangle$ , we obtain that

$$(4) 0 = \langle \dots, a, \dots, 0, \dots \rangle (\Theta),$$

Using the completeness of  $\Theta$  and (4), we get:

$$0 \equiv \bigvee (\langle \dots, a, \dots, 0, \dots \rangle \mid a \in D_j^-) = 1 \quad (\Theta),$$

hence  $\Theta = \iota$ .

#### References

- Soo-Key Foo, Lattice Constructions, Ph.D. thesis, University of Winnebago, Winnebago, MN, December, 1990.
- [2] George A. Menuhin, Universal algebra. D. Van Nostrand, Princeton, 1968.
- [3] Ernest T. Moynahan, On a problem of M. Stone, Acta Math. Acad. Sci. Hungar. 8 (1957), 455–460.
- [4] Ernest T. Moynahan, Ideals and congruence relations in lattices. II, Magyar Tud. Akad. Mat. Fiz. Oszt. Közl. 9 (1957), 417–434.

Computer Science Department, University of Winnebago, Winnebago, MN 53714

# 4.2 An article template

In this section, you create an article template. To start a new article, open the template and start writing!

Make a copy of intrart.tex and give the copy an appropriate name. I named mine gg.tex (it is in the samples folder). Remember the naming rule (page 4): The name should have no spaces, no special characters, and end with .tex. So the name my template.tex is not good, but MyTemplate.tex is fine.

# 4.2.1 Editing the top matter

Edit the top matter to contain the relevant information, e.g., title and address, for your template. Here are some simple rules to follow.

### **Rule** ■ Top matter

- 1. \thanks places an unmarked footnote at the bottom of the first page, for instance to acknowledge research support. If it is not needed, comment it out.
- 2. Separate the lines of your address with \\. Do not put a \\ at the end of the last line.
- 3. \date{\today} typesets today's date. If you do not want *any* date to appear, comment out the \date command. For a specific date, such as March 15, 2006, type \date{March 15, 2006}.
- 4. The \title command is the only required command. The others are optional.

Actually, if you do not give the \maketitle command, even the \title command is optional. On the other hand, if you do give the \maketitle command and omit the \title command, then you get the error message

! Undefined control sequence. <argument> \shorttitle

#### 1.27 \maketitle

Now delete all the content of the article, leaving you with the skeleton. Here is the edited gg.tex (it is in your samples folder):

% GG's article template: gg.tex
\documentclass{amsart}
\usepackage{amssymb,latexsym}

\usepackage{graphicx}

```
\newtheorem{theorem}{Theorem}
\newtheorem{lemma}{Lemma}
\newtheorem{definition}{Definition}
\newtheorem{notation}{Notation}
\begin{document}
\title{Title!}
\author{George Gr\"{a}tzer}
\address{Department of Mathematics\\
         University of Manitoba//
         Winnipeg, MB R3T 2N2\\
         Canada }
\date{\today}
\begin{abstract}
To come!
\end{abstract}
\maketitle
\section{Introduction}\label{S:intro}
\begin{thebibliography}{9}
\end{thebibliography}
\end{document}
    I also made a version for a joint article with another author: gg2.tex (see the
samples folder). It adds the lines
\author{Second author}
\address{line1\\
         line2\\
         line3\\
         line4}
```

before the \date command.

When I start writing an article, I open gg.tex or gg2.tex, save it under a new name, and edit the top matter. Here are two more rules about the top matter to keep in mind:

# **Rule** ■ Top matter (continued)

- 5. If necessary, break the title into separate lines with \\. Do not put a \\ at the end of the last line.
- 6. Multiple authors get separate \author and \address commands.

# 4.2.2 Sectioning

An article, as a rule, is divided into sections. To start the section Introduction, type \section{Introduction}\label{S:intro}

after the \maketitle command. Introduction typesets as the title of the section. I use the convention that S: starts the label for a section, so the label is S:intro (or something similar). The section's number is automatically assigned by LaTeX. You can refer to this section number with \ref{S:intro}:

```
In Section~\ref{S:intro}, we introduce
```

The command \section\* produces an unnumbered section.

Sections have subsections, and subsections have subsubsections. The corresponding commands are

\subsection \subsubsection

Their unnumbered variants are

\subsection\* \subsubsection\*

# 4.2.3 Invoking proclamations

In the preamble of the article intrart.tex, we defined the theorem, lemma, definition, and notation proclamations. These proclamations define environments.

For example, you type a theorem within a theorem environment. The body of the theorem, that is, the part of the source file that produces the theorem, is typed between the lines

 $\label{T:xxx} $$ \begin{theorem} \abel{T:xxx} \end{theorem} \label{T:xxx} $$$ 

and

\end{theorem}

where T: xxx is the label for the theorem. You should replace xxx with a label that is somewhat descriptive of the contents of your theorem. LaTeX automatically assigns a number to the theorem, and the theorem can be referenced by using a command of the form \ref{T: xxx}.

# 4.2.4 Inserting references

The works to be listed are placed in the bibliography. Below are typical entries for the most frequently used types of references, an article in a journal, a book, a Ph.D. thesis, and a technical report. For more examples, see the bibliographic template file, bibl.tpl, in the samples folder.

```
\begin{thebibliography}{9}
  \bibitem{sF90}
      Soo-Key Foo,
      \emph{Lattice Constructions},
      Ph.D. thesis.
      University of Winnebago, Winnebago, MN,
      December, 1990.
   \bibitem{gM68}
      George A. Menuhin,
      \emph{Universal algebra}.
      D.~Van Nostrand, Princeton, 1968.
  \bibitem{eM57}
      Ernest~T. Moynahan,
      \emph{On a problem of M. Stone},
      Acta Math. Acad. Sci. Hungar. \textbf{8} (1957),
      455--460.
  \bibitem{eM57a}
      Ernest~T. Moynahan,
      \emph{Ideals and congruence relations in
      lattices.} II,
      Magyar Tud. Akad. Mat. Fiz. Oszt. K\"{o}zl.
      \text{textbf}{9} (1957), 417--434.
\end{thebibliography}
```

Each item listed in the bibliography can be referenced in the body of the article. You reference with the \cite command. The argument is the argument of the \bibitem command. So to reference Menuhin's article, type

```
\cite{gM68}
which typesets as [2] since Menuhin's article is the second in the list. So
this result was first published in [2]
is typed as
this result was first published in \cite{gM68}
```

How you write each label is up to you, subject only to the rule in Section 10.4.2, provided the labels are unique. I use the convention that the label for a \bibitem consists of the initials of the author and the year of publication. For example, a publication by Andrew B. Reich in 1987 would have the label aR87 (a second publication by that author from that year would be aR87a). For joint publications, the label consists of the initials of the authors and the year of publication. For example, a publication by John Bradford and Andrew B. Reich in 1987 would have the label BR87.

You have to arrange the references in your document's thebibliography environment in the order you wish to see them. LATEX only takes care of the numbering and the citations in the text.

# 4.3 On using LATEX

Now that you are ready to type your first article, we give you some pointers on using LATEX.

#### 4.3.1 LATEX error messages

You probably make a number of mistakes in your first article. These mistakes fall into the following categories:

- 1. Typographical errors, which LATEX blindly typesets
- 2. Errors in mathematical formulas or in the formatting of the text
- 3. Errors in your instructions to LATEX, that is, in commands and environments

Typographical errors can be corrected by viewing and spell checking the typeset article, finding the errors, and then editing the source file.

Mistakes in the second and third categories probably trigger errors during the typesetting process, such as the math errors in Section 3.2. Some of these mistakes may have to be corrected before your article can be completely typeset.

We now look at some examples of the third class of errors by deliberately introducing a number of mistakes into the source file of the article intrart.tex (in your samples folder, source file on pages 35–41, and shown typeset on pages 42–43), and examining the error messages that occur.

When LATEX displays a ? prompt, you can either try to continue typesetting the document by pressing Return, or type x to stop typesetting immediately. See Section D.4 for other options.

**Experiment 1** In intrart.tex, go to line 20 by using your editor's Go to Line command and remove the closing brace so that it reads

\begin{abstract

When you typeset intrart.tex, LATEX reports a problem:

Line 26 of the file is the line after \end{abstract}. The error message informs you that the name of the environment that ends before line 26 is not completed before the end of the paragraph. Press Return to tell LaTeX to typeset the remainder of the article, leaving out the abstract.

Runaway argument? is an error message that comes up often. It usually means that the argument of a command is either longer than expected or it contains material that the argument cannot accept. Most often a closing brace solves the problem, as in the experiment.

**Experiment 2** Now correct line 20, then go to line 25 and change it from

```
\end{abstract}

to
\end{abstrac}

and typeset the article again. LATEX informs you of another error:
! LaTeX Error: \begin{abstract} on input line 20 ended by \end{abstrac}.

1.25 \end{abstrac}
```

This is perfect. LATEX correctly analyzes the problem and tells you where to make the change.

You may continue type setting the article by pressing Return.  $\LaTeX$  then gives you the message:

```
! Missing } inserted.
<inserted text>
          }
1.25 \end{abstrac}
```

The missing } inserted is the "special brace" \end{abstract} (more about this in Section 5.3.2). Press Return. LaTeX recovers from this error and the article is typeset correctly.

#### **Experiment 3** Instead of correcting the error in line 25, comment it out with

% \end{abstrac}

and also comment out the four lines of the figure environment using block comment. Introduce an additional error in line 96. This line reads

and \$\Theta\$ is a complete congruence relation,

Change \Theta to \Teta:

and \$\Teta\$ is a complete congruence relation,

Now, when you typeset the article, LATEX reports

! Undefined control sequence. <recently read>\Teta

1.96 and \$\Teta

\$ is a complete congruence relation,

Pressing Return results in the message

! LaTeX Error: \begin{abstract} on input line 20 ended by \end{document}.

Type H <return> for immediate help.
...

#### 1.150 \end{document}

These two mistakes are easy to identify: \Teta is a misspelling of \Theta, and since \end{abstract} is missing, LATEX is trying to match

\begin{abstract}

with

\end{document}

Now undo the changes you made to lines 25 and 96. Uncomment the figure.

**Experiment 4** In line 42, delete the closing brace of the \label command:

```
\begin{definition}\label{D:P*
```

This results in a message for line 54, the blank line following the paragraph, that

! Paragraph ended before \label was complete.

This is easy to understand. You cannot begin a new paragraph within the argument of a \label command.

Undo the change to line 42.

**Experiment 5** Add a blank line following line 58:

```
\langle \dots, 0, \dots, d, \dots, 0, \dots \rangle
```

This change results in the message

```
! Missing $ inserted.
<inserted text>
$
1.59
```

There can be no blank lines within a displayed math environment. LATEX catches the mistake, but the message itself is misleading. Pressing Return does not help; you cannot recover from the error. Delete the blank line.

**Experiment 6** Add a \$ somewhere in line 58 (such errors often occur when cutting and pasting formulas):

```
\langle $\dots, 0, \dots, d, \dots, 0, \dots \rangle
```

You get the message:

Maybe this could be more to the point?

Error messages from LaTeX are not always helpful, but there is always some information that can be gleaned from them. Try to identify the structure, that is, the command or environment, that causes the error—read the section of this book that describes that command or environment. This should help you correct the error. Keep in mind that the error could be quite far from the line LaTeX indicates, but it is always on or before that line in the source file.

If you have difficulty isolating a problem, block comment all but the paragraph you suspect might have problems. If necessary, split a large paragraph into smaller pieces.

**Tip** Typeset often.

To some extent, you can avoid having to isolate problems by following this tip. For instance, if I were to typeset *First Steps into LATEX* [29], with the closing brace of the first \caption command on line 480 of the source file missing, I would get the error message

```
! Text line contains an invalid character. 1.1227 ...pletely irreducible^^?
```

where the reference is to line 1227, about 700 lines removed from the actual error. However, if the only thing I did before typesetting was to insert that figure with its incorrect caption command, at least I would know where to look for errors. If you make a dozen corrections and then typeset, you may not know where to start.

#### 4.3.2 Logical and visual design

The typeset version of intrart.tex (pp. 42–43) looks impressive. To produce such articles, you need to understand that there are two aspects to article design: *visual* and *logical*.

As an example, let us look at a theorem from intrart.tex (see the typeset form of the theorem on page 43). You tell LATEX that you want to state a theorem by using a theorem environment:

```
\begin{theorem}\label{T:P*}
Let $D_{i}$, $i \in I$, be complete distributive
lattices satisfying condition~\textup{(J)}.
Let $\Theta$ be a complete congruence relation on
$\Pi^{*} ( D_{i} \mid i \in I )$.
If there exist $i \in I$ and $d \in D_{i}$ with
$d < 1_{i}$ such that, for all $d \leq c < 1_{i}$,
\begin{equation}\label{E:cong1}
\langle \dots, d, \dots, 0, \dots \rangle \equiv \langle \dots, c, \dots, 0, \dots \rangle \pod{\Theta},
\end{equation}
then $\Theta = \iota$.
\end{theorem}</pre>
```

The logical part of the design is choosing to define a theorem by placing material inside a theorem environment. For the visual design, LATEX makes hundreds of decisions. Could you have specified all of the spacing, font size changes, centering, numbering, and so on? Maybe, but would you want to? And would you want to repeat that process for every theorem in your document?

Even if you did, you would have spent a great deal of time and energy on the *visual design* of the theorem rather than on the *logical design* of your article. The idea

behind LaTeX is that you should concentrate on what you have to say and let LaTeX take care of the visual design.

This approach allows you to easily alter the visual design by changing the document class (or its options, see Sections 11.5, 12.1.2, and 18.1). Section 11.1 provides some examples. If you code the visual design into the article—hard coding it, as a programmer would say—such changes are much harder to accomplish, for you and for the journal publishing the article.

# 4.4 Converting an article to a presentation

To produce a document in LaTeX for use as a presentation, you have to output it as a PDF file. You make your presentation using a PDF viewer such as Adobe Reader or print the pages of the PDF file on transparencies and use a projector.

So a *presentation* is a PDF file. To display the presentation, connect your computer to a projector. Open the PDF file in Adobe Reader, put it in full screen mode. Then project the presentation a page at a time by pressing the space bar or the forward and back arrow keys.

In LaTeX, you use a presentation package—really, a document class—to prepare such a PDF file. We deal with presentations in detail in Chapter 14, but as a quick introduction, we convert intrart.tex into a presentation.

For the conversion, we use the presentation package FoilTeX, while in Chapter 14 we discuss the beamer package. To use the FoilTeX package, we have to learn only one new command. \foilhead.

Open intrart.tex, save it as intropres.tex in the work folder. We introduce some changes to the document to prepare it for the conversion. Once you are satisfied with the changes made, the tex file created for FoilTeX is typeset so as to produce the PDF file. For WinEdt, click on the PDF TeXify icon. For TeXShop, just click on Typeset. For other TeX installations, check your user manual on how to create a PDF output.

#### 4.4.1 Preliminary changes

Make the following changes in the preamble, top matter, and abstract.

- Change the first line to
   Introductory presentation:intropres.tex
- 2. Change the document class to foils.
- 3. Add the line

\usepackage{amsmath} after the documentclass line. We have to do this because FoilTeX does not automatically load the AMS math package.

- 4. Delete the definitions of theorem, lemma, and definition. FoilTEX redefines these.
- 5. Copy the address into the \author command:

```
\author{George~A. Menuhin\\
Computer Science Department\\
University of Winnebago\\
Winnebago, MN 53714}
```

and delete the \address command. This may seem strange, but it is necessary because FoilTeX is based on a legacy document class that does not have an \address command (see Chapter 12).

- 6. Move the abstract after the \maketitle command, as was customary in legacy document classes.
- 7. Add the [scale=2] option to the \includegraphics command, so the command becomes

```
\centering\includegraphics[scale=2]{products}
```

FoilT<sub>E</sub>X uses fonts in 20 point size, twice the usual size. So it is appropriate that we scale up the illustration to 200%.

So the new version is

% Introductory presentation:intropres.tex

```
\emph{complete-simple distributive lattices,}
that is, complete distributive lattices
with only two complete congruences.
\end{abstract}
```

#### Declarations in the body

In your LATEX editor, perform four search and replace operations in the body of the article. Change all of the following:

- 1. {theorem} to {Theorem}
- 2. {lemma} to {Lemma}
- 3. {definition} to {Definition}
- 4. {proof} to {Proof}

FoilT<sub>E</sub>X defines and uses the capitalized versions.

#### Sectioning

Comment out all the \section commands. FoilTEX uses the \foilhead command to break the material into pages and also as a substitute for sectioning.

#### 4.4.2 Making the pages

We cut the presentation into pages (transparencies or foils) by inserting as many page breaking commands of FoilTeX, \foilhead{}, as seems appropriate. The argument of the command becomes the "title" for the page. If the argument is empty, the page has no title.

Add the \foilhead{The result} command after the abstract. This ends the title page and adds the title The result to the next page.

See the intropres.tex document for all the other \foilhead{} commands we have added.

#### 4.4.3 Fine tuning

We have eliminated the equation numbering, because it would make the equations too wide. Also, in a presentation, references to another page are not recommended. We made some additional changes to accommodate that we have fewer characters per line. Compare the documents intrart.tex and intropres.tex to see all the changes. Note how in the PDF file the fonts are automatically changed to sans serif, because sans serif text is easier to read when projected. The font size is 20pt, twice the size of the font in the article.

Of course, intropres.tex is not the most elegant presentation. But I hope it helps you to make your first presentation. On pages 57 and 58, we show the first two pages of this presentation.

There are, of course, a number of useful commands in FoilTEX in addition to the one we used, \foilhead. We did not even do justice to this one command. It has an optional argument to enlarge or shrink the space between the header and the body of the foil. So

\foilhead[-.5in]{A diagram}

shrinks that space by half an inch. This is especially useful with large diagrams. For numerous other features of FoilT<sub>E</sub>X, see the user manual [33].

# A construction of complete-simple distributive lattices

George A. Menuhin Computer Science Department University of Winnebago Winnebago, MN 53714

March 15, 2006

#### **Abstract**

In this presentation, we prove that there exist *complete-simple distributive lattices*, that is, complete distributive lattices with only two complete congruences.

# The result

In this presentation, we prove the following result:

**Theorem 1.** There exists an infinite complete distributive lattice K with only the two trivial complete congruence relations.

# Typing text

In Chapter 2, we briefly discussed how to type text in a document. Now we take up this topic more fully.

This chapter starts with a discussion of the keyboard in Section 5.1 and continues with the rules for spaces in Section 5.2. We cover a very important topic that must precede any in-depth discussion of LATEX, how to control LATEX with commands and environments, in Section 5.3.

A document may contain symbols that cannot be found on your keyboard. In Section 5.4, we show how to get these symbols in our typeset documents by using commands.

Some other characters are defined by LATEX as command characters. For example, the % character plays a special role in the source document. In Section 5.5.1, you will see how % is used to comment out lines. In Section 5.5.2, we introduce the command for footnotes.

In Section 5.6, we discuss the commands (and environments) for changing fonts, their shapes and sizes. In Section 5.7, you learn about lines, paragraphs, and pages. The judicious use of horizontal and vertical spacing is an important part of document

formatting, and also the topic of Section 5.8. In Section 5.9, you learn how to typeset text in a "box", which behaves as if it were a single large character.

To help the discussion along, we shall use the terms *text mode* and *math mode* to distinguish between typesetting text and math.

# 5.1 The keyboard

Most of the keys on your computer's keyboard produce characters, while others are function or modifier keys.

#### 5.1.1 Basic keys

The basic keys are grouped as follows:

**Letters** The 52 letter keys:

```
\texttt{a} \;\; \texttt{b} \;\; \texttt{c} \; \dots \; \texttt{z} \qquad \texttt{A} \;\; \texttt{B} \;\; \texttt{C} \; \dots \; \texttt{Z}
```

**Digits** The ten digits:

```
1 2 ... 9 0
```

Old-style digits are available with the \oldstylenums command. The next line shows the default digits followed by the old style digits:

**Punctuation** There are nine punctuation marks:

```
, ; . ? ! : ' ' -
```

The first six are the usual punctuation marks. The ' is the *left single quote*—also known as the *grave accent*—while ' doubles as the *right single quote* and *apostrophe* (see Section 5.4.1). The – key is the *dash* or *hyphen* (see Sections 5.4.2 and 5.4.9).

**Parentheses** There are four:

```
( ) [ ]
( and ) are parentheses; [ and ] are called (square) brackets.
```

5.1 The keyboard 63

**Math symbols** Seven math symbols correspond to keys. The math symbols are:

$$* + = - < > /$$

The last four characters have a role also in text mode:

- The minus sign corresponds to the hyphen key, (see Section 7.4.1).
- The math symbols < and > correspond to the keys < and >; use them only in math mode.

Note that there is also a version of colon (:) for math formulas (see Sections 8.1 and B.2).

**Space keys** Pressing the space bar gives the *space character*. Pressing the tab key gives the *tab character*. When typesetting the source file, LATEX does not distinguish between these two. Pressing the *Return* key gives the *end-of-line character*.

These keys produce *invisible characters* that are normally not displayed on your monitor by the text editor. Different computer systems have different end-of-line characters, which may cause some problems when transferring files from one system to another. A good text editor translates end-of-line characters automatically or on demand. Section 5.2.1 explains how LATEX handles the invisible characters.

When explaining some rules of LaTeX, sometimes it is important to show if a space is required. In such cases, I use the symbol  $\sqcup$  to indicate a space, for instance,  $\ \square$  and  $\ \square$ .

The tilde ~ produces a *nonbreakable space* or *tie* (see Section 5.4.3 and the footnote on page 11).

### 5.1.2 Special keys

There are 13 special keys on the keyboard:



They are mostly used to give instructions to L<sup>A</sup>T<sub>E</sub>X and some are used in math mode (see Chapter 7), and some in B<sub>IB</sub>T<sub>E</sub>X (see Chapter 16). See Section 5.4.4 on how to print these characters in text. Only @ requires no special command, type @ to print @.

#### 5.1.3 Prohibited keys

Keys other than those discussed in Sections 5.1.1 and 5.1.2 are prohibited! Specifically, do not use the computer's modifier keys—Control, Alt, Escape, and others—to produce special characters, such as accented characters. LaTeX will either reject or misunderstand them.

Prohibited characters may not cause problems in some newer LaTeX implementations. They may just print Ł if your source file has Ł, and ignore the invisible invalid characters. However, for portability reasons, you should avoid using prohibited characters.

The babel package provides support for using some modifier keys (see Appendix G).

**Tip** If there is a prohibited character in your document, you may receive an error message such as

- ! Text line contains an invalid character.
- 1.222 completely irreducible^??

^^?

Delete and retype the offending word or line until the error goes away.

# 5.2 Words, sentences, and paragraphs

Text consists of words, sentences, and paragraphs. In text, *words* are separated by one or more spaces, which may include a single end-of-line character (see the rule, **Spacing in text**), or by parentheses and punctuation marks. A group of words terminated by a period, exclamation point, or question mark forms a *sentence* (not all periods terminate a sentence, see the discussion in Section 5.2.2). A group of sentences terminated by one or more blank lines constitutes a *paragraph*.

#### 5.2.1 Spacing rules

Here are the most important LATEX rules about spaces in text in the source file.

#### **Rule** ■ Spacing in text

- 1. Two or more spaces in text are the same as one.
- 2. A tab or end-of-line character is the same as a space.
- 3. A blank line, that is, two end-of-line characters separated only by spaces and tabs, indicates the end of a paragraph. The \par command is equivalent.
- 4. Spaces at the beginning of a line are ignored.

Rules 1 and 2 make cutting and pasting text less error-prone. In your source file, you do not have to worry about the line length or the number of spaces separating words

or sentences, as long as there is at least one space or end-of-line character separating any two words. Thus

```
You
       do not have to
                          worry
 about the number of
                        spaces
separating words, as long as there
     at least one space or end-of-line character
separating any two words.
produces the same typeset text as
You do not have to worry about the number of spaces
separating words, as long as there is at least one space
or end-of-line character separating any two words.
However,
the number of
                spaces separating words,
as long
and
the number of
                spaces separating words
```

produce different results:

, as long

the number of spaces separating words, as long the number of spaces separating words , as long

Notice the space between "words" and the comma in the second line. That space was produced by the end-of-line character in accordance with Rule 2.

It is very important to maintain the readability of your source file. LATEX may not care about the number of spaces or line length, but you, your coauthor, or your editor might.

Rule 3 contradicts Rules 1 and 2, consider it an exception. Sometimes—especially when defining commands and environments (see Sections 15.1 and 15.2)—it is more convenient to indicate the end of a paragraph with \par.

When e-mailing a source file, e-mail clients tend to break longer lines into shorter ones. Because of the space rules, this does not effect the typeset version most of the time.

#### 5.2.2 Periods

LATEX places a certain size space between words—the *interword space*—and a somewhat larger space between sentences—the *intersentence space*. To know which space to use, LATEX must decide whether or not a period indicates the end of a sentence.

#### Rule 1 ■ Period

To LATEX, a period after a capital letter, for instance, A. or caT., signifies an abbreviation or an initial. Generally, every other period signifies the end of a sentence.

This rule works most of the time. When it fails—for instance, twice with e.g.—you need to specify the type of space you want, using the following two rules.

#### Rule 2 ■ Period

If an abbreviation does not end with a capital letter, for instance, etc., and it is not the last word in the sentence, then follow the period by an interword space ( $\L$ ) or a tie ( $\L$ ), if appropriate (see Section 5.4.3).

Recall that \□ provides an interword space.

The result was first published, in a first approximation, in the Combin.\ Journal. The result was first published, in a first approximation, in the Combin. Journal.

prints as

The result was first published, in a first approximation, in the Combin. Journal. The result was first published, in a first approximation, in the Combin. Journal.

Notice that Combin. in the first line is followed by a regular interword space. The intersentence space following Combin. in the second line is a little wider.

A tie (or nonbreakable space)—see also Section 5.4.3—is more appropriate than  $\ \ \ \$  in phrases such as Prof. Smith, typed as Prof. Smith, and pp. 271–292, typed as pp. ~271–292.

**Tip** The thebibliography environment handles periods properly. You do not have to mark periods for abbreviations (in the form .\) in the name of a journal, so

Acta Math. Acad. Sci. Hungar.

is correct.

#### Rule 3 ■ Period

If a capital letter is followed by a period and is at the end of a sentence, precede the period with \0.

For example,

- (1) follows from condition  $^{\sim}H\$  We can proceed  $\$
- (1) follows from condition~H. We can proceed

prints:

- (1) follows from condition H. We can proceed
- (1) follows from condition H. We can proceed

Notice that there is not enough space after H. in the second line.

Most typographers agree on the following rule (see, e.g., Robert Bringhurst's *The Elements of Typographic Style* [8], p. 30):

#### Rule 4 ■ Period

Add no space or a thin space  $(\,)$  within strings of initials and be consistent.

So W.H. Lampstone with no space or W.H. Lampstone with thin space is preferred over W. H. Lampstone. My personal choice is W.H. Lampstone with thin space.

To make all intersentence spaces equal to the interword space—as required in French typography—you can use the command

\frenchspacing

To switch back to using spaces of different sizes, give the command

\nonfrenchspacing

# 5.3 Commanding LATEX

How do you command L<sup>A</sup>T<sub>E</sub>X to do something special for you, such as starting a new line, changing emphasis, or displaying the next theorem? You use *commands* and special pairs of commands called *environments*, both briefly introduced at the start of Chapter 2.

Most, but not all, commands have *arguments*, which are usually fairly brief. Environments have *contents*, the text between the \begin and \end commands. The contents of an environment can be several paragraphs long.

#### 5.3.1 Commands and environments

The  $\ensuremath{\mbox{text}}\ command$  instructs LATEX to emphasize its argument, text. The  $\ensuremath{\mbox{text}}\ command$  has no argument. It instructs LATEX to typeset & (see Section 5.4.4).

The flushright *environment* instructs LATEX to right justify the content, the text between the two commands

```
\begin{flushright}
\end{flushright}
```

The content of the document environment is the body of the article (see Section 4.1) and the content of the abstract environment is the abstract.

#### Rule Environments

An environment starts with the command

\begin{name}

and ends with

\end{name}

Between these two lines is the *content* of the environment, affected by the definition of the environment.

#### Rule Commands

A LATEX command starts with a backslash, \, and is followed by the *command name*. The *name* of a command is either a *single non-alphabetic character* other than a tab or end-of-line character or a *string of letters*, that is, one or more letters.

So # and ' are valid command names. The corresponding commands \# and \' are used in Sections 5.4.4 and 5.4.7, respectively. input and date are also valid command names. However, input3, in#ut, and in\_ut are not valid names because 3, #, and u should not occur in a multicharacter command name. Note that u is a command name, the command \u produces a blank.

LATEX has a few commands, for instance, \$ (see Section 7.1) that do not follow this naming scheme, that is, they are not of the form \name. See also Section 15.1.8 for special commands with special termination rules.

#### Rule Command termination

LATEX finds the end of a command name as follows:

- If the first character of the name is not a letter, the name is the first character.
- If the first character of the name is a letter, the command name is terminated by the first nonletter.

If the command name is a string of letters, and is terminated by a space, then LaTeX discards all spaces following the command name.

While input3 is an invalid name, \input3 is not an incorrect command. It is the \input command followed by the character 3, which is either part of the text following the command or the argument of the command.

LATEX also allows some command names to be modified with \*. Such commands are referred to as \*-ed commands. Many commands have \*-ed variants. \hspace\* is an often-used \*-ed command (see Section 5.8.1).

#### **Rule** Command and environment names

Command and environment names are *case sensitive*. \ShowLabels is not the same as \showlabels.

#### Rule Arguments

Arguments are enclosed in braces, { }.

Optional arguments are enclosed in brackets, [].

Commands may have *arguments*, typed in braces immediately after the command. The argument(s) are used in processing the command. Accents provide very simple examples. For instance,  $\ \ \$  which produces  $\ \$  consists of the command  $\ \$  and the argument o (see Section 5.4.7). In  $\ \$  article1, the command is  $\ \$  bibliography and the argument is article1 (see Section 16.2.2).

Sometimes, if the argument is a single character, the braces can be dropped: \'o also typesets as \'o.

Some environments also have arguments. For example, the alignat environment (see Section 9.5.4) is delimited by the commands

```
\begin{alignat}{2}
and
\end{alignat}
```

The argument, 2, is the number of columns—it could be any number 1, 2, ... A command or environment may have more than one argument. The \frac command (see Section 7.4.1) has two,  $\frac{1}{2}$  typesets as  $\frac{1}{2}$ . The user-defined command \con has three (see Section 15.1.2).

Some commands and environments have one or more *optional arguments*, that is, arguments that may or may not be present. The \sqrt command (see Section 7.4.5) has an optional argument for specifying roots other than the square root. To get  $\sqrt[3]{25}$ , type \sqrt[3]{25}. The \documentclass command has an argument, the name of a document class, and an optional argument, a list of options (see Section 10.2), for instance,

\documentclass[12pt,draft,leqno]{amsart}

**Tip** If you get an error when using a command, check that:

- The command is spelled correctly, including the use of uppercase and lowercase letters.
- 2. You have specified all required arguments in braces.
- 3. Any optional argument is in brackets, not braces or parentheses.
- 4. The command is properly terminated.
- 5. The package providing the command is loaded with the \usepackage command.

Most errors in the use of commands are caused by breaking the termination rule. We can illustrate some of these errors with the \today command, which produces today's date. You have already seen this command in Section 2.4 (see also Section 5.4.8). The correct usage is

```
\today\ is the day
or
\today{} is the day
which both typeset as
-
July 19, 2006 is the day
```

In the first case,  $\today$  was terminated by  $\t_{\sqcup}$ , the command that produces an interword space. In the second case, it was terminated by the *empty group* { }.

If there is no space after the \today command, as in

\todayis\_the\_day

you get the error message

- ! Undefined control sequence.
- 1.3 \todayis

the day

LATEX thinks that \todayis is the command, and, of course, does not recognize it.

If you type one or more spaces after \today:

```
\today__is_the_day
```

LATEX interprets the two spaces as a single space by the first space rule (see page 64), and uses that one space to delimit \today from the text that follows it. So LATEX produces

```
July 19, 2006 is the day
```

Section 15.1.8 discusses how best to avoid such errors.

**Tip** If a command—or environment—can have an optional argument and

- none is given, and
- the text following the command starts with [,

then type this as {[]}.

This may happen, for instance, with the command \item (see page 123). To get an example for an environment, see Section 9.6.1 for subsidiary math environments and page 229 for the alignment options. See what happens if no option is given but the math starts, say, with [x].

# 5.3.2 Scope

A command issued inside a pair of braces { } has no effect beyond the right brace, except for the seldom occurring *global* commands (see Section 5.3.3). You can have any number of pairs of braces:

```
{ ... { ... { ... } ... } ... }
```

The innermost pair containing a command is the *scope* of that command. The command has no effect outside its scope. We can illustrate this concept using the \bfseries command that switches the font to boldface:

```
{some text \bfseries bold text} no more bold
```

```
typesets as

some text bold text no more bold
```

The commands \begin{name} and \end{name} bracketing an environment act also as a pair of braces. In particular, \$, \[, and \] are special braces.

#### Rule Braces

- **1.** Braces must be balanced: An opening brace has to be closed, and a closing brace must have a matching opening brace.
- 2. Pairs of braces cannot overlap.

Violating the first brace rule generates warnings and error messages. If there is one more opening brace than closing brace, the document typesets, but you get a warning:

```
(\end occurred inside a group at level 1)
```

For two or more unmatched opening braces, you are warned that \end occurred inside a group at level 2, and so on. There is a tendency to disregard such warnings since your article is already typeset and the error may be difficult to find. However, such errors may have strange consequences. At one point in the writing of my second LaTeX book, there were two extra opening braces in Chapter 2. As a result, the title of Chapter 7 was placed on a page by itself! So it is best not to disregard such warnings.

If you have one unmatched closing brace, you get an error message such as

```
! Too many }'s
```

If special braces, say, \begin{name} and \end{name}, do not balance, you get an error message such as those discussed in Section 4.3.1:

```
! LaTeX Error: \begin{name} on input line 21 ended by \end{document}.

or
```

! LaTeX Error: \begin{document} ended by \end{name}.

To illustrate the second rule, here are two simple examples of overlapping braces.

#### Example 1

```
{\bfseries some text \begin{lemma}
```

```
more text} final text
\end{lemma}
```

#### Example 2

```
{some \bfseries text, then math: $\sqrt{2} }, \sqrt{3}$
```

In Example 1, the scope of \bfseries overlaps the braces \begin{lemma} and \end{lemma}, whereas in Example 2, the scope of \bfseries overlaps the special braces \$ and \$. Example 1 is easy to correct:

```
{\bfseries some text}
\begin{lemma}
    {\bfseries more text}
    final text
\end{lemma}
```

Example 2 may be corrected as follows:

```
{some \bfseries text, then math:} $\sqrt{2}, \sqrt{3}$
```

Actually,  $\sqrt{2}$  does not even have a bold version (see Section 8.3.3).

If the braces do overlap and they are of the same kind, LATEX simply misunderstands the instructions. The closing brace of the first pair is regarded as the closing brace of the second pair, an error that may be difficult to detect. LATEX can help if special braces overlap. Typesetting Example 1 gives the error message

# 5.3.3 Types of commands

It may be useful at this point to note that commands can be of various types.

Some commands have arguments, and some do not. Some commands effect change only in their arguments, while some commands declare a change. For instance, \textbf{This is bold} typesets the phrase This is bold in bold type: This is bold and has no effect on the text following the argument of the command. On the other hand, the command \bfseries declares that the text that follows should be bold. This command has no argument. I call a command that declares change a *command declaration*. So \bfseries is a command declaration, while \textbf is not. As a rule, command declarations are commands without arguments.

Commands with arguments are called *long* if their argument(s) can contain a blank line or a \par command; otherwise they are *short*. For example, \textbf is a short

command. So are all the top matter commands discussed in Section 11.2. The \parbox command, discussed in Section 5.9.4, is long.

Finally, as discussed in Section 5.3.2, the effect of a command remains within its scope. This is true only of *local* commands. There are also some *global* commands, such as the \setcounter command described in Section 15.5.1.

#### Fragile commands

As a rule, LATEX reads a paragraph of the source file, typesets it, and then goes on to the next paragraph (see Section D.5). Some information from the source file, however, is separately stored for later use.

Examples include the title of an article, which is reused as a running head (Section 11.2.1); titles of parts, sections, subsections, and other sectioning commands, which are used in the table of contents (Sections 18.2 and 10.4.1); footnotes (Section 5.5.2); table and figure captions (Section 10.4.3), which are used in lists of tables and figures (Section 10.4.3); and index entries (Chapter 17).

These are *movable arguments*, and certain commands embedded in them must be protected from damage while being moved. LATEX commands that need such protection are called *fragile*. The inline math delimiter commands (introduced on page 18) \(() \) and \() are fragile, while \( \) is not.

In a movable argument, fragile commands must be protected with a \protect command. Thus

```
The function \ (f(x^{2})\ ) is not an appropriate section title, but The function \ \ (f(x^{2})\ \ ) is. So is The function \ f(x^{2})\
```

To be on the safe side, you should protect every command that might cause problems in a movable argument. Section 18.2 shows an example of what happens if a fragile command is not protected. Alternatively, use commands declared with

\DeclareRobustCommand

This command works the same way as \newcommand but the command defined is *robust*, that is, not fragile.

# 5.4 Symbols not on the keyboard

A typeset document may contain symbols that cannot be typed. Some of these symbols may even be available on the keyboard but you are prohibited from using them (see

Section 5.1.3). In this section, we discuss the commands that typeset some of these symbols in text.

#### 5.4.1 Quotation marks

```
To produce single and double quotes, as in

'subdirectly irreducible' and "subdirectly irreducible"

type

'subdirectly irreducible' and ''subdirectly irreducible''
```

Here, ' is the left single quote and ' is the right single quote. Note that the double quote is obtained by pressing the single quote key twice, and *not* by using the double quote key. If you need single and double quotes together, as in "She replied, 'No.'", separate them with \, (which provides a thin horizontal space):

```
"She replied, "No.","
```

#### 5.4.2 Dashes

Dashes come in three lengths. The shortest dash, called a *hyphen*, is used to connect words:

```
Mean-Value Theorem
```

This phrase is typed with a single dash:

Mean-Value Theorem

A medium-sized dash, called an *en dash*, is typed as -- and is used

• For number ranges; for instance, the phrase see pages 23–45, is typed as

```
see pages~23--45
```

Note: ~ is a nonbreakable space or tie (see Section 5.4.3).

• In place of a hyphen in a compound adjective when one of the elements of the adjective is an open compound (such as New York) or hyphenated (such as non-English). For instance, the phrase Jonathan Schmidt–Freid adjoint, is typed as

```
Jonathan Schmidt--Freid adjoint
```

A long dash—called an *em dash*—is used to mark a change in thought or to add emphasis to a parenthetical clause, as in this sentence. The two em dashes in the last sentence are typed as follows:

```
A long dash---called an \emph{em dash}---is used
```

In math mode, a single dash is typeset as the minus sign - (a binary operation) with some spacing on both sides, as in 15-3 or the "negative" as in -3 (see Sections 5.1.1 and 7.4.1).

Note that there is no space before or after an en dash or em dash.

#### 5.4.3 Ties or nonbreakable spaces

A *tie* or *nonbreakable space* (sometimes called a *blue space*) is an interword space that cannot be broken across lines. For instance, when referencing P. Neukomm in an article, you do not want the initial P. at the end of a line and the surname Neukomm at the beginning of the next line. To prevent such an occurrence, you should type P. Neukomm.

If your keyboard does not have ~, use the \nobreakspace command instead, and type P.\nobreakspace Neukomm.

The following examples show some typical uses:

```
Theorem~\ref{T:main} in Section~\ref{S:intro}

Donald~E. Knuth

assume that $f(x)$ is (a)~continuous, (b)~bounded

the lattice~$L$.

Sections~\ref{S:modular} and~\ref{S:distributive}

In~$L$, we find

Of course, if you add too many ties, as in

Peter~G.~Neukomm% Incorrect!
```

LATEX may send you a line too wide error message (see Section 5.7.1).

The tie ( $\tilde{}$ ) absorbs spaces, so typing P. $_{\square}$ \_ $\square$ Neukomm works just as well. This feature is convenient when you add a tie during editing.

#### 5.4.4 Special characters

The characters corresponding to nine of the 13 special keys (see Section 5.1.2) are produced by typing a backslash ( $\backslash$ ) and then the key, as shown in Table 5.1.

If for some reason you want to typeset a backslash in your document, type the command \textbackslash, which typesets as \. You might think that you could get a typewriter style backslash by utilizing the \texttt command introduced in Section 2.4

#### \texttt{\textbackslash}

but this is not the case, \textbackslash and \texttt{\textbackslash} produce the same symbol, \, which is different from the typewriter style backslash: \. Look at them side by side: \\. For a typewriter style backslash you can use the \bsl command introduced in Section 15.1.1 or the \texttt{\symbol{92}} command introduced later in this section.

The  $\mid$  key is seldom used in text. If you need to typeset the math symbol  $\mid$  in text, type  $\texttt{\textbar}$ .

Note that in text, \* typesets as \*, whereas in a formula it typesets centered as \*. To typeset a centered star in text, use the command \textsteriskcentered.

@ typesets as @.

Finally, the "key should never be used in text. See Section 5.4.1 for the proper way to typeset double quotes. Nevertheless, sometimes "may be used to typeset ", as in the computer code segment print("Hello!"). In BIBTEX and *MakeIndex*, " has special meanings (see Chapters 16 and 17).

**Tip** Be careful when typing \{ and \} to typeset the braces { }. Typing a brace without its backslash results in unbalanced braces, in violation of the first brace rule in Section 5.3.2.

We illustrated in Section 5.3.2 some consequences of unbalanced braces. You may avoid some of these problems by introducing user-defined commands, as introduced in Section 15.3.

You can also produce special characters with the \symbol command:

\symbol{94} typesets as ^

\symbol{126} typesets as ~

Name	Type	Typeset
Ampersand	\&	&
Caret	\^{}	^
Dollar Sign	\\$	\$
Left Brace	\{	{
Right Brace	\}	}
Underscore (or Lowline)	\_	_
Octothorp	\#	#
Percent	\%	%
Tilde	\~{}	~

Table 5.1: Nine special characters.

	0	1	2	3	4	5	6	7	8	9
х	Γ	Δ	Θ	Λ	Ξ	П	Σ	Υ	Φ	Ψ
1x	Ω	1	1	1	i	į	1	J	•	-
2x	~	_	-	۰	د	ß	æ	œ	ø	Æ
3x	Œ	Ø	Ш	!	"	#	\$	%	&	,
4x	(	)	*	+	,	-		/	0	1
5x	2	3	4	5	6	7	8	9	:	;
6x	<	=	>	?	0	Α	В	C	D	E
7x	F	G	Н	Ι	J	K	L	M	N	0
8x	P	Q	R	S	T	U	V	W	Х	Y
9x	Z	[	\	]	^	_	(	a	b	С
10x	d	е	f	g	h	i	j	k	1	m
11x	n	0	p	q	r	s	t	u	v	W
12x	x	У	z	{	- 1	}	~			

Table 5.2: Font table for the Computer Modern typewriter style font.

```
\texttt{\symbol{92}} typesets as \
```

The argument of the \symbol command is a number matching the slot of the symbol in the layout (encoding) of the font. The layout for the Computer Modern typewriter style font is shown in Table 5.2.

Alternatively, instead of \texttt{\symbol{92}}, can use

```
\texttt{\char'\\}
```

Any character x in the font can be accessed by typing the character itself as 'x. This way you don't have to look up the position of the symbol.

You can obtain similar tables for any font in your LATEX implementation by using the fonttbl.tex file in your samples folder. The table format in this file is used in Section 6.6 as an example of the tabular environment.

For more about font tables, see the nfssfont.tex file, part of the standard LATEX distribution (see Section 12.3) and see also Section 7.5.7 of *The LATEX Companion*, 2nd edition [46].

# 5.4.5 Ellipses

The text ellipsis, ..., is produced using the \dots command. Typing three periods produces ... (notice that the spacing is wrong).

\dots is one of several commands that can be used to create ellipses in formulas (see Section 7.4.3).

#### 5.4.6 Ligatures

Certain groups of characters, when typeset, are joined together—such compound characters are called *ligatures*. There are five ligatures that LATEX typesets automatically (if you use the Computer Modern fonts): ff, fi, ff, ff, and ffl.

If you want to prevent LaTeX from forming a ligature, separate the characters with the command \textcompwordmark. Compare iff with iff, typed as iff and

#### if\textcompwordmark f

Enclosing the second character in braces ({}) is a crude method of preventing the ligature, as used in Formula 4 of the *Formula Gallery* (see Section 7.9). This method, in some instances, may interfere with LaTeX's hyphenation algorithm.

#### 5.4.7 Accents and symbols in text

LETEX provides 15 European accents. Type the command for the accent (\ and a character), followed by the letter (in braces) on which you want the accent placed (see Table 5.3).

For example, to get Grätzer György, type

Gr\"{a}tzer Gy\"{o}rgy

and to get  $\ddot{O}$  type \"{0}.

To place an accent on top of an i or a j, you must use the *dotless* version of i and j. These are obtained by the commands \i and \j: \'{\i} typesets as í and \v{\j} typesets as j. Tables 5.4 and 5.5 list some additional text symbols and European characters available in LaTeX when typing text. Using localized versions of LaTeX, you get more accented and combined characters such as the Catalan geminated ell (see Appendix G).

Name	Type	Typeset	Name	Type	Typeset
acute	\'{o}	ó	macron	\={o}	ō
breve	$\u{o}$	ŏ	overdot	\.{g}	ġ
caron/haček	\v{o}	ŏ	ring	$\r\{u\}$	ů
cedilla	\c{c}	ç	tie	\t{oo}	oo
circumflex	\^{o}	ô	tilde	$\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ $	$ ilde{ ext{n}}$
dieresis/umlaut	\"{u}	ü	underdot	$\d{m}$	m
double acute	\H{o}	ő	underbar	\b{o}	$\underline{\mathbf{O}}$
grave	\'{o}	ò			
dotless i	\i	1	dotless j	\j	J
	\'{\i}	í		\v{\j}	ď

Table 5.3: European accents.

Note that the \textcircled command (in Table 5.5) takes an argument. It seems to work best with a single lowercase character, like (a) or (a). Capitals such as (b) are not very satisfactory. Section 5.9.6 explains how to create the symbol (A).

#### 5.4.8 Logos and dates

\TeX produces  $T_EX$ , \LaTeX produces  $I_FT_EX$ , and \LaTeXe produces  $I_FT_EX$   $2_{\varepsilon}$  (the original name of the current version of  $I_FT_EX$ ). The \AmS command produces the logo  $\mathcal{A}_{\mathcal{MS}}$ .

Remember to type  $\texttt{TeX}_{\sqcup}$  or  $\texttt{TeX}_{\exists}$  if you need a space after  $\texttt{TeX}_{\exists}$  (similarly for the others). A better way to handle this problem is discussed in Section 15.1.1.

LATEX also stores some useful numbers:

- \time is the time of day in minutes since midnight
- \day is the day of the month
- \month is the month of the year
- year is the current year

You can include these numbers in your document by using the \the command:

```
Year: \the\year; month: \the\month; day: \the\day
produces a result such as
Year: 2006; month: 7; day: 11
```

Of more interest is the \today command, which produces today's date in the form: July 11, 2006. It is often used as the argument of the \date command (see Section 11.2.1).

Remember the termination rule (Rule 3 in Section 5.3.1).

```
today's date in the form: \today (you may want produces today's date in the form: July 11, 2006(you may want today's date in the form: July 11, 2006)
```

To get the desired effect, type  $\setminus \cup$  or {} after the  $\setminus today$  command:

```
today's date in the form: \today\ (you may want
```

Name	Type	Typeset	Type	Typeset
a-ring	\aa	å	<b>\AA</b>	Å
aesc	\ae	æ	\AE	Æ
ethel	\oe	œ	\0E	Œ
eszett	\ss	ß	\SS	SS
inverted question mark	?'	į		
inverted exclamation mark	!'	i		
slashed L	\1	ł	\L	Ł
slashed O	\0	Ø	\0	Ø

Table 5.4: European characters.

Name	Type	Typeset
ampersand	\&	&
asterisk bullet	\textasteriskcentered	*
backslash	\textbackslash	\
bar (caesura)	\textbar	ĺ
brace left	<b>\</b> {	{
brace right	\}	}
bullet	\textbullet	•
circled a	\textcircled{a}	<u>a</u>
circumflex	\textasciicircum	^
copyright	\copyright	©
dagger	\dag	© † ‡ \$
double dagger (diesis)	\ddag	‡
dollar	<b>\</b> \$	\$
double quotation left	\textquotedblleft or ''	"
double quotation right	\textquotedblright or ''	"
em dash	\textemdash or	_
en dash	\textendash or	_
exclamation down	\textexclamdown or ! '	i
greater than	\textgreater	>
less than	\textless	<
lowline	\_	_
midpoint	\textperiodcentered	
octothorp	\#	#
percent	\%	%
pilcrow (paragraph)	\P	$\P$
question down	\textquestiondown or ?'	į
registered trademark	\textregistered	; R §
section	\S	8

Table 5.5: Extra text symbols.

#### 5.4.9 Hyphenation

LATEX reads the source file one line at a time until it reaches the end of the current paragraph and then tries to balance the lines (see Section D.3.2). To achieve this goal, LATEX hyphenates long words using a built-in hyphenation algorithm, a database stored in the hyphen.tex file, and a long hyphenation list in the AMS document classes. If you use a document class not containing such a list, copy the hyphenation list from amsart to your document.

#### **Rule** ■ Optional hyphen

If you find that LATEX cannot properly hyphenate a word, put *optional hyphens* in the word. An optional hyphen is typed as \-, and allows LATEX to hyphenate the word where the optional hyphen is placed—and only at such points—if the need arises.

Examples: data\-base,an\-ti\-thet\-ic, set\-up Note that:

- Optional hyphens prevent hyphenation at any other point in the word.
- Placing an optional hyphen in a particular occurrence of a word does not affect the hyphenation of any other occurrences of that word.

#### **Rule Hyphenation specifications**

List the words that often need help in a command:

\hyphenation{set-up as-so-ciate}

All occurrences of the listed words following this command in your document are hyphenated as specified.

Note that in the \hyphenation command the hyphens are designated by – and not by \–, and that the words are separated by spaces not by commas.

You must use optional hyphens for words with accented characters, as in

Gr\"{a}t\-zer

Such words cannot be included in a \hyphenation list (unless you use the T1 font encoding—see Appendix G).

#### **Rule** ■ Preventing hyphenation

To *prevent* hyphenation of a word, put it in the argument of a \text command or place it unhyphenated in a \hyphenation command.

For example, type

\text{database}

if you do not want this instance of database hyphenated, or type

\hyphenation{database}

if you do not want LATEX to hyphenate any occurrence of the word after this command in your document. Of course, typing data\-base overrides the general prohibition for this one instance.

You can have any number of \hyphenation commands in your document.

Tip LateX does not break a hyphenated word except at the hyphen, nor does it break a word followed by or preceding an em dash or en dash (see Section 5.4.2). LateX often needs help with such words.

Sometimes a hyphen in a phrase should not be broken. For instance, the phrase m-complete lattice should not be broken after m; so type it as

\text{\$\mathfrak{m}\$-com}\-plete lattice

(see Section 8.3.2 for \mathfrak).

Use the \nobreakdash command (placed before the hyphen)

\nobreakdash- \nobreakdash-- \nobreakdash---

to prevent such breaks. For example,

pages~24\nobreakdash--47

Since LATEX does not hyphenate a hyphenated word except at the hyphen,

\nobreakdash-

prevents the hyphenation of the whole word as though it were enclosed in a \text command. The form

\nobreakdash-\hspace{0pt}

allows the normal hyphenation of the word that follows the hyphen. For example,

\$\mathfrak{m}\$\nobreakdash-\hspace{Opt}complete lattice

allows the word complete to be hyphenated.

This coding of the phrase m-complete lattice is a natural candidate for a user-defined command (see Section 15.1.1).

Tip If you want to know how LATEX would hyphenate a list of words, place it in the argument of a \showhyphens command.

For instance,

\showhyphens{summation reducible latticoid}

The result,

sum-ma-tion re-ducible lat-ti-coid

is shown in the log file.

**Tip** Some text editors wrap lines in a source file by breaking them at a hyphen, introducing errors in your typeset document.

For instance.

It follows from Theorem $^{T:M}$  that completesimple lattices are very large.

is typeset by LaTEX as follows:

It follows from Theorem 2 that complete- simple lattices are very large.

As you can see, there is a space between the hyphen and the word simple. The text editor inserted an end-of-line character after the hyphen (by the second space rule, see Section 5.2.1). This end-of-line character was interpreted by LaTeX as a space. To correct the error, make sure that there is no such line break, or comment out (see Section 5.5.1) the end-of-line character:

It follows from Theorem~\ref{T:M} that complete-% simple lattices are very large.

Better yet, rearrange the two lines:

It follows from Theorem \ref{T:M} that complete-simple lattices are very large.

Of course, L<sup>A</sup>T<sub>E</sub>X does not know everything about the complicated hyphenation rules of the English language. Consult *The Chicago Manual of Style*, 15th edition [11] and Lyn Dupré's *BUGS in Writing: A Guide to Debugging Your Prose*, 2nd edition [13] for additional guidance.

# 5.5 Comments and footnotes

Various parts of your source file do not get typeset like most of the rest. The two primary examples are comments that do not get typeset at all and footnotes that get typeset at the bottom of the page.

#### 5.5.1 Comments

The % symbol tells LATEX to ignore the rest of the line. A common use might be a comment to yourself in the source file:

```
therefore, a reference to Theorem~1 % check this!
```

The % symbol has many uses. For instance, a document class command (see Section 11.5),

\documentclass[twocolumn,twoside,legalpaper]{amsart}

may be typed with explanations, as

```
\documentclass[%
```

twocolumn,% option for two-column pages
twoside,% format for two-sided printing
legalpaper% print on legal-size paper
]{amsart}

so you can easily comment out some at a later time, as in

```
\documentclass[%
```

%twocolumn,% option for two-column pages
%twoside,% format for two-sided printing
legalpaper% print on legal-size paper
]{amsart}

Notice that the first line is terminated with a % to comment out the end-of-line character.

**Tip** Some command arguments do not allow any spaces. If you want to break a line within an argument list, you can terminate the line with a %, as shown in the previous example.

It is often useful to start a document with a comment line giving the file name and identifying the earliest version of LATEX that must be used to typeset it.

```
% This is article.tex
\NeedsTeXFormat{LaTeX2e}[1994/12/01]
```

The second line specifies the December 1, 1994 (or later) release of LaTeX. You may need to use such a declaration if your document uses a feature that was not available in earlier releases. Since LaTeX changes very little these days, this command is of limited use. (See, however, the discussion on page 311.)

Other uses of % include marking parts of the article for your own reference. For instance, you may include comments to explain command definitions (as in Section 15.3). If something goes wrong inside a multiline math display (see Chapter 9), LATEX does not tell you precisely where the error is. You can try commenting out all but one of the lines, until each line works separately.

Note that % does not comment out lines in a BIBTEX database document (see Section 16.2.4).

#### Tip The 25% rule

If you want a % sign in text, make sure you type it as \%. Otherwise, % comments out the rest of the line. LATEX does not produce a warning.

Using % to comment out large blocks of text can be tedious even with block comment. The verbatim package includes the comment environment:

```
\begin{comment}
    ...the commented out text...
\end{comment}
```

# Rule ■ comment environments

- 1. \end{comment} must be on a line by itself.
- 2. There can be no comment within a comment.

In other words,

```
\begin{comment}
  commented out text...
  \begin{comment}
    some more commented out text...
  \end{comment}
```

```
and some more commented out text...
\end{comment}
```

is not allowed. LaTeX may give one of several error messages, depending on the circumstances. For instance,

! LaTeX Error: \begin{document} ended by \end{comment}.

#### 1.175 \end{comment}

The comment environment can be very useful in locating errors. Suppose you have unbalanced braces in your source file (see Section 5.3.2). Working with a *copy* of your source file, comment out the first half at a safe point (not within an environment!) and typeset. If you still get the same error message, the error is in the second half. If there is no error message, the error is in the first half. Comment out the half that has no error.

Now comment out half of the remaining text and typeset again. Check to see whether the error appears in the first half of the remaining text or the second. Continue applying this method until you narrow down the error to a paragraph that you can inspect visually.

Since the comment environment requires the verbatim package, you must include the line

```
\usepackage{verbatim}
```

in the preamble of the source file (see Sections 12.3.1 and E.1).

#### 5.5.2 Footnotes

The text of a footnote is typed as the argument of a \footnote command. To illustrate the use of footnotes, I have placed one here. This footnote is typed as

```
\footnote{Footnotes are easy to place.}
```

If you want to use symbols to designate the footnotes, instead of numbers, type the command

```
\renewcommand{\thefootnote}
```

```
{\ensuremath{\fnsymbol{footnote}}}
```

before the first footnote; this provides up to nine symbols. In Section 15.1.1, we discuss the \ensuremath command. Section 3.2 of *The LATEX Companion*, 2nd edition [46] describes how to further customize footnotes.

In addition, there are title-page footnotes, such as the \thanks and \date commands in the top matter. See page 42 for a typeset example of \date. See also Section 11.2 and the typeset title page footnotes on page 286.

<sup>&</sup>lt;sup>1</sup>Footnotes are easy to place.

You can add a footnote marked by \* to the title of an article. For instance, type the title

The footnote will appear as the first footnote on page 1 marked by \*. All the other footnotes are unmarked.

# 5.6 Changing font characteristics

Although a document class and its options determine how LATEX typesets characters, there are occasions when you want control over the shape or size of the font used.

# 5.6.1 Basic font characteristics

You do not have to be a typesetting expert to recognize the following basic font attributes:

**Shape** Normal text is typeset:

upright (or roman) as this textslanted as this textitalic as this textsmall caps AS THIS TEXT

Monospaced and proportional Typewriters used *monospaced* fonts, that is, fonts all of whose characters are of the same width. Most text editors display text using a monospaced font. LaTeX calls monospaced fonts *typewriter style*. In this book, such a font is used to represent user input and LaTeX's response, such as "typewriter style text". Whereas, normal text is typeset in a *proportional* font, such as "proportional text with ii and mm", in which i is narrow and m is wide:

```
mmmmmm } monospaced

mmmmmmm } proportional
```

**Serifs** A *serif* is a small horizontal (sometimes vertical) stroke used to finish off a vertical stroke of a letter, as on the top and bottom of the letter M. LaTeX's standard serif font is Computer Modern roman, such as "serif text". Fonts without serifs are called *sans serif*, such as "sans serif text". Sans serif fonts are often used for titles or for special emphasis.

**Series: weight and width** The *series* is the combination of weight and width. A font's *weight* is the thickness of the strokes and the *width* is how wide the characters are.

Light, medium (or normal), and bold often describe weight.

Narrow (or condensed), medium (or normal), and extended often describe width.

The Computer Modern family includes **bold fonts**. Traditionally, when the user asks for bold CM fonts, LATEX actually provides *bold extended* (a somewhat wider version).

**Size** Most LATEX articles are typeset with 10 point text unless otherwise instructed. Larger sizes are used for titles, section titles, and so on. Abstracts and footnotes are often set in 8-point type.

**Font family** The collections of all sizes of a font is called a *font family*.

# 5.6.2 Document font families

In a document class, the style designer designates three document font families:

- 1. Roman (upright and serifed) document font family
- 2. Sans serif document font family
- 3. Typewriter style document font family

and picks one of these (for articles, as a rule, the roman document font family) as the *document font family* or *normal family*. In all the examples in this book, the document font family is the roman document font family except for presentations which use sans serif (see Section 4.4 and Chapter 14). When you use Computer Modern fonts in LaTeX, which is the default, the three document font families are Computer Modern roman, Computer Modern sans serif, and Computer Modern typewriter. The document font family is Computer Modern roman.

In this book, the roman document font family is Times, the sans serif document font family is Helvetica, and the typewriter style document font family is Computer Modern typewriter. The document font family is the roman document font family Times.

The document font family (normal family) is the default font. You can always switch back to it with

```
\textnormal{...} or {\normalfont ...}
```

Table 5.6 shows these two commands and three additional pairs of commands to help
you switch among the three basic document font families. It also shows the command
pairs for the basic font shapes.

Command with Argument	Command Declaration	Switches to the font family
<pre>          </pre>	<pre>{\normalfont} {\normalfont} {\rmfamily} {\sffamily} {\ttfamily} {\upshape} {\itshape} {\slshape} {\scshape} {\hofseries} {\mdseries}</pre>	document emphasis roman sans serif typewriter style upright shape italic shape slanted shape SMALL CAPITALS bold normal weight and width

Table 5.6: Font family switching commands.

# Command pairs

The font-changing commands of Table 5.6 come in two forms:

- A command with an argument, such as \textrm{...}, changes its argument. These are short commands, i.e., they cannot contain a blank line or a \par command.
- A command declaration, such as \rmfamily, carries out the font change following the command and within its scope (see Section 5.3.2).

You should always use commands with arguments for small changes within a paragraph. They have two advantages:

- You are less likely to forget to change back to the normal font.
- You do not have to worry about italic corrections (see Section 5.6.4).

Note that *MakeIndex* requires you to use commands with arguments to change the font in which page numbers are typeset (see Section 17.1).

For font changes involving more than one paragraph, use command declarations. These commands are preferred if you want to create user-defined commands and environments (see Chapter 15).

# 5.6.3 Shape commands

There are five pairs of commands to change the font shape:

- \textup{...} or {\upshape ...} switch to the upright shape.
- \textit{...} or {\itshape ...} switch to the *italic shape*.
- \textsl{...} or {\slshape ...} switch to the slanted shape.
- \textsc{...} or {\scshape ...} switch to SMALL CAPITALS.
- $\ensuremath{\mbox{\mbox{emph}}}$  (emph $\{\ldots\}$ ) or  $\{\ensuremath{\mbox{\mbox{\mbox{\mbox{\mbox{emph}}}}}$  switch to emphasis.

The document class specifies how emphasis is typeset. As a rule, it is italic or slanted unless the surrounding text is italic or slanted, in which case it is upright. For instance,

```
\emph{Rubin space}
```

in the statement of a theorem is typeset as

the space satisfies all three conditions, a so-called Rubin space that  $\dots$ 

The emphasis changed the style of Rubin space from italic to upright.

**Tip** Be careful not to interchange the command pairs. For instance, if by mistake you type {\textit serif}, the result is serif. Only the s is italicized since \textit takes s as its argument.

# **Rule** Abbreviations and acronyms

For abbreviations and acronyms use small caps, except for two-letter geographical acronyms.

So Submitted to TUG should be typed as

Submitted to \textsc{tug}

Note that only the lowercase characters in the argument of the \textsc command are printed as small caps.

## 5.6.4 Italic corrections

may be typed as follows:

```
when using a {\itshape serif\/} font
```

The  $\$  command before the closing brace is called an *italic correction*. Notice that {\itshape M}M typesets as MM, where the M is leaning into the M. Type {\itshape M\/}M to get the correct spacing MM. Compare the typeset phrase from the previous example with and without an italic correction:

```
when using a serif font when using a serif font
```

The latter is not as pleasing to the eye.

# **Rule 1** ■ Italic correction

If the emphasized text is followed by a period or comma, you should not type the italic correction.

```
For example,

Do not forget. My party is on Monday.

should be typed as
{\itshape Do not forget.} My party is on Monday.
```

## Rule 2 ■ Italic correction

The shape commands with arguments do not require italic correction. The corrections are provided automatically where needed.

Thus you can type the phrase when using a *serif* font the easy way:

```
when using a \textit{serif} font
```

Whenever possible, let LATEX take care of the italic correction. However, if LATEX is adding an italic correction where you feel it is not needed, you can override the correction with the \nocorr command. LATEX does not add an italic correction before a period or a comma. These two punctuation marks are stored in the \nocorrlist command. By redefining this command, you can modify LATEX's behavior.

## **Rule 3** ■ Italic correction

The italic correction is required with the commands \itshape, \slshape, \em.

Command	Sample text
\Tiny	sample text
\tiny	sample text
\SMALL or \scriptsize	sample text
\Small or \footnotesize	sample text
\small	sample text
\normalsize	sample text
\large	sample text
\Large	sample text
\LARGE	sample text
\huge	sample text
\Huge	sample text

Table 5.7: Font size commands.

## **5.6.5** *Series*

These attributes play a very limited role with the Computer Modern fonts. There is only one important pair of commands,

```
\textbf{...} {\bfseries ...}
to change the font to bold (actually, bold extended). The commands
\textmd{...} {\mdseries ...}
```

which set both the weight and width to medium (normal) are seldom needed.

# 5.6.6 Size changes

Standard LaTeX documents are typeset in 10 point type. The 11 point and 12 point type are often used for greater readability and some journals require 12 point—if this is the case, use the 12pt document class option (see Sections 11.5, 12.1.2, and 18.1.3). The sizes of titles, subscripts, and superscripts are automatically set by the document class, in accordance with the font size option.

If you must change the font size for some text—it is seldom necessary to do so in an article—the following command declarations are provided (see Table 5.7):

The command \SMALL is also called \scriptsize and the command \Small is also called \footnotesize. The font size commands are listed in order of increasing—to be more precise, nondecreasing—size.

Two commands allow the user to increase or decrease font size: \larger moves up one size, \smaller moves down one. Both commands take an optional argument. For example, \larger[2] moves up 2 sizes.

# 5.6.7 Orthogonality

You are now familiar with the commands that change the font family, shape, series, and size. Each of these commands affects one and only one font attribute. For example, if you change the series, then the font family, shape, and size do not change. These commands act independently. In LATEX terminology, the commands are *orthogonal*. From the user's point of view this behavior has an important consequence: *The order in which these commands are given does not matter.* Thus

\Large \itshape \bfseries

has the same effect as

\bfseries \itshape \Large

Note that LATEX 2.09's two-letter commands (see Section 5.6.8) are not orthogonal.

Orthogonality also means that you can combine these font attributes in any way you like. For instance, the commands

\sffamily \slshape \bfseries \Large

instruct LATEX to change the font family to sans serif, the shape to slanted, the series to bold, and the size to \Large. If the corresponding font is not available, LATEX uses a font that is available, and issues a warning. The font substitution algorithm (see Section 7.9.3 of *The LATEX Companion*, 2nd edition [46] for details) may not provide the font you really want, so it is your responsibility to make sure that the necessary fonts are available. We discuss this topic further in Section 18.5.

#### 5.6.8 Obsolete two-letter commands

Users of LaTeX 2.09 and  $\mathcal{A}_{M}S$ -LaTeX version 1.1 are accustomed to using the two-letter commands \bf, \it, \rm, \sc, \sf, \sl, and \tt. These commands are not part of LaTeX. They are, however, still defined in most document classes. The two-letter commands

- 1. switch to the document font family,
- 2. change to the requested shape.

There are a number of reasons not to use them. The two-letter commands

- are not part of LATEX,
- require manual italic corrections,
- are not orthogonal (see Section 5.6.7).
  \slshape \bfseries is the same as \bfseries \slshape (slanted bold), but
  \sl\bf is not the same as \bf\sl. Indeed, {\sl\bf sample} gives sample and
  {\bf\sl sample} produces sample.

#### 5.6.9 Low-level commands

The font-characteristic changing commands we discussed in this section are the *high-level* font commands. Each of these commands is implemented by LaTeX and the document class using *low-level* font commands. The low-level commands have been developed for document class and package writers. See Section 7.9 of *The LaTeX Companion*, 2nd edition [46].

There is one use of low-level commands you should keep in mind. When you choose a font size for your document or for some part thereof, you also determine the \baselineskip, the distance from the baseline of one line to the baseline of the next. Typically, a 10-point font size uses a 12 point \baselineskip. Occasionally, you may want to change the font size along with the \baselineskip. A command for accomplishing this is

```
\fontsize{9pt}{11pt}\selectfont
```

which changes the font size to 9 point and the \baselineskip to 11 point. To make this change for a single paragraph, you can type

```
{%special paragraph
\fontsize{9pt}{11pt}\selectfont
```

text

}%end special paragraph

Observe the blank line that follows text and marks the end of the paragraph; \par would accomplish the same thing.

# 5.7 Lines, paragraphs, and pages

When typesetting a document, LaTeX breaks the text into lines, paragraphs, and pages. Sometimes you may not like how LaTeX has chosen to lay out your text. There are ways to influence how LaTeX does its work and these are discussed in this section.

#### 5.7.1 Lines

LATEX typesets a document one paragraph at a time. It tries to split the paragraph into lines of equal width. If it fails to do so successfully and a line is too wide, you get an overfull \hbox message. Here is a typical example:

```
Overfull \hbox (15.38948pt too wide) in paragraph at lines 11--16
[]\OT1/cmr/m/n/10 In sev-eral sec-tions of the course on ma-trix
the-ory, the strange term ''hamiltonian-
```

The log file records these error messages. To place a visual warning in the typeset version of your document as well, use the draft document class option

```
\documentclass[draft]{amsart}
```

Lines that are too wide are be marked with a *slug* (a black box) in the margin. A slug is a vertical bar of width \overfullrule.

Do not worry about such messages while writing the document. If you are preparing the final version and receive a message for an overfull \hbox, the first line of defense is to see whether optional hyphens would help (see Section 5.4.9). Read the warning message carefully to see which words LaTeX cannot hyphenate properly. If adding optional hyphens does not help, a simple rephrasing of the problem sentence often does the trick.

Recall that there are 72.27 points in an inch (see Section 2.3). So if the error message indicates a 1.55812 pt overflow, for instance, you can safely ignore it.

**Tip** If you do not want the 1.55812pt overflow reported whenever the document is typeset, you can enclose the offending paragraph (including the blank line indicating the end of the paragraph) between the lines

```
{\setlength{\hfuzz}{2pt}
and
}% end of \hfuzz=2pt
```

Choose an argument that is slightly more than the reported error (maybe 2pt). This does not affect the typeset output, but the warning message and the slug, if you are using the draft option, are suppressed.

Alternatively, enclose the offending paragraph including the blank line indicating the end of the paragraph in a setlength environment:

```
\begin{setlength}{\hfuzz}{2pt}
\end{setlength}
```

#### **Breaking lines**

There are two forms of the line breaking command:

- The \\ and \newline commands break the line at the point of insertion but do not stretch it.
- The \linebreak command breaks the line at the point of insertion and stretches the line to make it of the normal width.

The text following any of these commands starts at the beginning of the next line, without indentation. The \\ command is often used, but \linebreak is rarely seen. (See Section 18.6 for an application of the \linebreak command.) I illustrate the effect of these commands:

```
There are two forms of the line breaking command:
```

```
There are two forms\\ of the line breaking command:
```

```
There are two forms \newline of the line breaking command:
```

There are two forms \linebreak of the line breaking command:

typeset as

There are two forms of the line breaking command:

There are two forms

of the line breaking command:

There are two forms

of the line breaking command:

There are two forms

of the line breaking command:

If you force a line break in the middle of a paragraph with the \linebreak command and LATEX thinks that there is too little text left on the line to stretch it to full width, you get a message such as

```
Underfull \hbox (badness 4328) in paragraph at lines 8--12
```

The \\ command has two important variants:

- \\[length], where length is the interline space you wish to specify after the line break, for instance, 12pt, .5in, or 1.2cm. Note how the units are abbreviated.
- \\\*, which prohibits a page break following the line break.

The  $\$  [length] form combines the two variants. We illustrate the  $\$  [length] command:

```
It is also semimodular.\\[15pt] In particular,
which is typeset as
It is also semimodular.
In particular,
    Since \\ can be modified by * or by [ ], LATEX may get confused if the line after
a \ command starts with a * or [. In such cases, type * as \{*\} or [ as \{[\}\}. For
instance, to get
There are two sources of problems:
[a] The next line starts with [.
type
There are two sources of problems:\\
{[}a] The next line starts with \texttt{[}.
If you fail to type {[]}, you get the error message
! Missing number, treated as zero.
<to be read again>
                      а
1.16 [a]
          The next line starts with \texttt{[].
```

# Rule ■ \\

Without optional arguments, the \\ command and the \newline command are the same *in text*, but not within environments or command arguments.

You can qualify the \linebreak command with an optional argument: 0 to 4. The higher the argument, the more it forces the occurrence of a line break. The \linebreak[4] command is the same as \linebreak, while \linebreak[0] allows the line break but does not force it.

The \nolinebreak command plays the opposite role. \nolinebreak[0] = \linebreak[0], and \nolinebreak[4] = \nolinebreak. \nolinebreak is seldom used since the tie (~) and the \text command (see Section 5.4.3) accomplish the same goal most of the time.

## Double spacing

It is convenient to proofread documents double spaced. Moreover, some journals require submissions to be double spaced.

To typeset a document double spaced, include the command

\renewcommand{\baselinestretch}{1.5}

in its preamble. Alternatively, get George D. Greenwade's setspace (see Section E.1 on how to get it). Load this package with a

\usepackage{setspace}

command in the preamble of the document and specify

\doublespacing

in the preamble. This changes not just the line spacing but a number of other parameters to make your article look good.

See also Section 3.1.13 of *The LATEX Companion*, 2nd edition [46].

# 5.7.2 Paragraphs

Paragraphs are separated by blank lines or by the \par command. Error messages always show paragraph breaks as \par. The \par form is also very useful in user-defined commands and environments (see Sections 15.1 and 15.2).

In some document classes, the first line of a paragraph is automatically indented. Indentation can be prevented with the \noindent command and can be forced with the \indent command.

Sometimes—for instance, in a schedule, glossary, or index—you may want a *hanging indent*, where the first line of a paragraph is not indented, and all the others are indented by a specified amount.

Hanging indents are created by specifying the amount of indentation specified by \hangindent and set with the \setlength command:

\setlength{\hangindent}{30pt}
\noindent

```
\textbf{sentence} a group of words terminated by
a period, exclamation point, or question mark.
```

\setlength{\hangindent}{30pt}

\noindent

\textbf{paragraph} a group of sentences terminated by a blank line or by the new paragraph command.

produces

**sentence** a group of words terminated by a period, exclamation point, or question mark.

**paragraph** a group of sentences terminated by a blank line or by the new paragraph command.

Notice that the \setlength command must be repeated for each paragraph.

Sometimes you may want to change the value of \hangafter, the length command that specifies the number of lines not to be indented. The default value is 1. To change it to 2, use the command

```
\setlength{\hangafter}{2}
```

For more about the \setlength command, see Section 15.5.2. *The LATEX Companion*, 2nd edition [46] discusses in Section 3.1.4 the style parameters of a paragraph.

The preferred way to shape a paragraph or series of paragraphs is with a custom list environment (see Section 15.6).

# 5.7.3 *Pages*

There are two page breaking commands:

- \newpage, which breaks the page at the point of insertion but does not stretch the content
- \pagebreak, which breaks the page at the point of insertion and stretches the page's content to normal length

Text following either command starts at the beginning of the next page, indented.

As you can see, the page breaking commands are analogous to the line breaking commands discussed in Section 5.7.1. This analogy continues with the optional argument, 0 to 4:

\pagebreak[0] to \pagebreak[4] \nopagebreak[0] to \nopagebreak[4]

There are also special commands for allowing or forbidding page breaks in multiline math displays (see Section 9.9).

When preparing the final version of a document (see Section 18.5), you may have to extend or shrink a page by a line or two to prevent it from breaking at an unsuitable line. You can do so with the \enlargethispage command. For instance,

\enlargethispage{\baselineskip}

adds one line to the page length. On the other hand,

\enlargethispage{-\baselineskip}

makes the page one line shorter.

\enlargethispage{10000pt}

makes the page very long.

There are two more variants of the \newpage command. The

\clearpage

command does a \newpage and typesets all the figures and tables waiting to be processed (see Section 10.4.3). The variant

\cleardoublepage

is used with the twoside document class option (see Sections 11.5 and 12.1.2). It does a \clearpage and in addition makes the next printed page a right-hand, that is, odd-numbered, page, by inserting a blank page if necessary. If for your document class this does not work, use the package cleardoublepage.sty in the samples folder.

Section 18.6 discusses the use of some of these commands in the final preparation of books.

# 5.7.4 Multicolumn printing

Many document classes provide the twocolumn option for two-column typesetting (see Sections 11.5 and 12.1.2). In addition, there is a \twocolumn command which starts a new page by issuing a \clearpage and then typesets in two columns. An optional argument provides a two-column wide title. Use the \onecolumn command to switch back to a one-column format.

Frank Mittelbach's multicol package (see Section 12.3.1) provides the much more sophisticated multicols environment, which can start in the middle of a page, can handle more than two columns, and can be customized in a number of ways (see Section 3.5.3 of *The LATEX Companion*, 2nd edition [46]).

#### 5.8 **Spaces**

The judicious use of horizontal and vertical space is an important part of the formatting of a document. Fortunately, most of the spacing decisions are made by the document class, but IATEX has a large number of commands that allow the user to insert horizontal and vertical spacing.

Remember that LATEX ignores excess spaces, tabs, and end-of-line characters. If you need to add horizontal or vertical space, then you must choose from the commands in this section. Use them sparingly.

#### 5.8.1 Horizontal spaces

and

In this section, we discuss fixed length horizontal space commands. Variable length horizontal space is discussed in Section 5.8.4.

When typing text, there are three commands that are often used to create horizontal space, shown between the bars in the display below:



The \quad command creates a 1 em space and \quad creates a 2 em space (see Section 5.8.3). The interword space created by \u can both stretch and shrink. There are other commands that create smaller amounts of space. All the math spacing commands of Section 8.1.3—with the exception of \mspace—can be used in ordinary text (see Sections B.9 and C.6), but the \hspace and \phantom commands are more appropriate.

The \hspace command takes a length as a parameter. The length may be negative. For example,

```
\textbar\hspace{12pt}\textbar
\textbar\hspace{.5in}\textbar
\textbar\hspace{1.5cm}\textbar
```

or \hspace{-40pt}. The command \hspace is often used with a negative argument when placing illustrations.

The \phantom{argument} command produces a space the width and height of the space that would be occupied by its typeset argument

```
\textbar need space\textbar
                                                need space
        \textbar\phantom{need space}\textbar
alpha \phantom{beta} gamma \phantom{delta}\\
\phantom{alpha} beta \phantom{gamma} delta
```

5.8 Spaces 103

```
produces

alpha gamma

beta delta
```

The \phantom command is very useful for fine tuning aligned math formulas (see Sections 8.1 and 9.5.3). The variant

```
\hphantom{argument}
```

creates a space with the horizontal dimension that would be occupied by its typeset argument and with zero height.

For instance, the last two lines of the dedication of this book were typed as follows:

```
\textbf{Emma} (2), \phantom{and \textbf{Kate} (0)}\\[8pt]
and \textbf{Kate} (0)
```

See Section C.6 for a table of all horizontal text-spacing commands.

## Horizontal space variant

When LATEX typesets a line, it removes all spaces from the beginning of the line, including the space created by \hspace, \quad, and other spacing commands. Using the \*-ed variant of \hspace, \hspace\*, prevents LATEX from removing the space you have specified.

For example,

```
And text\\
\hspace{20pt}And text\\
\hspace*{20pt}And text

is typeset as

And text

And text

And text

And text
```

Use the \hspace\* command for creating customized indentation. To indent a paragraph by 24 points, give the command

```
\noindent\hspace*{24pt}And text which typesets as
```

```
And text

To break a line and indent the next line by 24 points, give the command And text\\
\hspace*{24pt}And text

which produces

And text

And text
```

# 5.8.2 Vertical spaces

You can add some interline space with the command \\[length], as discussed in Section 5.7.1. You can also do it with the \vspace command, which works just like the \hspace command (see Section 5.8.1), except that it creates vertical space. Here are some examples:

```
\vspace{12pt} \vspace{.5in} \vspace{1.5cm}.
```

Standard amounts of vertical space are provided by the three commands

```
\smallskip \medskip \bigskip
```

The space these commands create depends on the document class and the font size. With the document class and font I am using for this book, they represent a vertical space of 3 points, 6 points, and 12 points, respectively. 12 points is the baseline skip (see Section 5.6.9) in standard LATEX documents with the default 10pt option.

# **Rule** • Vertical space commands

All vertical space commands add the vertical space *after* the typeset line in which the command appears.

```
To obtain

end of text.

New paragraph after vertical space
```

5.8 Spaces 105

```
end of text.

\vspace{12pt}

New paragraph after vertical space

The following example illustrates the unexpected way the vertical space is placed if the command that creates it does not start a new paragraph:

end of text.

\vspace{12pt}

The following example illustrates the unexpected way the vertical space is placed if the command that creates it does not start a new paragraph:

It typesets as
```

end of text. The following example illustrates the unexpected way the vertical

space is placed if the command that creates it does not start a new paragraph:

# Vertical space variants

LETEX removes vertical space from the beginning and end of each page, including space produced by \vspace. The space created by the variant \vspace\* is not removed by LETEX under any circumstances. Use this command, for instance, to start the typeset text (say, of a letter) not at the top of the page.

The \phantom command has also a vertical variant: \vphantom. The command \vphantom{argument} creates a vertical space with the vertical dimension that would be occupied by its typeset argument, argument.

# 5.8.3 Relative spaces

type

The length of a space is usually given in *absolute units*: 12pt (points), .5cm (centimeters), 1.5in (inches). Sometimes, *relative units*, em and ex, are more appropriate, units that are relative to the size of the letters in the current font. The unit 1 em is approximately the width of an M in the current font, 1 ex is approximately the height of an x in the current font. These units are used in commands such as

```
\hspace{12em} and \vspace{12ex}
```

The \quad and \qquad commands (Section 5.8.1) produce 1 em and 2 em spaces.

# 5.8.4 Expanding spaces

#### Horizontal spaces

The \hfill, \dotfill, and \hrulefill commands fill all available space in the line with spaces, dots, or a horizontal line, respectively. If there are two of these commands on the same line, the space is divided equally between them. These commands can be used to center text, to fill lines with dots in a table of contents, and so on.

To obtain

```
2. Boxes......34
ABC
                                                              DEF
ABC_{--}
                               and
                                                              DEF
type
2. Boxes\dotfill 34\\
ABC\hfill and\hfill DEF\\
ABC\hrulefill and\hrulefill DEF
   In a centered environment—such as a \title (see Section 11.2.1) or a center
environment (see Section 6.3)—you can use \hfill to set a line flush right:
                          This is the title
                                                         First Draft
                              Author
To achieve this effect, type
\begin{center}
  This is the title\\
  \hfill First Draft\\
  Author
\end{center}
```

## Vertical spaces

The vertical analogue of \hfill is \vfill. This command fills the page with vertical space so that the text before the command and the text after the command stretch to the upper and lower margin. You can play the same games with it as with \hfill in Section 5.8.4.

The command \vfill stands for \vspace{\fill}, so it is ignored at the beginning of a page. Use \vspace\*{\fill} if you need it at the beginning of a page.

5.9 Boxes 107

# 5.9 Boxes

Sometimes it can be useful to typeset text in an imaginary box, and treat that box as a single large character. A single-line box can be created with the \text or \makebox commands and a multiline box of a prescribed width can be created with the \parbox command or minipage environment.

#### 5.9.1 Line boxes

The \text command provides a *line box* that typesets its argument without line breaks. As a result, you may find the argument extending into the margin. The resulting box is handled by LATEX as if it were a single large character. For instance,

\text{database}

causes LATEX to treat the eight characters of the word database as if they were one. This technique has a number of uses. It prevents LATEX from braking the argument (see Section 5.4.9). It also allows you to use the phrase in the argument in a formula (see Section 7.4.6).

The argument of \text is typeset in a size appropriate for its use, for example, as a subscript or superscript. See Section 7.4.6 for an example.

#### Line boxes—a refinement

The \mbox command is the short form of the \makebox command. Both \mbox and \text prevent breaking the argument, but \mbox does not change size in subscripts and superscripts.

The full form of the \makebox command is

\makebox[width][alignment]{text}

where the arguments are

- width, the (optional) width of the box. If [width] is omitted, the box is as wide as necessary to enclose its contents.
- alignment, (optionally) one of c (the default), 1, r, or s. The text is centered by default, 1 sets the argument flush left, r right, and s stretches the text the full length of the box if there is blank space in the argument.
- text, the text in the box.

A width argument can be specified in inches (in), centimeters (cm), points (pt), or relative units such as em or ex (see Sections 5.8.3 and 15.5.2).

The following examples,

```
\makebox{Short title.}End\\
\makebox[2in][1]{Short title.}End\\
\makebox[2in][s]{Short title.}End\\
\makebox[2in][s]{Short title.}End\\
\makebox[2in][s]{Short title.}End

typeset as

Short title.End
Short title. End
Short title. End
Short title.End
Short title.End
```

The optional width argument, width, can use four length commands:

```
\height \depth \totalheight and \width
```

These are the dimensions of the box that would be produced without the optional width argument.

Here is a simple example. The command

```
\makebox{hello}
```

makes a box of width \width. To typeset hello in a box three times the width, that is, in a box of width \width, use the command

```
\makebox[3\width]{hello}
So
start\makebox[3\width]{hello}end
typesets as
start hello end
```

The formal definition of these four length commands is the following:

- height is the height of the box above the baseline
- \depth is the depth of the box below the baseline
- \totalheight is the sum of \height and \depth
- \width is the width of the box

5.9 Boxes 109

There is an interesting variant of the \makebox command. The \rlap command makes a box and pretends that it is of width zero. For instance,

## 5.9.2 Frame boxes

```
Boxed text is very emphatic. For example, Do not touch! is typed as \fbox{Do not touch!}
```

This is a *frame box*, hence the command \fbox or \framebox.

Boxed text cannot be broken, so if you want a frame around more than one line of text, you should put the text as the argument of a \parbox command or within a minipage environment (see Section 5.9.3), and then put that into the argument of an \fbox command. For instance,

```
\fbox{\parbox{3in}{Boxed text cannot be broken,
so if you want to frame more than one line
of text, place it in the argument of a
\bsl\texttt{parbox}
command or within a
\texttt{minipage} environment.}}
```

Boxed text cannot be broken, so if you want to frame more than one line of text, place it in the argument of a \parbox command or within a minipage environment.

The \bsl command is defined in Section 15.1.1. See Section 8.6.2 for boxed formulas.

The \framebox command works exactly like \makebox, except that it draws a frame around the box.

```
\framebox[2in][1]{Short title}
```

produces

typesets as

```
You can use this command to typeset the number 1 in a square box, as required by the title of Michael Doob's TeX Starting from 1 [12]:

\framebox{\makebox[\totalheight]{1}}

which typesets as

\[
\text{Index of the number 1 in a square box, as required by the title of Michael Doob's TeX Starting from 1 [12]:

\framebox{\makebox[\totalheight]{1}}

Note that
\framebox[\totalheight]{1}
```

which is not a square box. Indeed, \totalheight is the height of 1, which becomes the width of the box. The total height of the box, however, is the height of the character 1 to which you have to add twice the \fboxsep, the separation between the contents of the box and the frame, defined as 3 points, and twice the \fboxrule, the width of the line, or rule, defined as 0.4 points. These lengths are in general also added to the width of the box, but not in this case, because we forced the width to equal the height of the character.

You can use the \fbox command to frame the name of an author:

```
\author{\fbox{author's name}}
```

# 5.9.3 Paragraph boxes

A paragraph box works like a paragraph. The text it contains is wrapped around into lines. The width of these lines is set by the user.

The \parbox command typesets the contents of its second argument as a paragraph with a line width supplied as the first argument. The resulting box is handled by LATEX as a single large character. For example, to create a 3-inch wide column,

```
Fred Wehrung's new result shows the limitation of E. T. Schmidt's construction, especially for large lattices.
```

5.9 Boxes 111

type

```
\parbox{3in}{Fred Wehrung's new result shows the limitation of E.\,T. Schmidt's construction, especially for large lattices.}
```

Paragraph boxes are especially useful when working within a tabular environment. See the subsection on refinements in Section 6.6 for examples of multiline entries.

The width of the paragraph box can be specified in inches (in), centimeters (cm), points (pt), or the relative measurements em and ex (see Section 5.8.3), among others (see Section 15.5.2 for a complete listing of measurement units).

Tip The \parbox command requires two arguments. Dropping the first argument results in an error message such as

```
! Missing number, treated as zero. <to be read again>
```

1.175

Dropping the second argument does not yield an error message but the result is probably not what you intended. The next character is taken as the contents of the \parbox.

#### Paragraph box refinements

The "character" created by a \parbox command is placed on the line so that its vertical center is aligned with the center of the line. An optional first argument b or t forces the paragraph box to align along its bottom or top. For an example, see Section 6.6. The full syntax of \parbox is

```
\verb|\parbox[alignment][height][inner-alignment]{width}{text}|
```

Just as for the \makebox command (see Section 5.9.1), the

```
\height \depth \totalheight and \width
```

commands may be used in the *height* argument instead of a numeric argument.

The inner-alignment argument is the vertical equivalent of the alignment argument for \makebox, determining the position of text within the box and it may be any one of t, b, c, or s, denoting top, bottom, centered, or stretched alignment, respectively. When the inner-alignment argument is not specified, it defaults to alignment.

## Paragraph box as an environment

The minipage environment is very similar to the \parbox command. It typesets the text in its body using a line width supplied as an argument. It has an optional argument for bottom or top alignment, and the other \parbox refinements also apply. The difference is that the minipage environment can contain displayed text environments discussed in Chapter 6.

The minipage environment can also contain footnotes (see Section 5.5.2) that are displayed within the minipage. See Section 3.2.1 of *The LaTeX Companion*, 2nd edition [46] for complications that may arise therefrom.

# 5.9.4 Marginal comments

A variant of the paragraph box, the \marginpar command, allows you to add marginal comments. So

Do not use this much.

\marginpar{Do not use this much.}

produces the comment displayed in the margin.

The AMS warning in the book [30] (also displayed here below the marginal comment) is defined as



```
\marginpar{{\Large%
\textcircled{\raisebox{.7pt}{\normalsize\textbf A}}}}
```

The \textcircled command is discussed in Section 5.4.7, while the \raisebox command is introduced in Section 5.9.6.

# **Rule** Marginal comments and math environments

Do not use marginal comments in equations or multiline math environments.

**Tip** Avoid using too many marginal comments on any given page—LATEX may have to place some of them on the next page.

If the document is typeset two-sided, then the marginal comments are set in the outside margin. The form

\marginpar[left-comment] {right-comment}

uses the required argument right-comment when the marginal comment is set in the right margin and the optional argument left-comment when the marginal comment is set in the left margin.

5.9 Boxes 113

The width of the paragraph box for marginal comments is stored in the length command \marginparwidth (see Section 15.5.2 for length commands). If you want to change it, use

The default value of this width is set by the document class. If you want to know the present setting, type

\the\marginparwidth

in your document and typeset it, or, in interactive mode (see Sections 15.1.7 and D.4), type

\*\showthe\marginparwidth

(\* is the interactive prompt).

See Sections 3.2.8 and 4.1 of *The LATEX Companion*, 2nd edition [46] for other style parameters pertaining to marginal notes.

# 5.9.5 Solid boxes

A solid filled box is created with a \rule command. The first argument is the width and the second is the height. For instance, to obtain

```
end of proof symbol: 

type

end of proof symbol: \rule{1.6ex}{1.6ex}

In fact, this symbol is usually slightly lowered:

end of proof symbol: 

This positioning is done with an optional first argument:

end of proof symbol: \rule[-.23ex]{1.6ex}{1.6ex}

Here is an example combining \rule with \makebox and \hrulefill:

1 inch:\quad\makebox[1in]{\rule{.4pt}{4pt}}

\hrulefill\rule{.4pt}{4pt}}
```

which produces

1 inch: \_\_\_\_\_

#### Struts

Solid boxes of zero width are called *struts*. Struts are invisible, but they force LATEX to make room for them, changing the vertical alignment of lines. Standard struts can also be added with the \strut or \mathstrut command. To see how struts work, compare

typed as

\fbox{ab} and \fbox{\strut ab} and \fbox{\mathstrut\$ab}

Struts are especially useful for fine tuning tables (see Section 6.6, page 139) and formulas (see math struts in Section 8.4).

#### Rule ■ Zero distance

Opt, Oin, Ocm, Oem all stand for zero width. O by itself is not acceptable.

For example,  $\left(0\right)_{1.6ex}$  gives the error message

! Illegal unit of measure (pt inserted). <to be read again>

. .

 $1.251 \text{ } \text{rule}\{0\}\{1.6ex\}$ 

If the \rule command has no argument or only one, LATEX generates an error message. For instance, \rule{1.6ex} gives the message

! Paragraph ended before \@rule was complete.

or

! Missing number, treated as zero.

In the first error message, the reference to \@rule suggests that the problem is with the \rule command. Checking the syntax of the \rule command, you find that an argument is missing. The second error message is more informative, since there is, indeed, a missing number.

5.9 Boxes 115

# 5.9.6 Fine tuning boxes

The command

\raisebox{displacement}{text}

typesets text in a box with a vertical displacement. If displacement is positive, the box is raised; if it is negative, the box is lowered.

The \raisebox command allows us to play games:

```
\label{limiting} $$ fine-\arrown{.5ex}{tun}\simeq {-.5ex}{ing}$ produces $$ fine-tun$_{ing}.
```

The \raisebox command has two optional arguments:

```
\raisebox{0ex}[1.5ex][0.75ex]{text}
```

forces LATEX to typeset text as if it extended 1.5 ex above and 0.75 ex below the line, resulting in a change in the interline space above and below the line. A simple version of this command, \smash, is discussed in Section 8.4.

In the AMS warning in the book [30] (shown on page 112), the \raisebox command is used to properly center the bold A in the circle:

\Large\textcircled{\raisebox{.7pt}{\normalsize\textbf A}}

# Text environments

There are three types of text environments in LaTeX:

- 1. Displayed text environments; text within such an environment usually is typeset with some vertical space around it
- 2. Text environments that create a "large symbol"
- 3. Style and size environments

We start by discussing a very important rule about blank lines in displayed text environments. Then we proceed in Section 6.2 to the most often used displayed text environments: lists. We continue with the style and size environments in Section 6.3.

The most important displayed text environments in math are proclamations or theorem-like structures, proclamations with style, and the proof environment, discussed in detail in Sections 6.4 and 6.5.

The tabular environment discussed in Section 6.6 produces a "large symbol", a table, which is of limited use in math.

In Section 6.7, we discuss the tabbing environment, which is often used for computer code. The legacy environments quote, quotation, and verse are discussed in Section 6.8, along with the verbatim environment, which is often used to display LATEX source in a typeset LATEX document.

# 6.1 Some general rules for displayed text environments

As you know, blank lines play a special role in LaTeX, usually indicating a paragraph break. Since displayed text environments structure the printed display themselves, the rules about blank lines are relaxed somewhat. However, a blank line trailing an environment signifies a new paragraph for the text following the environment.

# Rule ■ Blank lines in displayed text environments

- 1. Blank lines are ignored immediately after \begin{name} or immediately before \end{name} except in a verbatim environment.
- 2. A blank line after \end{name} forces the text that follows to start a new paragraph.
- 3. As a rule, you should not have a blank line before \begin{name}.
- 4. The line after any theorem or proof always begins a new paragraph, even if there is no blank line or \par command.

The page breaking commands in Section 5.7.3 apply to text environments, as does the line breaking command \\ discussed in Section 5.7.1.

# 6.2 List environments

LATEX provides three list environments: enumerate, itemize, and description. LATEX also provides a generic list environment that can be customized to fit your needs. See Section 15.6 on custom lists.

Most document classes redefine the spacing and some stylistic details of lists, especially since the list environments in the legacy document classes are not very pleasing. In this section, the list environments are formatted as they are by our standard document class, amsart. Throughout the rest of the book, lists are formatted as specified by this book's designer.

6.2 List environments 119

#### 6.2.1 Numbered lists

A *numbered list* is created with the enumerate environment:

This space has the following properties:

- (1) Grade 2 Cantor;
- (2) Half-smooth Hausdorff;
- (3) Metrizably smooth.

Therefore, we can apply the Main Theorem.

typed as

```
\noindent This space has the following properties:
\begin{enumerate}
   \item Grade 2 Cantor\label{Cantor};
   \item Half-smooth Hausdorff\label{Hausdorff};
   \item Metrizably smooth\label{smooth}.
\end{enumerate}
Therefore, we can apply the Main Theorem.
```

Each item is introduced with an \item command. The numbers LaTeX generates can be labeled and cross-referenced (see Section 10.4.2). This construct can be used in theorems and definitions, for listing conditions or conclusions.

If you use \item in the form \item[], you get an unnumbered item in the list.

#### 6.2.2 Bulleted lists

A *bulleted list* is created with the itemize environment:

We set out to accomplish a variety of goals:

- To introduce the concept of smooth functions.
- To show their usefulness in differentiation.
- To point out the efficacy of using smooth functions in Calculus.

is typed as

```
\noindent We set out to accomplish a variety of goals:
\begin{itemize}
  \item To introduce the concept of smooth functions.
  \item To show their usefulness in differentiation.
  \item To point out the efficacy of using smooth
    functions in Calculus.
\end{itemize}
```

# 6.2.3 Captioned lists

In a *captioned list* each item has a title (caption) specified by the optional argument of the \item command. Such lists are created with the description environment:

```
In this introduction, we describe the basic techniques:
   Chopped lattice: a reduced form of a lattice;
   Boolean triples: a powerful lattice construction;
   Cubic extension: a subdirect power flattening the congruences.

is typed as

\noindent In this introduction, we describe
   the basic techniques:
\begin{description}
   \item[Chopped lattice] a reduced form of a lattice;
   \item[Boolean triples] a powerful lattice construction;
   \item[Cubic extensions] a subdirect power flattening
        the congruences.
\end{description}
```

# 6.2.4 A rule and combinations

There is only one rule you must remember.

## **Rule** List environments

An \item command must immediately follow \begin{enumerate}, \begin{itemize}, or \begin{description}.

Of course, spaces and line breaks can separate them.

If you break this rule, you get an error message. For instance,

6.2 List environments 121

If you see this error message, remember the rule for list environments and check for text preceding the first \item.

You can nest up to four list environments; for instance,

```
(1) First item of Level 1.
        (a) First item of Level 2.
              (i) First item of Level 3.
                  (A) First item of Level 4.
                  (B) Second item of Level 4.
              (ii) Second item of Level 3.
        (b) Second item of Level 2.
   (2) Second item of Level 1.
Referencing the second item of Level 4: 1(a)iB
which is typed as
\begin{enumerate}
   \item First item of Level 1.
   \begin{enumerate}
       \item First item of Level 2.
       \begin{enumerate}
          \item First item of Level 3.
          \begin{enumerate}
             \item First item of Level 4.
             \item Second item of Level 4. \label{level4}
           \end{enumerate}
           \item Second item of Level 3.
        \end{enumerate}
        \item Second item of Level 2.
   \end{enumerate}
   \item Second item of Level 1.
\end{enumerate}
Referencing the second item of Level 4: \ref{level4}
Note that the label level4 collected all four of the counters (see Section 10.4.2).
    You can also mix list environments:
```

```
(1) First item of Level 1.
         • First item of Level 2.
             (a) First item of Level 3.
                   - First item of Level 4.
                   - Second item of Level 4.
             (b) Second item of Level 3.
         • Second item of Level 2.
   (2) Second item of Level 1.
Referencing the second item of Level 4: 1a
which is typed as
\begin{enumerate}
   \item First item of Level 1.
   \begin{itemize}
      \item First item of Level 2.
      \begin{enumerate}
          \item First item of Level 3.
          \begin{itemize}
             \item First item of Level 4.
             \item Second item of Level 4.\label{enums}
           \end{itemize}
           \item Second item of Level 3.
        \end{enumerate}
        \item Second item of Level 2.
   \end{itemize}
   \item Second item of Level 1.
\end{enumerate}
Referencing the second item of Level 4: \ref{enums}
```

Now the label enums collects only the two enumerate counters (see Section 10.4.2).

The indentations are, of course, not needed. I use them to keep track of the level of nesting.

In all three types of list environment, the \item command may be followed by an optional argument, which is displayed at the beginning of the typeset item:

```
\item[label]
```

Note that for enumerate and itemize the resulting typography may leave something to be desired.

Tip If the text following an \item command starts with an opening square bracket, [, then LaTeX thinks that \item has an optional argument. To prevent this problem from occurring, type [ as {[}. Similarly, a closing square bracket, ], inside the optional argument should be typed as {]}.

You may want to use a list environment solely for the way the items are displayed, without any labels. You can achieve this effect by using \item[].

You can change the style of the numbers in an enumerate environment by redefining the counter as suggested in Section 15.5.1:

```
\renewcommand{\labelenumi}{{\normalfont (\roman{enumi})}}
```

The labels then are displayed as (i), (ii), and so on. This modification only works if you do not want to reference these items. If you want the \ref command to work properly, use David Carlisle's enumerate package (see Section 12.3.1). For an example of how to use Carlisle's environment, see Section 15.2.1.

Section 3.3 of *The LATEX Companion*, 2nd edition [46] explains how to customize the three list environments and discusses Bernd Schandl's paralist package, which provides a number of new list environments and makes customizing the three legacy list environments much easier. For custom lists, see Section 15.6.

# 6.3 Style and size environments

There are several text environments that allow you to set font characteristics. They have the same names as their corresponding command declarations:

```
rmfamily sffamily ttfamily
upshape itshape em slshape scshape
bfseries
```

For instance,

```
\begin{ttfamily}
    text
\end{ttfamily}
```

typesets text just like {\ttfamily text} would. Remember to use the command-declaration names for the environment names, that is, use rmfamily, not textrm and ttfamily, not texttt (see Section 5.6.2). There are also text environments for changing the font size, from tiny to Huge (see Section 5.6.6).

If you are getting overwhelmed by the large number of environments changing style and size, consult Tables 5.6 and 5.7 (see also Section C.3.2).

Horizontal alignment of a paragraph is controlled by the flushleft, flush-right, and center environments. Within the flushright and center environments, it is customary to force new lines with the \\ command, while in the flushleft environment, you normally allow LATEX to wrap the lines.

These text environments can be used separately or in combination, as in

The **simplest** text environments set the printing style and size.

The commands and the environments have similar names.

```
typed as

\begin{flushright}
   The \begin{bfseries}simplest\end{bfseries}
   text environments set the
   printing style and size.\\
   The commands and the environments have similar names.
\end{flushright}
```

There are command declarations that correspond to these environments:

- \centering centers text
- \raggedright left aligns text
- \raggedleft right aligns text

The effect of one of these commands is almost the same as that of the corresponding environment except that the environment places additional vertical space before and after the displayed paragraphs. For such a command declaration to affect the way a paragraph is formatted, the scope must include the whole paragraph, including the blank line at the end of the paragraph, preferably indicated with a \par command.

The \centering command is used often with the \includegraphics command (see Section 10.4.3).

# 6.4 Proclamations (theorem-like structures)

Theorems, lemmas, definitions, and so forth are a major part of mathematical writing. In LATEX, these constructs are typed in displayed text environments called *proclamations* or *theorem-like structures*.

In the intrart.tex sample article (see pp. 42–43), there are two theorems, a definition, and a notation. These four environments have similar structures, only their names are different.

In the sampart.tex sample article (see pp. 286–288), there are a number of different proclamations in a variety of styles, with varying degrees of emphasis. Proclamations with style are discussed in Section 6.4.2.

We discuss in Section 4.2.3 the two steps required by proclamations:

**Step 1** *Define* the proclamation with a \newtheorem command *in the preamble* of the document. For instance, the line

```
\newtheorem{theorem}{Theorem}
```

defines a theorem environment.

**Step 2** *Invoke* the proclamation as an environment *in the body* of your document. Using the proclamation definition from Step 1, type

In the proclamation definition

```
\newtheorem{theorem}{Theorem}
```

the first argument, theorem, is the name of the environment that invokes the theorem. The second argument, Theorem, is the name that is used when the proclamation is typeset. LATEX numbers the theorems automatically and typesets them with vertical space above and below. The phrase **Theorem 1.** appears, followed by the theorem itself, which may be emphasized. Of course, the formatting of the theorem depends on the document class and on the proclamation style (see Section 6.4.2).

You may also specify an optional argument,

```
\begin{theorem}[The Fuchs-Schmidt Theorem]
  The statement of the theorem.
\end{theorem}

that appears as the name of the theorem:
```

```
Theorem 1 (The Fuchs-Schmidt Theorem). The statement of the theorem.
```

LATEX is very fussy about how proclamations are defined. For example, in the introductory article intrart.tex (see Section 4.1), if the closing brace is dropped from the end of line 8,

\newtheorem{definition}{Definition

you get an error message such as

Runaway argument?

{Definition \newtheorem {notation}{Notation}

! Paragraph ended before \@ynthm was complete.

<to be read again>

\par

1.10

Line 10 is the line after the \newtheorem commands. The message conveys the information that something is wrong in the paragraph before line 10.

If you forget an argument, as in

\newtheorem{definition}

LATEX produces an error message such as

! LaTeX Error: Missing \begin{document}.

1.9 \newtheorem{n

otation}{Notation}

In the error message, the line

! LaTeX Error: Missing \begin{document}.

usually means that LaTeX became confused and believes that some text typed in the preamble should be moved past the line

\begin{document}

The mistake could be anywhere in the preamble above the line LATEX indicates. If you encounter such an error message, try to isolate the problem by commenting out parts of the preamble (see Section 5.5.1 and also Section 4.3.1).

### **Rule** Lists in proclamations

If a proclamation starts with a list environment, precede the list by \hfill.

```
If you do not, as in
```

```
\begin{definition}\label{D:prime}
  \begin{enumerate}
  \item $u$ is \emph{bold} if $u = x^2$.\label{mi1}
  \item $u$ is \emph{thin} if $u = \sqrt{x}$.\label{mi2}
  \end{enumerate}
\end{definition}
```

your typeset list starts on the first line of the proclamation:

```
Definition 1. (1) u is bold if u = x^2. (2) u is thin if u = \sqrt{x}.
```

If you add the \hfill command,

```
\begin{definition}\hfill
\begin{enumerate}
```

the list in the definition typesets correctly:

### Definition 1.

- (1) u is bold if  $u = x^2$ .
- (2) u is thin if  $u = \sqrt{x}$ .

### Consecutive numbering

If you want to number two sets of proclamations consecutively, you can do so by first defining one proclamation, and then using its name as an optional argument of the second proclamation. For example, to number the lemmas and propositions in your paper consecutively, you type the following two lines in your preamble:

```
\newtheorem{lemma}{Lemma}
\newtheorem{proposition}[lemma]{Proposition}
```

Lemmas and propositions are then consecutively numbered as Lemma 1, Proposition 2, Proposition 3, and so on.

Let me emphasize: The optional argument of a proclamation definition must be the name of a proclamation that *has already been defined*.

#### Numbering within a section

The \newtheorem command may also have a different optional argument; it causes LaTeX to number the lemmas within sections. For example,

\newtheorem{lemma}{Lemma}[section]

numbers the lemmas in Section 1 as Lemma 1.1 and Lemma 1.2. In Section 2, you have Lemma 2.1 and Lemma 2.2, and so on.

Instead of section, you may use any sectioning command provided by the document class, such as chapter, section, and subsection.

Consecutive numbering and numbering within a section can be combined. For example,

```
\newtheorem{lemma}{Lemma}[section]
\newtheorem{proposition}[lemma]{Proposition}
```

sets up the lemma and proposition environments so that they are numbered consecutively within sections: Lemma 1.1, Proposition 1.2, Proposition 1.3 and Proposition 2.1, Lemma 2.2, and so on.

### 6.4.1 The full syntax

The full form of \newtheorem is

\newtheorem{envname}[procCounter]{Name}[secCounter]

where the two optional arguments are mutually exclusive, and

envname is the name of the environment to be used in the body of the document. For instance, you may use theorem for the envname of a theorem, so that a theorem is typed inside a theorem environment. Of course, envname is just a label; you are free to choose any environment name, such as thm or george (as long as the name is not in use as the name of another command or environment). This argument is also the name of the counter LATEX uses to number these text environments.

procCounter is an optional argument. It sets the new proclamation to use the counter of a previously defined proclamation and the two proclamations are consecutively numbered.

Name is the text that is typeset when the proclamation is invoked. So if Theorem is given as Name, then you get Theorem 1, Theorem 2, and so on in your document.

secCounter is an optional argument that causes Name environments to be numbered within the appropriate sectioning units. So if theorem is the envname and section is the secCounter, then in Section 1 you have Theorem 1.1, Theorem 1.2, and so on. In Section 2 you get Theorem 2.1, Theorem 2.2, and so on. Proclamations may be numbered within subsections, sections, chapters, or any other sectioning unit automatically numbered by LATEX.

### 6.4.2 Proclamations with style

You can choose one of three styles for your proclamations by preceding the definitions with the \theoremstyle{style} command, where *style* is one of the following:

- plain, the most emphatic
- definition
- remark, the least emphatic

There are a few extra options, including the \newtheorem\* command, an unnumbered version of \newtheorem.

The following commands set the styles in the sampart.tex article (see page 290). The typeset sample article (on pages 286–288) shows how the chosen styles affect the typeset proclamations.

```
\theoremstyle{plain}
\newtheorem{theorem}{Theorem}
\newtheorem{corollary}{Corollary}
\newtheorem*{main}{Main Theorem}
\newtheorem{lemma}{Lemma}
\newtheorem{proposition}{Proposition}
\theoremstyle{definition}
\newtheorem{definition}{Definition}
\theoremstyle{remark}
\newtheorem*{notation}{Notation}
```

A proclamation created by a \newtheorem command has the style of the last \theoremstyle command preceding it. The default style is plain.

#### Three examples

Here are three sets of proclamation definitions to illustrate different styles and numbering schemes.

#### Example 1

```
\theoremstyle{plain}
\newtheorem{theorem}{Theorem}
\newtheorem{lemma}[theorem]{Lemma}
\newtheorem{definition}[theorem]{Definition}
\newtheorem{corollary}[theorem]{Corollary}
```

In a document with this set of proclamation definitions you can use theorems, lemmas, definitions, and corollaries, typeset in the most emphatic (plain) style. They are all numbered consecutively: **Definition 1**, **Definition 2**, **Theorem 3**, **Corollary 4**, **Lemma 5**, **Lemma 6**, **Theorem 7**, and so on.

#### Example 2

```
\theoremstyle{plain}
\newtheorem{theorem}{Theorem}
\newtheorem*{main}{Main Theorem}
\newtheorem{definition}{Definition}[section]
\newtheorem{lemma}[definition]{Lemma}
\theoremstyle{definition}
\newtheorem*{Rule}{Rule}
```

In this document you may use theorems, definitions, and lemmas in the most emphatic (plain) style, and unnumbered rules in the less emphatic (definition) style. Definitions and lemmas are numbered consecutively within sections. You may also use the unnumbered Main Theorem. So, for example, you may have **Definition 1.1**, **Definition 1.2**, **Main Theorem**, **Rule**, **Lemma 1.3**, **Lemma 2.1**, **Theorem 1**, and so on.

### Example 3

```
\theoremstyle{plain}
\newtheorem{theorem}{Theorem}
\newtheorem{corollary}{Corollary}
\newtheorem*{main}{Main Theorem}
\newtheorem{lemma}{Lemma}
\newtheorem{proposition}{Proposition}
\theoremstyle{definition}
\newtheorem{definition}{Definition}
\theoremstyle{remark}
\newtheorem*{notation}{Notation}
```

With these proclamation definitions you can use theorems, corollaries, lemmas, and propositions in the most emphatic (plain) style, and an unnumbered Main Theorem. You can have definitions in the less emphatic (definition) style. All are separately numbered. So in the document you may have Definition 1, Definition 2, Main Theorem, Lemma 1, Proposition 1, Lemma 2, Theorem 1, Corollary 1, and so on. You can also have Notations which are unnumbered and typeset in the least emphatic (remark) style.

### Number swapping

Proclamations can be numbered on the left, as for instance, **3.2 Theorem**. To accomplish this, type the \swapnumbers command before the \newtheorem command corresponding to the proclamation definition you want to change. This command affects all of the proclamation definitions that follow it, so the proclamation definitions in the preamble should be in two groups. The regular ones should be listed first, followed by the \swapnumbers command, then all the proclamations that swap numbers.

Do not swap numbers unless the publisher demands it.

#### Custom theorem styles

You can define custom theorem styles with the \newtheoremstyle command. You should very seldom do this, the three theorem styles of the document class should suffice. For more detail, see [5].

# 6.5 Proof environments

A proof is the contents of a proof environment. For instance,

```
Proof. This is a proof, delimited by the q.e.d. symbol.

typed as

begin{proof}
This is a proof, delimited by the q.e.d.\ symbol.
\end{proof}
```

A proof is set off from the surrounding text with some vertical space. The end of the proof is marked with the symbol  $\square$  at the end of the line. There are a few examples of the proof environment in the sampart.tex sample article (pages 286–293).

We start with the same rule for proofs as we have for proclamations on page 126.

### **Rule** ■ Lists in proofs

If a proof starts with a list environment, precede the list by \hfill.

If you want to suppress the symbol at the end of a proof, give the command

```
\begin{proof}
    ...
\renewcommand{\qedsymbol}{}
\end{proof}
```

```
To suppress the end of the proof symbol in the whole article, give the
\renewcommand{\qedsymbol}{}
command in the preamble.
    To substitute another phrase for Proof, such as Necessity, as in
Necessity. This is the proof of necessity.
                                                                            use the proof environment with an optional argument:
\begin{proof} [Necessity]
This is the proof of necessity.
\end{proof}
The optional argument may contain a reference, as in
\begin{proof}[Proof of Theorem~\ref{T:smooth}]
which might be typeset as
Proof of Theorem 5. This is the proof.
                                                                            It is easy to make the mistake of placing the optional argument after \begin:
\begin[Proof of Theorem~\ref{T:P*}]{proof}
    You get an error message
! LaTeX Error: Bad math environment delimiter.
1.91 \begin{equation}
                         \label{E:cong2}
which is not very helpful.
    There is a problem with the placement of the q.e.d. symbol if the proof ends with
a displayed formula (or a list environment). For instance,
\begin{proof}
Now the proof follows from the equation
١/
   a^2 = b^2 + c^2.
\backslash
\end{proof}
```

typesets as

*Proof.* Now the proof follows from the equation

$$a^2 = b^2 + c^2$$
.

To correct the placement of the q.e.d. symbol, use the \qedhere command:

```
\begin{proof}
Now the proof follows from the equation
\[
    a^2 = b^2 + c^2.\qedhere
\]
\end{proof}
which typesets as
```

*Proof.* Now the proof follows from the equation

$$a^2 = b^2 + c^2.$$

# 6.6 Tabular environments

A tabular environment creates a table that LATEX treats as a "large symbol". In particular, a table cannot be broken across pages.

	Name	1	2	3		
Here is a simple table,	Peter	2.45	34.12	1.00	, typeset inline.	Thic
fiele is a simple table,	John	0.00	12.89	3.71	, typeset iiiiie.	11115
	David	2.00	1.85	0.71		

looks awful, but it does make the point that the table is just a "large symbol". The table is typed as

with no blank line before or after the environment.

This table can be horizontally centered with a center environment (see Section 6.3). It can also be placed within a table environment (see Section 10.4.3). This sets the table off from the surrounding text with vertical space and you can also use the float controls b, t, h, p to specify where the table should appear (see Section 10.4.3). This also allows you to define a caption, which can be placed before or after the table:

```
\begin{table}
   \begin{center}
     \begin{tabular}{ | 1 | r | r | r | }
       \hline
       Name
                & 1
                        & 2
                                & 3
                                      \\ \hline
                & 2.45 & 34.12 & 1.00\\ \hline
       Peter
                & 0.00 & 12.89 & 3.71\\ \hline
       John
       David
                & 2.00 & 1.85 & 0.71\\ \hline
     \end{tabular}
     \caption{Tabular table.}\label{Ta:first}
   \end{center}
\end{table}
```

This table is displayed as Table 6.1.

Name	1	2	3
Peter	2.45	34.12	1.00
John	0.00	12.89	3.71
David	2.00	1.85	0.71

Table 6.1: Tabular table.

It can be listed in a list of tables (see Section 10.4.3) and the table number may be referenced using the command \ref{Ta:first}. Note that the label must be typed between the caption and the \end{table} command.

For another example, look at the two tables in the fonttbl.tex file in your samples folder. The first is typed as

```
\begin{tabular}{r|1|1|1|1|1|1|1|1|1}
& 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9\\ \hline

0& \symbol{0} &\symbol{1}&\symbol{2}&\symbol{3}& \symbol{4}&\symbol{5}&\symbol{6}&\symbol{7}& \symbol{8}&\symbol{9}\\ \hline
```

. . .

The second table is the same except that the numbers run from 128 to 255. The typeset table is shown in Section 5.4.4.

### Rule ■ tabular environments

- \begin{tabular} requires an argument consisting of a character 1, r, or c, meaning left, right, or center alignment, for each column, and optionally, the | symbols.
   Each | indicates a vertical line in the typeset table. Spaces in the argument are ignored but can be used for readability.
- 2. Columns are separated by ampersands (&) and rows are separated by \\.
- 3. & absorbs spaces on either side.
- 4. The \hline command creates a horizontal rule in the typeset table. It is placed either at the beginning of the table (after the \begin line) or it must follow a \\ command.
- 5. If you use a horizontal line to finish the table, you must separate the last row of the table from the \hline command with the \\ command.
- 6. \begin{tabular} takes an optional argument, b or t, to specify the bottom or the top vertical alignment of the table with the baseline. The default is center alignment.

Remember to put the optional argument b or t in square brackets, as in

```
\begin{tabular}[b]{ | 1 | r | r | r | }
```

If you forget to place an \hline command right after \\ in the last row, you get an error message such as

### More column-formatting commands

The required argument of the tabular environment may contain column-formatting commands of various types.

An @-expression, for instance, @{.}, replaces the space LATEX normally inserts between two columns with its argument. For example,

```
\begin{tabular}{r @{.} 1}
    3&78\\
    4&261\\
    4
\end{tabular}
```

creates a table with two columns separated by a decimal point. In effect, you get a single, decimal-aligned column:

```
3.78
4.261
4.
```

This example is an illustration. You should use David Carlisle's dcolumn package if you need a decimal-aligned column (see Section 12.3.1).

The width of a column depends on the entries in the column by default. You can specify a width by using the p column specifier:

```
p{width}
```

For instance, if you want the first column of Table 6.1 to be 1 inch wide, then type

```
\begin{tabular}{ | p{1in} | r | r | r | }\hline

Name & 1 & 2 & 3 \\ hline

Peter & 2.45 & 34.12 & 1.00\\ hline

John & 0.00 & 12.89 & 3.71\\ hline

David & 2.00 & 1.85 & 0.71\\ \hline

\end{tabular}
```

which typesets as

Name	1	2	3
Peter	2.45	34.12	1.00
John	0.00	12.89	3.71
David	2.00	1.85	0.71

To center the items in the first column, precede *each* item with a \centering command (see Section 6.3). Note that the first column is actually somewhat over 1 inch wide, because of the extra space provided around the column boundaries.

The p column specifier can also be used for multiline entries.

#### Refinements

\hline draws a horizontal line the whole width of the table.  $\cline{a-b}$  draws a horizontal line from column a to column b. For instance,

$$\left(1-3\right)$$
 or  $\left(4-4\right)$ 

Another useful command is \multicolumn, which is used to span more than one column, for example,

```
\multicolumn{3}{c}{\emph{absent}}
```

The first argument is the number of columns spanned by the entry, the second is the alignment (an optional vertical line designator | for this row only can also be included), and the third argument is the entry. Note that the entry for the spanned columns is in braces. An example is shown in Table 6.2, typed as follows:

### \begin{table}[h!]

Name	1	2	3
Peter	2.45	34.12	1.00
John		absent	
David	2.00	1.85	0.71

Table 6.2: Table with \multicolumn.

Name	Month	Week	Amount
Peter	Jan.	1	1.00
		2	12.78
		3	0.71
		4	15.00
	Total		29.49
John	Jan.	1	12.01
		2	3.10
		3	10.10
		4	0.00
	Total		25.21
Grand 7	Гotal		54.70

Table 6.3: Table with \multicolumn and \cline.

\begin{center}

```
& 1
                                                                       & 2
                                                                                              & 3\\ \hline
                          Name
                          Peter
                                                  & 2.45 & 34.12 & 1.00\\ \hline
                           John
                                                  & \mbox{\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{}\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{}\box{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{}
                           \hline
                          David
                                                  & 2.00 & 1.85 & 0.71\\ \hline
                  \end{tabular}
                  \caption{Table with \bsl\texttt{multicolumn}.}
                  \label{Ta:mc}
         \end{center}
\end{table}
           The next example, shown in Table 6.3, uses the \multicolumn and \cline com-
mands together:
\begin{table}[t]
         \begin{center}
                  Name & Month & Week & Amount \\ \hline
                          Peter & Jan. & 1 & 1.00\\ \cline{3-4}
                                            &₹.
                                                                    & 2
                                                                                        & 12.78\ \cline{3-4}
                                            lг.
                                                                    & 3
                                                                                         & 0.71\ \cline{3-4}
                                                                    & 4
                                                                                         & 15.00\\ \cline{2-4}
                                            & \multicolumn{2}{| 1}{Total} & 29.49\\
                                            \hline
                          John & Jan. & 1
                                                                                         & 12.01\\ \cline{3-4}
                                                                    & 2
                                                                                         & 3.10\\ \cline{3-4}
                                            &
                                                                                         & 10.10\\ \cline{3-4}
                                            &
                                                                    & 3
                                                                                         & 0.00\ \cline{2-4}
                                                                    & 4
                                            & \multicolumn{2}{| 1}{Total} & 25.21\\
                                             \hline
                                 \mathcal{S}_{1}^{3}_{1}^{1}_{Grand Total} \& 54.70
                                \hline
                  \end{tabular}
                  \caption{Table with \bsl\texttt{multicolumn}
                  and \bsl\texttt{cline}.}\label{Ta:multicol+cline}
         \end{center}
\end{table}
```

The \parbox command (see Section 5.9.3) can be used to produce a single multiline entry. Recall that the first argument of \parbox is the width of the box. A p{} width designator creates a column in which all entries can be multiline. As an example, to replace Grand Total by Grand Total for Peter and John, type the last line as

Note the use of the bottom alignment option (see Section 5.9.3). The last row of the modified table prints

Grand Total	
for Peter and John	54.70

The spacing above Grand Total is not quite right. It can be adjusted with a strut (see Section 5.9.5),

Finally, vertical spacing can be adjusted by redefining  $\arraystretch$ . For instance, in the table

	Area	Students
5th Grade:	$63.4 \text{ m}^2$	22
6th Grade:	$62.0 \text{ m}^2$	19
Overall:	$62.6 \text{ m}^2$	20

```
typed as
```

you may find that the rows are too crowded. The vertical spacing may be adjusted by adding the line

```
\renewcommand{\arraystretch}{1.25}
```

to the tabular environment. To limit its scope, add it after

```
\begin{center}
```

The adjusted table is typeset as

	Area	Students
5th Grade:	$63.4~\mathrm{m}^2$	22
6th Grade:	$62.0 \text{ m}^2$	19
Overall:	$62.6 \text{ m}^2$	20

In some tables, horizontal and vertical lines do not always intersect as desired. Fine control over these intersections is provided by the hhline package (see Section 12.3.1).

Chapter 5 of *The LATEX Companion*, 2nd edition [46] deals with tabular material, discussing many extensions, including multipage tables, decimal-point alignment, footnotes in tables, tables within tables, and so on.

### 6.6.1 Table styles

LATEX can draw double horizontal and vertical lines in tables with ease. As a result, there are far too many double lines in LATEX tables, resulting in cluttered and confusing tables. *The Chicago Manual of Style*, 15th edition [11] has almost 80 pages on tables. For simple tables it advocates a simple style, as shown in Table 6.4. Notice

- the generous space above and below the column heads, which has been achieved with the \rule[-8pt]{0pt}{22pt} command,
- some extra space above the first line of data, which has been achieved with the \rule{0pt}{14pt} command,
- the columns of equal width, which has been achieved with p{70pt} commands,
- and no vertical lines.

Most tables in this book have been designed according to this style using Simon Fear's booktabs package (see Section E.1).

	Smoke	Don't Smoke	Total
Males	1,258	2,104	3,362
Females	1,194	2,752	3.946
Total	2,452	4,856	7,308

Table 6.4: Smokers and Nonsmokers, by Sex.

# 6.7 Tabbing environments

Although of limited use for mathematical typesetting, the tabbing environment can be useful for typing algorithms, computer programs, and so forth. LaTeX calculates the width of a column in the tabular environment based on the widest entry (see Section 6.6). The tabbing environment allows you to control the width of the columns.

The \\ command is the line separator, tab stops are set by \= and are remembered by LATEX in the order they are given, and \> moves to the next tab position.

You can easily reset tab positions. For instance, if you are past the second tab position by using \> twice, and there is a third tab position, the \= command resets it.

Lines of comments may be inserted with the \kill command, see the examples below, or with the % character. The difference is that a line with \kill can be used to set tab stops, whereas a commented out line cannot.

A simple example:

```
PrintTime
     Block[timing],
          timing = Timing[expr];
          Print[ timing[[1]] ];
     ٦
End[]
typed as
{\ttfamily
\begin{tabbing}
   Print\=Time\\
   \>Block\=[{timing},\\
   \>\timing = Timing[expr];\\
   (careful with initialization)\kill
   \>\Print[ timing[[1]] ];\\
   \>]\\
   End[]
\end{tabbing}
}% end \ttfamily
```

An alternative method is to use a line to set the tab stops, and then \kill the line so it does not print:

```
{\ttfamily
\begin{tabbing}
  \hspace*{.25in}\=\hspace{2ex}\=\hspace{2ex}\=
```

```
\hspace{2ex}\kill
   \> $k := 1$\\
   \> $1_k := 0$; $r_k := 1$\\
   \> loop\\
  \> \> if $w < m_k$ then\\
   \> \> \b_k := 0$; $r_k := m_k$\\
   \> \> else if $w > m_k$ then\\
  \> \> \b_k := 1$; $l_k := m_k$\\
   \> \> end if\\
   \> \> $k := k + 1$\\
   \> end loop
\end{tabbing}
}% end \ttfamily
which typesets as
   k := 1
   l_k := 0; \ r_k := 1
   loop
    m_k := (l_k + r_k)/2
    if w < m_k then
      b_k := 0; \ r_k := m_k
    else if w > m_k then
      b_k := 1; \ l_k := m_k
     end if
    k := k + 1
   end loop
```

Some simple rules:

- There is no \\ command on a line containing the \kill command.
- You may set the tabs in a \kill line with \hspace commands.
- The \> command moves to the next tab stop, even if the text you have already typed extends past that stop, which can result in overprinting.
- The tabbing environment has to be typeset with typewriter style font—note the \ttfamily command.

To illustrate the third rule, type

```
\begin{tabbing}
   This is short.\=\\
   This is much longer, \> and jumps back.
\end{tabbing}
which typesets as
This is short.
This is muchdodgemps back.
```

If you do not follow the fourth rule, be careful with your tabbing. You do not really have to use typewriter style font—just beware of the pitfalls.

For more information, please consult Chapter 5 of *The LATEX Companion*, 2nd edition [46].

# 6.8 Miscellaneous displayed text environments

There are four more displayed text environments, of limited use in math: quote, quotation, verse, and verbatim. We also discuss an inline version of the verbatim environment, the \verb command.

#### Quotes

The quote environment is used for short (one paragraph) quotations:

```
It's not that I'm afraid to die. I just don't want to be there when
it happens. Woody Allen

Literature is news that STAYS news. Ezra Pound

which is typed as:

\begin{quote}
    It's not that I'm afraid to die. I just don't
    want to be there when it happens.
    \emph{Woody Allen}

Literature is news that STAYS news.
    \emph{Ezra Pound}
\end{quote}
```

Note that multiple quotes are separated by blank lines.

### Quotations

```
In the quotation environment, blank lines mark new paragraphs:
KATH: Can be present at the birth of his child?
  ED: It's all any reasonable child can expect if the dad is present
at the conception.
                                                   Joe Orton
is typed as
\begin{quotation}
   KATH: Can he be present at the birth of his child?
   ED: It's all any reasonable child can expect
   if the dad is present at the conception.
   \begin{flushright}
       \emph{Joe Orton}
   \end{flushright}
\end{quotation}
Verses
A verse environment,
I think that I shall never see
A poem lovely as a tree.
Poems are made by fools like me,
But only God can make a tree.
                                                 Joyce Kilmer
is typed as
\begin{verse}
   I think that I shall never see\\
   A poem lovely as a tree.
   Poems are made by fools like me, \\
   But only God can make a tree.
   \begin{flushright}
       \emph{Joyce Kilmer}
```

```
\end{flushright}
\end{verse}
```

Lines are separated by \\ and stanzas by blank lines. Long lines are typeset with hanging indent.

#### Verbatim typesetting

Finally, there is the verbatim text environment. You may need it if you write *about* LaTeX or some other computer program or if you have to include portions of a source file or user input in your typeset work. Most of the displayed source in this book was written in a verbatim environment. For instance, you may have to write to a journal about an article you are proofreading:

Formula (2) in Section 3 should be typed as follows:

```
\label{eq:def:D} $$D = \{\, x_0 \in x_0 \in x_0 \in x_1 \,\ \a_1 \,\ \a_2\} \in \{equation\}$
```

Please make the necessary corrections.

The problem is that if you just type

Formula (2) in Section 3 should be typed as follows: begin{equation}

$$D = \{\, x_0 \in x_0 \in x_1 , \}$$
 \tag{2} \end{equation}

Please make the necessary corrections.

it typesets as

Formula (2) in Section 3 should be typed as follows:

$$(2) D = \{ x_0 \mid x_0 \Rightarrow a_1 \}$$

Please make the necessary corrections.

To get the proper typeset form, type it as follows:

```
Formula (2) in Section 3 should be typed as follows: \begin{verbatim} \\ begin{equation} \\ D = \\ \\ x_0 \in x_0 \\ a_1 \\ a_1 \\ begin{equation} \\ a_1 \in x_0 \\ a_2 \\ a_3 \\ a_4 \\ a_4 \\ a_5 \\ a_6 \\ a_
```

\end{verbatim}

Please make the necessary corrections.

### Rule ■ verbatim text environments

A verbatim environment cannot be placed within

- Another verbatim environment
- The argument of a command
- The closing line, \end{verbatim}, must be on a line by itself.

A violation of the first rule results in unmatched environment delimiters. You get an error message such as

- ! \begin{document} ended by \end{verbatim}.

  A violation of the second rule gives an error message such as
- ! Argument of \@xverbatim has an extra }.

**Tip** There are two traps to avoid when using the verbatim environment.

- 1. If the \end{verbatim} line starts with spaces, a blank line is added to the typeset version.
- 2. Any characters following \end{verbatim} on the same line are dropped and you get a LATEX warning.

To illustrate the first trap, type the last two lines of the previous example as follows:

\_\end{verbatim}

Please make the necessary corrections.

Then you find an unintended blank line before the last line.

The second trap can be seen if you type the last line of the above example as

\end{verbatim} Please make the necessary corrections.

When typeset, Please make the necessary corrections. does not appear, and you receive a warning

LaTeX Warning: Characters dropped after '\end{verbatim}' on input line 17.

Several improved versions of the verbatim environment are provided by the verbatim package (see Section 12.3.1). To use this package, include the command \usepackage{verbatim}

in the preamble. In fact, the rules discussed in this section are those of the verbatim package.

The verbatim environment has some interesting variants and a number of them are discussed in Section 3.4 of *The LATEX Companion*, 2nd edition [46]. For instance, the alltt package, which is part of the standard LATEX distribution (see Section 12.3) is used to type the command syntax in this book. See the full syntax of \newtheorem on page 128 for an example.

#### Verbatim typesetting inline

The verbatim environment also has an inline version called \verb. Here is an example:

```
Some European e-mail addresses contain \%; recall that you have to type \verb+\%+ to get \%. which prints
```

Some European e-mail addresses contain %; recall that you have to type  $\$  to get %.

The character following the \verb command is a delimiter. In this example I have used +. The argument starts with the character following the delimiter, and it is terminated by the next occurrence of the delimiter. In this example, the argument is \%.

Choose the delimiter character carefully. For instance, if you want to typeset

Indeed, the argument of \verb is \\sin(\pi/2 because the second + terminates the \verb command. Then LATEX tries to typeset \alpha) \\$+, but cannot because it is not in math mode. Use another character, such as !, in place of +:

```
\verb!sin(\pi/2 + \alpha)$!
```

### Rule ■ verb commands

- The entire \verb command must be on a single line of your source file.
- There can be no space between the \verb command and the delimiter.
- The \verb command cannot appear in the argument of another command.
- The \verb command cannot be used within an aligned math environment.
- Do not use \* as a delimiter.

If you violate the first rule, as in

```
\verb!$\sin(\pi/2 +
\alpha)$!
```

you get the error message

! LaTeX Error: \verb command ended by end of line.

```
1.6 \text{verb!} \sin(\pi/2 +
```

The \verb command has a \*-ed version which prints spaces as \( \) symbols. For example, \today\_\the is typed as \verb\*+\today \the+.

The \verb command can perform the function of the verbatim environment. The last error message, which was displayed in a verbatim environment, may be typed as follows:

```
you get the error message\\[8pt]
\verb|! LaTeX Error: \verb command ended by end of line.|\\
\verb| |\\
\verb|1.6 \verb!$\sin(\pi/2 +|\\[8pt]
```

#### Rule ■ Simulating verbatim with verb

- 1. End the line before the verbatim environment with \\[8pt].
- 2. Each line xxx of the verbatim environment is placed in the construct:

```
\verb|xxx|
```

If | occurs in xxx, then choose a different delimiter.

3. The last line yyy of the verbatim environment is placed in the construct:

 $\verb|yyy|\\[8pt]$ 

If | occurs in yyy, then choose a different delimiter.

# Typing math

LATEX was designed for typesetting math. I address this topic in detail.

A math formula can be typeset *inline*, as part of the current paragraph, or *displayed*, on a separate line or lines with vertical space before and after the formula.

In this and the next chapter we discuss formulas that are set inline or displayed on a *single line*. In Chapter 9 we address *multiline* math formulas.

We start with a discussion of LaTeX's basic math environments (Section 7.1), spacing rules in math (Section 7.2), and continue with the equation environment (Section 7.3). The basic constructs of a formula—arithmetic (including subscripts and superscripts), binomial coefficients, ellipses, integrals, roots, and text—are discussed in detail in Section 7.4. From the basic constructs of that section, you can build very complicated formulas, one step at a time. The process is illustrated in Section 7.4.7.

Delimiters, operators, and math accents are dealt with in Sections 7.5–7.7. In Section 7.8, we discuss three types of stretchable horizontal lines that can be used above or below a formula: braces, bars, and arrows. There are also stretchable arrow math symbols.

Section 7.9 is our *Formula Gallery*, in which you find a large number of illustrations, some straightforward, some more imaginative, of the math constructs introduced in the preceding sections.

# 7.1 Math environments

A formula in a LATEX document can be typeset *inline*, like the congruence  $a \equiv b \ (\theta)$  or the integral  $\int_{-\infty}^{\infty} e^{-x^2} dx = \sqrt{\pi}$ , or *displayed*, as in

$$a \equiv b \quad (\theta)$$

or

$$\int_{-\infty}^{\infty} e^{-x^2} \, dx = \sqrt{\pi}$$

Notice how changing these two formulas from inline to displayed affects their appearance.

Inline and displayed math formulas are typeset using the *math environments* math and displaymath, respectively. Because math formulas occur so frequently, LATEX has abbreviations: the special braces \( ( and \) or \$ are used for the math environment, and \[ [ and \] for the displaymath environment.\(^1 \) So our inline example may be typed as

```
$a \equiv b \pod{\theta}$
or
\( a \equiv b \pod{\theta} \)
or
\begin{math}
    a \equiv b \pod{\theta}
\end{math}

The displayed example can be typed as
\[
    \int_{-\infty}^{\infty} e^{-x^{2}} \, dx = \sqrt{\pi}
\]
or
\begin{displaymath}
    \int_{-\infty}^{\infty} e^{-x^{2}} \, dx = \sqrt{\pi}
\end{displaymath}
\end{displaymath}
```

Using \$ as a delimiter for a math environment is a bit of an anomaly, since the same character is used as both an opening and closing delimiter. This dual purpose use makes it more difficult for LATEX to diagnose an incorrect use of \$. For instance,

<sup>&</sup>lt;sup>1</sup>T<sub>E</sub>X uses \$\$ to open and close a displayed math environment. In LAT<sub>E</sub>X, this may occasionally cause problems. Don't do it! Try the fleqn document class option of amsart (see Section 11.5) as an example of what can go wrong.

7.1 Math environments 153

Let \$a be a real number, and let \$f\$ be a function. would be interpreted by LATEX as follows:

- Let is ordinary text
- \$a be a real number, and let \$ is math
- f is interpreted as ordinary text
- \$ be a function. is thought to be a math environment (opened by \$) that should be closed by the next \$ in the paragraph

Because the paragraph ends with no more dollar signs appearing, you get the error message

and giving you the line number of the end of the paragraph. This message tells you that LaTeX would place a \$ at the end of the paragraph when it proceeds with the typesetting. Press Return and LaTeX produces the following:

The text that ended up in a math environment is run together because math environments ignore spaces (see Section 7.2).

If you use  $\$  ( and  $\$ ) as special braces for the math environment,  $\$  handles the same mistake more elegantly:

! LaTeX Error: Bad math environment delimiter.

```
1.25 Let \ \ \  a be a real number, and let \ \ \ \ \  be a function.
```

LATEX realizes that the first \() opens a math environment, so the second \() must be in error. In this case, the line number in the error message is correct.

Throughout this book, like nearly everyone else, I use \$ to delimit inline math.

### **Rule Math environments**

No blank lines are permitted in a math or displaymath environment.

If you violate this rule, LATEX generates an error message,

where the line number points inside the environment.

Multiline math environments, such as the examples in Sections 3.4.2–3.4.3, are discussed in Chapter 9.

# 7.2 Spacing rules

In text, the most important spacing rule is that any number of spaces in the source file equals one space in the typeset document. The spacing rule for math mode is even more straightforward.

### Rule ■ Spacing in math

LATEX ignores spaces in math.

In other words, all spacing in math mode is provided by LATEX. For instance,

```
a+b=c
and
a+b=c
are both typeset as a+b=c.
There are two exceptions to this rule:
```

1. A space indicating the end of a command name is recognized. For instance, in

```
$a \quad b$
```

LATEX does not ignore the space between \quad and b.

2. If you switch back to text mode inside a math formula with a \text command (see Section 7.4.6), then the text spacing rules apply in the argument of such a command.

So, LaTeX provides controls for spaces in typeset math. The spaces you type in math do not affect the typeset document. But keep this tip in mind.

**Tip** Format your source file so that it is easy to read.

155

When typing a source file, the following is good practice:

- Place \ [ and \] on lines by themselves.
- Leave spaces before and after binary operations and binary relations, including the equal sign.
- Indent—by three spaces, for example—the contents of environments so they stand
- Keep a formula on a single line of the source file, if you can.

Develop your own style of typing math, and stick with it.

Tip The spacing after a comma is different in math and text.

> I use the following rule: If the comma could be replaced with the word "and" or "or", then I break the formula and move the comma out of the formula.

```
Example 1. Type "a, b \in B" as
$a$, $b \in B$
and not as
$a, b \in B$
Example 2. Type "x = a, b, \text{ or } c" as
x = a, $b$, or $c$
and not as
x = a, b, or c
Compare:
x = a, b, or c (typed as x = a, b, or c
x = a, b, \text{ or } c (typed as x = a, b, or c)
Example 3. Type "for i = 1, 2, \ldots, n" as
"for $i = 1$,~$2$, \dots,~$n$"
```

Tip Do not leave a trailing comma in inline math. So do not type

If a = b, then

but move the comma out.

# 7.3 Equations

An *equation* is a numbered formula displayed on a single typeset line.

Equations are typed in an equation environment. The equation environment and displaymath environment are exactly the same except that the equation environment assigns a number to the displayed formula

$$\int_{-\infty}^{\infty} e^{-x^2} dx = \sqrt{\pi}$$

This example is typed as

\begin{equation}\label{E:int}
\int\_{-\infty}^{\infty} e^{-x^{2}} \, dx = \sqrt{\pi}
\end{equation}

The \label command in the equation environment is optional. If you use a \label command, the number assigned to the equation can be referenced with the \ref command. So

```
see~(\ref{E:int})
```

typesets as see (1). Even better, use the \eqref command, which places the parentheses automatically:

```
see~\eqref{E:int}
```

also typesets as see (1). In fact, the \eqref command does more: It typesets the reference *upright*, even in italicized or slanted text. For more information about cross-referencing, see Section 10.4.2.

Analogously, the \upn command forces the use of upright characters for digits, punctuations, parentheses, etc.

IATEX numbers equations consecutively. As a rule, equations are numbered consecutively throughout articles, whereas in books, numbering starts from 1 at the start of each chapter. You may also choose to have equations numbered within each section— $(1.1), (1.2), \ldots$ , in Section 1;  $(2.1), (2.2), \ldots$ , in Section 2; and so on—by including the command

\numberwithin{equation}{section}

7.4 Basic constructs 157

in the preamble of your document (see Section 10.2). "Manual control" of numbering is discussed in Section 15.5.1, group numbering in Section 9.4.4.

The \*-ed form of the equation environment suppresses numbering, so it is equivalent to the displaymath environment (or the special braces \[ and \]).

# Rule Equation environment

No blank lines are permitted within an equation or equation\* environment.

If you typeset

```
\label{E:int} $$ \inf_{-\inf y}^{\int E:int} \ dx = \sqrt{pi} .
```

\end{equation}

LATEX generates the familiar, but misleading, error message

! Missing \$ inserted.

# 7.4 Basic constructs

A formula is built up by combining various basic constructs. This section discusses the following constructs:

- Arithmetic operations
  - Subscripts and superscripts
- Binomial coefficients
- Ellipses
- Integrals
- Roots

Read carefully the basic constructs *important for your work*. Additional constructs are discussed in subsequent sections.

# 7.4.1 Arithmetic operations

The arithmetic operations are typed pretty much as you would expect. To get a + b, a - b, -a, a/b, and ab, type

```
$a + b$, $a - b$, $-a$, $a / b$, $a b$
```

There are two other forms of multiplication and one of division:  $a \cdot b$ ,  $a \times b$ , and  $a \div b$ . They are typed as follows:

\$a \cdot b\$, \$a \times b\$, \$a \div b\$

In displayed formulas, *fractions* are usually typed with the \frac command. To get

$$\frac{1+2x}{x+y+xy}$$

type

You can use display-style fractions inline with \dfrac, and inline-style fractions in displayed math environments with \tfrac; for example,  $\frac{3+a^2}{4+b}$  is typed as  $\frac{3+a^2}{4+b}$  is typed as

$$\frac{3+a^2}{4+b}$$

is typed as

The \dfrac command is often used in matrices whose entries would look too small with the \frac command. See Formula 20 in the *Formula Gallery* (Section 7.9) for an example, and Section 8.6.1 for other fraction variants.

### Subscripts and superscripts

*Subscripts* are typed with \_ and *superscripts* with ^. Remember to enclose the subscripted or superscripted expression in braces:

typesets as

$$a_1, a_{i_1}, a^2, a^{b^c}, a^{i_1}, a_{i+1}, a_{i+1}, a_1^2, a_1^2$$

For  $a^{b^c}$ , type  $a^{b^c}$ , not  $a^{b^c}$ . If you type the latter, you get the error message

7.4 Basic constructs 159

! Double superscript.

Similarly,  $a_{b_c}$  is typed as  $a_{b_c}$ , not as  $a_{b_c}$ .

In many instances, the braces for the subscripts and superscripts could be omitted, but you should type them anyway.

**Tip** You may safely omit the braces for a subscript or superscript that is a single digit or letter, as in  $a_1$  and  $a_1$  because  $a_1$  and  $a_1$  and  $a_1$  because  $a_1$  and  $a_1$  typesets as  $a_1$ .

There is one symbol that is automatically superscripted in math mode, the prime, that is, '. To get f'(x), type f'(x). However, to get  $f'^2$  you must type

Typing  $f'^2$  results in  $f'^2$ , with the 2 too high; typing it as  $f'^2$  causes a double superscript error. Sometimes you may want a symbol to appear superscripted or subscripted by itself, as in the phrase

use the symbol  $^\dagger$  to indicate the dual space

typed as

use the symbol \${}^{\dagger}\$ to indicate the dualspace

where {} is the *empty group*. The empty group can be used to separate symbols, to terminate commands, or as the base for subscripting and superscripting.

The \sb and \sp commands also typeset subscripts and superscripts, respectively, as in

$$a\$$
b{1} - a\sp{x + y}\$

which produces  $a_1 - a^{x+y}$ . These commands are seldom used, however, except in the alltt environment (see Section 12.3) and in the *Mathematical Reviews* of the AMS.

For multiline subscripts and superscripts, see Section 7.6.5.

# 7.4.2 Binomial coefficients

Binomials are typeset with the \binom command. Here are two examples shown inline,  $\binom{a}{b+c}$  and  $\binom{n^2-1}{2}$ , and displayed:

$$\binom{a}{b+c}$$
 and  $\binom{\frac{n^2-1}{2}}{n+1}$ 

The latter is typed as

```
\[ \binom{a}{b + c} \text{ and } \binom{\frac{n^{2} - 1}{2}}{n + 1} \]
```

You can use display-style binomials inline with \dbinom, and inline-style binomials in displayed math environments with \tbinom. For example,  $\begin{pmatrix} a \\ b+c \end{pmatrix}$  is typed as \$\dbinom{a}{b} + c}\$. See Section 8.6.1 for other variants.

# 7.4.3 Ellipses

There are two types of ellipsis in math, the low or on-the-line ellipsis, as in

$$F(x_1, x_2, \ldots, x_n)$$

and the centered ellipsis, as in

$$x_1 + x_2 + \cdots + x_n$$

These two formulas are typed as

LATEX uses the symbol following a \dots command to decide whether to use a low or centered ellipsis. If it fails to make the right decision as in

$$\alpha(x_1+x_2+\dots)$$

typed as

help LaTeX by giving the command \ldots for low and \cdots for centered ellipsis. So to get the last formula right, type

7.4 Basic constructs 161

and it typesets correctly:

$$\alpha(x_1+x_2+\cdots)$$

There are five more variants of the \dots command:

- \dotsc, for an ellipsis followed by a comma
- \dotsb, for an ellipsis followed by a binary operation or relation
- \dotsm, for an ellipsis followed by multiplication
- \dotsi, for an ellipsis with integrals
- \dotso, for an "other" ellipsis

These commands not only force the ellipsis to be low or centered, but also adjust the spacing.

See Section 9.7.1 for an example of *vertical dots* with the \vdots command and *diagonal dots* with the \ddots command.

# 7.4.4 Integrals

You have already seen the formula  $\int_{-\infty}^{\infty} e^{-x^2} \, dx = \sqrt{\pi}$  in both inline and displayed forms in the first section of this chapter. The lower limit is typeset as a subscript and the upper limit is typeset as a superscript. To force the limits below and above the integral symbol, use the \limits command. The \nolimits command does the reverse. To typeset  $\int\limits_{-\infty}^{\infty} e^{-x^2} \, dx = \sqrt{\pi}$ , type

$$-\infty$$
 \$\int\limits\_{-\infty}^{\infty} e^{-x^{2}} \, dx

See Section 11.5 for a discussion of the intlimits document class option. There are five commands to produce variants of the basic integral symbol:

which typeset as

= \sqrt{\pi}\$

$$\oint \iint \iiint \int \cdots \int$$

For complicated bounds, use the \substack command or the subarray environment (see Section 7.6.5).

#### 7.4.5 Roots

The \sqrt command produces a square root, for instance,

$$\$$
 typesets as  $\sqrt{5}$  \$\sqrt{a + 2b + c^{2}}\$ typesets as  $\sqrt{a+2b+c^2}$ 

Here is a more interesting example:

$$\sqrt{1+\sqrt{1+rac{1}{2}\sqrt{1+rac{1}{3}\sqrt{1+rac{1}{4}\sqrt{1+\cdots}}}}}$$

typed as

For *n*-th roots other than the square root, that is,  $n \neq 2$ , specify *n* with an optional argument. To get  $\sqrt[3]{5}$ , type  $\gamma = 13$ .

### Root refinement

In  $\sqrt[g]{5}$ , typed as  $\sqrt[g]{5}$ , the placement of g is not very pleasing. LaTeX provides two additional commands to allow you to adjust the position of g:

\leftroot moves *g left*—or *right* with a negative argument

\uproot moves *g up*—or *down* with a negative argument

You may prefer one of the following variants:

```
\sqrt[g]{5} typed as \left[\left(\frac{2}{2}\right)\right] typed as \left(\frac{2}{5}\right) typed as \left(\frac{2}{5}\right)
```

Experiment with \leftroot and \uproot to find the best spacing.

Note that LaTeX is very finicky with this optional argument. Typing a space after [, as in \$\sqrt[ \uproot{2} g]{5}\$, gives the error message

! Package amsmath Error: Invalid use of \uproot.

There may also be problems with vertical spacing under the root symbol (see Section 8.4).

### 7.4.6 Text in math

LATEX allows you to include text in formulas with the \text command. The formula

$$A = \{ x \mid x \in X_i, \text{ for some } i \in I \}$$

is typed as

7.4 Basic constructs 163

```
\[
    A = \{\, x \mid x \in X_{i}, \text{ for some }
        i \in I \,\}
\]
```

Note that you have to leave space before for and after some inside the argument of \text. The argument of the \text command is always typeset in a single line.

Sometimes it is more convenient to go into math mode within the argument of a \text command rather than end the \text and start another, as in

$$A = \{ x \mid \text{for } x \text{ large } \}$$

which is typed as

The  $\t$  command correctly sizes its argument to match the context. The formula

$$a_{\text{left}} + 2 = a_{\text{right}}$$

is typed as

```
\[ a_{\text{left}} + 2 = a_{\text{right}} \]
```

Note that \text typesets its argument *in the size and shape* of the surrounding text. If you want the text in a formula to be typeset in the document font family (see Section 5.6.2) independent of the surrounding text, use

```
\textnormal{ ... }
or
{\normalfont ...}
```

For instance, if you have a constant  $a_{right}$ , then in a theorem:

**Theorem 1.** The constant  $a_{right}$  is recursive in a.

The subscript is wrong. To get it right, type the constant as

```
$a_{\normalfont\text{right}}$
```

Now the theorem typesets as

**Theorem 1.** The constant  $a_{right}$  is recursive in a.

Any of the text font commands with arguments (see Section 5.6.3) can also be used in math formulas. For instance, \textbf uses the size and shape of the surrounding text to typeset its argument in bold (extended).

### 7.4.7 Building a formula step-by-step

It is easy to build up complex formulas from the components described in this section. Try the formula

$$\sum_{i=1}^{\left[\frac{n}{2}\right]} \binom{x_{i,i+1}^{i^2}}{\left[\frac{i+3}{3}\right]} \frac{\sqrt{\mu(i)^{\frac{3}{2}}(i^2-1)}}{\sqrt[3]{\rho(i)-2}+\sqrt[3]{\rho(i)-1}}$$

Build this formula in several steps. Create a new file in your work folder. Name it formula.tex, type in the following lines, and save it:

% File: formula.tex
\documentclass{amsart}
\usepackage{amssymb,latexsym}
\begin{document}
\end{document}

At present, the file has an empty document environment. Type each part of the formula as an inline or displayed formula within this environment so that you can typeset the document and check for errors.

**Step 1** We start with  $\lfloor \frac{n}{2} \rfloor$ . Type the following line into formula.tex:

 $\left[ \frac{n}{2} \right]$ 

and test it by typesetting the document.

Step 2 Now you can do the sum

$$\sum_{i=1}^{\left[\frac{n}{2}\right]}$$

For the superscript, you can copy and paste the formula created in Step 1 (without the dollar signs), so that you have

**Step 3** Next, do the two formulas in the binomial

$$x_{i,i+1}^{i^2} \qquad \left\lceil \frac{i+3}{3} \right\rceil$$

Type them as separate formulas in formula.tex:

$$\begin{array}{lll} & & & \\ & & \\ & & & \\ & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\$$

7.4 Basic constructs 165

**Step 4** Now it is easy to do the binomial. Piece together the following formula by copying and pasting the previous formulas and dropping the \quad command:

which typesets as

$$\begin{pmatrix} x_{i,i+1}^{i^2} \\ \left[\frac{i+3}{3}\right] \end{pmatrix}$$

**Step 5** Next, type the formula under the square root,  $\mu(i)^{\frac{3}{2}}(i^2-1)$ :

$$\mu(i)^{ (i^{2} - 1)}$$

and then the square root,  $\sqrt{\mu(i)^{\frac{3}{2}}(i^2-1)}$ :

**Step 6** The two cube roots,  $\sqrt[3]{\rho(i)-2}$  and  $\sqrt[3]{\rho(i)-1}$ , are easy to type:

$$\[3]{ \rho(i) - 2 }$$
 \$\sqrt[3]{ \rho(i) - 1 }\$

**Step 7** Now the fraction

$$\frac{\sqrt{\mu(i)^{\frac{3}{2}}(i^2-1)}}{\sqrt[3]{\rho(i)-2}+\sqrt[3]{\rho(i)-1}}$$

is typed, copied, and pasted together as

**Step 8** Finally, the whole formula,

$$\sum_{i=1}^{\left[\frac{n}{2}\right]} \binom{x_{i,i+1}^{i^2}}{\left[\frac{i+3}{3}\right]} \frac{\sqrt{\mu(i)^{\frac{3}{2}}(i^2-1)}}{\sqrt[3]{\rho(i)-2} + \sqrt[3]{\rho(i)-1}}$$

is formed by copying and pasting the pieces together, leaving only one pair of displayed math delimiters:

```
\[
\sum_{i = 1}^{ \left[ \frac{n}{2} \right] }
\binom{ x_{i, i + 1}^{i^{2}} }

{ \left[ \frac{i + 3}{3} \right] }

\frac{ \sqrt{ \mu(i)^{ \frac{3}{2}} (i^{2} - 1) } }

{\sqrt[3]{\rho(i)-2} + \sqrt[3]{\rho(i) - 1}}
```

Note the use of

- Hierarchical indentation, to keep track of the structure of the formula
- Spacing to help highlight the braces—some text editors help you balance braces
- Separate lines for the various pieces of formulas that are more than a line long

It is to your advantage to *keep your source file readable*. LaTeX does not care how its input is formatted, and would happily accept the following:

```
\[ \sum_{i=1}^{\left[\frac{n}{2}\right]} \sum_{x_{i,i+1}} f(x_{i,i+1})^{i^{2}} f(x_{i+3},x_{i,i+1})^{i^{2}} f(x_{i+3},x_{i,i+1}) f(x_{i,i+1})^{(i^{2}-1)} f(x_{i,i+
```

But this haphazard style not only makes it more difficult for your coauthors or editor to work with your source file, it also makes finding mistakes difficult. Try to find the error in the next version:

Answer:  $\frac{3}{2}$  should be followed by  $}$  and not by  $}$ .

# 7.5 Delimiters

Delimiters are used to enclose some subformulas. In the following formula we use two delimiters: parentheses and square brackets:  $(a*b)+(c*d)^2$ ; this typesets as  $(a*b)+(c*d)^2$ . Let  $(a*b)+(c*d)^2$ . Let  $(a*b)+(c*d)^2$  when  $(a*b)+(c*d)^2$  is the square brackets are delimiters, and spaces them accordingly.

The standard delimiters are shown in Table 7.1.

Note that delimiters are math symbols with special spacing rules and you can use them in any way you please, not only in pairs. LATEX does not stop you from typing  $\protect\operatorname{uparrow}(x)$ , which typesets as  $\uparrow(x)$ .

Observe the difference in spacing between ||a|| and ||a||. The first, ||a||, was typed incorrectly as ||a|| a ||a||. As a result, the vertical bars are too far apart. The second

7.5 Delimiters 167

Name	Туре	Typeset
left parenthesis	(	(
right parenthesis	)	)
left bracket	[ or \lbrack	[
right bracket	] or \rbrack	]
left brace	$\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ $	{
right brace	<pre>\} or \rbrace</pre>	}
backslash	\backslash	\
forward slash	/	/
left angle bracket	\langle	<
right angle bracket	\rangle	>
vertical line	or \vert	
double vertical line	\  or \Vert	
left floor	\lfloor	L
right floor	\rfloor	Ī
left ceiling	\lceil	
right ceiling	\rceil	]
upward	\uparrow	$\uparrow$
double upward	\Uparrow	$\uparrow$
downward	\downarrow	$\downarrow$
double downward	\Downarrow	$\Downarrow$
up-and-down	\updownarrow	$\mathop{\updownarrow}_{\vdash}$
double up-and-down	\Updownarrow	1
upper-left corner	\ulcorner	Ė
upper-right corner	\urcorner	٦
lower-left corner	\llcorner	L
lower-right corner	\lrcorner	٦

Table 7.1: Standard delimiters.

was typed correctly using the appropriate delimiter commands:  $\$  a \|\$. Here they are again side-by-side, enlarged:  $||a||\ ||a||.$ 

# 7.5.1 Stretching delimiters

All delimiters, except the four "corners", can stretch to enclose the subformula. For example,

$$\left(\frac{1}{2}\right)^{\alpha}$$

is typed as

$$\label{lem:left( \frac{1}{2} \right)^{\alpha} } % \end{substitute} % $$ $$ \left( \frac{1}{2} \right)^{\alpha} $$$$

The \left and \right commands instruct LATEX to stretch the parentheses.

The general construction is

\left delim1 and \right delim2

where <code>delim1</code> and <code>delim2</code> are chosen from Table 7.1. They are usually, but not always, a matching pair—see the examples below. LATEX inspects the formula between the \left and \right commands and decides what size delimiters to use. The \left and \right commands <code>must be paired</code> in order for LATEX to know the extent of the material to be vertically measured. However, the delimiters need not be the same.

If you want to stretch a single delimiter, you have to pair it with a *blank delimiter*, represented by the \left. and \right. commands.

Here are some examples of stretching delimiters:

$$\left| \frac{a+b}{2} \right|, \quad \left\| A^2 \right\|, \quad \left( \frac{a}{2}, b \right], \quad F(x) \right|_a^b$$

typed as

```
\[
  \left| \frac{a + b}{2} \right|, \quad
  \left\| A^{2} \right\|, \quad
  \left( \frac{a}{2}, b \right], \quad
  \left. F(x) \right|_{a}^{b}
\]
```

There are also two convenient abbreviations:

```
\left< for \left\langle
\right> for \right\rangle
```

The \left and \right commands have one more use. For the delimiters |, \|, and all the arrows, the same symbol represents the left and right delimiters, which can sometimes cause problems as in Example 2 in Section 8.1.4. In such cases, you should use the \left and \right commands to tell LATEX whether the delimiter is a left or a right delimiter. LATEX also provides the \lvert and \rvert for | as left and right delimiter, and \lvert and \rvert for \|.

### 7.5.2 Delimiters that do not stretch

LATEX provides the \big, \Big, \bigg, and \Bigg commands to produce delimiters of larger sizes. These delimiters do not stretch. For example,

```
\[
    (\quad \big(\quad \Big(\quad \bigg(\quad \Bigg(\))
```

7.5 Delimiters 169

typesets as

LATEX also provides the more specific

\big1, \Big1, \bigg1, \bigg1, \bigr, \Bigr, \biggr, and \Biggr commands to produce larger left and right delimiters.

For integral evaluation, you can choose one of the following:

$$F(x)|_a^b F(x)|_a^b F(x)|_a^b$$

typed as

# 7.5.3 Limitations of stretching

In a number of situations the stretching done by LATEX is not ideal, so you should use a larger sized non-stretching variant. Here are some typical examples:

#### 1. Large operators

typesets as

$$\left[\sum_i a_i\right]^{1/p} \quad \left[\sum_i a_i\right]^{1/p}$$

You may prefer the second version with \biggl[ and \biggr].

### 2. Groupings

```
\[ \left( (a_1 b_1) - (a_2 b_2) \right) \left( (a_2 b_1) + (a_1 b_2) \right) \quad
```

typesets as

$$((a_1b_1) - (a_2b_2))((a_2b_1) + (a_1b_2)) \quad ((a_1b_1) - (a_2b_2))((a_2b_1) + (a_1b_2))$$

You may prefer the clearer groupings provided by \bigl( and \bigr).

### 3. Inline formulas

The delimiters produced by \left and \right use too much interline space in  $\left|\frac{b'}{d'}\right|$ , typed as

\left\lvert \frac{b'}{d'} \right\rvert

Use \big1 and \bigr to produce delimiters that fit within the normal line spacing:  $\left|\frac{b'}{d'}\right|$ , typed as

\bigl\lvert \frac{b'}{d'} \bigr\rvert

### 7.5.4 Delimiters as binary relations

The symbol | can be used as a delimiter, as in |x+y|, and also as a binary relation, as in  $\{x\in\mathcal{R}\mid x^2\leq 2\}$ . As a binary relation it is typed as \mid. The previous formula is typed as

\bigm and \biggm produce larger variants, with spacing on either side like binary relations. For example,

$$\left\{ x \mid \int_0^x t^2 \, dt \le 5 \right\}$$

is typed as

# 7.6 Operators

You cannot just type sin x to typeset the sine function in math mode. Indeed,

\$sin x\$

7.6 *Operators* 171

produces sinx instead of sin x, as you intended. Type this function as

\$\sin x\$

The \sin command prints sin with the proper style and spacing. LaTeX calls \sin an *operator* or log-*like function*.

### 7.6.1 Operator tables

There are two types of operators:

- 1. Operators without limits, such as \sin
- 2. Operators with limits, such as \lim, that take a subscript in inline mode and a "limit" in displayed math mode. For example,  $\lim_{x\to 0} f(x) = 1$  is typed as

$$\lim_{x \to 0} f(x) = 1$$

The same formula displayed,

$$\lim_{x \to 0} f(x) = 1$$

is typed as

The operators are listed in Tables 7.2 and 7.3 (see also Section B.6). The entries in the last two rows of Table 7.3 can be illustrated by

$$\frac{\lim}{x \to 0}$$
  $\lim_{x \to 0}$   $\lim_{x \to 0}$   $\lim_{x \to 0}$   $\lim_{x \to 0}$ 

which are typed as

```
\[
   \varliminf_{x \to 0} \quad \varlimsup_{x \to 0} \quad
   \varinjlim_{x \to 0} \quad \varprojlim_{x \to 0}
\]
```

The following examples illustrate some more entries from Table 7.3:

$$\inf_{x \to 0} \lim \inf_{x \to 0} \quad \limsup_{x \to 0} \quad \operatorname{proj\,lim}_{x \to 0}$$

These operators were typed as

```
\[
\injlim_{x \to 0} \quad \liminf_{x \to 0} \quad
\limsup_{x \to 0} \quad \projlim_{x \to 0}
\]
```

You can force the limits in a displayed formula into the subscript position with the \nolimits command. For example, the formulas

Type	Typeset	Type	Typeset	Type	Typeset	Type	Typeset
\arccos \arcsin \arctan \arg \cos \cosh	arccos arcsin arctan arg cos cosh	\cot \coth \csc \deg \dim \exp	cot coth csc deg dim exp	<pre>\hom \ker \lg \ln \log \sec</pre>	hom ker lg ln log sec	\sin \sinh \tan \tanh	sin sinh tan tanh

Table 7.2: Operators without limits.

Туре	Typeset	Туре	Typeset
\det	det	\limsup	$\limsup$
\gcd	$\operatorname{gcd}$	\max	max
\inf	$\inf$	\min	$\min$
\lim	$\lim$	\Pr	$\Pr$
\liminf	$\lim\inf$	\sup	$\sup$
\injlim	inj lim	\projlim	$\operatorname{projlim}$
\varliminf	$\underline{\lim}$	\varlimsup	$\overline{\lim}$
\varinjlim	$\stackrel{\lim}{\longrightarrow}$	\varprojlim	lim ←

Table 7.3: Operators with limits.

7.6 *Operators* 173

### 7.6.2 Defining operators

The powerful \DeclareMathOperator command defines a new operator:

\DeclareMathOperator{\opCommand}{opName}

Invoke the new operator with \opCommand, which is then typeset with opName.

The \DeclareMathOperator command must be placed in the preamble. For example, to define the operator Truncat, invoked by the command \Trunc, place this in the preamble:

\DeclareMathOperator{\Trunc}{Truncat}

An operator is typeset in math roman with a little space after it, so  $\Gamma A$  typesets as Truncat A.

The second argument is typeset in math mode but - and \* are typeset as they would be in text. Here are some more examples. Define in the preamble two operators:

```
\DeclareMathOperator{\Trone}{Trunc_{1}}
\DeclareMathOperator{\Ststar}{Star-one*}
Then in the body of the article
\Gamma A is typeset as Truncat_1 A
Ststar A is typeset as Star-one^* A
    To define an operator with limits, use the *-ed form
\DeclareMathOperator*{\doublesum}{\sum\sum}
and then (see Section 7.6.5 for multiline subscripts)
1/
    \doublesum_{\begin{subarray}{1}
              i^2+j^2 = 50
              i,\ j \leq 10
              \end{subarray}}
              \frac{x^i + y^j}{(i + j)!}
\]
typesets as
                               \sum_{i^2+j^2=50} \frac{x^i + y^j}{(i+j)!}
```

# 7.6.3 Congruences

\mod is a special operator used for congruences. Congruences are usually typeset using the \pmod or \pod variant. There is also the \bmod command, which is used as a binary operation. All four commands are shown in Figure 7.4.

See Sections 15.1.2 and 15.1.8 for a discussion of related user-defined commands.

Туре	Typeset
<pre>\$a \equiv v \mod{\theta}\$</pre>	$a \equiv v \mod \theta$
\$a \bmod b\$	$a \bmod b$
<pre>\$a \equiv v \pmod{\theta}\$</pre>	$a \equiv v \pmod{\theta}$
<pre>\$a \equiv v \pod{\theta}\$</pre>	$a \equiv v \ (\theta)$

Table 7.4: Congruences.

### 7.6.4 Large operators

Here is a sum typeset inline,  $\sum_{i=1}^{n} x_i^2$ , and displayed,

$$\sum_{i=1}^{n} x_i^2$$

In the latter form, the sum symbol is larger. Operators that behave in this way are called *large operators*. Table 7.5 gives a complete list of large operators.

You can use the \nolimits command if you wish to show the limits of large operators as subscripts and superscripts in a displayed math environment.

The formula

$$\bigsqcup_{\mathbf{m}} X = a$$

is typed as

You can use the \limits command if you wish to show the limits of large operators below and above the operator symbol in an inline math environment. For example,  $\bigsqcup_{m} X = a$  is typed as

\$\bigsqcup\limits\_{ \mathfrak{m} } X = a\$

Sums and products are very important constructs. The examples

$$\frac{z^d - z_0^d}{z - z_0} = \sum_{k=1}^d z_0^{k-1} z^{d-k} \quad \text{and} \quad (T^n)'(x_0) = \prod_{k=0}^{n-1} T'(x_k)$$

are typed as

$$frac{z^{d} - z_{0}^{d}}$$
  
 $z - z_{0} =$ 

7.6 *Operators* 175

Туре	Inline	Displayed
\int_{a}^{b}	$\int_a^b$	$\int_a^b$
\oint_{a}^{b}	$\oint_a^b$	$\oint_a^b$
\iint_{a}^{b}	$\iint_a^b$	$\iint_a^b$
\iiint_{a}^{b}	$\iiint_a^b$	$\iiint_a^b$
$\left( \frac{a}^{b} \right)$	$\iiint_a^b$	$\iiint_a^b$
$\left( a^{2}\right) $	$\int \cdots \int_a^b$	$\int \dots \int_a^b$
\prod_{i=1}^{n}	$\prod_{i=1}^{n}$	$\prod_{i=1}^{n}$
$\coprod_{i=1}^n n$	$\coprod_{i=1}^{n}$	$\coprod_{i=1}^n$
$\bigcap_{i=1}^{n}$	$\bigcap_{i=1}^n$	$\bigcap_{i=1}^{n}$
$\big( i=1 ^{n} $	$\bigcup_{i=1}^n$	$\bigcup_{i=1}^{n}$
\bigwedge_{i=1}^{n}	$\bigwedge_{i=1}^n$	$\bigwedge_{i=1}^{n}$
\bigvee_{i=1}^{n}	$\bigvee_{i=1}^{n}$	$\bigvee_{i=1}^{n}$
\bigsqcup_{i=1}^{n}	$\bigsqcup_{i=1}^{n}$	$\begin{bmatrix} n \\ \vdots \\ i=1 \end{bmatrix}$
\biguplus_{i=1}^{n}	$\biguplus_{i=1}^{n}$	$\biguplus_{i=1}^{n}$
$\begin{tabular}{ll} \verb&\begin{tabular}{ll} $	$\bigotimes_{i=1}^n$	$\bigotimes_{i=1}^{n}$
\bigoplus_{i=1}^{n}	$\bigoplus_{i=1}^n$	$\bigoplus_{i=1}^{n}$
\bigodot_{i=1}^{n}	$igodot_{i=1}^n$	$\bigcup_{i=1}^{n}$
\sum_{i=1}^{n}	$\sum_{i=1}^{n}$	$\sum_{i=1}^{n}$

Table 7.5: Large operators.

```
 \begin{tabular}{ll} $$ \sum_{k = 1}^{d} z_{0}^{k - 1} z^{d - k} $$ \text{text}\quad and\quad and\quad T^{n}'(x_{0}) = \frac{k=0}^{n - 1} T'(x_{k}) $$ \end{tabular}
```

# 7.6.5 Multiline subscripts and superscripts

The \substack command provides multiline limits for large operators. For instance,

$$\sum_{i < n} x_i^2$$

is typed as

There is only one rule to remember. Use the line separator command \\. You can use the \substack command wherever subscripts or superscripts are used.

The lines are centered by \substack, so if you want them set flush left, as in

$$\sum_{\substack{i < n \\ i \text{ even}}} x_i^2$$

then use the subarray environment with the argument 1:

See Section 7.6.2 for another example.

# 7.7 Math accents

The accents used in text (see Section 5.4.7) cannot be used in math formulas. For accents in formulas a separate set of commands is provided. All math accents are shown in Table 7.6 (see also Section B.8). The amsxtra package is needed for the accents in the second column. To use them, make sure to place the line

7.7 Math accents 177

### \usepackage{amsxtra}

in the preamble. For instance,  $a\$  b\spddot\ c\sptilde\$ typesets as  $a^{\sim}b^{\sim}c^{\sim}$ .

You can also use double accents, such as

which typesets as  $\hat{A}$ .

The two "wide" varieties, \widehat and \widetilde, expand to fit the symbols (their arguments) covered:  $\widehat{A}$ ,  $\widehat{ab}$ ,  $\widehat{iii}$ ,  $\widehat{aiai}$ ,  $\widehat{iiiii}$ , and  $\widetilde{A}$ ,  $\widetilde{ab}$ ,  $\widehat{iii}$ ,  $\widetilde{aiai}$ ,  $\widehat{iiiii}$  (the last example is typed as  $\widetilde{b}$ ). If the base is too wide, the accent is centered:

$$\widehat{ABCDE}$$

The "sp" commands, provided by the amsxtra package, are used for superscripts, as illustrated in Table 7.6. If you use a lot of accented characters, you should appreciate user-defined commands (see Section 15.1.1).

Notice the difference between  $\bar{a}$  and  $\bar{a}$ , typed as

### \$\bar{a}\$ \$\overline{a}\$

		amsxtra	
Type	Typeset	Type	Typeset
\acute{a}	$\acute{a}$		
\bar{a}	$\bar{a}$		
\breve{a}	$reve{a}$	\spbreve	•
$\check{a}$	$\check{a}$	\spcheck	V
$\det\{a\}$	$\dot{a}$	\spdot	•
\ddot{a}	$\ddot{a}$	\spddot	••
\dddot{a}	$\ddot{a}$	\spdddot	•••
\ddddot{a}	$\ddot{a}$		
\grave{a}	$\grave{a}$		
\hat{a}	$\hat{a}$		
\widehat{a}	$\widehat{a}$	\sphat	^
\mathring{a}	$\mathring{a}$		
$\tilde{a}$	$ ilde{a}$		
$\widetilde{a}$	$\widetilde{a}$	\sptilde	~
\vec{a}	$\vec{a}$		

Table 7.6: Math accents.

For other examples of the \overline command, see Section 7.8.2.

To use an arbitrary symbol as an accent or to create "underaccents", use Javier Bezos' accents package (see Section E.1 on how to obtain it).

# 7.8 Stretchable horizontal lines

LATEX provides three types of stretchable horizontal lines that appear above or below a formula, braces, bars, and arrows. There are also stretchable arrow math symbols.

### 7.8.1 Horizontal braces

The \overbrace command places a brace of variable size above its argument, as in

$$\overbrace{a+b+\cdots+z}$$

which is typed as

A superscript adds a label to the brace, as in

$$\underbrace{a+a+\cdots+a}^{n}$$

which is typed as

The \underbrace command works similarly, placing a brace below its argument. A subscript adds a label to the brace, as in

$$\underbrace{a+a+\cdots+a}_{n}$$

which is typed as

The following example combines these two commands:

$$\underbrace{a+\cdots+a}^{(m-n)/2} + \underbrace{b+\cdots+b}_{m} + \underbrace{a+\cdots+a}_{m}$$

This example is typed as

```
\[
   \underbrace{
      \overbrace{a + \dots + a}^{(m - n)/2}
      + \underbrace{b + \dots + b}_{n}
      + \overbrace{a + \dots + a}^{(m - n)/2}
    }_{m}
\]
```

#### 7.8.2 Overlines and underlines

The \overline and \underline commands draw lines above or below a formula. For example,

$$\overline{\overline{\overline{X}} \cup \overline{\overline{\overline{X}}}} = \overline{\overline{\overline{X}}}$$

is typed as

```
\[
  \overline{X} \cup \overline{X}} }
  = \overline{X} }
\]
```

Similarly, you can place arrows above and below an expression:

```
\overleftarrow{a} \overrightarrow{aa}
\overleftarrow{aaa} aaaaa aaaaaa aaaaaa
```

\begin{gather\*}
 \overleftarrow{a} \quad \overrightarrow{aa}\\
 \overleftrightarrow{aaa} \quad \underleftarrow{aaaa}\quad
 \underrightarrow{aaaaaaa}
\end{gather\*}

# 7.8.3 Stretchable arrow math symbols

which is typed as

There are two stretchable arrow math symbols that extend to accommodate a formula above or below the arrows with the \xleftarrow and \xrightarrow commands. The formula on top is given as the argument (possibly empty) and the formula below is an optional argument.

$$A \xrightarrow{\text{1-1}} B \xleftarrow{\text{onto}}_{\alpha \to \beta} C \xleftarrow{\gamma} D \leftarrow E$$

is typed as

There are other stretchable arrow math symbols described in Section 9.8, but they can only be used in commutative diagrams.

# 7.9 Formula Gallery

In this section I present a collection of formulas—some simple, some complex—that illustrate the power of LaTeX.

Some of these examples require the amssymb package, so it is a good idea to include the line

\usepackage{amssymb,latexsym}

following the \documentclass line of any article.

#### **Formula 1** A set-valued function

$$x \mapsto \{ c \in C \mid c \le x \}$$

```
\[
    x \mapsto \{\, c \in C \mid c \leq x \,\}
\]
```

To equalize the spacing around  $c \in C$  and  $c \le x$ , a thin space (\,) was added inside each brace (see Section 8.1). The same technique is used in several other formulas in this section.

#### Formula 2

$$\left|\bigcup (\,I_j\mid j\in J\,)\right|<\mathfrak{m}$$

```
\[
    \left| \bigcup (\, I_{j} \mid j \in J \,) \right|
    < \mathfrak{m}
\]</pre>
```

We use the delimiters \left| and \right| (see Section 7.5.1). The Fraktur m is introduced in Section 8.3.2.

**Formula 3** Note that you have to add spacing both before and after the text fragment for some in the following example. The argument of \text is typeset in text mode, so spaces are recognized.

$$A = \{ \, x \in X \mid x \in X_i, \text{ for some } i \in I \, \}$$
   
 \[ A = \{\, x \in X \mid x \in X\_{i}, \text{ for some \$i \in I\$} \,\}

**Formula 4** Space to show logical structure:

$$\langle a_1,a_2\rangle \leq \langle a_1',a_2'\rangle \qquad \text{iff} \qquad a_1 < a_1' \quad \text{or} \quad a_1 = a_1' \text{ and } a_2 \leq a_2'$$
 \[ \langle a\_{1}, a\_{2} \rangle \leq \langle a\_{1}, a'\_{2} \rangle \quad \text{if{f}} \quad a\_{1} < a'\_{1} \quad \text{or} \quad a\_{1} = a'\_{1} \text{ and } a\_{2} \leq a'\_{2} \]

Note that in if{f} (in the argument of the first \text) the second f is enclosed in braces to avoid the use of the ligature—the merging of the two f's. For the proper way of typesetting iff without a ligature, see Section 5.4.6.

**Formula 5** Here are some examples of Greek letters:

$$\Gamma_{u'} = \{ \gamma \mid \gamma < 2\chi, \ B_{\alpha} \not\subseteq u', \ B_{\gamma} \subseteq u' \}$$
 \[ \Gamma\_{u'} = \{\,\gamma \mid \gamma < 2\chi,\ B\_{\alpha} \nsubseteq u', \ B\_{\gamma} \subseteq u',\\}

See Section B.1 for a complete listing of Greek letters. We use the command  $\setminus_{\square}$  to properly space the formula. This command can be used both in text and in math.

**Formula 6** \mathbb allows you to use the blackboard bold math alphabet, which only provides capital letters:

$$A = B^2 \times \mathbb{Z}$$

```
A = B^{2} \times \mathbb{Z}
```

Formula 7 \left[ and \right] provide stretched delimiters:

$$y^C \equiv z \vee \bigvee_{i \in C} \left[ s_i^C \right] \pmod{\Phi}$$

```
\[ y^C \equiv z \vee \bigvee_{ i \in C } \left[ s_{i}^{C} \right] \pmod{ \Phi }
\]
```

Notice how the superscript is set directly above the subscript in  $s_i^C$ .

Formula 8 A complicated congruence:

**Formula 9** Use \nolimits to force the "limit" of the large operator to display as a subscript (see Section 7.6.4):

$$f(\mathbf{x}) = \bigvee_{\mathbf{m}} \left( \bigwedge_{\mathbf{m}} (x_j \mid j \in I_i) \mid i < \aleph_{\alpha} \right)$$
 \[ f(\mathbf{x}) = \bigvee\nolimits\_{\!\mathfrak{m}} \left(\, \bigwedge\nolimits\_{\mathfrak{m}} (\, x\_{j} \mid j \in I\_{i} \,) \mid i < \aleph\_{\alpha} \,\right) \]

Notice that a negative space ( $\setminus$ !) was inserted to bring the m a little closer to the big join symbol  $\bigvee$ .

**Formula 10** The \left. command gives a blank left delimiter, which is needed to balance the \right| command:

$$\widehat{F}(x)\Big|_{a}^{b} = \widehat{F}(b) - \widehat{F}(a)$$

```
\[
  \left. \widehat{F}(x) \right|_{a}^{b}
  = \widehat{F}(b) - \widehat{F}(a)
\]
```

**Formula 11** The \underset and \overset commands build new symbols (see Section 8.2.1):

$$u + v \stackrel{1}{\sim} w \stackrel{2}{\sim} z$$

\[
 u \underset{\alpha}{+} v \overset{1}{\thicksim} w
 \overset{2}{\thicksim} z
\]

Note that the new symbols  $\stackrel{1}{\sim}$  and  $\stackrel{2}{\sim}$  are binary relations and + is a binary operation.

### Formula 12 Small size bold def:

$$f(x) \stackrel{\mathbf{def}}{=} x^2 - 1$$

\[ f(x) \overset{ \mathbf{def} }{ = } x^{2} - 1 \]

#### **Formula 13** Math accents run amok:

$$\overbrace{a^{\vee} + b^{\vee} + \dots + z^{\vee}}^{\check{n}}$$

\[
 \overbrace{a\spcheck + b\spcheck + \dots + z\spcheck}^
 {\breve{\breve{n}}}
\]

Recall that for the \sp commands you need the amsxtra package.

#### Formula 14

$$\begin{vmatrix} a+b+c & uv \\ a+b & c+d \end{vmatrix} = 7$$

\[
 \begin{vmatrix}
 a + b + c & uv\\
 a + b & c + d
 \end{vmatrix}
 = 7
\]

$$\begin{vmatrix} a+b+c & uv \\ a+b & c+d \end{vmatrix} = 7$$

```
\[
   \begin{Vmatrix}
    a + b + c & uv\\
    a + b & c + d
   \end{Vmatrix}
   = 7
\]
```

#### Formula 15

$$\alpha^2 \sum_{j \in \mathbf{N}} b_{ij} \hat{y}_j = \sum_{j \in \mathbf{N}} b_{ij}^{(\lambda)} \hat{y}_j + (b_{ii} - \lambda_i) \hat{y}_i \hat{y}$$

```
\[
  \boldsymbol{\alpha}^2\sum_{j \in \mathbf{N}} b_{ij}
  \hat{y}_{j} = \sum_{j \in \mathbf{N}}
  b^{(\lambda)}_{ij}\hat{y}_{j}
  + (b_{ii} - \lambda_{i}) \hat{y}_{i} \hat{y}
\]
```

\mathbf{N} makes a bold N and \boldsymbol{\alpha} produces a bold  $\alpha$  (see Section 8.3.2).

#### **Formula 16** To produce the formula

$$\left(\prod_{j=1}^{n} \hat{x}_{j}\right) H_{c} = \frac{1}{2} \hat{k}_{ij} \det \widehat{\mathbf{K}}(i|i)$$

try typing

```
\[ \left( \prod^n_{\, j = 1} \hat{ x }_{j} \right) H_{c}= 
\frac{1}{2} \hat{k}_{ij} \det \hat{ \mathbf{K} }(i|i) 
\]
```

which typesets as

$$\left(\prod_{j=1}^{n} \hat{x}_{j}\right) H_{c} = \frac{1}{2} \hat{k}_{ij} \det \hat{\mathbf{K}}(i|i)$$

This is not quite right. You can correct the overly large parentheses by using the  $\Big\{$ biggl and  $\Big\}$ biggr commands in place of  $\Big\{$ left( and  $\Big\}$ right), respectively (see Section 7.5.2). Adjust the small hat over K by using  $\Big\}$ 

\]

```
\[
  \biggl( \prod^n_{\, j = 1} \hat{ x }_{j} \biggr)
  H_{c} = \frac{1}{2}\hat{ k }_{ij}
  \det \widehat{ \mathbf{K} }(i|i)
\]
```

which gives you the desired formula.

**Formula 17** In this formula, I have used \overline{I} to get  $\overline{I}$ . You could, instead, use \bar{I}, which is typeset as  $\overline{I}$ .

$$\det \mathbf{K}(t=1,t_1,\ldots,t_n) = \sum_{I\in\mathbf{n}} (-1)^{|I|} \prod_{i\in I} t_i \prod_{j\in I} (D_j + \lambda_j t_j) \det \mathbf{A}^{(\lambda)}(\overline{I}|\overline{I}) = 0$$
 \[ \det \mathbf{K} (t = 1, t\_{1}, \dots, t\_{n}) = \sum\_{I \in \mathbf{n}}(-1)^{|I|} \prod\_{i \in I}t\_{i} \prod\_{j} \in I} (D\_{j} + \lambda\_j t\_j) \det \mathbf{A}^{(i)} (\lambda\_j) \det \mathbf{A}^{(i)} (\lambda\_j) \det (\lambda\_j) \det (\lambda\_j) \det \mathbf{A}^{(i)} (\lambda\_j) = 0

**Formula 18** The command \| provides the || math symbol in this formula:

**Formula 19** This formula uses the calligraphic math alphabet (see Section 8.3.2):

$$\int_{\mathcal{D}} |\overline{\partial u}|^2 \Phi_0(z) e^{\alpha |z|^2} \geq c_4 \alpha \int_{\mathcal{D}} |u|^2 \Phi_0 e^{\alpha |z|^2} + c_5 \delta^{-2} \int_A |u|^2 \Phi_0 e^{\alpha |z|^2}$$
 \[ \int\_{\mathcal{D}} | \overline{\partial u} |^{2} \Phi\_{0}(z) e^{\alpha |z|^2} \geq c\_{4} \alpha \int\_{\mathcal{D}} |u|^{2} \Phi\_{0} e^{\alpha |z|^2} + c\_{5} \delta^{-2} \int\_{A} |u|^{2} \Phi\_{0} e^{\alpha |z|^2} \Phi\_{0} e^{\alpha |z|^2}

Formula 20 The \hdotsfor command sets dots that span multiple columns in a matrix. The \dfrac command is the displayed variant of the \frac command (see Section 7.4.1), used here because the matrix entries with \frac would look too small.

$$\mathbf{A} = \begin{pmatrix} \frac{\varphi \cdot X_{n,1}}{\varphi_1 \times \varepsilon_1} & (x + \varepsilon_2)^2 & \cdots & (x + \varepsilon_{n-1})^{n-1} & (x + \varepsilon_n)^n \\ \frac{\varphi \cdot X_{n,1}}{\varphi_2 \times \varepsilon_1} & \frac{\varphi \cdot X_{n,2}}{\varphi_2 \times \varepsilon_2} & \cdots & (x + \varepsilon_{n-1})^{n-1} & (x + \varepsilon_n)^n \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \frac{\varphi \cdot X_{n,1}}{\varphi_n \times \varepsilon_1} & \frac{\varphi \cdot X_{n,2}}{\varphi_n \times \varepsilon_2} & \cdots & \frac{\varphi \cdot X_{n,n-1}}{\varphi_n \times \varepsilon_{n-1}} & \frac{\varphi \cdot X_{n,n}}{\varphi_n \times \varepsilon_n} \end{pmatrix} + \mathbf{I}_n$$

```
\[
   \mathcal{A} =
   \begin{pmatrix}
     \dfrac{\varphi \cdot X_{n, 1}} {\varphi_{1} \times
       \vorepsilon_{1}\ & (x + \vorepsilon_{2})^{2}
       & \cdots & (x + \gamma_n - 1)^{n - 1}
       & (x + \text{varepsilon}_{n})^{n} \setminus [10pt]
     \dfrac{\varphi \cdot X_{n, 1}} {\varphi_{2} \times
       \varepsilon_{1}} & \dfrac{\varphi \cdot X_{n, 2}}
       {\varphi_{2} \times \varepsilon_{2}} & \cdots &
       (x + \text{varepsilon}_{n - 1})^{n - 1}
       & (x + \text{varepsilon}_{n})^{n} \
     \hdotsfor{5}\\
     \dfrac{\varphi \cdot X_{n, 1}} {\varphi_{n} \times
       \varepsilon_{1}} & \dfrac{\varphi \cdot X_{n, 2}}
       {\varphi_{n} \times \varepsilon_{2}} & \cdots
       & \displaystyle \frac{x_{n, n - 1}}{ \left( x_{n, n} \right)} 
       \times \varepsilon_{n - 1}} &
       \dfrac{\varphi\cdot X_{n, n}}
             {\varphi_{n} \times \varepsilon_{n}}
   \end{pmatrix}
    + \mathbf{I}_{n}
\]
```

Recall the discussion of \dots vs. \cdots and \ldots in Section 7.4.3. In this formula, we have to use \cdots. Matrices are discussed in detail in Section 9.7.1.

Note the use of the command \\[10pt]. If you use \\ instead, the first and second lines of the matrix are set too close.

I show you in Section 15.1.2 how to rewrite the formula to make it shorter and more readable.

CHAPTER

# More math

In the previous chapter, we discuss the basic building blocks of a formula and how to put them together to form more complex formulas. This chapter starts out by going one step lower, to the characters that make up a formula. We discuss math symbols and math alphabets.

LATEX was designed for typesetting math, so it is not surprising that it contains a very large number of math symbols. Section 8.1 classifies and describes them. Section 8.2 discusses how to build new symbols from existing ones. Math alphabets and symbols are discussed in Section 8.3. Horizontal spacing commands in math are described in Section 8.4.

LATEX provides a variety of ways to number and tag equations. These techniques are described in Section 8.5. We conclude the chapter with two minor topics: generalized fractions (Section 8.6.1) and boxed formulas (Section 8.6.2).

# 8.1 Spacing of symbols

LaTeX provides a large variety of math symbols: Greek characters  $(\alpha)$ , binary operations  $(\circ)$ , binary relations  $(\leq)$ , negated binary relations  $(\nleq)$ , arrows  $(\nearrow)$ , delimiters  $(\lbrace)$ , and so on. All the math symbols provided by LaTeX are listed in the tables of

Appendix B.

Consider the formula

$$A = \{ x \in X \mid x\beta \ge xy > (x+1)^2 - \alpha \}$$

which is typed as

The spacing of the symbols in the formula varies. In  $x\beta$ , the two symbols are very close. In  $x \in X$ , there is some space around the  $\in$ , and in x+1, there is somewhat less space around the +. There is a little space after  $\{$  and before  $\}$ —not quite enough for this formula, which is why the thinspace commands  $(\setminus,)$  were added.

### 8.1.1 Classification

LATEX classifies symbols into several categories or *types* and spaces them accordingly. In the formula

$$A = \{ x \in X \mid x\beta \ge xy > (x+1)^2 - \alpha \}$$

we find

- Ordinary math symbols:  $A, x, X, \beta$ , and so on
- Binary relations: =,  $\in$ , |,  $\geq$ , and >
- Binary operations: + and -
- Delimiters: {, }, (, and )

As a rule, you do not have to be concerned with whether or not a given symbol in a formula, say  $\times$ , is a binary operation. LATEX spaces the typeset symbol correctly.

# 8.1.2 Three exceptions

There are three symbols with more than one classification: +, -, and |.

+ or - could be either a binary operation, for instance, a-b, or a sign, for instance, -b.

#### Rule $\blacksquare$ + and -

+ or - are binary operations when preceded and followed by a symbol or an empty group ( $\{\}$ ).

So, for instance, in

$$(A + BC)x + Cy = 0,$$
  
$$Ex + (F + G)y = 23.$$

which is typed as (see the alignat\* environment in Section 9.5.4)

\begin{alignat\*}{2} (A + B C)x &{}+{} &C &y = 0,\\ Ex &{}+{} &(F + G)&y = 23. \end{alignat\*}

we use the empty groups, { }, to tell LATEX that the second + in line 1 and the first + in line 2 of the formula are binary operations. If we leave out the empty groups, and type instead

\begin{alignat\*}{2}   
 (A + B C)x &+ &C &y = 0,\\ Ex &+ &(F + G)&y = 23.   
 \end{alignat\*}   
 we get 
$$(A + BC)x + Cy = 0, \\ Ex + (F + G)y = 23.$$

Another illustration is given later in this section using the \phantom command.

This problem often arises in split formulas, for example if the formula is split just before a + or -, you should start the next line with  $\{\}+$  or  $\{\}-$ . See Section 9.3 for examples.

The | symbol can play several different roles in a math formula, so LaTeX provides separate commands to specify the symbol's meaning.

### Rule ■ The four roles of the | symbol

- ordinary math symbol
- \mid binary relation
- \left| left delimiter
- \right| right delimiter

Note the differences between the spacing in a|b, typed as  $a \mid b$ , and in  $a \mid b$ , typed as  $a \mid b$ .

Name	Width	Short	Long
1 mu (math unit)	ı		\mspace{1mu}
thinspace	Ш	١,	\thinspace
medspace	Ц	\:	\medspace
thickspace	Ш	\;	\thickspace
interword space	Ш	\_	
1 em			
2 em			\qquad
Negative space			
1 mu	1		\mspace{-1mu}
thinspace	И	<b>\!</b>	\negthinspace
medspace	Ц		\negmedspace
thickspace	Ц		\negthickspace

Table 8.1: Math spacing commands.

# 8.1.3 Spacing commands

There are some situations where LaTeX cannot typeset a formula properly and you have to add spacing commands. Luckily, LaTeX provides a variety of spacing commands, listed in Table 8.1. The \neg commands remove space by "reversing the print head".

The  $\qquad$  and  $\qquad$  commands are often used to adjust aligned formulas (see Chapter 9) or to add space before text in a math formula. The size of  $\qquad$  and  $\qquad$  and  $\qquad$  depends on the current font.

The  $\$ , and  $\!$  commands are the most useful for fine tuning math formulas, see some examples in the *Formula Gallery* and in the next section. The  $\$ mspace command and the math unit mu provides you with even finer control. 18 mu = 1 em, defined in Section 5.8.3. For example,  $\$ mspace{3mu} adds a space that is 1/6 em long. There is an interesting use of mu on page 109.

# 8.1.4 Examples

The *Formula Gallery* in Section 7.9 starts out with an example that shows the importance of fine tuning. In set notation, when using \mid for "such that", thin spaces are inserted just inside the braces. Some more examples of fine tuning follow. One more example can be found in Section 8.2.1.

**Example 1** In Section 3.3, we type the formula  $\int_0^{\pi} \sin x \, dx = 2$  as

$$\int_{0}^{\pi} \sin x \, dx = 2$$

Notice the thinspace spacing command \ , between \sin x and dx. Without the command, LeTeX would have crowded  $\sin x$  and dx:  $\int_0^\pi \sin x dx = 2$ .

191

**Example 2** |-f(x)|, typed as |-f(x)|, is spaced incorrectly. — becomes a binary operation by the + and - rule. To get the correct spacing, as in |-f(x)|, type |-f(x)| this form tells LaTeX that the first | is a left delimiter, by the | rule, and therefore - is the unary minus sign, not the binary subtraction operation.

**Example 3** In  $\sqrt{5}$ side, typed as

\$\sqrt{5} \text{side}\$

 $\sqrt{5}$  is too close to side. So type it as

 $\scriptstyle \$  \sqrt{5} \, \text{side}\$

which typesets as  $\sqrt{5}$  side.

**Example 4** In  $\sin x/\log n$ , the division symbol / is too far from  $\log n$ , so type

 $\sin x / \le \log n$ 

which prints  $\sin x/\log n$ .

**Example 5** In  $f(1/\sqrt{n})$ , typed as

\$f(1 / \sqrt{n})\$

the square root almost touches the closing parenthesis. To correct it, type

\$f(1 / \sqrt{n}\,)\$

which typesets as  $f(1/\sqrt{n})$ .

There is one more symbol with special spacing: the \colon command, used for formulas such as  $f: A \to B$  (typed as \$f \colon A \to B\$). Observe that \$f: A \to B\$ typesets as  $f: A \to B$ . The spacing is awful.

See Section 8.2.3 on how to declare the type of a symbol.

### 8.1.5 The phantom command

The \phantom{argument} command (introduced for text in Section 5.8.1) produces a space in a formula equivalent to the space that would be occupied by its typeset argument. This command is one of the most powerful tools available to us for fine tuning alignments. Here are two simple illustrations:

$$A = \begin{pmatrix} 1 & 3 & 1 \\ 2 & 1 & 1 \\ -2 & 2 & -1 \end{pmatrix}$$

```
typed as
١/
  A = \begin{pmatrix}
         \phantom{-}1 & \phantom{-}3 & \phantom{-}1\\
         \phi_{-}2 \ \phi_{-}1 \ \ \phi_{-}1\
                   -2 & \phantom{-}2 &
                                                -1\\
      \end{pmatrix}
\]
and
                       a+b+c+d = 0,
                            c + d + e = 5.
typed as
\begin{align*}
     a + b + c & + d \phi { = 0, \}
             c & + d + e
   \end{align*}
```

Note that  $\phi = \text{yields incorrect spacing by the} + \text{and} - \text{rule:}$ 

$$a+b+c+d = 0,$$
  
$$c+d+e = 5.$$

See Section 9.6.2 for an additional example.

# 8.2 Building new symbols

No matter how many math symbols LaTeX provides—see a complete listing in Appendix B—users always seem to want more. LaTeX gives you excellent tools to build new symbols from existing ones.

# 8.2.1 Stacking symbols

To place any symbol above, or below, any other, for instance,  $\stackrel{\text{u}}{\sim}$ , use the \overset command. It takes two arguments—the first argument is set in a smaller size above the second argument. The spacing rules of the symbol in the second argument remain valid, i.e., the type remains the same. Since  $\sim$  is a binary relation, so is  $\stackrel{\text{u}}{\sim}$ . The \underset command is the same except that the first argument is set under the second argument. For example,

$$\stackrel{\alpha}{a}$$
  $X$   $\stackrel{\alpha}{a_i}$   $\stackrel{\alpha}{a_i}$ 

are typed as

<sup>&</sup>lt;sup>1</sup>The best is yet to come, see Section H.3.

```
\[
  \overset{\alpha}{a} \qquad
  \underset{\boldsymbol{\cdot}}{X} \qquad
  \overset{\alpha}{ a_{i} } \qquad
  \overset{\alpha}{a}_{i}
\]
```

For the \boldsymbol command, see Section 8.3.3. Note that in the third example,  $a_i^{\alpha}$ , the  $\alpha$  seems to be sitting too far to the right but the fourth example corrects that.

You can also use these commands with binary relations, as in

$$f(x) \stackrel{\text{def}}{=} x^2 - 1$$

which is typed as

Since = is a binary relation,  $\stackrel{\text{def}}{=}$  becomes a binary relation, as shown by the spacing on either side. Here is another example,

$$\frac{a}{b} + \frac{c}{d} + \frac{e}{f}$$

which is typed as

```
\[
  \frac{a}{b} \overset{u}{+} \frac{c}{d}
  \overset{1}{+} \frac{e}{f}
\]
```

Note that  $\stackrel{u}{+}$  and  $\stackrel{l}{+}$  are properly spaced as binary operations.

As we discuss in Section 7.4.6, the safer definitions for these examples are

```
\[
   f(x) \overset{ \normalfont\text{def} }{=} x^{2} - 1
\]
and
\[
   \frac{a}{b} \overset{\normalfont u}{+} \frac{c}{d}
   \overset{\normalfont 1}{+} \frac{e}{f}
\]
```

# 8.2.2 Negating and side-setting symbols

You can negate with the \not command; for instance,  $a \notin b$  and  $a \neq b$  are typed as  $a \not b$  and  $a \not b$  and  $a \not b$  are typed as  $a \not b$  and  $a \not b$  and  $a \not b$  are typed as  $a \not b$  and  $a \not b$  and  $a \not b$  are typed as  $a \not b$  and  $a \not b$  are typed as  $a \not b$  and  $a \not b$  are typed as  $a \not b$  and  $a \not b$  and  $a \not b$  are typed as  $a \not b$  and  $a \not b$  and  $a \not b$  are typed as  $a \not b$  and  $a \not b$  and  $a \not b$  are typed as  $a \not b$  and  $a \not b$  are typed as  $a \not b$  and  $a \not b$  are typed as  $a \not b$  and  $a \not b$  are typed as  $a \not b$  and  $a \not b$  are typed as  $a \not b$  and  $a \not b$  are typed as  $a \not b$  and  $a \not b$  are typed as  $a \not b$  and  $a \not b$  are typed as  $a \not b$  and  $a \not b$  are typed as  $a \not b$  and  $a \not b$  are typed as  $a \not b$  and  $a \not b$  are typed as  $a \not b$  and  $a \not b$  are typed as  $a \not b$  and  $a \not b$  are typed as  $a \not b$  and  $a \not b$  are typed as  $a \not b$  are typed a

LATEX provides the \sideset command to set symbols at the corners of large operators other than the "corners" (the last four delimiters in Table 7.1). This command takes three arguments:

```
\left\{ _{ll}^{ul} \right\} \left\{ _{lr}^{ur} \right\} \left\{ _{ur} \right\}
```

where ll stands for the symbol to be placed at the lower left, ul for upper left, lr for lower right, and ur for upper right;  $large\_op$  is a large operator. These two examples,

$$\prod_a^c$$
 and  $e^{\prod_a}$ 

are typed as

 $\label{a}^{c}_{a}^{c}}{\prod}\text{ and } \sideset{^{e}}_{\prod}^{\}}$ 

Note that the two first arguments are compulsory, although one or the other may be empty, while the third argument must contain the large operator.

Here is a more meaningful example:

is typeset as

$$\sum_{\substack{i<10\\j<10}}' x_i z_j$$

In this example, note that prime (') is an automatically superscripted symbol (see Section 7.4.1), so you do not have to type ^' in the second argument. Typing \sum' would not work, since LaTeX would place the prime above the sum symbol.

Thus, \sideset helps in mixing sub- and superscripts in "limit" positions with others in "nolimit" positions, allowing for a total of six positions in displayed operators with limits. Try

$$a\prod_{i=1}^{r}a_{e}^{i}$$

typed as

### 8.2.3 Changing the type of a symbol

Some symbols are binary relations and some are binary operations (see Section 8.1). In fact, you can force any symbol to behave like either type.

The \mathbin command declares its argument to be a binary operation. For example,

\mathbin{\alpha}

makes this instance of \alpha behave like a binary operation, as in  $a \alpha b$ , typed as

You can use the \mathrel command to make a symbol behave like a binary relation, as in the formula  $a \alpha b$ , typed as

```
$a \mathrel{ \alpha } b$
```

You can see

```
a \alpha b ($a \mathbin{\alpha} b$)
```

 $a \mathrel{\alpha} b \quad ($a \mathbf{b} \ b$)$ 

that a binary relation provides a bit more space than a binary operation. There is an interesting use of \mathbin on page 109.

In Section 7.6.2, we discussed the \DeclareMathOperator command and its \*-ed version, to declare a symbol—or any text or formula—a math operator.

# 8.3 Math alphabets and symbols

The classification of math symbols in the context of spacing was discussed in Section 8.1. The symbols in a formula can also be classified as *characters from math alphabets* and *math symbols*. In the formula

$$A = \{x \in X \mid x\beta \ge xy > (x+1)^2 - \alpha\}$$

the following characters come from math alphabets:

$$A \quad x \quad X \quad y \quad 1 \quad 2$$

whereas these characters are math symbols:

$$= \{ \in | \beta \geq > (+) - \alpha \}$$

# 8.3.1 Math alphabets

The letters and digits typed in a math formula come from *math alphabets*. LaTeX's default math alphabet—the one you get if you do not ask for something else—is Computer Modern math italic for *letters*. In the formula  $x^2 \vee y_3 = \alpha$ , the characters x and y come from this math alphabet. The default math alphabet for *digits* is Computer Modern roman and the digits 2 and 3 in this formula are typeset in Computer Modern roman.

LATEX has a number of commands to switch type style in math. The two most important commands select the bold and italic versions:

Command	Math alphabet	Produces
\mathbf{a}	math bold	<b>2</b> Greek gammas, $\gamma$ and $\Gamma$
$\mathbf{a}$	math italic	2 Greek gammas, $\gamma$ and $\Gamma$

These commands change the style of letters, numbers, and upper case Greek characters. But beware of the pitfalls. For instance, in  $\mathbf{tfleft-side}$  the hyphen typesets as a minus: left-side.

There are four more commands that switch math alphabets:

Command	Math Alphabet	Produces
a	math sans serif	2 Greek gammas, $\gamma$ and $\Gamma$
$\mathbf{mathrm{a}}$	math roman	2 Greek gammas, $\gamma$ and $\Gamma$
$\mathbf{a}$	math typewriter	2 Greek gammas, $\gamma$ and $\Gamma$
$\mathbf{a}$	math italic	2 Greek gammas, $\gamma$ and $\Gamma$

Math roman is used in formulas for operator names, such as  $\sin x$ , and for text. For operator names, you should use the \DeclareMathOperator command or the \*-ed version, which sets the name of the operator in math roman, and also provides the proper spacing (see Section 8.2.3). For text, you should use the \text command (see Section 7.4.6).

The \mathnormal command switches to the default math alphabet, but this command is seldom used in practice.

The Computer Modern fonts include a math bold italic alphabet, but LaTeX does not provide a command to access it.

## Rule ■ Math alphabets vs. text alphabets

Do not use text alphabets in a math formula, except in the argument of a \text command.

It may not be easy for you to see the difference, but some things will not look right or may not align properly.

## 8.3.2 Math symbol alphabets

You may have noticed that  $\alpha$  was not classified as belonging to an alphabet in the example at the beginning of this section. Indeed,  $\alpha$  is treated by LaTeX as a math symbol rather than as a member of a math alphabet. You cannot italicize or slant it, nor is there a sans serif version. There is a bold version, but you must use the \boldsymbol command to produce it. For instance,  $\alpha_{\beta}$ , is typed as

```
$\boldsymbol{\alpha}_{\boldsymbol{\beta}}$
```

Note that  $\beta$  appears in a small size in  $\alpha_{\beta}$ .

Four "alphabets of symbols" are built into LATEX.

**Greek** The examples  $\alpha$ ,  $\beta$ , and  $\Gamma$  are typed as

```
$\alpha$, $\beta$, $\Gamma$
```

See Section B.1 for the symbol table.

**Calligraphic** an uppercase-only alphabet invoked with the \mathcal command. The examples  $\mathcal{A}$ ,  $\mathcal{C}$ , and  $\mathcal{E}$  are typed as

```
$\mathcal{A}$, $\mathcal{C}$, $\mathcal{E}$
```

**Euler Fraktur** invoked by the \mathfrak command. The examples  $\mathfrak{n}, \mathfrak{p}, \mathfrak{N}$ , and  $\mathfrak{P}$  are typed as

```
$\mathfrak{n}$, $\mathfrak{p}$, $\mathfrak{N}$,
$\mathfrak{P}$
```

**Blackboard bold** uppercase-only math alphabet, invoked with \mathbb. The examples  $\mathbb{A}$ ,  $\mathbb{B}$ ,  $\mathbb{C}$  are typed as

```
$\mathbb{A}$, $\mathbb{B}$, $\mathbb{C}$
```

# 8.3.3 Bold math symbols

In math, most characteristics of a font are specified by LaTeX. One exception is bold-face. To make a *letter* from a math alphabet within a formula bold, use the \mathbf command. For instance, in

```
we choose the vector \mathbf{v}
```

v is produced by  $\infty$ 

To obtain bold math *symbols*, use the \boldsymbol command. For example, the bold symbols

```
5 \quad \alpha \quad \Lambda \quad \mathcal{A} \quad \rightarrow \quad A
```

Note that  $\boldsymbol{A}$  typesets as  $\boldsymbol{A}$ , a bold math italic A. To get an upright  $\boldsymbol{A}$ , type  $\boldsymbol{A}$ .

5 did not really need \boldsymbol; \mathbf{5} gives the same result.

To make an entire formula bold, use the \mathversion{bold} command, as in

```
{\mathversion{bold} $a \equiv c \pod{\theta}$}
```

which typesets as  $a \equiv c$  ( $\theta$ ). Note that the \mathversion{bold} command is given before the formula.

To typeset  $\mathcal{AMS}$ , type

```
$\boldsymbol{ \mathcal{A} } \boldsymbol{ \mathcal{M} }
\boldsymbol{ \mathcal{S} }$
or
```

\$\boldsymbol{ \mathcal{AMS} }\$

or

{\mathversion{bold} \$\mathcal{AMS}\$}

Within the scope of \mathversion{bold}, you can undo its effect with

\mathversion{normal}

Not all symbols have bold variants. For example, if you type

```
$\sum \quad \boldsymbol{\sum}$
```

you get  $\sum$   $\sum$ , two identical symbols. If you want to obtain a bold version, use the *poor man's bold* invoked by the \pmb command. This command typesets the symbol three times very close to one another producing a bold symbol of some quality. Note that \pmb does destroy the type of the symbol, \pmb{\sum} is no longer spaced like a large operator. To make it into a large operator, declare in the preamble

\DeclareMathOperator{\boldsum}{\pmb{\sum}}

and

\DeclareMathOperator\*{\boldsumlim}{\pmb{\sum}}

Compare the following four variants of sum:

$$\sum_{i=1}^{n} i^{2} \sum_{i=1}^{n} i^{2} \sum_{i=1}^{n} i^{2} \sum_{i=1}^{n} i^{2}$$

The first sum is typed (in displayed math mode) as

$$\sum_{i=1}^{n} i^{2}$$

The second uses poor man's bold, but does not declare the result to be a large operator:

$$\pmb{\sum_{i=1}^{n} i^{2}}$$

The third uses the math operator declared:

$$\boldsum_{i = 1}^{n} i^{2}$$

The fourth uses the math operator with limit declared:

$$\boldsumlim_{i = 1}^{n} i^{2}$$

# 8.3.4 Size changes

There are four math font sizes, invoked by the command declarations

- \displaystyle, normal size for displayed formulas
- \textstyle, normal size for inline formulas
- \scriptstyle, normal size for subscripted and superscripted symbols
- \scriptscriptstyle, normal size for doubly subscripted and superscripted symbols

These commands control a number of style parameters in addition to the size. Compare the two fractions

$$\frac{1}{2+\frac{1}{3}} \quad \frac{1}{2+\frac{1}{3}}$$

which are typed as

## 8.3.5 Continued fractions

In addition to the \frac, \dfrac, and \tfrac commands (see Section 7.4.1), LATEX makes typesetting continued fractions even easier by providing the \cfrac command. The \cfrac command takes an optional argument, 1 or r, to place the numerator on the left or on the right. For example,

$$\frac{1}{2 + \frac{1}{3 + \cdots}}$$
  $\frac{1}{2 + \frac{1}{3 + \cdots}}$ 

is typed as

# 8.4 Vertical spacing

As a rule, all horizontal and vertical spacing in a math formula is done by LaTeX. Nevertheless, you often need to adjust horizontal spacing (see Section 8.1). There is seldom a need to adjust vertical spacing, but there are a few exceptions.

The formula  $\sqrt{a} + \sqrt{b}$  does not look quite right, because the square roots are not uniform. You can correct this with \mathstrut commands, which inserts an invisible vertical space:

\$\sqrt{\mathstrut a} + \sqrt{\mathstrut b}\$

typesets as  $\sqrt{a} + \sqrt{b}$ . See Section 5.9.5 for struts in general.

Another way to handle this situation is with the \vphantom (vertical phantom) command, which measures the height of its argument and places a math strut of that height into the formula. So

\$\sqrt{\vphantom{b} a} + \sqrt{b}\$

also prints uniform square roots,  $\sqrt{a}+\sqrt{b}$ . The \vphantom method is more versatile than the previous one.

Here is a more complicated example from a recent research article:

$$\Theta_i = \bigcup \left( \Theta(\overline{a \wedge b}, \overline{a} \wedge \overline{b}) \mid a, \ b \in B_i \right) \vee \bigcup \left( \Theta(\overline{a \vee b}, \overline{a} \vee \overline{b}) \mid a, \ b \in B_i \right),$$

typed as

\[
\Theta\_i = \bigcup \big(\, \Theta (\,\overline{a})

```
\wedge b},\overline{\vphantom{b}a} \wedge
  \overline{b}) \mid a,\ b \in B_i \,\big)
  \vee \bigcup \big(\, \Theta(\,\overline{a \vee b},
  \overline{\vphantom{b}a} \vee \overline{b} \,)
  \mid a,\ b \in B_i \,\big),
\]
```

Another useful command for vertical spacing is the \smash command. It directs LATEX to pretend that its argument does not protrude above or below the line in which it is typeset.

For instance, the two lines of this admonition:

It is very important that you memorize the integral  $\frac{1}{\int f(x) dx} = 2g(x) + C$ , which will appear on the next test.

are too far apart because LaTeX had to make room for the fraction. However, in this instance, the extra vertical space is not necessary because the second line is very short. To correct this, place the formula in the argument of a \smash command:

```
It is \emph{very important} that you memorize the integral \frac{1}{\int f(x) \, dx} = 2g(x) + C, which will appear on the next test.
```

LATEX produces the following:

It is very important that you memorize the integral  $\frac{1}{\int f(x) dx} = 2g(x) + C$ , which will appear on the next test.

An optional argument to the \smash command controls which part of the formula is ignored, t to smash the top, and b to smash the bottom.

# 8.5 Tagging and grouping

You can attach a name to an equation using the \tag command. In the equation or equation\* environments,

```
\tag{name}
```

attaches the tag name to the equation—name is typeset as text. The tag replaces the number.

Recall that the numbering of an equation is *relative*, that is, the number assigned to an equation is relative to the placement of the equation with respect to other equations in the document. An equation tag, on the other hand, is *absolute*—the tag remains the same even if the equation is moved.

\1

If you want to reference the number generated by  $\LaTeX$  for an equation, then you have to attach a  $\lowert$  command. You reference the number with the  $\row$  or  $\ensuremath{\texttt{name}}$  command.

Note that an equation may contain both a tag and a label. The tag is typeset and the label can be used for page referencing with the \pageref command (see Section 10.4.2).

If there is a tag, the equation and the equation\* environments are equivalent. For example,

(Int) 
$$\int_{-\infty}^{\infty} e^{-x^2} \, dx = \sqrt{\pi}$$
 may be typed as 
$$\begin{array}{l} \text{begin}\{\text{equation*}\} \\ \text{int}_{-\in \mathbb{N}}^{\infty} = \sqrt{2} \\ \text{end}\{\text{guation*}\} \\ \text{or} \\ \text{begin}\{\text{equation}\} \\ \text{int}_{-\in \mathbb{N}}^{\infty} = \sqrt{2} \\ \text{end}\{\text{equation}\} \\ \text{or} \\ \text{end}\{\text{equation}\} \\ \text{or} \\ \text{or} \\ \text{lint}_{-\in \mathbb{N}}^{\infty} = \sqrt{2} \\ \text{or} \\ \text{lint}_{\infty} = \sqrt{2} \\ \text{or} \\ \text{or} \\ \text{lint}_{\infty} = \sqrt{2} \\ \text{or} \\ \text{or} \\ \text{lint}_{\infty} = \sqrt{2} \\ \text{or} \\ \text{lint}_{\infty} = \sqrt{2} \\ \text{or} \\ \text{lint}_{\infty} = \sqrt{2} \\ \text{lint$$

Note that \label works in a starred display math environment if a tag is present.

The \tag\* command is the same as \tag except that it does not automatically enclose the tag in parentheses. To get

Tagging allows numbered variants of equations. For instance, the equation

$$A^{[2]} \diamond B^{[2]} \cong (A \diamond B)^{[2]}$$

may need a variant:

$$A^{\langle 2 \rangle} \diamond B^{\langle 2 \rangle} \equiv (A \diamond B)^{\langle 2 \rangle}$$

If the label of the first equation is E:first, then the second equation may be typed as follows:

```
\begin{equation}\tag{\ref{E:first}$'$}
    A^{\langle 2 \rangle} \diamond B^{\langle 2 \rangle}
    \equiv (A \diamond B)^{\langle 2 \rangle}
\end{equation}
```

Such a tag is absolute in the sense that it does not change if the equation is moved. But if it references a label and the number generated by LATEX for the label changes, the tag changes.

In contrast, *grouping* applies to a group of *adjacent* equations. Suppose the last equation was numbered (1) and the next group of equations is to be referred to as (2), with individual equations numbered as (2a), (2b), and so on. Enclosing these equations in a subequations environment accomplishes this goal. For instance,

(1a) 
$$A^{[2]} \diamond B^{[2]} \cong (A \diamond B)^{[2]}$$

and its variant

(1b) 
$$A^{\langle 2 \rangle} \diamond B^{\langle 2 \rangle} \equiv (A \diamond B)^{\langle 2 \rangle}$$

are typed as

```
\begin{subequations}\label{E:joint}
  \begin{equation}\label{E:original}
     A^{[2]} \diamond B^{[2]} \cong (A \diamond B)^{[2]}
  \end{equation}

\begin{equation}\label{E:modified}
     A^{\langle 2 \rangle} \diamond B^{\langle 2 \rangle}
     \equiv (A \diamond B)^{\langle 2 \rangle}
  \end{equation}
\end{subequations}
```

Referring to these equations, you find that

- \eqref{E: joint} resolves to (1)
- \eqref{E:original} resolves to (1a)

\eqref{E:modified} resolves to (1b)

Note that in this example, references to the second and third labels produce numbers, (1a) and (1b), that also appear in the typeset version. The group label, E: joint, references the entire group, but (1) does not appear in the typeset version unless referenced.

A subequations environment can contain the multiline math constructs discussed in Chapter 9 (see Section 9.4.4).

# 8.6 Miscellaneous

# 8.6.1 Generalized fractions

The generalized fraction command provides the facility to typeset many variants of fractions and binomials, such as  $\frac{a+b}{c}$  and  $\begin{bmatrix} a+b \\ c \end{bmatrix}$ . The syntax is

#### where

- left-delim is the left delimiter for the formula (default: none)
- right-delim is the right delimiter for the formula (default: none)
- thickness is the thickness of the fraction line, in the form xpt (default: the normal weight, 0.4pt), for instance, 12pt for 12 point width
- mathstyle is one of
  - 0 for \displaystyle
  - 1 for \textstyle
  - 2 for \scriptstyle
  - 3 for \scriptscriptstyle
  - Default: Depends on the context. If the formula is being set in display style, then the default is 0, and so on
- numerator is the numerator
- denominator is the denominator

All arguments must be specified. The empty argument, {}, gives the default value.

#### **Examples**

\frac{numerator}{denominator}
 is the same as

8.6 Miscellaneous 205

\genfrac{}{}{}{}{numerator}{denominator}

2. \dfrac{numerator}{denominator} is the same as

\genfrac{}{}{}{0}{numerator}{denominator}

3. \tfrac{numerator}{denominator}
 is the same as

 $\genfrac{}{}{1}{numerator}{denominator}$ 

4. \binom{numerator}{denominator} is the same as

\genfrac{(){)}{Opt}{}{numerator}{denominator}

5. Here are some more examples:

$$\frac{a+b}{c}$$
  $\frac{a+b}{c}$   $\frac{a+b}{c}$   $\frac{a+b}{c}$   $\begin{bmatrix} a+b \\ c \end{bmatrix}$   $\begin{bmatrix} a+b \\ c \end{bmatrix}$ 

typed as

You can choose the delimiters from Table 7.1.

If a \genfrac construct is used repeatedly, you should name it. See Section 15.1 for user-defined commands.

# 8.6.2 Boxed formulas

The \boxed command puts its argument in a box, as in

$$(2) \int_{-\infty}^{\infty} e^{-x^2} dx = \sqrt{\pi}$$

typed as

```
\begin{equation}
  \boxed{ \int_{-\infty}^{\infty} e^{-x^{2}}\, dx
  = \sqrt{\pi} }
\end{equation}

The \boxed command can also be used in the argument of a \text command.
    Note that

\fbox{Hello world}

and

$\boxed{\text{Hello world}}$

produce the same Hello world.
    Morten Høgholm's mathtools package (see Section E.1 on how to get it), contains many variants of boxes.
```

# Multiline math displays

# 9.1 Visual Guide

Let TeX is about typesetting math. It knows a lot about typesetting inline formulas, but not much about how to display a multiline formula to best reflect its meaning in a visually pleasing way. So you have to decide the visual structure of a multiline formula and then use the tools provided by Let TeX to code and typeset it.

For many mathematical documents the three constructs of Chapter 3 suffice: *simple* and *annotated* alignments, and the *cases* construct. To help you choose the appropriate tool for more complicated constructs, we start by introducing the basic concepts and constructions with the *Visual Guide* shown on the next page.

# Adjusted environments

$$x_1x_2 + x_1^2x_2^2 + x_3 \qquad (x_1x_2x_3x_4x_5x_6)^2$$

$$x_1x_3 + x_1^2x_3^2 + x_2 \qquad + (x_1x_2x_3x_4x_5 + x_1x_3x_4x_5x_6 + x_1x_2x_4x_5x_6 + x_1x_2x_3x_5x_6)^2$$

$$+ (x_1x_2x_3x_4 + x_1x_2x_3x_5 + x_1x_2x_4x_5 + x_1x_3x_4x_5)^2$$

gather one column, centered

multline flush left, centered, flush right

# Adjusted subsidiary environments

# Aligned environments

$$f(x) = x + yz \qquad g(x) = x + y + z \qquad f(x) = x + yz \qquad g(x) = x + y + z \\ h(x) = xy + xz + yz \qquad k(x) = (x + y)(x + z)(y + z) \qquad h(x) = xy + xz + yz \qquad k(x) = (x + y)(x + z)(y + z)$$
 align and multicolumn, aligned multicolumn, aligned 
$$(17) \qquad a_{11}x_1 + a_{12}x_2 + a_{13}x_3 \qquad = y_1 \\ (18) \qquad a_{21}x_1 + a_{22}x_2 \qquad + a_{24}x_4 = y_2 \\ (19) \qquad a_{31}x_1 \qquad + a_{33}x_3 + a_{34}x_4 = y_3 \\ \text{alignat} \qquad \text{multicolumn, aligned}$$

# Aligned subsidiary environment

$$(3.4) \qquad 0 = \langle \dots, 0, \dots, \stackrel{i}{d}, \dots, 0, \dots \rangle \land \langle \dots, 0, \dots, \stackrel{j}{a}, \dots, 0, \dots \rangle$$

$$\equiv \langle \dots, 0, \dots, \stackrel{j}{a}, \dots, 0, \dots \rangle \pmod{\Theta}$$

$$\texttt{split}$$
one column, aligned

Figure 9.1: The *Visual Guide* for multiline math formulas.

9.1 Visual Guide 209

#### 9.1.1 Columns

Multiline math formulas are displayed in *columns*. The columns are either *adjusted*, that is, centered, or set flush left or right, or *aligned*, that is, an alignment point is designated for each column and for each line. Moreover, the columns are either separated by the *intercolumn space* or adjacent with no separation.

#### One column

As in Chapter 3, we start with a simple align:

$$r^2 = s^2 + t^2,$$
  
$$2u + 1 = v + w^{\alpha}$$

This is a single column, aligned at the = signs, and coded with the align environment (see Section 3.4.2).

#### Two columns

The annotated align, coded with the align environment,

$$x = x \land (y \lor z)$$
 (by distributivity)  
=  $(x \land y) \lor (x \land z)$  (by condition (M))  
=  $y \lor z$ 

has two columns. The first column is aligned like our example of simple align, but the second column is aligned flush left. There is a sizeable intercolumn space.

# 9.1.2 Subsidiary math environments

The cases example in Chapter 3:

$$f(x) = \begin{cases} -x^2, & \text{if } x < 0; \\ \alpha + x, & \text{if } 0 \le x \le 1; \\ x^2, & \text{otherwise.} \end{cases}$$

introduces a new concept. The part of the formula to the right of = is a multiline construct. This is an example of a *subsidiary math environment* that can only be used *inside another math environment*. It creates a "large math symbol", in this case

$$\begin{cases}
-x^2, & \text{if } x < 0; \\
\alpha + x, & \text{if } 0 \le x \le 1; \\
x^2, & \text{otherwise.} 
\end{cases}$$

So the cases example:

$$f(x) =$$
large math symbol

is a single line displayed formula, where "large math symbol" is replaced by the cases construct.

# 9.1.3 Adjusted columns

An *adjusted column* is either set *centered*, or *flush left*, or *flush right*. This may happen by default, built into the environment, or so specified in the code.

For instance, in the displayed formula

$$x_1x_2 + x_1^2x_2^2 + x_3,$$
  
$$x_1x_3 + x_1^2x_3^2 + x_2$$

typeset with the gather environment, by default all the lines are centered.

On the other hand, in

$$\left(\begin{array}{ccc} 1 & 100 & 115 \\ 201 & 0 & 1 \end{array}\right)$$

coded with the array subsidiary math environment, the first column is flush left, the second centered, the third flush right.

# 9.1.4 Aligned columns

Aligned columns, on the other hand, are only of one kind, aligned by you. For instance,

$$f(x) = x + yz$$
  $g(x) = x + y + z$   
 $h(x) = xy + xz + yz$   $k(x) = (x + y)(x + z)(y + z)$ 

is coded with the alignat environment. It has two aligned columns, both aligned at the = sign.

# 9.1.5 Touring the Visual Guide

Figure 9.1, the *Visual Guide*, shows thumbnail pictures of the various kinds of multiline math environments and subsidiary math environments.

The first part of the *Visual Guide* illustrates gather and multline. The gather environment is a one-column, centered math environment—discussed in Section 9.2—which is used to display a *number of formulas* collected into one multiline formula. In contrast, multline—discussed in Section 9.3—displays *one long formula* in a number of lines. The first line is set flush left, the last line set flush right, and the rest (if any) of the lines are centered.

The third part of the *Visual Guide* illustrates the align environment and two of its variants, alignat and flalign, discussed in Section 9.5.

Three adjusted subsidiary math environments—matrix, cases, and array—are illustrated in second part of the *Visual Guide* and presented in Section 9.7.

The aligned subsidiary math environments aligned and gathered look just like the align and gather environments, so they are not illustrated in the *Visual Guide*. The aligned and gathered environments—along with \itemref—are discussed in Section 9.6, along with the split subsidiary math environment; this last one is illustrated in the last part of the *Visual Guide*.

# 9.2 Gathering formulas

The gather environment groups a number of one-line formulas, each centered on a separate line:

$$(1) x_1 x_2 + x_1^2 x_2^2 + x_3,$$

$$(2) x_1 x_3 + x_1^2 x_3^2 + x_2,$$

$$(3) x_1x_2x_3.$$

Formulas (1)–(3) are typed as follows:

```
\label{E:1.1} $$x_{1} x_{2}+x_{1}^{2} x_{2}^{2} + x_{3},\lambda_{E:1.1}\\ x_{1} x_{3}+x_{1}^{2} x_{3}^{2} + x_{2},\lambda_{E:1.2}\\ x_{1} x_{2} x_{3}.\lambda_{E:1.3}\\ \end{gather}
```

# Rule ■ gather environment

- 1. Lines are separated with \\. Do not type a \\ at the end of the last line!
- 2. Each line is numbered unless it has a \tag or \notag on the line before the line separator \\.
- 3. No blank lines are permitted within the environment.

The gather\* environment is like gather, except that all lines are unnumbered. They can still be \tag-ged.

It would seem natural to code formulas (1)–(3) with three equation environments:

Note how bad this looks typeset:

$$(1) x_1 x_2 + x_1^2 x_2^2 + x_3,$$

$$(2) x_1 x_3 + x_1^2 x_3^2 + x_2,$$

(3) 
$$x_1 x_2 x_3$$
.

# 9.3 Splitting long formulas

The multline environment is used to split one very long formula into several lines. The first line is set flush left, the last line is set flush right, and the middle lines are centered:

$$(4) \quad (x_1x_2x_3x_4x_5x_6)^2 + (y_1y_2y_3y_4y_5 + y_1y_3y_4y_5y_6 + y_1y_2y_4y_5y_6 + y_1y_2y_3y_5y_6)^2 + (z_1z_2z_3z_4z_5 + z_1z_3z_4z_5z_6 + z_1z_2z_4z_5z_6 + z_1z_2z_3z_5z_6)^2 + (u_1u_2u_3u_4 + u_1u_2u_3u_5 + u_1u_2u_4u_5 + u_1u_3u_4u_5)^2$$

This formula is typed as

```
\begin{multline}\label{E:mm2}
  (x_{1} x_{2} x_{3} x_{4} x_{5} x_{6})^{2}\\
  + (y_{1} y_{2} y_{3} y_{4} y_{5} \\
  + y_{1} y_{2} y_{4} y_{5} y_{6} \\
  + y_{1} y_{2} y_{4} y_{5} y_{6} \\
  + y_{1} y_{2} y_{4} y_{5} y_{6} \\
  + y_{1} y_{2} z_{3} z_{5} z_{5} \\
  + (z_{1} z_{2} z_{3} z_{4} z_{5} \\
  + z_{1} z_{2} z_{4} z_{5} z_{6} \\
  + z_{1} z_{2} z_{5} z_{6} \\
  + z_{1} z_{6} z_{6} \\
  + z_{1} z_{6} z_{6} \\
  + z_{6} z_{6} \\
  + z_{1} z_{6} z_{6} \\
  + z_{
```

## Rule multline environment

- 1. Lines are separated with \\. Do not type a \\ at the end of the last line!
- 2. The formula is numbered *as a whole* unless it is \tag-ged or the numbering is suppressed with \notag. (Alternatively, use the multline\* environment.)
- 3. No blank lines are permitted within the environment.
- 4. Each line is a subformula (see Section 9.4.2).

If you are very observant, you may have noticed that we failed to type {}+ following the line separators of the formula. In Section 8.1.2, you were told that this omission would result in the second line being typeset as

$$+(y_1y_2y_3y_4y_5+y_1y_3y_4y_5y_6+y_1y_2y_4y_5y_6+y_1y_2y_3y_5y_6)^2$$

The multline environment, however, knows that a long formula is being broken and so typesets + as a binary operation.

A common mistake is to write multiline for multline, resulting in the message:

! LaTeX Error: Environment multiline undefined.

In the multline\* environment, the formula is not numbered but can be \tag-ged. The indentation of the first and last lines is controlled by the \multlinegap length command, with a default of 10 points, unless there is a tag on one of those lines. You can adjust the indentation by enclosing the multline environment in a setlength environment (see Section 15.5.2), as follows:

```
\begin{multline*}

(x_{1} x_{2} x_{3} x_{4} x_{5} x_{6})^{2}\\
+ (x_{1} x_{2} x_{3} x_{4} x_{5} + x_{5} + x_{1} x_{2} x_{4} x_{5} + x_{6} + x_{1} x_{2} x_{4} x_{5} x_{6} + x_{1} x_{2} x_{4} x_{5} x_{6} + x_{1} x_{2} x_{3} x_{5} x_{6} + x_{1} x_{2} x_{3} x_{5} x_{6} + x_{1} x_{2} x_{3} x_{5} + x_{1} x_{2} x_{3} x_{5} + x_{1} x_{2} x_{3} x_{4} + x_{1} x_{2} x_{3} x_{5} + x_{1} x_{2} x_{4} x_{5} + x_{5} x_{6} + x_{1} x_{2} x_{3} x_{4} x_{5} x_{5} + x_{5} + x_{1} x_{2} x_{4} x_{5} x_{5} + x_{1} x_{2} x_{4} x_{5} x_{5} + x_{1} x_{2} x_{4} x_{5} x_{5} x_{6} + x_{1} x_{2} x_{4} x_{5} x_{6} + x_{1} x_{1} x_{5} x_{6} + x_{1} x_
```

+ 
$$x_{1}$$
  $x_{2}$   $x_{3}$   $x_{5}$   $x_{6}$ )^{2}\\
+  $(x_{1})$   $x_{2}$   $x_{3}$   $x_{4}$  +  $x_{1}$   $x_{2}$   $x_{3}$   $x_{5}$  +  $x_{1}$   $x_{2}$   $x_{4}$   $x_{5}$  +  $x_{1}$   $x_{3}$   $x_{4}$ )^{2}\
end{multline\*}

\end{setlength}

which typesets as

$$(x_1x_2x_3x_4x_5x_6)^2 + (x_1x_2x_3x_4x_5 + x_1x_3x_4x_5x_6 + x_1x_2x_4x_5x_6 + x_1x_2x_3x_5x_6)^2 + (x_1x_2x_3x_4 + x_1x_2x_3x_5 + x_1x_2x_4x_5 + x_1x_3x_4)^2$$

$$(x_1x_2x_3x_4x_5x_6)^2 + (x_1x_2x_3x_4x_5 + x_1x_3x_4x_5x_6 + x_1x_2x_4x_5x_6 + x_1x_2x_3x_5x_6)^2 + (x_1x_2x_3x_4 + x_1x_2x_3x_5 + x_1x_2x_4x_5 + x_1x_3x_4)^2$$

Notice that the second variant is not indented.

Any line of a multline environment can be typeset flush left or right by making it the argument of a \shoveleft or \shoveright command, respectively (same with multline\*). For instance, to typeset the second line of formula (4) flush left, as in

$$(x_1x_2x_3x_4x_5x_6)^2 + (x_1x_2x_3x_4x_5 + x_1x_3x_4x_5x_6 + x_1x_2x_4x_5x_6 + x_1x_2x_3x_5x_6)^2 + (x_1x_2x_3x_4 + x_1x_2x_3x_5 + x_1x_2x_4x_5 + x_1x_3x_4x_5)^2$$

type the formula as follows:

#### \begin{multline\*}

\end{multline\*}

Observe that the entire line is the argument of the \shoveleft command, which is followed by \\ unless it is the last line of the environment.

# 9.4 Some general rules

#### 9.4.1 General rules

Even though you have only seen a few examples of multiline math environments, I venture to point out now that the multiline math environments and subsidiary math environments share a number of rules.

#### **Rule Multiline** math environments

- 1. Lines are separated with \\. Do not type a \\ at the end of the last line!
- 2. No blank lines are permitted within an environment.
- 3. If an environment contains more than one formula, then, as a rule, each formula is numbered separately. If you add a \label command to a line, then the equation number generated for that line can be cross-referenced.
- 4. You can suppress the numbering of a line by using a \notag command on the line.
- 5. You can also override numbering with the \tag command, which works just as it does for equations (see Section 8.5).
- 6. \tag and \label should always precede the line separator \\ for lines that are regarded as formulas in their own right. For instance, the lines of the multline environment cannot be individually numbered or tagged. The \tag command works for individual lines, not for the environment as a whole.
- 7. For cross-referencing, use \label, \ref, and \eqref in the same way you would for an equation (see Section 10.4.2).
- 8. Each multiline math environment has a \*-ed form, which suppresses numbering. Individual formulas can still be \tag-ged.

A \notag command placed after the environment is ignored, but a  $\t$ tag command gives the error message

! Package amsmath Error: \tag not allowed here.

# 9.4.2 Subformula rules

A formula in the multline environment is split into a number of parts by \\ commands; for instance, formula (4) is split into three parts:

1. 
$$(x_{1} x_{2} x_{3} x_{4} x_{5} x_{6})^{2}$$

3. 
$$+ (x_{1} x_{2} x_{3} x_{4}+x_{1} x_{2} x_{3} x_{5} + x_{1} x_{2} x_{4} x_{5}+x_{1} x_{2} x_{4} x_{5})^{2}$$

Such parts of a formula are called subformulas.

The first line of the aligned formula  $r^2=s^2+t^2$ —from the simple alignment example in Section 3.4.2—which is typed as

$$r^{2} \&= s^{2} + t^{2}$$

is split into two parts:

1. 
$$r^{2}$$

2. = 
$$s^{2} + t^{2}$$

In general, in a line of an aligned formula, the first part is everything between the beginning of the line and the first & symbol. There can then be a number of parts delimited by two consecutive & symbols. Finally, the last part is from the last & symbol to the end of the line or the line separator \\. These parts are also called *subformulas*.

Here are the last of the general rules.

#### Rule Subformula

- 1. Each subformula must be a formula that LATEX can typeset independently.
- 2. If a subformula starts with the binary operation + or -, type it as  $\{\}+$  or  $\{\}-$ .
- 3. If a subformula ends with the binary operation + or -, type it as  $+\{\}$  or  $-\{\}$ .

Suppose that you want to split the formula

$$x_1 + y_1 + \left(\sum_{i < 5} {5 \choose i} + a^2\right)^2$$

just before the binomial coefficient. Try

```
\begin{multline}
    x_{1} + y_{1} + \left( \sum_{i < 5}\\
    \binom{5}{i} + a^{2} \right)^{2}
\end{multline}</pre>
```

When typesetting this formula, you get the error message

! Missing \right. inserted.

because the first subformula violates the first subformula rule.

$$x_{1} + y_{1} + \left( \sum_{i < 5} \right)$$

cannot be typeset by LATEX because the \left( command must be matched by the \right command and some delimiter.

Testing for the first subformula rule is easy. Split the formula into its subformulas, and test each subformula separately by typesetting it.

# 9.4.3 Breaking and aligning formulas

You do not have to know where and how to break inline math formulas because LATEX does all the work for you.

Unfortunately, multiline formulas are different. LaTeX gives you excellent tools for displaying multiline math formulas, but offers you no advice on deciding where to break a long formula into lines. And that is how it should be. You, the author, are the only judge of where to break a long formula so that the result is mathematically informative and follows the traditions of mathematical typesetting.

A strict set of rules is formulated in *Mathematics into Type* by Ellen Swanson, Arlene Ann O'Sean, and Antoinette Tingley Schleyer [58]. I state only three.

# Rule ■ Breaking displayed formulas

- 1. Try to break a long formula *before* a binary relation or binary operation.
- 2. If you break a formula before a + or -, start the next line with  $\{\}+ or \{\}-$ .
- 3. If you break a formula within a bracket, indent the next line so that it begins *to the right of* the opening bracket.

Formula (4) on page 212 illustrates the first rule. Here is an illustration of the third rule:

$$f(x, y, z, u) = [(x + y + z) \times (x^2 + y^2 + z^2 - 1) \times (x^3 + y^3 + z^3 - u) \times (x^4 + y^4 + z^4 + u)]^2$$

The rules for aligning columns are similar.

# **Rule** ■ Aligning columns

- 1. Try to align columns at a binary relation or a binary operation.
- 2. If you align a column at a binary relation, put the & symbol immediately *to the left* of the binary relation.
- 3. If you align a column at the binary operation + or -, put the & symbol to the left of the binary operation.

# 9.4.4 Numbering groups of formulas

With most constructs in this chapter, you have a number of equations typeset together, arranged in some way, aligned or adjusted. Each equation is numbered separately, unless \tag-ged or \notag-ged. Often, you may want the equations to share a common number, but still be able to reference each equation separately.

You can change the numbering of the equations on page 211 in formulas (1)–(3) to (1), (1a), and (1b) as follows:

```
\begin{gather}
    x_{1} x_{2} + x_{1}^{2} x_{2}^{2} + x_{3},
    \label{E:1}\\
    x_{1} x_{3} + x_{1}^{2} x_{3}^{2} + x_{2},
    \tag{\ref{E:1}a}\\
    x_{1} x_{2} x_{3};\tag{\ref{E:1}b}
\end{gather}
```

produces the desired result:

$$(1) x_1 x_2 + x_1^2 x_2^2 + x_3,$$

$$(1a) x_1 x_3 + x_1^2 x_3^2 + x_2,$$

(1b) 
$$x_1 x_2 x_3;$$

To obtain (1') or (1') type

Alternatively, you may include the gather environment in a subequations environment (see Section 8.5):

(5a) 
$$x_1 x_2 + x_1^2 x_2^2 + x_3,$$

(5b) 
$$x_1x_3 + x_1^2x_3^2 + x_2$$
,

(5c) 
$$x_1 x_2 x_3$$
,

typed as

\begin{subequations}\label{E:gp}
 \begin{gather}
 x\_{1} x\_{2} + x\_{1}^{2} x\_{2}^{2} + x\_{3},
 \label{E:gp1}\\
 x\_{1} x\_{3} + x\_{1}^{2} x\_{3}^{2} + x\_{2},
 \label{E:gp2}\\
 x\_{1} x\_{2} x\_{3},\label{E:gp3}
 \end{gather}

\end{subequations}

Then \eqref{E:gp} references the whole group of equations as (5), while

\eqref{E:gp1}, \eqref{E:gp2}, and \eqref{E:gp3}

reference the individual formulas as (5a), (5b), and (5c).

# 9.5 Aligned columns

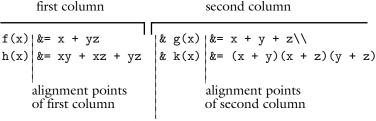
The lines of multiline formulas are naturally divided into columns. In this section, we discuss how to typeset such formulas with *aligned columns*. All of these constructs are implemented with the align math environment and its variants.

In Section 3.4.2, you saw two simple, one-column examples of aligned columns—which we called *simple alignment*—and a special case of aligned columns—which we called *annotated alignment*.

The align environment can also create multiple aligned columns. The number of columns is restricted only by the width of the page. In the following example, there are two aligned columns:

(6) 
$$f(x) = x + yz$$
  $g(x) = x + y + z$   $h(x) = xy + xz + yz$   $k(x) = (x + y)(x + z)(y + z)$ 

typed as



start of second column

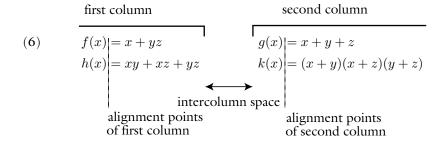


Figure 9.2: Two aligned columns: source and typeset.

Use Figure 9.2 to visualize how the alignment points in the source turn into alignment points in the typeset formula and the role played by the intercolumn space. Remember that the visual layout of the source is for your benefit only.

In a multicolumn align environment, the ampersand (&) plays two roles. It is a mark for the *alignment point* and it is also a *column separator*. In the line

$$f(x) \&= x + yz$$
 &  $g(x) \&= x + y + z$ 

the two columns are

$$f(x) &= x + yz$$

and

$$g(x) &= x + y + z$$

In each column, we use a single ampersand to mark the alignment point. Of the three & symbols in the previous example,

- The first & marks the *alignment point* of the first column.
- The second & is a *column separator* that separates the first and second columns.
- The third & marks the *alignment point* of the second column.

I use the convention of typing a space on the left of an alignment point & and no space on the right, and of putting spaces on both sides of & as a column separator.

If the number of columns is three, then there should be five &'s in each line. Evennumbered &'s are column separators and odd-numbered &'s are alignment marks.

# Rule Ampersands

If there are n aligned columns, then each line should have at most 2n-1 ampersands. Even-numbered &'s are column separators; odd-numbered &'s mark the alignment points.

So for a single aligned column, you have to place one alignment point for each line. For two aligned columns, you have to place at most three alignment points for each line. The beginning of the line to the second & is the first column, then from the second & to the end of the line is the second column. Each line of each column has an alignment point marked by &.

A column in a line may be empty—a gap is produced—or it may have only a few columns. Both of these are illustrated by

$$a_1 & c_1 \\ b_2 & c_2 \\ \\ a_3 \\ \text{typed as} \\ \text{begin{align*}} \\ \& \ a_1 \ \& \ \& \ \& c_1 \\ \& \ \& \ \& b_2 \ \& \ \& c_2 \\ \& \ a_3 \\ \text{end{align*}} \\$$

# 9.5.1 An align variant

A variant of align is the flush alignment environment flalign, which moves the leftmost column as far left and the rightmost column as far right as space allows, making more room for the formula. Here is formula (6) again, followed by the flalign variant:

(6) 
$$f(x) = x + yz$$
  $g(x) = x + y + z$   
 $h(x) = xy + xz + yz$   $k(x) = (x + y)(x + z)(y + z)$ 

(7) 
$$f(x) = x + yz$$
  $g(x) = x + y + z$   
 $h(x) = xy + xz + yz$   $k(x) = (x + y)(x + z)(y + z)$ 

The variant is typed as follows:

# 9.5.2 eqnarray, the ancestor of align

LATEX's original aligned math environment is equarray. Here is an example:

which typesets as

You can type the same formulas with align:

which typesets as

$$(10) x = 17y$$

$$(11) y > a + b + c$$

In the eqnarray environment the spacing is based on the spacing of the columns rather than on the spacing requirements of the symbols.

I mention eqnarray not for historical reasons but for a very practical one. Unfortunately, a large number of journal submissions still use this construct, and have to be recoded in the editorial offices. Be kind to your editor, and do not use eqnarray.

## 9.5.3 The subformula rule revisited

Suppose that you want to align the formula

$$x_1 + y_1 + \left(\sum_{i} {5 \choose i} + a^2\right)^2$$

with

$$\left(\sum_{i} {5 \choose i} + \alpha^2\right)^2$$

so that the  $\,+\,a^2$  in the first formula aligns with the  $\,+\,\alpha^2$  in the second formula. You might try typing

\begin{align\*}

\end{align\*}

But when you typeset this formula, you get the error message

! Extra }, or forgotten \right.

This alignment structure violates the subformula rule because LATEX cannot typeset

$$x_{1} + y_{1} + \left( \sum_{i=1}^{5} i \right)$$

so it is not a subformula.

As another simple example, try to align the + in  $\binom{a+b}{2}$  with the + in x+y:

\begin{align}

 $\ \binom{a &+ b}{2}\$ 

x &+ y

\end{align}

When typesetting this formula, you get the error message

! Missing } inserted.

Again, LATEX cannot typeset the subformula \binom{a.

To align the two formulas in the first example, add a \phantom command to push the second line to the right:

\begin{align\*}

yielding

$$x_1 + y_1 + \left(\sum_{i < 5} {5 \choose i} + a^2\right)^2$$
$$\left(\sum_{i < 5} {5 \choose i} + \alpha^2\right)^2$$

# 9.5.4 The alignat environment

Another variant of the align environment is the alignat environment, which is one of the most important alignment environments. While the align environment calculates how much space to put between the columns, the alignat environment leaves spacing up to the user. It is important to note that the alignat environment has a required argument, the number of columns.

Here is formula (6) typed with the alignat environment:

which typesets as

(12) 
$$f(x) = x + yz \qquad g(x) = x + y + z$$
$$h(x) = xy + xz + yzk(x) = (x + y)(x + z)(y + z)$$

This attempt did not work very well because alignat did not separate the two formulas in the second line. So you must provide the intercolumn spacing. For instance, if you want a \qquad space between the columns, as in

(13) 
$$f(x) = x + yz g(x) = x + y + z$$
$$h(x) = xy + xz + yz k(x) = (x + y)(x + z)(y + z)$$

then type the formula as

The alignat environment is especially appropriate when annotating formulas where you would normally want a \quad between the formula and the text. To obtain

(14) 
$$x = x \wedge (y \vee z)$$
 (by distributivity) 
$$= (x \wedge y) \vee (x \wedge z)$$
 (by condition (M)) 
$$= y \vee z$$

type

alignat is very important for typing systems of equations such as

$$(15) (A+BC)x + Cy = 0,$$

(16) 
$$Ex + (F+G)y = 23.$$

typed as follows:

\end{alignat}

Note again +{}. See the subformula rule in Section 9.4.2.

As a last example, consider

$$(17) a_{11}x_1 + a_{12}x_2 + a_{13}x_3 = y_1,$$

$$(18) a_{21}x_1 + a_{22}x_2 + a_{24}x_4 = y_2,$$

$$(19) a_{31}x_1 + a_{33}x_3 + a_{34}x_4 = y_3.$$

typed as

Note that the argument of alignat does not have to be precise. If you want two columns, the argument can be 2, or 3, or any larger number. If you want to, you can simply type 10 and just ignore the argument. You may define a new environment (see Section 15.2.1) that does just that.

# 9.5.5 Inserting text

The \intertext command places one or more lines of text in the middle of an aligned environment. For instance, to obtain

Г

(20) 
$$h(x) = \int \left( \frac{f(x) + g(x)}{1 + f^2(x)} + \frac{1 + f(x)g(x)}{\sqrt{1 - \sin x}} \right) dx$$

The reader may find the following form easier to read:

$$= \int \frac{1+f(x)}{1+g(x)} dx - 2\arctan(x-2)$$

you would type

Notice how the equal sign in the first formula is aligned with the equal sign in the second formula even though a line of text separates the two.

Here is another example, this one using align\*:

Г

$$f(x) = x + yz g(x) = x + y + z$$

The reader may also find the following polynomials useful:

$$h(x) = xy + xz + yz \qquad \qquad k(x) = (x+y)(x+z)(y+z)$$
 is typed as   
 \begin{align\*} f(x) &= x + yz & \qquad g(x) &= x + y + z\\ \intertext{The reader may also find the following polynomials useful:}   
 h(x) &= xy + xz + yz   
 & \qquad k(x) &= (x + y)(x + z)(y + z)   
 \end{align\*}

The \intertext command must follow a line separator command, \\ or \\\* (see Section 9.9). If you violate this rule, you get the error message

The text in \intertext can be centered using a center environment or with the \centering command (see Section 6.3).

# 9.6 Aligned subsidiary math environments

A *subsidiary math environment* is a math environment that can only be used *inside* another math environment. Think of it as creating a "large math symbol".

In this section, we discuss aligned subsidiary math environments. We discuss adjusted subsidiary math environments, including cases, in Section 9.7.

# 9.6.1 Subsidiary variants

The align, alignat, and gather environments (see Sections 9.5, 9.5.4, and 9.2) have subsidiary versions. They are called aligned, alignedat, and gathered. To obtain

$$x = 3 + \mathbf{p} + \alpha$$
  $\mathbf{p} = 5 + a + \alpha$   
 $y = 4 + \mathbf{q}$   $\mathbf{q} = 12$   
 $z = 5 + \mathbf{r}$  using  $\mathbf{r} = 13$   
 $u = 6 + \mathbf{s}$   $\mathbf{s} = 11 + d$ 

```
type
\[
   \begin{aligned}
     x \&= 3 + \mathcal{p} + \alpha 
     y \&= 4 + \mathbf{q} \
     z \&= 5 + \mathbf{r} \
     u \&=6 + \mathbb{s}
   \end{aligned}
   \text{\qquad using\qquad}
   \begin{gathered}
      \mathcal{p} = 5 + a + \alpha
      \mathbf{q} = 12
      \mathbf{r} = 13
      \mathcal{S} = 11 + d
   \end{gathered}
\]
```

Note how the list of aligned formulas

$$x = 3 + p + \alpha$$
$$y = 4 + \mathbf{q}$$
$$z = 5 + \mathbf{r}$$
$$u = 6 + \mathbf{s}$$

and the list of centered formulas

$$\mathbf{p} = 5 + a + \alpha$$
$$\mathbf{q} = 12$$
$$\mathbf{r} = 13$$
$$\mathbf{s} = 11 + d$$

are treated as individual large symbols.

The aligned, alignedat, and gathered subsidiary math environments follow the same rules as align and gather. The aligned subsidiary math environment allows any number of columns, but you must specify the intercolumn spacing as in the alignat environment.

You can use the aligned subsidiary math environment to rewrite formula (5) from Section 3.4.2 so that the formula number is centered between the two lines:

(21) 
$$h(x) = \int \left( \frac{f(x) + g(x)}{1 + f^2(x)} + \frac{1 + f(x)g(x)}{\sqrt{1 - \sin x}} \right) dx$$
$$= \int \frac{1 + f(x)}{1 + g(x)} dx - 2 \arctan(x - 2)$$

See Section 9.6.2 for a better way to split a long formula.

Symbols, as a rule, are vertically centrally aligned. This is not normally an issue with math symbols, but it may be important with large symbols created by subsidiary math environments. The subsidiary math environments, aligned, gathered, and array, take c, t, or b as optional arguments to force vertically centered, top, or bottom alignment, respectively. The default is c (centered). To obtain

$$x = 3 + \mathbf{p} + \alpha$$
  $\mathbf{p} = 5 + a + \alpha$   
 $y = 4 + \mathbf{q}$   $\mathbf{q} = 12$   
 $z = 5 + \mathbf{r}$   $\mathbf{r} = 13$   
 $u = 6 + \mathbf{s}$  using  $\mathbf{s} = 11 + d$ 

for example, you would type

```
\[
\begin{aligned}[b]
    x &= 3 + \mathbf{p} + \alpha\\
    y &= 4 + \mathbf{q}\\
    z &= 5 + \mathbf{r}\\
    u &=6 + \mathbf{s}
\end{aligned}
\text{\quad using\quad}
\begin{gathered}[b]
    \mathbf{p} = 5 + a + \alpha\\
    \mathbf{q} = 12\\
    \mathbf{r} = 13\\
    \mathbf{s} = 11 + d
\end{gathered}
\]
```

There is no numbering or \tag-ing allowed in subsidiary math environments because LATEX does not number or tag what it considers to be a single symbol.

# 9.6.2 Split

The split subsidiary math environment is used to split a long formula into aligned parts. There are two major reasons to use split:

- 1. The math environment that contains it considers the split environment to be a single equation, so it generates only one number for it.
- 2. If a split environment appears inside an align environment, the alignment point of the split environment is recognized by align and is used in aligning all the formulas in the align environment.

To illustrate the first reason, consider

\end{equation}

$$(22) \frac{(x_1x_2x_3x_4x_5x_6)^2}{+(x_1x_2x_3x_4x_5+x_1x_3x_4x_5x_6+x_1x_2x_4x_5x_6+x_1x_2x_3x_5x_6)^2} \\ \text{typed as} \\ \text{begin{equation}\label{E:mm7}} \\ \text{begin{split}} \\ (x_{1}x_{2}&x_{3}x_{4}x_{5}x_{6})^{2} \\ & & \text{$k+(x_{1}x_{2}x_{3}x_{4}x_{5})^{2}$} \\ & & \text{$k+(x_{1}x_{2}x_{3}x_{4}x_{5})^{2}$} \\ & & + x_{1}x_{2}x_{3}x_{4}x_{5}x_{6} \\ & & + x_{1}x_{2}x_{4}x_{5}x_{6} \\ & & + x_{1}x_{2}x_{3}x_{4}x_{5}x_{6} \\ & & + x_{1}x_{2}x_{3}x_{5}x_{6} \\ & & + x_{1}x_{2}x_{3}x_{4}x_{5} \\ & & + x_{2}x_{3}x_{4}x_{5} \\ & & + x_{2}x_{3}x_{5} \\ & & + x_{2}x_$$

See also the two examples of split in the sampart.tex sample article in Section 11.3 and in the samples folder (see page 4).

To illustrate the second reason, here is an example of a split subsidiary math environment within an align environment:

$$f = (x_1x_2x_3x_4x_5x_6)^2$$

$$= (x_1x_2x_3x_4x_5 + x_1x_3x_4x_5x_6 + x_1x_2x_4x_5x_6 + x_1x_2x_3x_5x_6)^2,$$
(24)  $g = y_1y_2y_3.$ 
which is typed as
$$\begin{array}{ll} \text{begin{align}\label{E:mm8}} \\ \text{begin{split}} \\ \text{f &= (x_{1} x_{2} x_{3} x_{4} x_{5} x_{6} + x_{1}x_{2}x_{3}x_{5}x_{6})^{2}, \\ \text{which is typed as} \\ \text{hegin{split}} \\ \text{f &= (x_{1} x_{2} x_{3} x_{4} x_{5} x_{6})^{2}, \\ \text{which is typed as} \\ \text{hegin{split}} \\ \text{f &= (x_{1} x_{2} x_{3} x_{4} x_{5} x_{6})^{2}, \\ \text{which is typed as} \\ \text{hegin{split}} \\ \text{f &= (x_{1} x_{2} x_{4} x_{5} x_{6} x_{6})^{2}, \\ \text{which is typed as} \\ \text{hegin{split}} \\ \text{f &= (x_{1} x_{2} x_{4} x_{5} x_{6} x_{6})^{2}, \\ \text{which is typed as} \\ \text{hegin{split}} \\ \text{f &= (x_{1} x_{2} x_{5} x_{6} x_{6} x_{6})^{2}, \\ \text{which is typed as} \\ \text{hegin{split}} \\ \text{f &= (x_{1} x_{2} x_{5} x_{6} x_{6}$$

```
+ x_{1} x_{3} x_{4} x_{5} x_{6}
+ x_{1} x_{2} x_{4} x_{5} x_{6}
+ x_{1} x_{2} x_{3} x_{5} x_{6})^{2},
\end{split}\\
    g &= y_{1} y_{2} y_{3}.\label{E:mm9}
\end{align}
```

Notice the \\ command following \end{split} to separate the lines for align.

# Rule ■ split subsidiary math environment

- split can only be used inside another math environment, such as displaymath, equation, align, gather, flalign, gathered and their \*-ed variants.
- 2. A split formula has only one number, automatically generated by LATEX, or one tag from a \tag command. Use the \notag command to suppress numbering.
- The \label, \tag, or \notag command must precede \begin{split} or follow \end{split}.

If you try to use split outside a displayed math environment, you get the error message

! Package amsmath Error: \begin{split} won't work here.

You may want to read the discussion of AMS document classes and amsmath package options in Section 11.5 that modify the placement of equation numbers.

# 9.7 Adjusted columns

In an *adjusted* multiline math environment, the columns are adjusted so that they are displayed centered, flush left, or flush right, instead of aligned (as in Section 9.5). Since you have no control line by line over the alignment of the columns, & has only one role to play, it is the column separator.

In Sections 9.2 and 9.3, we discussed two adjusted one-column math environments, gather and multline. All the other adjusted constructs are subsidiary math environments. For example, a matrix environment (see Section 9.7.1) produces a multicolumn centered display:

$$\begin{pmatrix} a+b+c & uv & x-y & 27 \\ a+b & u+v & z & 1340 \end{pmatrix} = \begin{pmatrix} 1 & 100 & 115 & 27 \\ 201 & 0 & 1 & 1340 \end{pmatrix}$$

The array environment (see Section 9.7.2) produces a multicolumn adjusted display:

$$\begin{pmatrix} a+b+c & uv & x-y & 27 \\ a+b & u+v & z & 1340 \end{pmatrix} = \begin{pmatrix} 1 & 100 & 115 & 27 \\ 201 & 0 & 1 & 1340 \end{pmatrix}$$

The columns are centered, flush left, or flush right. In this example, the first matrix has three centered columns and one flush right column, while the second matrix has four flush right columns. A variant, cases (see Sections 3.4.3 and 9.7.3), produces two columns set flush left:

(25) 
$$f(x) = \begin{cases} -x^2, & \text{if } x < 0; \\ \alpha + x, & \text{if } 0 \le x \le 1; \\ x^2, & \text{otherwise.} \end{cases}$$

#### 9.7.1 Matrices

Use the matrix subsidiary math environment to typeset matrices. For example,

```
\begin{equation*}
  \left(
  \begin{matrix}
    a + b + c & uv & x - y & 27\\
    a + b & u + v & z & 1340
  \end{matrix}
  \right) =
  \left(
  \begin{matrix}
    1 & 100 & 115 & 27\\
    201 & 0 & 1 & 1340
  \end{matrix}
  \right)
  \end{matrix}
  \right)
  \end{end{matrix}
  \right)
  \end{end{equation*}
```

produces

$$\begin{pmatrix} a+b+c & uv & x-y & 27 \\ a+b & u+v & z & 1340 \end{pmatrix} = \begin{pmatrix} 1 & 100 & 115 & 27 \\ 201 & 0 & 1 & 1340 \end{pmatrix}$$

If you use matrix on its own, i.e., outside a math environment,

you get the error message

obliquely reminding you that matrix is a subsidiary math environment.

The matrix subsidiary math environment provides a matrix of up to 10 centered columns. If you need more columns, you have to ask for them. The following example sets the number of columns to 12:

We discuss \setcounter and other counters further in Section 15.5.1.

You can have dots span any number of columns with the \hdotsfor command. The argument of the command specifies the number of columns to fill (which is one more than the number of &'s the command replaces). The \hdotsfor command must either appear at the beginning of a row or immediately following an ampersand (&). If you violate this rule, you get the error message

```
! Misplaced \omit.
\multispan #1->\omit
\mscount #1\relax \loop \ifnum
\mscount ...
```

#### 1.12 \end{equation}

The \hdotsfor command also takes an optional argument, a number that multiplies the spacing between the dots. The default is 1. For instance, if we replace \hdotsfor{7} in the previous example by \hdotsfor[3]{7}, then we get

We can replace a part of a matrix column with a large figure.

$$a = \begin{pmatrix} (a_{11}) \\ \cdots \\ (a_{n1}) \end{pmatrix}, \quad (a_{k1}) = \begin{pmatrix} 0 \dots 0 & 1 & 0 \dots 0 \\ 0 & \cdots & 0 \end{pmatrix}$$

typed as

```
\newcommand{\BigFig}[1]{\parbox{12pt}{\Huge #1}}
\newcommand{\BigZero}{\BigFig{0}}}
١/
a=\left(
\begin{matrix}
(a_{11})\
\cdots & \BigZero \\
(a_{n1})\
\end{matrix}
\right) ,\quad
(a_{k1})=\left( 
\begin{matrix}
0\ldots 0 & 1 & 0\ldots 0\\
 & 0\\
\BigZero & \cdots & \BigZero\\
& 0\\
\end{matrix}
\right)
\]
```

#### Matrix variants

A matrix may be enclosed by delimiters (see Section 7.5.1) in a number of different ways:

$$\begin{vmatrix} a+b+c & uv \\ a+b & c+d \end{vmatrix} \qquad \begin{vmatrix} a+b+c & uv \\ a+b & c+d \end{vmatrix} \qquad \begin{vmatrix} a+b+c & uv \\ a+b & c+d \end{vmatrix}$$
$$\begin{vmatrix} a+b+c & uv \\ a+b & c+d \end{vmatrix} \qquad \begin{vmatrix} a+b+c & uv \\ a+b & c+d \end{vmatrix}$$

The first matrix is typed as

The others are typed in the same way, except that they use the pmatrix, bmatrix, vmatrix, Vmatrix, and Bmatrix environments, respectively. We can use other delimiters, as in

$$\begin{pmatrix} 1 & 0 & \dots & 0 \\ 0 & 1 & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & 1 \end{pmatrix}$$

This example also uses *vertical dots* provided by the \vdots commands and *diagonal dots* provided by the \ddots commands.

#### Small matrix

If you put a matrix in an inline math formula, it may be too large. Instead, use the smallmatrix environment. Compare  $\begin{pmatrix} a+b+c & uv \\ a+b & c+d \end{pmatrix}$ , typed as

```
$\begin{pmatrix}
    a + b + c & uv\\
    a + b & c + d
\end{pmatrix}$

with the small matrix \(\begin{a + b + c & uv \\ a + b & c + d \\
    begin{smallmatrix}
    a + b + c & uv\\
    a + b & c + d \\
    \end{smallmatrix}
\right)$
```

There are no delimited variants of smallmatrix similar to those of matrix. Instead, use the \left and \right commands with delimiters to enclose a small matrix. The \hdotsfor command does not work in a small matrix.

# 9.7.2 Arrays

The array subsidiary math environment is similar to the matrix subsidiary math environment. There are two major differences, however. For an array you must specify the alignment of each column and you have more options to customize it.

The first matrix in the introduction to Section 9.7 would be typed as follows using the array subsidiary math environment:

```
\left(
  \left(
```

## Rule array subsidiary math environment

- 1. Adjacent columns are separated by an ampersand (&).
- 2. The argument of \begin{array} is mandatory. The argument is a series of the letters 1, r, or c, signifying that the corresponding column in the array should be set flush left, flush right, or centered, respectively.

The matrix

$$\left(\begin{array}{cccc}
a+b+c & uv & x-y & 27 \\
a+b & u+v & z & 134
\end{array}\right)$$

could not have been typeset with matrix since the last column is set flush right. Of course, this is not quite true. In a matrix environment, \hfill 27 would force the number 27 to be set flush right (see Section 5.8.4).

If the argument of \begin{array} is missing, as in

LATEX generates the error message

! Package array Error: Illegal pream-token (a): 'c' used.

If you change the first entry of the matrix to c + b + a, then the error message is

! Extra alignment tab has been changed to \cr. <recently read> \endtemplate

1.5 
$$c + b + a \& uv \& x - y \& 27 \$$

Note that the first character in c + b + a is not an

Illegal character in array arg.

because c is one possible argument of \begin{array}.

If the closing brace of the argument of \begin{array} is missing, as in

\begin{equation}

\begin{array}{cccc

\end{equation}

you get the error message

Runaway argument?

! Paragraph ended before \@array was complete.

In fact, the argument of array can be more complex than stated in the rule. Indeed, the array subsidiary math environment can take any argument that the tabular environment can take (see Section 6.6). For instance, here is a matrix with headers:

	a	b	c
1	1	1	1
2	1	-1	-1
2	2	1	0

typed as

```
\[
\begin{array}{r|rrr}
& a & b & c \\
\hline
1 & 1 & 1 & 1 \\
2 & 1 & -1 & -1 \\
2 & 2 & 1 & 0
\end{array}
\]
```

In Section 9.7.1 we have the matrix example:

$$a = \begin{pmatrix} (a_{11}) & \\ \cdots & \\ (a_{n1}) & \end{pmatrix}$$

If rows are spanned, we need to use array instead of matrix:

$$\begin{bmatrix} a & b & \mathbf{0} \\ c & d & \mathbf{0} \\ \mathbf{0} & k & l \end{bmatrix}$$

typed as (the \BigZero command is defined on page 234)

#### 9.7.3 Cases

The cases environment is also a subsidiary math environment. Here is the example from Section 3.4.3 and the introduction to this section:

$$f(x) = \begin{cases} -x^2, & \text{if } x < 0; \\ \alpha + x, & \text{if } 0 \le x \le 1; \\ x^2, & \text{otherwise.} \end{cases}$$

It is typed as

It would be easy to code the cases environment as a special case of the array subsidiary math environment:

or of the alignedat subsidiary math environment:

```
\legin{equation*}
  f(x) =
  \left\{
  \begin{alignedat}{2}
    &-x^{2},    &&\quad\text{if $x < 0$;}\\
    &\alpha + x,    &&\quad\text{if $0 \leq x \leq 1$;}\\
    &x^{2},    &&\quad\text{otherwise.}
  \end{alignedat}
  \right.
\end{equation*}</pre>
```

# 9.8 Commutative diagrams

The amscd package provides the CD subsidiary math environment for typesetting simple commutative diagrams. To use it, make sure that the command

\usepackage{amscd}

is in the preamble of the document.

For instance, to obtain



type

A commutative diagram is a matrix made up of two kinds of rows, *horizontal rows*, that is, rows with horizontal arrows; and *vertical rows*, rows with vertical arrows. For example,

is a typical horizontal row. It defines two columns and a connecting horizontal arrow @>>>. There may also be more than two columns, as in

The connecting pieces can be:

- Stretchable right arrows, @>>>
- Stretchable left arrows, 0<<<</li>
- Stretchable equal signs, @=
- Blanks, @.

The label above a stretchable arrow should be typed between the first and second > or < symbols, whereas the label below should be typed between the second and third > or < symbols. You can have both.

The following is a typical vertical row containing vertical arrows:

QVVV QVVV QAAA

The vertical pieces could be

- Stretchable down arrows, @VVV
- Stretchable up arrows, @AAA
- Double vertical lines, @| or @\vert
- Blanks, @.

The vertical arrows are placed starting with the first column.

The label to the left of a stretchable vertical arrow should be typed between the first and second V or A, whereas the label on the right should be typed between the second and third V or A symbols. You can have both.

These constructs are illustrated in

$$\begin{array}{cccc}
\mathbb{C} & \xrightarrow{H_1} & \mathbb{C} & \xrightarrow{H_2} & \mathbb{C} \\
P_{c,3} \downarrow & P_{\bar{c},3} \downarrow & & \downarrow P_{-c,3} \\
\mathbb{C} & \xrightarrow{H_1} & \mathbb{C} & \xrightarrow{H_2} & \mathbb{C}
\end{array}$$

typed as

Here is another example utilizing the \text command, followed by its source:

```
١/
   \begin{CD}
                               @>>\text{bottom}>
                                                     C
      Α
             @>\log>>
                         В
                                                     Ε
             @=
                         D
                               0<<<
             0<<<
                         F\\
      @V\text{one-one}VV
                                    @AA\text{onto}A
                                                       @|\\
                             @.
      X
                             Y
                                    @>>>
                                                       Z
                             U\\
               @>>>
                             @AA\gamma A
      @A\beta AA
                                              @VVV
                                                     @VVV\\
               @>\alpha>>
                             Ε
                                              @>>>
                                                     Η
                             I\\
   \end{CD}
/]
```

Diagrams requiring more advanced commands should be done with a drawing (or drafting) application or with specialized packages. The AMS recommends Kristoffer H. Rose and Ross Moore's xy-pic package (see Section E.1).

# 9.9 Adjusting the display

By default, the math environments described in this chapter do not allow page breaks. While a page break in a cases environment is obviously not desirable, it may be acceptable in an align or gather environment. You can allow page breaks by using the

\allowdisplaybreaks

command. It allows page breaks in a multiline math environment within its scope. For instance,

```
{\allowdisplaybreaks
\begin{align}\label{E:mm13}
   a &= b + c,\\
   d &= e + f,\\
   x &= y + z,\\
   u &= v + w.
\end{align}
}% end of \allowdisplaybreaks
```

allows a page break after any one of the first three lines.

Within the scope of an \allowdisplaybreaks command, use the \\* command to prohibit a break after that line. The line separators \\ and \\\* can use an optional argument to add some additional interline space (see Section 5.7.2).

Just before the line separator command (\\), include a \displaybreak command to force a break, or a

#### \displaybreak[0]

command to allow one.  $\displaybreak[n]$ , where n is 1, 2, or 3, specifies the intermediate steps between allowing and forcing a break.  $\displaybreak[4]$  is the same as  $\displaybreak$ . You can easily visualize these rules:

Note the similarity between the displaybreak sequence and the pagebreak sequence in Section 5.7.3.

If you want to allow page breaks in all multiline math environments in your document, place the \allowdisplaybreaks[1] command in the preamble of your document. The optional argument can be varied from 1 to 4, in order of increasing permissiveness.

Note that none of the subsidiary math environments are affected by any variant of the \displaybreak or the \allowdisplaybreaks commands.

# LATEX documents

In this chapter, we take up the organization of shorter documents. Longer documents and books are discussed in Part VI.

If you are writing a *simple article*, start with a template (see Sections 4.2 and 11.4), then you can safely ignore much of the material discussed in this chapter. In more complicated articles you may need the material discussed in this chapter.

Section 10.1 discusses document structure in general, Section 10.2 presents the preamble. Section 10.3 discusses the top matter, in particular, the abstract environment. Section 10.4 presents the main matter, including sectioning, cross-referencing, tables, and figures. Section 10.5 covers the back matter, including the bibliography and index.

In Section 10.1–10.5 we discuss the logical design of a LATEX document. The visual design is largely left to the document class. In Section 10.6, however, we briefly discuss one frequently adjusted aspect of visual design, the page style.

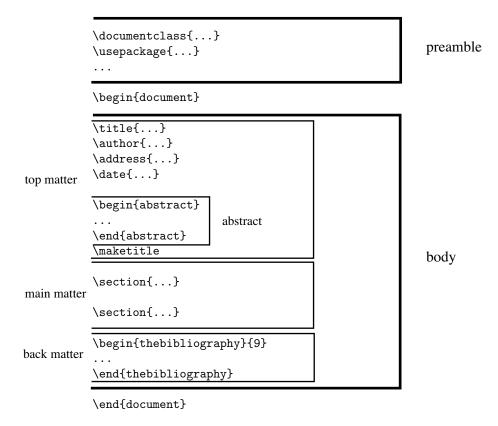


Figure 10.1: The structure of a LATEX document.

# 10.1 The structure of a document

The source file of a LATEX document is divided into two main parts: the preamble and the body (see Figure 10.1).

**Preamble** This is the portion of the source file before the

```
\begin{document}
```

command. It contains definitions and instructions that affect the entire document.

**Body** This is the content of the document environment. It contains all the material to be typeset.

These statements oversimplify the situation somewhat. For instance, you can define a command in the preamble to typeset some text that will appear wherever the command is used in the body, but the text is actually typed in the preamble. Nevertheless, I hope the division between the preamble and the body is clear.

The body is divided into three parts:

Top matter This is the first part of the body. It is concluded with the \maketitle command. Traditionally it included only the \title, the \author, and the \date commands. The top matter is derived from these commands and from it the title page of an article was designed. This evolved to include a lot more information about the author(s), for instance, their e-mail addresses, academic affiliations, home pages, and about the article, for instance, research support, subject classification. The typeset top matter now is split into several locations, the top and bottom of the first page and the bottom of the last page. See pages 286 and 288 for an example and Section 18.1.2 for more components that can be used in longer documents and books.

**Main matter** This is the main part of the document, including any appendices.

**Back matter** This is the material that is typeset at the end of the document. For a typical shorter document, the back matter is just the bibliography. See Section 18.1.2 for more information about additional components—such as the index—that are often used in longer documents and books.

# 10.2 The preamble

You were introduced to the preamble of a document in Section 4.1. Recall that the preamble contains the crucial \documentclass line, specifying the document class and the options that modify its behavior. For instance,

\documentclass[draft,regno]{amsart}

loads the document class amsart with the draft option, which paints a slug in the margin indicating lines that are too wide (see Section 5.7.1), and the requo option, which places the equation numbers on the right (see Section 11.5).

 $\operatorname{article}$  is the most popular legacy document class (see Section 12.1). The command

\documentclass[titlepage,twoside]{article}

loads the document class article with the titlepage option, which creates a separate title page and places the abstract on a separate page, and the twoside option, which formats the typeset article for printing on both sides of the paper.

The \documentclass command is usually followed by the \usepackage commands, which load Lagrange enhancements called packages. For instance,

\usepackage{latexsym}

loads a package that defines some additional LATEX symbol names (see Section 12.3), whereas

\usepackage[demo]{graphicx}

loads the graphicx package (see Section 10.4.3) with the demo option that inserts rectangles in place of the illustrations. Document class options are also passed on to the packages as possible options, so

```
\documentclass[demo]{amsart}
\usepackage{graphicx}
```

would also load the graphicx package with the demo option unless it is invoked with

```
\usepackage[final]{graphicx}
```

Any document class options that are not relevant for a package are ignored. \usepackage commands can also be combined:

```
\usepackage{amssymb,latexsym} is the same as
```

```
\usepackage{amssymb}
\usepackage{latexsym}
```

Document class files have a cls extension, whereas package files are designated by the sty extension. The document class amsart is defined in the amsart.cls file, the graphicx package is defined in the graphicx.sty file. You may define your own packages, such as the newlattice package described in Section 15.3.

The preamble normally contains any user-defined commands (see Chapter 15) and the proclamation definitions (see Section 6.4). Some commands can only be in the preamble. \DeclareMathOperator is such a command (see Section 7.6.2) and so is \numberwithin (see Section 7.3). If you put such a command in the body, for example, \DeclareMathOperator, you get an error message:

```
! LaTeX Error: Can be used only in preamble. 1.103 \DeclareMathOperator
```

There is one command that may only be placed before the

```
\documentclass{...}
```

line:

```
\NeedsTeXFormat{LaTeX2e}[2005/12/01]
```

This command checks the version of LaTeX being used to typeset the document and issues a warning if it is older than December 1, 2005 or whatever date you specified. Use this optional date argument if your document contains a feature that was introduced on or after the date specified or if an earlier version had a bug that would materially affect the typesetting of your document.

10.3 Top matter 251

For instance, if you use the \textsubscript command, introduced in the December 1, 2005 release (see page 311), then you may use the \NeedsTeXFormat line shown above. LaTeX now hardly changes from year to year, so this command is rarely used except in document class files or package files. See, however, the discussion on page 311.

# 10.3 Top matter

The top matter of an article is part of the article body and, as a rule, it contains the material used to create the "title page" and, optionally, an abstract.

Discussion of the top matter should take place in the context of a particular document class. We discuss the top matter of the amsart document class in Section 4.2, and we continue discussing it in much more detail in Section 11.2. The top matter of the article document class is covered in Section 12.1.1.

Long documents, such as books, have rather complicated top matter such as tables of contents (see Chapter 18). In this section, we only discuss the abstract.

#### 10.3.1 Abstract

Most standard document classes, except those for letters and books, make provision for an abstract, typed in an abstract environment.

The document class formats the heading as ABSTRACT, or some variant, and, as a rule, typesets the text of the abstract in smaller type with wider margins.

The amsart document class requires that you place the abstract environment *before* the \maketitle command (see Figure 10.1). See the abstract in the sample article intrart.tex on page 37. If you forget to place it there, you get the warning

Class amsart Warning:

Abstract should precede \maketitle in AMS documentclasses; reported on input line 21.

and the abstract is typeset wherever the abstract environment happens to be placed.

In the article document class you place the abstract *after* the \maketitle command. If you place the abstract before the \maketitle command, the abstract is placed on page 1, and the article starts on page 2.

If the abstract and the "footnotes" from the top matter fill the first page, the second page has no running head. To fix this, follow the \maketitle command with the \clearpage command (see Section 5.7.3).

# 10.4 Main matter

The main matter contains most of the essential parts of the document, including the appendices.

We discuss now how to structure the main matter. We describe sectioning in Section 10.4.1, cross-referencing in Section 10.4.2, and tables and figures in Section 10.4.3.

## 10.4.1 Sectioning

The main matter of a typical shorter document is divided into *sections*. See Section 18.1.1 for a discussion on sectioning longer documents.

#### Sections

LATEX is instructed to start a section with the \section command, which takes the title of the section as its argument. This argument may also be used for the running head and it is also placed in the table of contents (see Section 18.2), which means that you need to protect fragile commands with the \protect command (see Section 5.3.3). LATEX automatically assigns a section number and typesets the section number followed by the section title.

Any \section command may be followed by a \label command, so that you can refer to the section number generated by LATEX, as in

```
\section{Introduction}\label{S:intro}
```

The command \ref{S:intro} refers to the number of the section and the command \pageref{S:intro} refers to the number of the typeset page where the section title appears.

#### Other sectioning commands

A section may be subdivided into *subsections*, which may themselves be divided into *subsubsections*, *paragraphs*, and *subparagraphs*. Subsections are numbered within a section (in Section 1, they are numbered 1.1, 1.2, and so on). Here is the whole hierarchy:

```
\subsection
\subsection
\subsubsection
\paragraph
\subparagraph
```

It is important to understand that the five levels of sectioning are not just five different styles for typesetting section headers but they form a hierarchy. You should never have a subsection outside a section, a subsubsection outside a subsection, and so on. For instance, if the first sectioning command in your document is \subsection, the subsections are numbered  $0.1, 0.2, \ldots$  Or if in the first section of your document

10.4 Main matter 253

the first sectioning command is  $\subsubsection$ , the subsubsections are numbered  $1.0.1, 1.0.2, \ldots$  Both are clearly undesirable.

There are two additional sectioning commands provided by the report and by the book document classes (book and amsbook): \chapter and \part (see Section 18.1.1).

Any sectioning command may be followed by a \label command so that you can refer to the number (if any) generated by LATEX and the page on which it appears (see Section 10.4.2).

There is also the seldom used top level \specialsection command. Articles do not have parts and chapters, but sometimes a long article may require further division using the \specialsection command.

#### The form of sectioning commands

All sectioning commands take one of the following three forms, illustrated below with the \section command:

#### Form 1 The simplest form is

```
\scalebox{section}{title}
```

where *title* is the section title, of course. You need to protect any fragile commands in *title* with the \protect command (see Section 5.3.3).

#### Form 2 The sectioning command may have an optional argument

```
\section[short_title]{title}
```

The optional *short\_title* argument is used in the running head. See Section 18.2 on what goes into the table of contents. Protect any fragile commands in *short\_title* with the \protect command (see Section 5.3.3).

#### Form 3 Finally, we consider the \*-ed version

```
\section*{title}
```

There are no section numbers printed and the title is not included in the running head. Remember that if you \* a section, all subsections, and so on, must also be \*-ed to avoid having strange section numbers.

#### Sectioning commands typeset

Consider the following text:

```
\section{Introduction}\label{S:Intro}
We shall discuss the main contributors of this era.
\subsection{Birkhoff's contributions}\label{SS:contrib}
```

\subsubsection{The years 1935--1945}\label{SSS:1935}
Going to Oxford was a major step.
\paragraph{The first paper}
What should be the definition of a universal algebra?
\subparagraph{The idea}
One should read Whitehead very carefully.

This is how it looks typeset in the amsart document class:

## 1 Introduction

We shall discuss the main contributors of this era.

## 1.1 Birkhoff's contributions

#### 1.1.1 The years 1935–1945

Going to Oxford was a major step.

The first paper What should be the definition of a universal algebra?

**The idea** One should read Whitehead very carefully.

Notice that paragraphs and subparagraphs are not displayed prominently by the AMS. By contrast, look at the same text typeset in the legacy article document class:

#### 1. Introduction

We shall discuss the main contributors of this era.

#### 1.1. Birkhoff's contributions.

1.1.1. The years 1935–1945. Going to Oxford was a major step. The first paper. What should be the definition of a universal algebra? The idea. One should read Whitehead very carefully.

This illustrates vividly one huge difference between the two document classes, the visual handling of sectioning.

Section 15.5.1 discusses how you can change the format of the section numbers, and how to specify which sectioning levels are to be numbered.

10.4 Main matter 255

Section 2.2 of *The LATEX Companion*, 2nd edition [46] explains how to change the layout of section headings, especially useful for document class designers.

#### **Appendix**

In the main matter, if the article contains appendices, mark the beginning of the appendices with the \appendix command. After the \appendix command, the \section command starts the appendices (for books, see Section 18.1.2):

#### \appendix

```
\section{A proof of the Main Theorem}\label{S:geom}
```

This produces Appendix A with the given title, typeset just like a section.

Note that appendices may be labeled and cross-referenced like any other section. In an appendix, subsections are numbered A.1, A.2, and so on, subsubsections within A.1 are numbered A.1.1, A.1.2, and so on.

Let me repeat, \appendix is not like \section. It is not a command with an argument. Appendices are named by arguments of the \section—or for books, \chapter—commands placed after the \appendix command.

# 10.4.2 Cross-referencing

There are three types of cross-referencing available in LATEX:

- 1. Symbolic referencing with \ref and \eqref for equations
- 2. Page referencing with \pageref
- 3. Bibliographic referencing with \cite

In this section, we discuss the first two, while bibliographies are discussed in Section 10.5.1 and in Chapter 16.

#### Symbolic referencing

Wherever Lagrange can automatically generate a number in your document, you can place a \label command

```
\label{symbol}
```

Then, at any place in your document, you can use the \ref command

```
\ref{symbol}
```

to place that number in the document. We call symbol the label.

You can use labels for sectioning units, equations, figures, tables, items in an enumerated list environment (see Section 6.2.1), as well as for theorems and other proclamations.

If the equation labeled E:int is the fifth equation in an article, then LaTeX stores the number 5 for the label E:int, so \ref{E:int} produces the number 5. If equations are numbered within sections (see Section 7.3), and an equation is the third equation in Section 2, then LaTeX stores the number 2.3 for the label E:int, so the reference \ref{E:int} produces the number 2.3.

#### **Example 1** The present section starts with the command

```
\section{Main matter}\label{S:MainMatter}
```

So  $ref{S:MainMatter}$  produces the number 10.4 and we get the number of the typeset page where the section title appears with  $pageref{S:MainMatter}$ , which is 251.

#### Example 2

```
\begin{equation}\label{E:int}
  \int_{0}^{\pi} \sin x \, dx = 2.
\end{equation}
```

In this case, \ref{E:int} produces the number of the equation, \eqref{E:int} produces the number of the equation in parentheses.

**Tip** If you have to reference an equation in the statement of a theorem, always use \eqref. Do not use \eqref to reference anything but proclamations. (See the \itemref command introduced in Section 15.1.2.)

#### Example 3

```
\begin{theorem}\label{T:fund}
    Statement of theorem.
\end{theorem}
```

The reference  $\mathbf{T:fund}$  produces the number of the theorem.

**Tip** Typeset a document twice to see a change in a cross-reference.

See Section D.3.4 for a discussion of how LaTeX stores these numbers and why you have to typeset twice. If you typeset only once, and LaTeX suspects that the cross-references have not been updated, you get a warning:

```
LaTeX Warning: Label(s) may have changed. Rerun to get cross-references right.
```

10.4 Main matter 257

## Rule 1 ■ \label command

The argument of the \label command is a string of letters, punctuation marks, and digits. It is case sensitive, so S:intro is different from S:Intro.

#### Rule 2 ■ \label command

Place a \label command immediately after the command that generates the number.

The following is not compulsory but advisable.

#### **Tip** When referencing:

```
see Section~\ref{S:Intro} proved in Theorem~\ref{T:main}
or
see Sections~\ref{S:Intro} and~\ref{S:main}
use ties (~).
```

It is difficult to overemphasize how useful automatic cross-referencing can be when writing a document.

Tip Make your labels meaningful to yourself, so they are easy to remember. Systematize your labels. For example, start the label for a section with S:, theorem with T:, lemma with L:, and so on.

When you are cross-referencing, even if you follow these tips, it may not be easy to remember a label. David Carlisle's showkeys package may help you out. It is part of the tools distribution (see Section 12.3.1 and Section E.1). Include the line

\usepackage{showkeys}

in the preamble of your document. The showkeys package shows all symbolic references in the margin of the typeset document. With the notcite option, my preference,

\usepackage[notcite]{showkeys}

showkeys does not show the labels for bibliographic references. When the document is ready for final typesetting, then comment out this line.

Section 2.4 of *The LATEX Companion*, 2nd edition [46] describes varioref, a package which extends the power of \ref, and xr, a package for referencing external documents.

#### Page referencing

```
The command

\pageref{symbol}

produces the number of the typeset page corresponding to the location of the command
\label{symbol}. For example, if the following text is typeset on page 5,

There may be three types of problems with the
construction of such lattices.\label{problem}

and you type

Because of the problems associated with
the construction (see page \pageref{problem})

anywhere in the document, LaTeX produces

Because of the problems associated with the construction (see page 5)
```

Because of the way LATEX typesets a page, page references may be off by one. See the discussion in Section 18.6 on how to guarantee that the page number is correct.

## 10.4.3 Floating tables and illustrations

Many documents contain tables and illustrations. These must be treated in a special way since they cannot be broken across pages. If necessary, LATEX moves—floats—a table or an illustration to the top or bottom of the current or the next page if possible and further away if not.

LATEX provides the table and the figure environments for typesetting floats. The two are essentially identical except that the figure environments are named Figure 1, Figure 2, and so on, whereas the table environments are numbered as Table 1, Table 2, and so on.

#### **Tables**

A table environment is set up as follows:

```
\begin{table}
    Place the table here
    \caption{title}\label{Ta:xxx}
\end{table}
```

10.4 Main matter 259

The \caption command is optional and may also precede the table. The optional \label command must be placed between the command \caption and the command \end{table}. The label is used to reference the table's number. A table environment can have more than one table, each with its own caption.

The table environment is primarily used for tables made with the tabular or similar environments (see Section 6.6). There are many examples of tables in this book, for instance, Section 5.4 has four.

If your document uses the twocolumn document class option, the table environment produces tables that span only one column and the table\* environment produces tables that span both columns. Such tables can be placed only at the top of a page.

#### **Figures**

Illustrations, also called *graphics* or *figures*, include drawings, scanned images, digitized photos, and so on. These can be inserted with a figure environment:

```
\begin{figure}
    Place the graphics here
    \caption{title}\label{Fi:xxx}
\end{figure}
```

The above discussion of captions and labels for tables also applies to figures. Like the table environment, if your document uses the twocolumn document class option, the figure environment produces figures that span only one column, but the figure\* environment produces figures that span both columns. However, these figures can be placed only at the top of a page.

The standard way of including a graphics file is with the commands provided by the graphicx package by David Carlisle and Sebastian Rahtz, which is part of the LATEX distribution (see Section 12.3). Save your graphics in EPS (Encapsulated PostScript) or PDF (Portable Document Format) format. Your graphics can also be made within a picture environment, an approach that is neither encouraged nor discussed in this book.

Using the graphicx package, a typical figure is specified as follows:

```
\begin{figure}
  \centering\includegraphics{file}
  \caption{title}\label{Fi:xxx}
\end{figure}
```

The illustration circle.eps is included with the command

```
\includegraphics{circle}
```

without the extension! LaTeX and the graphicx package assumes the eps extension. On the other hand, versions of LaTeX that produce a typeset file in PDF format assume the pdf extension.

If you have to scale the graphics image, say to 68% of its original size, use the command

```
\includegraphics[scale=.68]{file}
For instance, the figure on page 526 is included with the commands
\begin{figure}
   \centering\includegraphics[scale=.8]{StrucLaT}
   \caption{The structure of \protect\LaTeX.}
   \label{Fi:StrucLaT}
\end{figure}
```

#### Float control

The table and figure environments may have an optional argument, with which you can influence LaTeX's placement of the typeset table. The optional argument consists of one to four letters:

- b, the bottom of the page
- h, here (where the environment appears in the text)
- t, the top of the page
- p, a separate page

For instance,

```
\begin{table}[ht]
```

requests LaTeX to place the table "here" or at the "top" of a page. The default is [tbp] and the order of the optional arguments is immaterial, for example, [th] is the same as [ht]. If h is specified, it takes precedence, followed by t and b.

LATEX has more than a dozen internal parameters that control a complicated algorithm that determines the placement of tables and figures. If you want to override these parameters *for one table or figure only*, add an exclamation mark (!) to the optional argument. For instance, [!h] requests that this table or figure be placed where it is in the source file even if this placement violates the rules as set by some of the parameters. For a detailed discussion of the float mechanism, see Chapter 6 of *The LATEX Companion*, 2nd edition [46].

The \suppressfloats command stops LATEX from placing any more tables or figures on the page it appears on. An optional argument t or b (but not both) prohibits placement of floats at the top or bottom of the current page. The table or figure that is *suppressed* appears on the next page or later in the document, if necessary.

Your demands and LaTeX's float mechanism may conflict with one another with the result that LaTeX may not place material where you want it. The default values 10.5 Back matter 261

of the float placement parameters are good only for documents with a small number of floating objects. Combining two tables or illustrations into one sometimes helps. The \clearpage command not only starts a new page with the \newpage command, but also forces LaTeX to print all the tables and figures it has accumulated but not yet placed in the typeset document. See also some related commands discussed in Section 5.7.3.

For more information on graphics, see Chapter 10 of *The LATEX Companion*, 2nd edition [46] and Chapter 2 of *The LATEX Graphics Companion* [17]. See also the documentation for the graphicx package in the LATEX distribution (see Section 12.3).

# 10.5 Back matter

The back matter of an article is very simple, as a rule. It is either empty or consists of only a bibliography. A long document, such as a book, may have more complicated back matter (see Chapter 18). In this section, we discuss only the *bibliography* and a very simple *index*.

## 10.5.1 Bibliographies in articles

The simplest way to typeset a bibliography is to type it directly into the article. For an example, see the bibliography in the intrart.tex article (on page 43). This sample bibliography contains two examples, one short and one long, of each of the seven most frequently used kinds of items.

You type the text of a bibliography in a thebibliography environment, as shown in the following examples.

```
\begin{thebibliography}{99}
\bibitem{hA70}
  Henry~H. Albert,
  \emph{Free torsoids},
  Current trends in lattice theory.
  D. "Van Nostrand, 1970.
\bibitem{hA70a}
  Henry~H. Albert,
  \emph{Free torsoids},
  Current trends in lattice theory
  (G.\,H. Birnbaum, ed.).
  vol.~7, D.~Van Nostrand, Princeton, January, 1970,
  no translation available, pp.~173--215 (German).
\bibitem{sF90}
  Soo-Key Foo,
  \emph{Lattice Constructions},
  Ph.D. thesis, University of Winnebago, 1990.
```

```
\bibitem{sF90a}
   Soo-Key Foo,
   \emph{Lattice Constructions},
  Ph.D. thesis, University of Winnebago, Winnebago, MN,
  December 1990, final revision not yet available.
\bibitem{gF86}
  Grant~H. Foster,
   \emph{Computational complexity in lattice theory},
   tech. report, Carnegie Mellon University, 1986.
\bibitem{gF86a}
   Grant~H. Foster,
   \emph{Computational complexity in lattice theory},
  Research Note 128A, Carnegie Mellon University,
  Pittsburgh, PA, December, 1986,
  research article in preparation.
\bibitem{pK69}
  Peter Konig,
   \emph{Composition of functions}.
   Proceedings of the Conference on Universal Algebra
   (Kingston, 1969).
\bibitem{pK69a}
  Peter Konig,
   \emph{Composition of functions}.
  Proceedings of the Conference on Universal Algebra
   (G.~H. Birnbaum, ed.).
   vol.~7, Canadian Mathematical Society,
  Queen's Univ., Kingston, ON,
   available from the Montreal office,
  pp.~1--106 (English).
\bibitem{wL75}
  William~A. Landau.
   \emph{Representations of complete lattices},
   Abstract: Notices Amer. Math. Soc. \textbf{18}, 937.
\bibitem{wL75a}
  William~A. Landau,
   \emph{Representations of complete lattices},
   Abstract: Notices Amer. Math. Soc. \textbf{18}, 937,
  December, 1975.
\bibitem{gM68}
   George A. Menuhin,
   \emph{Universal algebra}.
  D. "Van Nostrand, Princeton, 1968.
```

10.5 Back matter 263

```
\bibitem{gM68a}
   George A. Menuhin,
   \emph{Universal algebra}. 2nd ed.,
   University Series in Higher Mathematics, vol. 58,
   D.~Van Nostrand, Princeton,
   March, 1968 (English), no Russian translation.
\bibitem{eM57}
   Ernest~T. Moynahan,
   \emph{On a problem of M. Stone},
   Acta Math. Acad. Sci. Hungar.
   \text{textbf}\{8\}^{\sim}(1957), 455--460.
\bibitem{eM57a}
   Ernest~T. Moynahan,
   \emph{On a problem of M. Stone},
   Acta Math. Acad. Sci. Hungar.
   \text{textbf}\{8\}^{\sim}(1957), 455--460
   (English), Russian translation available.
\end{thebibliography}
```

Figure 10.2 shows a typeset version of this bibliography in the amsart document class.

By contrast, look at the same bibliography typeset in the legacy article document class in Figure 10.3.

You can find these entries in the document inbibl.tpl in the samples folder (see page 4).

I use the convention that the label for a \bibitem consists of the initials of the author and the year of publication. The first cited publication by Andrew B. Reich in 1987 would have the label aR87 and the second, aR87a. Of course, you can use any label you choose, but such conventions make the items easier to reuse.

The thebibliography environment takes an argument—in the previous example, this argument is 99—telling LATEX that the widest reference number it must generate is two digits wide. For fewer than 10 items, use 9 and for 100 or more items, use 999.

If the argument of \begin{thebibliography} is missing, you get the error message

```
! LaTeX Error: Something's wrong--perhaps a missing \item.
```

Each bibliographic item is introduced with \bibitem, which is used like the \label command. In your text, use \cite, in a similar way to \eqref—it provides the number enclosed in brackets. So if the 13th bibliographic item is introduced with

```
\bibitem{eM57}
```

then

\cite{eM57}

refers to that item and typesets it as [13]. The bibliography of the article itself is automatically numbered by LATEX. It is up to the author to make sure that the listing of the bibliographic items is in the proper order.

**Tip** Do not leave spaces in a \cite command. For example, \cite{eM57<sub>□</sub>} produces [?] indicating an unknown reference.

You can use \cite to cite two or more items in the form

\cite{hA70,eM57}

which typesets as [1, 13]. There is also an optional argument for \cite to specify additional information. For example,

#### References

- [1] Henry H. Albert, Free torsoids, Current trends in lattice theory. D. Van Nostrand, 1970.
- Henry H. Albert, Free torsoids, Current trends in lattice theory (G. H. Birnbaum, ed.). vol. 7,
   D. Van Nostrand, Princeton, January, 1970, no translation available, pp. 173–215 (German).
- [3] Soo-Key Foo, Lattice Constructions, Ph.D. thesis, University of Winnebago, 1990.
- [4] Soo-Key Foo, Lattice Constructions, Ph.D. thesis, University of Winnebago, Winnebago, MN, December 1990, final revision not yet available.
- [5] Grant H. Foster, Computational complexity in lattice theory, tech. report, Carnegie Mellon University, 1986.
- [6] Grant H. Foster, Computational complexity in lattice theory, Research Note 128A, Carnegie Mellon University, Pittsburgh, PA, December, 1986, research article in preparation.
- [7] Peter Konig, Composition of functions. Proceedings of the Conference on Universal Algebra (Kingston, 1969).
- [8] Peter Konig, Composition of functions. Proceedings of the Conference on Universal Algebra (G. H. Birnbaum, ed.). vol. 7, Canadian Mathematical Society, Queen's Univ., Kingston, ON, available from the Montreal office, pp. 1–106 (English).
- [9] William A. Landau, Representations of complete lattices, Abstract: Notices Amer. Math. Soc. 18, 937.
- [10] William A. Landau, Representations of complete lattices, Abstract: Notices Amer. Math. Soc. 18, 937, December, 1975.
- [11] George A. Menuhin, Universal algebra. D. Van Nostrand, Princeton, 1968.
- [12] George A. Menuhin, Universal algebra. 2nd ed., University Series in Higher Mathematics, vol. 58, D. Van Nostrand, Princeton, March, 1968 (English), no Russian translation.
- [13] Ernest T. Moynahan, On a problem of M. Stone, Acta Math. Acad. Sci. Hungar. 8 (1957), 455–460.
- [14] Ernest T. Moynahan, On a problem of M. Stone, Acta Math. Acad. Sci. Hungar. 8 (1957), 455–460 (English), Russian translation available.

Figure 10.2: The most important bibliographic entry types.

10.5 Back matter 265

# References

[1] Henry H. Albert, *Free torsoids*, Current trends in lattice theory, D. Van Nostrand, 1970.

- [2] Henry H. Albert, *Free torsoids*, Current trends in lattice theory (G. H. Birnbaum, ed.), vol. 7, D. Van Nostrand, Princeton, January, 1970, no translation available, pp. 173–215 (German).
- [3] Soo-Key Foo, *Lattice Constructions*, Ph.D. thesis, University of Winnebago, 1990.
- [4] Soo-Key Foo, Lattice Constructions, Ph.D. thesis, University of Winnebago, Winnebago, MN, December 1990, final revision not yet available.
- [5] Grant H. Foster, Computational complexity in lattice theory, tech. report, Carnegie Mellon University, 1986.
- [6] Grant H. Foster, Computational complexity in lattice theory, Research Note 128A, Carnegie Mellon University, Pittsburgh, PA, December, 1986, research article in preparation.
- [7] Peter Konig, Composition of functions. Proceedings of the Conference on Universal Algebra (Kingston, 1969).
- [8] Peter Konig, Composition of functions. Proceedings of the Conference on Universal Algebra (G. H. Birnbaum, ed.), vol. 7, Canadian Mathematical Society, Queen's Univ., Kingston, ON, available from the Montreal office, pp. 1–106 (English).
- [9] William A. Landau, Representations of complete lattices, Abstract: Notices Amer. Math. Soc., 18, 937.
- [10] William A. Landau, Representations of complete lattices, Abstract: Notices Amer. Math. Soc. 18, 937, December, 1975.
- [11] George A. Menuhin, Universal algebra. D. van Nostrand, Princeton, 1968.
- [12] George A. Menuhin, Universal algebra. Second ed., University Series in Higher Mathematics, vol. 58, D. van Nostrand, Princeton, March, 1968 (English), no Russian translation.
- [13] Ernest T. Moynahan, On a problem of M. Stone, Acta Math. Acad. Sci. Hungar. 8 (1957), 455–460.
- [14] Ernest T. Moynahan, On a problem of M. Stone, Acta Math. Acad. Sci. Hungar. 8 (1957), 455–460 (English), Russian translation available.

Figure 10.3: Bibliography in the article document class.

```
typesets as [13, pages 2–15].

If you wish to use labels rather than numbers to identify bibliographic items, then you can specify those labels with an optional argument of the \bibitem command:
```

```
[EM57] Ernest T. Moynahan, On a problem of M. Stone, Acta Math. Acad. Sci. Hungar. 8 (1957), 455-460.

typed as

\bibitem[EM57]{eM57}

Ernest~T. Moynahan, \emph{On a problem of M. Stone},
Acta Math. Acad. Sci. Hungar.
\textbf{8} (1957), 455--460.
```

If this optional argument of \bibitem is used, then the \cite command produces [EM57]. The argument of \begin{thebibliography} must be set wide enough to allow for such labels.

## Rule ■ Label for a bibliographic item

\cite[pages~2--15]{eM57}

A label cannot contain a comma or a space.

The examples I have used follow the formatting rules set by the AMS. Only titles are italicized, and only volume numbers of journals are set in boldface. You also have to watch the order in which the items are given, the punctuation, and the capitalization.

If an author appears repeatedly, use the \bysame command, which replaces the author's name with a long dash followed by a thin space. For example,

```
\bibitem{gF86}
    Grant~H. Foster,
    \emph{Computational complexity in lattice theory},
    tech. report, Carnegie Mellon University, 1986.
\bibitem{gF86a}
    \bysame,
    \emph{Computational complexity in lattice theory},
    Research Note 128A, Carnegie Mellon University,
    Pittsburgh PA, December 1986,
    research article in preparation.
```

See sampart.tex on page 293 for a typeset example.

10.5 Back matter 267

**Tip** If you want a different title for your bibliography, say Bibliography, place the command

```
\renewcommand{\refname}{Bibliography}
```

anywhere before the thebibliography environment (see Section 15.1.6). If you use a legacy document class or amsbook.cls, use the line

\renewcommand{\bibname}{Bibliography}

You may have more than one thebibliography environment in a document. Because each bibliography would number the entries from 1, you should provide labels as optional parameters of the \bibitem commands for cross-referencing.

## 10.5.2 Simple indexes

Using the \label and \pageref commands (see Section 10.4.2), it is quite simple to produce a small index in a theindex environment. At each point in the text that you want to reference in the index, place a \label command. The corresponding entry in the index typesets the page number with the \pageref command.

The \item, \subitem, and \subsubitem commands create an entry, subentry, and subsubentry, respectively. If you need additional vertical spacing when the first letter changes, for instance, between the "h" entries and the "i" entries, you can use the \indexspace command. Here are some examples of index entries:

#### And here is the typeset index:

Index

Lakser, H., 2 Lattice, 14, 25 distributive, 18 modular, 19, 37 Linear subspace, 38

For a larger index, you should use the *MakeIndex* application (see Chapter 17).

# 10.6 Visual design

In this chapter, we have discussed the logical design of a LATEX document. The visual design is largely left to the document class. But there is one small aspect of the visual design we have to discuss, the page style.

To get a visual representation of the page style of your document, use layout package of Kent McPherson (see Section 12.3.1). Load the package with

\usepackage{layout}

and place the \layout command somewhere in the body of your article. LATEX produces a graphical representation of the page layout. Figure 10.4 shows the page layout for odd pages for the amsart document class with no options.

A typeset page has three parts, the *running head* or *header*, the *body*, and the *footer*. As a rule, the document class takes care of the contents and formatting of all three parts.

For the running head and footer, however, you can override the page design of the document class with the command

\pagestyle{style}

where the argument style is one of the following:

plain The running head is empty and the footer contains only the page number

empty Both the running head and the footer are blank

headings The running head contains the information provided by the document class and the footer is empty

myheadings The running head contains the information provided by the commands \markboth and \markright, the footer is empty

The \markright command takes only one argument. The last \markright on a page provides the running head information for that page. The \markboth command has two arguments. The first provides the running head information for a left-hand page, the second provides the running head information for a right-hand page. The AMS

10.6 Visual design 269

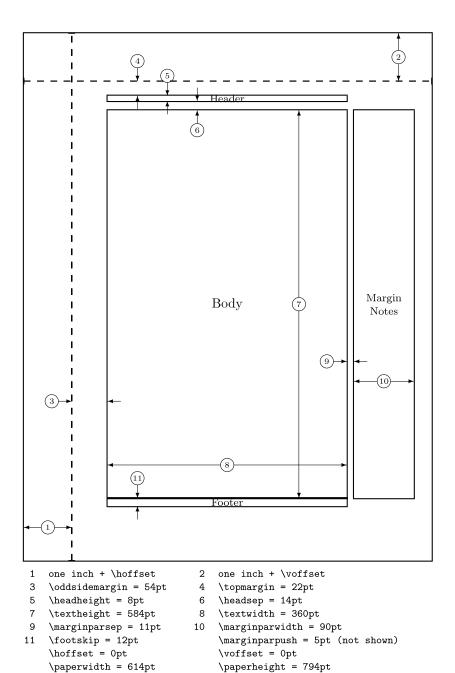


Figure 10.4: Page layout for the amsart document class.

document classes also have a \markleft command for the running head information for a right-hand page.

The \thispagestyle command is the same as \pagestyle except that it affects only the current page.

For instance, if the current page is a full-page graphic, you might want to issue the command

\thispagestyle{empty}

The \maketitle command automatically issues a

\thispagestyle{plain}

command, so if you want to suppress the page number on the first page of a document, you have to put

\thispagestyle{empty}

immediately after the \maketitle command.

The commands listed in Figure 10.4 are length commands (see Section 15.5.2) and can be changed with the commands introduced in that section. As a rule, you do not have to worry about these settings, they are chosen by the document class for you. Sometimes, however, you have a job that requires such changes. I once had to submit a research plan on a form with a 7.5 inch by 5 inch box. To be able to cut and paste the typeset report, I had to produce the text with a \textwidth of 7 inches. If I simply set

\setlength{\textwidth}{7in}

the text would overflow the printed page and the last few characters of each line would be missing. So I had to change the margins by starting the document with

\documentclass[12pt]{report}
\setlength{\textwidth}{7in}
\setlength{\oddsidemargin}{0pt}

All of Chapter 4 of *The LATEX Companion*, 2nd edition [46] deals with page layouts. There you can find a description of the geometry package of Hideo Umeki, which computes all the parameters from the ones you supply. Also you find there a discussion of Piet van Oostrum's excellent package, fancyhdr, which allows you to create your own page style (see also [24]). See Section E.1 on how to get these packages.

However, if you submit an article to a journal, do not change the type size, page dimensions, headers. Use the document class and the article templates the journal provides (if any). This will make your submission easier for you and the journal.

# CHAPTER 1

# The AMS article document class

In this chapter, we discuss amsart, the main AMS document class for journal articles. The AMS book document class is discussed in Chapter 18.

In Section 11.1, I argue that there are good reasons why you should write your articles for publication in amsart. Section 11.2 introduces the rules governing the top matter in the amsart document class. Section 11.3 contains a detailed sample article. We present the source file and the typeset version juxtaposed. In Section 4.2, you created a simple template for amsart articles. In Section 11.4, you are guided through the process for creating more detailed templates.

A document class is shaped by its options. In Section 11.5, we discuss the options of amsart. Section 11.6 briefly describes the various packages in the AMS distribution and their interdependencies.

# 11.1 Why amsart?

# 11.1.1 Submitting an article to the AMS

You want to submit an article written with the amsart document class to the Proceedings of the American Mathematical Society.

For general information on the AMS journals, go to the AMS Web site

```
http://www.ams.org/
```

and start discovering the wealth of relevant information in the column Publications & Tools, especially in the Author Resource Center.

Then click on the journal from the list, and on the Proceedings page, click on Author packages. The page that comes up has everything you need, in particular, the proc-l.cls, the document class for the Proceedings. Click on it to download the document class. Place it in the folder with your article.

There is a more direct way to find proc-l.cls, and this will always work even when the AMS changes the layout of its Web site. At the AMS Web site click on Search. In the search field, type proc-l.cls. Do the search and click on the link to proc-l.cls.

Now, in the preamble of your article, replace the line

```
\documentclass{amsart}
```

with

\documentclass{proc-1}

Typeset the article and you are done. Your article is formatted as it will appear in the Proceedings.

# 11.1.2 Submitting an article to Algebra Universalis

There are many journals whose document class is based on amsart. For instance,

```
http://www.math.umanitoba.ca/homepages/au/
```

takes you to the home page of the journal *Algebra Universalis*. To find the document class, click on Instructions for authors and then click where indicated to get au.cls. Now in your article make the replacement

\documentclass{au}

and your article typesets in the format appropriate for this journal.

# 11.1.3 Submitting to other journals

A large number of journals use document classes based on amsart. Not all are as friendly as *Algebra Universalis*, but as a rule a small number of changes in the article suffice.

All of them share the attribute that the top matter is given as the arguments of many commands. In the introductory sample article, intrart.tex, on page 37, there were only four, but in the sample article sampart.tex, on page 290, there are nine—there

could be many more. Contrast this with the legacy article class (see Section 12.1.1). As a result, the document class is able to shape the top matter as the journal requires. Even if the names of some of these commands are different (e.g., affiliation instead of address), the principles you learn from the amsart document class apply.

Many journals insist that you use their own document classes. For these, you may have to add the AMS packages (see Section 11.6) to continue to use the enhancements of the AMS.

A shrinking number of journals use document classes incompatible with the AMS packages. If you can, avoid these journals.

## 11.1.4 Submitting to conference proceedings

The AMS also has a document class for articles for book-form proceedings of meetings. The differences in the rules for the amsart and amsproc document classes are so minor that you can safely ignore them.

# 11.2 The top matter

For a fairly representative example, see the typeset top matter of the sampart.tex article on pages 286 and 288. As you may recall from Section 4.1, part of the author information is moved to the end of the typeset article—see page 288.

Title page information is provided as arguments of several commands. For your convenience, I divide them into three groups: information about the article, information about the author, and AMS related information.

There is only one general rule.

## **Rule** ■ Top matter commands

All top matter commands are *short*.

This means that there can be no blank lines (or \par commands) in the argument of any of these commands (see Section 5.3.3).

# 11.2.1 Article information

You have to supply five pieces of information about the article.

#### Rule Title

- Command: \title
- Separate lines with \\

- Optional argument: Short title for running head
- Do not put a period at the end of a title
- Do not use user-defined commands in the title

The typeset title is placed on the front page of the typeset article.

Many titles are too long to be typeset on a single line in the font used by the amsart document class for titles. If the way LATEX breaks the title is not satisfactory, you can indicate where the title should be broken with the \\ command. Alternatively, you may nudge LATEX in the right direction with ~ (see Section 5.4.3). For instance, the title:

```
The \texttt{amsart} document class
```

is broken by LATEX between document and class. So either add \\:

```
The \texttt{amsart}\\ document class
```

or replace document class with document class:

```
The \texttt{amsart} document~class
```

The *running head* (see Section 10.6) is the title on odd-numbered pages, set in capital letters. If the title is more than a few words long, use an optional argument to specify a short title for the running head. Do not use \\ in the short title.

Example of a title:

\title{A construction of distributive lattices}

A title with a short title:

```
\title[Complete-simple distributive lattices]
{A construction of\\ complete-simple
distributive lattices}
```

Note the AMS rules about short titles and the table of contents on Section 18.2.1.

#### Rule Translator

- Command: \translator
- Do not put a period at the end of the argument.

The typeset \translator is placed on the last page of the typeset article, before the address(es). There can be more than one translator. Each should be given as the argument of a separate \translator command.

Example:

\translator{Harry~M. Goldstein}

#### Rule Dedication

- Command: \dedicatory
- Separate lines with \\

The typeset dedication is placed under the author(s).

Example:

\dedicatory{To the memory of my esteemed
friend and teacher,\\ Harry~M. Goldstein}

#### Rule ■ Date

■ Command: \date

The typeset \date is placed on the front page of the typeset article as a footnote.

Examples:

\date{January 22, 2006}

You can use the \today command to get today's date:

\date{\today}

Do not use this when you submit an article; specify the submission date.

To suppress the date, use \date{} or omit the \date command entirely.

# 11.2.2 Author information

There are seven pieces of information about yourself.

#### Rule ■ Author

Command: \author

• Optional argument: Short form of the name for the running head

The typeset author is placed on the front page of the typeset article.

Examples:

An author:

\author{George~A. Menuhin}

An author with a short form of the name for the running head:

\author[G.\,A. Menuhin]{George~A. Menuhin}

Section 11.2.4 discusses how to specify multiple authors.

## Rule ■ Contributor

■ Command: \contrib

Optional argument: Describing the contribution

The typeset contributor's name is placed on the front page of the typeset article. This command is very recent. It was introduced in amsart version 2.20.

Examples:

A contributor authoring an appendix:

\contrib[with an appendix by]{John Blaise}

If this appendix has two authors:

```
\contrib[with an appendix by]{J. Blaise}
\contrib[]{W. Blaise}
```

This typesets (with author G. A. Menuhin) the author line as

```
G. A. MENUHIN, WITH AN APPENDIX BY J. BLAISE AND W. BLAISE
```

Contributors can have addresses, current addresses, etc., just like authors.

#### Rule Address

■ Command: \address

Separate lines with \\

Optional argument: Name of author

The typeset address is placed at the end of the typeset article.

Example:

Department of Applied Mathematics, University of Winnebago, Winnebago, MN 53714

which is typed as

```
\address{Department of Applied Mathematics\\
University of Winnebago\\
Winnebago, MN 53714}
```

Notice that LaTeX replaces the \\ line separators with commas.

If there are several authors, you can use the author's name as an optional argument of \address to avoid ambiguity. See Example 4 in Section 11.2.5 (page 283) for a complete example.

#### Rule ■ Current address

■ Command: \curraddr

Separate lines with \\

Optional argument: name of author

The typeset current address is placed at the end of the typeset article.

Example:

```
\label{eq:current} \textit{Current address:} \ \ \text{Department of Mathematics, University of York, Heslington, York, England}
```

is typed as

```
\curraddr{Department of Mathematics\\
    University of York\\
    Heslington, York, England}
```

If there are several authors, you can use the author's name as an optional argument of \curraddr to avoid ambiguity; for some examples, see Section 11.2.5.

#### Rule ■ E-mail address

■ Command: \email

• Optional argument: Name of author

The typeset e-mail address is placed at the end of the typeset article.

Example:

\email{gmen@ccw.uwinnebago.edu}

**Tip** Some e-mail addresses contain the special underscore character ( \_ ). Recall (see Section 5.4.4) that you have to type \\_ to get \_.

Example:

\email{George\\_Gratzer@umanitoba.ca}

Tip Some older e-mail addresses contain the percent symbol (%); recall that you have to type \% to get % (see Section 5.4.4).

Example:

\email{h1175moy\%ella@relay.eu.net}

#### Rule ■ Web (home) page (URL)

■ Command: \urladdr

• Optional argument: Name of author

The typeset Web (home) page is placed at the end of the typeset article. *Example:* 

\urladdr{http://www.maths.umanitoba.ca/homepages/gratzer/}

**Tip** Many Internet addresses contain the tilde (~), indicating the home directory of the user. Type ~ to get ~ and not \~, as recommended in Section 5.4.4. \$\sim\$ is also unacceptable.

Example:

\urladdr{http://kahuna.math.hawaii.edu/~ralph/}

#### **Rule** Research support or other acknowledgments

- Command: \thanks
- Do not specify linebreaks.
- Terminate the sentence with a period.

The typeset research support or other acknowledgments is placed on the front page of the typeset article as an unmarked footnote.

Example:

\thanks{Supported in part by NSF grant PAL-90-2466.}

A \thanks{} command is ignored in typesetting.

# 11.2.3 AMS information

The AMS requires that you supply two more pieces of information about the article.

The following are collected at the bottom of the first page as unmarked footnotes along with the arguments of the \thanks and \date commands.

# **Rule** ■ AMS subject classifications

- Command: \subjclass
- Optional argument: 2000—the default is 1991.

- amsart supplies the phrase 1991 Mathematics Subject Classification and a period at the end of the subject classification—with the optional argument 2000, the phrase is 2000 Mathematics Subject Classification
- The argument should be either a five-character code or the phrase Primary: followed by a five-character code, a semicolon, the phrase Secondary: and one or more additional five-character codes.

The typeset AMS subject classifications is placed at the bottom of the front page of the typeset article as a footnote.

Examples:

```
\subjclass[2000]{06B10}
\subjclass[2000]{Primary: 06B10; Secondary: 06D05}
```

The current subject classification scheme for mathematics was adopted in 2000, making the 1991 classification scheme obsolete. Thus, 2000 should be considered as a *compulsory* optional argument—maybe the only one in all of LaTeX.

The current subject classification scheme, MSC 2000, is available from the AMS Web site

```
http://www.ams.org/
```

Search for MSC. Or in the Author Resource Center click on MSC.

#### Rule ■ Keywords

- Command: \keywords
- Do not indicate line breaks.
- amsart supplies the phrase Key words and phrases. and a period at the end of the list of keywords.

The typeset keywords are placed on the front page of the typeset article as a footnote. *Example:* 

```
\keywords{Complete lattice, distributive lattice,
complete congruence, congruence lattice}
```

Keywords are optional for many journals.

**Further footnotes** An additional \thanks command creates an unmarked footnote. *Examples:* 

# 11.2.4 Multiple authors

If an article has several authors, repeat the author information commands for each one. Take care that the e-mail address follows the address.

If two authors share the same address, omit the \address command for the second author, who can still have a different e-mail address and Web home page. An additional \thanks command for the first author should precede any \thanks commands for the second author. Since the footnotes are not marked, the argument of the \thanks command for research support should contain a reference to the author:

```
\thanks{The research of the first author was supported in part by NSF grant PAL-90-2466.} \thanks{The research of the second author was supported by the Hungarian National Foundation for Scientific Research, under Grant No.~9901.}
```

Finally, if an article has more than two authors, supply the author information for each author as usual, but explicitly specify the running heads with the \markleft command:

```
\mathsf{Markleft}\{first\ author\ \mathsf{ET}\ \mathsf{AL.}\}
```

where first author must be all capitals.

If there are multiple authors, sometimes it may not be clear whose address, current address, e-mail address, or Web home page is being given. In such cases you can give the name of the author as an optional argument for these commands. For example,

```
Email address, Ernest T. Moynahan: emoy@ccw.uwinnebago.edu.

is typed as

\email[Ernest~T. Moynahan]{emoy@ccw.uwinnebago.edu}

See also Example 4 in Section 11.2.5.
```

# 11.2.5 Examples

The following examples show typical top matter commands and can be found in the topmat.tpl file in the samples folder (see page 4).

#### **Example 1** One author.

```
% Article information
\title[Complete-simple distributive lattices]
      {A construction of complete-simple\\
       distributive lattices}
\date{\today}
% Author information
\author{George A. Menuhin}
\address{Computer Science Department\\
         University of Winnebago\\
         Winnebago, MN 53714}
\email{gmen@ccw.uwinnebago.edu}
\urladdr{http://math.uwinnebago.edu/homepages/menuhin/}
\thanks{This research was supported by
        the NSF under grant number 23466.}
% AMS information
\keywords{Complete lattice, distributive lattice,
          complete congruence, congruence lattice}
\subjclass[2000]{Primary: 06B10; Secondary: 06D05}
```

In the \title command, supplying the optional argument for the running head is the rule, not the exception. The only required item is \title. If it is missing, you get the strange error message:

```
! Undefined control sequence. 
<argument> \shorttitle
```

#### 1.49 \maketitle

**Example 2** Two authors but only the first has a Web home page. I only show the author information section here. The other commands are the same as in Example 1.

```
% Author information
\author{George~A. Menuhin}
\address{Computer Science Department\\
        University of Winnebago\\
        Winnebago, MN 53714}
```

**Example 3** Two authors, same department. I only show the author information section here. The other commands are identical to those in Example 1.

Note that the second author has no \address.

**Example 4** Three authors, the first two from the same department, the second and third with e-mail addresses and research support. I only show the author information section. The other commands are unchanged. There are various ways of handling this situation. This example shows one solution.

```
% Author information
\author{George~A. Menuhin}
```

```
\address[George~A. Menuhin and Ernest~T. Moynahan]
   {Computer Science Department\\
    University of Winnebago\\
    Winnebago, MN 53714}
\email[George~A. Menuhin]{gmen@ccw.uwinnebago.edu}
\urladdr[George~A. Menuhin]%
        {http://math.uwinnebago.edu/homepages/menuhin/}
\thanks{The research of the first author was
        supported by the NSF under grant number 23466.}
\author{Ernest~T. Moynahan}
\email[Ernest~T. Moynahan]{emoy@ccw.uwinnebago.edu}
\thanks{The research of the second author was supported
        by the Hungarian National Foundation for
        Scientific Research, under Grant No. 9901.}
\author{Ferenc~R. Richardson}
\address[Ferenc~R. Richardson]
   {Department of Mathematics\\
    California United Colleges\\
    Frasco, CA 23714}
\email[Ferenc~R. Richardson]{frich@ccu.frasco.edu}
\thanks{The research of the third author was
        supported by the NSF under grant number 23466.}
```

Tip The most common mistake in the top matter is the misspelling of a command name; for instance, \adress. LATEX sends the error message

```
! Undefined control sequence.
```

{Computer Science Department\\

which tells you exactly what you mistyped. Similarly, if you drop a closing brace, as in

\email{menuhin@ccw.uwinnebago.edu

you are told clearly what went wrong. Because the top matter commands are short (see Section 5.3.3), LATEX gives the error message

```
Runaway argument?
{menuhin@ccw.uwinnebago.edu \thanks
{The research of th\ETC.
!File ended while scanning use of \\email.
```

If you drop an opening brace,

<sup>1.37 \</sup>adress

LATEX uses the short title as the title and the real title is typeset before the title of the typeset article.

#### 11.2.6 Abstract

As we discussed in Section 10.3.1, you type the abstract in an abstract environment, which you place as the last item before the \maketitle command. The abstract should be self-contained, so do not include cross-references and do not cite from the bibliography. Avoid user-defined commands.

If you place the abstract *after* the \maketitle command, Lagrange it wherever it happens to be and sends a warning.

# 11.3 The sample article

sampart.tex is the source file for our more advanced sample article using amsart (in the samples folder, see page 4). A simpler article using amsart is presented in Part I (see Section 4.1).

The typeset sampart. tex is shown on the following three pages.

# A CONSTRUCTION OF COMPLETE-SIMPLE DISTRIBUTIVE LATTICES

#### GEORGE A. MENUHIN

ABSTRACT. In this note we prove that there exist *complete-simple distributive lattices*, that is, complete distributive lattices in which there are only two complete congruences.

#### 1. Introduction

In this note we prove the following result:

Main Theorem. There exists an infinite complete distributive lattice K with only the two trivial complete congruence relations.

## 2. The $D^{\langle 2 \rangle}$ construction

For the basic notation in lattice theory and universal algebra, see Ferenc R. Richardson [5] and George A. Menuhin [2]. We start with some definitions:

**Definition 1.** Let V be a complete lattice, and let  $\mathfrak{p} = [u, v]$  be an interval of V. Then  $\mathfrak{p}$  is called *complete-prime* if the following three conditions are satisfied:

- (1) u is meet-irreducible but u is not completely meet-irreducible;
- (2) v is join-irreducible but v is not completely join-irreducible;
- (3) [u, v] is a complete-simple lattice.

Now we prove the following result:

**Lemma 1.** Let D be a complete distributive lattice satisfying conditions (1) and (2). Then  $D^{\langle 2 \rangle}$  is a sublattice of  $D^2$ ; hence  $D^{\langle 2 \rangle}$  is a lattice, and  $D^{\langle 2 \rangle}$  is a complete distributive lattice satisfying conditions (1) and (2).

Proof. By conditions (1) and (2),  $D^{\langle 2 \rangle}$  is a sublattice of  $D^2$ . Hence,  $D^{\langle 2 \rangle}$  is a lattice. Since  $D^{\langle 2 \rangle}$  is a sublattice of a distributive lattice,  $D^{\langle 2 \rangle}$  is a distributive lattice. Using the characterization of standard ideals in Ernest T. Moynahan [3],  $D^{\langle 2 \rangle}$  has a zero and a unit element, namely,  $\langle 0,0 \rangle$  and  $\langle 1,1 \rangle$ . To show that  $D^{\langle 2 \rangle}$  is complete, let  $\varnothing \neq A \subseteq D^{\langle 2 \rangle}$ , and let  $a = \bigvee A$  in  $D^2$ . If  $a \in D^{\langle 2 \rangle}$ , then  $a = \bigvee A$  in  $D^{\langle 2 \rangle}$ ; otherwise, a is of the form  $\langle b,1 \rangle$  for some  $b \in D$  with b < 1. Now  $\bigvee A = \langle 1,1 \rangle$  in  $D^2$  and the dual argument shows that  $\bigwedge A$  also exists in  $D^2$ . Hence D is complete. Conditions (1) and (2) are obvious for  $D^{\langle 2 \rangle}$ .

Corollary 1. If D is complete-prime, then so is  $D^{(2)}$ .

Date: March 15, 2006.

<sup>2000</sup> Mathematics Subject Classification. Primary: 06B10; Secondary: 06D05.

 $Key\ words\ and\ phrases.$  Complete lattice, distributive lattice, complete congruence, congruence lattice.

Research supported by the NSF under grant number 23466.

The motivation for the following result comes from Soo-Key Foo [1].

**Lemma 2.** Let  $\Theta$  be a complete congruence relation of  $D^{\langle 2 \rangle}$  such that

(2.1) 
$$\langle 1, d \rangle \equiv \langle 1, 1 \rangle \pmod{\Theta},$$

for some  $d \in D$  with d < 1. Then  $\Theta = \iota$ .

*Proof.* Let  $\Theta$  be a complete congruence relation of  $D^{\langle 2 \rangle}$  satisfying (2.1). Then  $\Theta = \iota$ .

#### 3. The $\Pi^*$ construction

The following construction is crucial to our proof of the Main Theorem:

**Definition 2.** Let  $D_i$ , for  $i \in I$ , be complete distributive lattices satisfying condition (2). Their  $\Pi^*$  product is defined as follows:

$$\Pi^*(D_i \mid i \in I) = \Pi(D_i^- \mid i \in I) + 1;$$

that is,  $\Pi^*(D_i \mid i \in I)$  is  $\Pi(D_i^- \mid i \in I)$  with a new unit element.

Notation. If  $i \in I$  and  $d \in D_i^-$ , then

$$\langle \dots, 0, \dots, \stackrel{i}{d}, \dots, 0, \dots \rangle$$

is the element of  $\Pi^*(D_i \mid i \in I)$  whose *i*-th component is d and all the other components are 0.

See also Ernest T. Moynahan [4]. Next we verify:

**Theorem 1.** Let  $D_i$ , for  $i \in I$ , be complete distributive lattices satisfying condition (2). Let  $\Theta$  be a complete congruence relation on  $\Pi^*(D_i \mid i \in I)$ . If there exist  $i \in I$  and  $d \in D_i$  with  $d < 1_i$  such that for all  $d \le c < 1_i$ ,

$$(3.1) \qquad \langle \dots, 0, \dots, \overset{i}{d}, \dots, 0, \dots \rangle \equiv \langle \dots, 0, \dots, \overset{i}{c}, \dots, 0, \dots \rangle \pmod{\Theta},$$

then  $\Theta = \iota$ .

Proof. Since

$$(3.2) \qquad \langle \dots, 0, \dots, \stackrel{i}{d}, \dots, 0, \dots \rangle \equiv \langle \dots, 0, \dots, \stackrel{i}{c}, \dots, 0, \dots \rangle \pmod{\Theta},$$

and  $\Theta$  is a complete congruence relation, it follows from condition (3) that

(3.3) 
$$\langle \dots, \stackrel{i}{d}, \dots, 0, \dots \rangle$$

$$\equiv \bigvee (\langle \dots, 0, \dots, \stackrel{i}{c}, \dots, 0, \dots \rangle \mid d \le c < 1) \equiv 1 \pmod{\Theta}.$$

Let  $j \in I$  for  $j \neq i$ , and let  $a \in D_j^-$ . Meeting both sides of the congruence (3.2) with  $\langle \dots, 0, \dots, \stackrel{j}{a}, \dots, 0, \dots \rangle$ , we obtain

$$(3.4) 0 = \langle \dots, 0, \dots, \stackrel{i}{d}, \dots, 0, \dots \rangle \land \langle \dots, 0, \dots, \stackrel{j}{a}, \dots, 0, \dots \rangle$$
$$\equiv \langle \dots, 0, \dots, \stackrel{j}{a}, \dots, 0, \dots \rangle \pmod{\Theta}.$$

Using the completeness of  $\Theta$  and (3.4), we get:

$$0 \equiv \bigvee (\langle \dots, 0, \dots, \overset{j}{a}, \dots, 0, \dots \rangle \mid a \in D_j^-) = 1 \pmod{\Theta},$$

hence  $\Theta = \iota$ .

**Theorem 2.** Let  $D_i$  for  $i \in I$  be complete distributive lattices satisfying conditions (2) and (3). Then  $\Pi^*(D_i \mid i \in I)$  also satisfies conditions (2) and (3).

*Proof.* Let  $\Theta$  be a complete congruence on  $\Pi^*(D_i \mid i \in I)$ . Let  $i \in I$ . Define

$$\widehat{D}_i = \{\langle \dots, 0, \dots, \stackrel{i}{d}, \dots, 0, \dots \rangle \mid d \in D_i^-\} \cup \{1\}.$$

Then  $\widehat{D}_i$  is a complete sublattice of  $\Pi^*(D_i \mid i \in I)$ , and  $\widehat{D}_i$  is isomorphic to  $D_i$ . Let  $\Theta_i$  be the restriction of  $\Theta$  to  $\widehat{D}_i$ .

Since  $D_i$  is complete-simple, so is  $D_i$ , and hence  $\Theta_i$  is  $\omega$  or  $\iota$ . If  $\Theta_i = \rho$  for all  $i \in I$ , then  $\Theta = \omega$ . If there is an  $i \in I$ , such that  $\Theta_i = \iota$ , then  $0 \equiv 1 \pmod{\Theta}$ , hence  $\Theta = \iota$ .

The Main Theorem follows easily from Theorems 1 and 2.

#### References

- Soo-Key Foo, Lattice Constructions, Ph.D. thesis, University of Winnebago, Winnebago, MN, December, 1990.
- [2] George A. Menuhin, Universal algebra. D. Van Nostrand, Princeton, 1968.
- [3] Ernest T. Moynahan, On a problem of M. Stone, Acta Math. Acad. Sci. Hungar. 8 (1957), 455–460.
- [4] \_\_\_\_\_\_, Ideals and congruence relations in lattices. II, Magyar Tud. Akad. Mat. Fiz. Oszt. Közl. 9 (1957), 417–434 (Hungarian).
- [5] Ferenc R. Richardson, General lattice theory. Mir, Moscow, expanded and revised ed., 1982 (Russian).

Computer Science Department, University of Winnebago, Winnebago, MN 53714  $E\text{-}mail\ address:}$  menuhin@ccw.uwinnebago.edu

URL: http://math.uwinnebago.edu/homepages/menuhin/

The next two pages show the first page of the source file facing a fragment of the first page of the typeset article. It displays the part of this first typeset page that comes from the facing source file.

On the two pages after the facing first pages, some parts of the source file and the typeset version are shown juxtaposed, so that you can see how the marked-up source file becomes the typeset article.

```
% Sample file: sampart.tex
% The sample article for the amsart document class
\documentclass{amsart}
\usepackage{amssymb,latexsym}
\theoremstyle{plain}
\newtheorem{theorem}{Theorem}
\newtheorem{corollary}{Corollary}
\newtheorem*{main}{Main~Theorem}
\newtheorem{lemma}{Lemma}
\newtheorem{proposition}{Proposition}
\theoremstyle{definition}
\newtheorem{definition}{Definition}
\theoremstyle{remark}
\newtheorem*{notation}{Notation}
\numberwithin{equation}{section}
\begin{document}
\title[Complete-simple distributive lattices]
      {A construction of complete-simple\\
       distributive lattices}
\author{George A. Menuhin}
\address{Computer Science Department\\
         University of Winnebago\\
         Winnebago, MN 53714}
\email{menuhin@ccw.uwinnebago.edu}
\urladdr{http://math.uwinnebago.edu/homepages/menuhin/}
\thanks{Research supported by the NSF under grant number
\keywords{Complete lattice, distributive lattice,
   complete congruence, congruence lattice}
\subjclass[2000]{Primary: 06B10; Secondary: 06D05}
\date{March 15, 2006}
\begin{abstract}
   In this note we prove that there exist \emph{complete-simple distributive
   lattices,} that is, complete distributive lattices in which there are
   only two complete congruences.
\end{abstract}
\maketitle
\section{Introduction}\label{S:intro}
In this note we prove the following result:
\begin{main}
   There exists an infinite complete distributive lattice $K$ with only
   the two trivial complete congruence relations.
\section{The $D^{\langle 2 \rangle}$ construction}\label{S:Ds}
For the basic notation in lattice theory and universal algebra, see Ferenc~R.
Richardson~\cite{fR82} and George~A. Menuhin~\cite{gM68}. We start with some
definitions:
```

# A CONSTRUCTION OF COMPLETE-SIMPLE DISTRIBUTIVE LATTICES

#### GEORGE A. MENUHIN

ABSTRACT. In this note we prove that there exist *complete-simple distributive lattices*, that is, complete distributive lattices in which there are only two complete congruences.

#### 1. Introduction

In this note we prove the following result:

Main Theorem. There exists an infinite complete distributive lattice K with only the two trivial complete congruence relations.

# 2. The $D^{\langle 2 \rangle}$ construction

For the basic notation in lattice theory and universal algebra, see Ferenc R. Richardson [5] and George A. Menuhin [2]. We start with some definitions:

Date: March 15, 2006.

 $<sup>2000\</sup> Mathematics\ Subject\ Classification.\ {\it Primary:}\ 06B10;\ Secondary:\ 06D05.$ 

 $Key\ words\ and\ phrases.$  Complete lattice, distributive lattice, complete congruence, congruence lattice.

Research supported by the NSF under grant number 23466.

Since  $D^{\langle 2 \rangle}$  is a sublattice of a distributive lattice,  $D^{\langle 2 \rangle}$  is a distributive lattice. Using the characterization of standard ideals in Ernest T. Moynahan [3],  $D^{\langle 2 \rangle}$  has a zero and a unit element, namely,  $\langle 0,0 \rangle$  and  $\langle 1,1 \rangle$ . To show that  $D^{\langle 2 \rangle}$  is complete, let  $\varnothing \neq A \subseteq D^{\langle 2 \rangle}$ , and let  $a = \bigvee A$  in  $D^2$ . If  $a \in D^{\langle 2 \rangle}$ , then  $a = \bigvee A$  in  $D^{\langle 2 \rangle}$ ; otherwise, a is of the form  $\langle b,1 \rangle$  for some  $b \in D$  with b < 1. Now  $\bigvee A = \langle 1,1 \rangle$  in  $D^2$  and the dual argument shows that  $\bigwedge A$  also exists in  $D^2$ . Hence D is complete. Conditions (1) and (2) are obvious for  $D^{\langle 2 \rangle}$ .

Corollary 1. If D is complete-prime, then so is  $D^{(2)}$ .

The motivation for the following result comes from Soo-Key Foo [1].

**Lemma 2.** Let  $\Theta$  be a complete congruence relation of  $D^{\langle 2 \rangle}$  such that

(2.1) 
$$\langle 1, d \rangle \equiv \langle 1, 1 \rangle \pmod{\Theta},$$

for some  $d \in D$  with d < 1. Then  $\Theta = \iota$ .

```
Since $D^{\langle 2 \rangle}$ is a sublattice of a distributive
   lattice, $D^{\langle 2 \rangle}$ is a distributive lattice. Using
   the characterization of standard ideals in Ernest~T. Moynahan~\cite{eM57},
   $D^{\langle 2 \rangle}$ has a zero and a unit element,
   namely, $\langle 0, 0 \rangle$ and $\langle 1, 1 \rangle$.
   To show that $D^{\langle 2 \rangle}$ is complete, let
   $\varnothing \ne A \subseteq D^{\langle 2 \rangle}$, and let
   a = \beta A in D^{2}. If
   $a \in D^{\langle 2 \rangle}$, then
   $a = \bigvee A$ in $D^{\langle 2 \rangle}$; otherwise, $a$
   is of the form $\langle b, 1 \rangle$ for some
   b \in D with b < 1. Now bigvee A = langle 1, 1\rangle
   in $D^{2}$ and the dual argument shows that $\bigwedge A$ also
   exists in D^{2}. Hence D is complete. Conditions \operatorname{eqref}\{m-i\}
   and \eqref{j-i} are obvious for $D^{\langle 2 \rangle}$.
\end{proof}
\begin{corollary}\label{C:prime}
   If $D$ is complete-prime, then so is $D^{\langle 2 \rangle}$.
\end{corollary}
The motivation for the following result comes from Soo-Key Foo^\cite{sF90}.
\begin{lemma}\label{L:ccr}
   Let $\Theta$ be a complete congruence relation of
   $D^{\langle 2 \rangle}$ such that
   \begin{equation}\label{E:rigid}
     \langle 1, d \rangle \equiv \langle 1, 1 \rangle \pmod{\Theta},
   \end{equation}
   for some d \in D with d < 1. Then \theta = iota.
\end{lemma}
```

\end{thebibliography} \end{document}

Since  $D_i$  is complete-simple, so is  $\widehat{D}_i$ , and hence  $\Theta_i$  is  $\omega$  or  $\iota$ . If  $\Theta_i = \rho$  for all  $i \in I$ , then  $\Theta = \omega$ . If there is an  $i \in I$ , such that  $\Theta_i = \iota$ , then  $0 \equiv 1 \pmod{\Theta}$ , hence  $\Theta = \iota$ .

The Main Theorem follows easily from Theorems 1 and 2.

#### References

- [1] Soo-Key Foo, Lattice Constructions, Ph.D. thesis, University of Winnebago, Winnebago, MN, December, 1990.
- [2] George A. Menuhin, Universal algebra. D. Van Nostrand, Princeton, 1968.
- [3] Ernest T. Moynahan, On a problem of M. Stone, Acta Math. Acad. Sci. Hungar. 8 (1957),
- [4] \_\_\_\_\_\_, Ideals and congruence relations in lattices. II, Magyar Tud. Akad. Mat. Fiz. Oszt. Közl. 9 (1957), 417–434 (Hungarian).
- [5] Ferenc R. Richardson, General lattice theory. Mir, Moscow, expanded and revised ed., 1982 (Russian).

```
Computer Science Department, University of Winnebago, Winnebago, MN 53714
  E-mail address: menuhin@ccw.uwinnebago.edu
  \mathit{URL}: http://math.uwinnebago.edu/homepages/menuhin/
   Since D_{i}\ is complete-simple, so is \hat{D}_{i}\, and
   hence $\Theta_{i}$ is $\omega$ or $\iota$. If
   \hat{i} = \rho  for all i \in I, then
   $\Theta = \omega$. If there is an $i \in I$, such that
   \hat{i} = \text{iota}, \text{ then $0 \leq 1 \leq 1}, \text{ hence}
   \theta = \pi 
\end{proof}
The Main Theorem follows easily from Theorems \ref{T:P*} and \ref{T:P*a}.
\begin{thebibliography}{9}
   \bibitem{sF90}
     Soo-Key Foo, \emph{Lattice Constructions}, Ph.D. thesis, University
     of Winnebago, Winnebago, MN, December, 1990.
   \bibitem{gM68}
     George A. Menuhin, \emph{Universal algebra}. D. Van Nostrand,
     Princeton, 1968.
   \bibitem{eM57}
     Ernest~T. Moynahan, \emph{On a problem of M. Stone}, Acta Math.
      Acad. Sci. Hungar. \textbf{8} (1957), 455--460.
   \bibitem{eM57a}
     \bysame, \emph{Ideals and congruence relations in lattices}. II,
    Magyar Tud. Akad. Mat. Fiz. Oszt. K\"{o}zl. \textbf{9} (1957),
    417--434 (Hungarian).
   \bibitem{fR82}
     Ferenc~R. Richardson, \emph{General lattice theory}. Mir, Moscow,
     expanded and revised ed., 1982 (Russian).
```

# 11.4 Article templates

In this section, we create a template you can use for your amsart articles. A template is a read-only file. Open it with a text editor and save it under a different name. You can then start to write your new article using the new file, without having to remember the details governing the preamble and the top matter.

Create the template, which contains a customized preamble and top matter with sample bibliographic items, in several steps.

**Step 1** In your text editor, open the amsart.tpl document from the samples folder (see page 4) and save it in your work subfolder as myams.tpl. Alternatively, type in the lines as shown in this section.

The first few lines of the file are

```
% Sample file: amsart.tpl

% Preamble
\documentclass{amsart}
\usepackage{amssymb,latexsym}
```

Notice the use of commented out lines (lines that start with %) that have been added as comments about the file.

Edit line 1 to read

```
% Template file: myams.tpl
The lines
```

\documentclass{amsart}
\usepackage{amssymb,latexsym}

specify the amsart document class and the use of the amssymb and latexsym packages to gain access by name to all the symbols listed in Appendix B.

**Step 2** After the \usepackage command, there are sets of proclamation definitions corresponding to the examples in Section 6.4.2.

Choose Option 5 for myams.tpl by deleting all the lines related to the other options. You are left with the lines

```
% Theorems, corollaries, lemmas, and propositions, in the % most emphatic (plain) style. All are numbered separately. % There is a Main Theorem in the most emphatic (plain) % style, unnumbered. There are definitions, in the less % emphatic(definition) style. There are notations, in the % least emphatic (remark) style, unnumbered.
```

```
\theoremstyle{plain}
\newtheorem{theorem}{Theorem}
\newtheorem{corollary}{Corollary}
\newtheorem*{main}{Main Theorem}
\newtheorem{lemma}{Lemma}
\newtheorem{proposition}{Proposition}
\theoremstyle{definition}
\newtheorem{definition}{Definition}
\theoremstyle{remark}
\newtheorem*{notation}{Notation}
Step 3 Two more choices are presented. You can have either one or two authors—for
more complex situations, see Section 11.2.4. For the myams.tpl template, choose one
author by deleting everything between
% Two authors
and
% End Two authors
You are left with
\begin{document}
% One author
\title[shorttitle]{titleline1\\
                    titleline2}
\author{name}
\address{line1\\
         line2\\
         line3}
\email{name@address}
\urladdr{http://homepage}
\thanks{thanks}
% End one author
\keywords{keywords}
\subjclass[2000]{Primary: subject; Secondary: subject}
\date{date}
```

\begin{abstract}
 abstract

```
\end{abstract}
\maketitle
\begin{thebibliography}{99}
\end{thebibliography}
\end{document}
In the top matter, fill in your own personal information. For instance, I edited
\author{name}
to read
\author{George~Gr\"{a}tzer}
I also edited \address, \email, \urladdr, and \thanks. After editing, I had the
following:
% top matter
\title[shorttitle]{titleline1\\
                    titleline2}
\author{George~Gr\"{a}tzer}
\address{University of Manitoba\\
         Department of Mathematics\\
         Winnipeg, MB R3T 2N2\\
         Canada}
\email{gratzer@ms.umanitoba.ca}
\urladdr{http://server.maths.umanitoba.ca/homepages/gratzer/}
\thanks{Research supported by the NSERC of Canada.}
\keywords{keywords}
\subjclass[2000]{Primary: subject; Secondary: subject}
\date{date}
\begin{abstract}
   abstract
\end{abstract}
\maketitle
\begin{thebibliography}{99}
\end{thebibliography}
\end{document}
```

11.5 Options 297

Since this template is meant to be used for all my future articles, I do not edit the lines that change from article to article (\title, \keywords, and so on).

Remember that the short title is for running heads, the title shown at the top of every odd-numbered page other than the title page. If the title of your article is only one line long, delete the separation mark \\ and the second line, except for the closing brace. If the full title of your article is short, delete [shorttitle].

Now save myams.tpl. I saved my template under the name ggamsart.tpl (in the samples folder, see page 4). You can also make an additional template with two authors to be used as a template for joint articles. Note that at the end of the template, just before the line \end{document}, there are two lines:

```
\begin{thebibliography}{99}
```

```
\end{thebibliography}
```

The argument of \begin{thebibliography} should be 9 if there are fewer than 10 references, 99 with 10–99 references, and so forth. We discuss how to format bibliographic items in Sections 4.2.4 and 10.5.1. The templates for bibliographic items are listed after the \end{document} line.

To make sure that you do not overwrite your template, I recommend that you make it read-only. How you do this depends on your computer's operating system.

You should modify the template you create in this section to the template of the journal you submit your article to. In the samples folder, you find the AMS template for the Proceedings of the AMS, called amsproc.template.

# 11.5 Options

The amsart document class supports a number of options, affecting many attributes. For each attribute there is a *default value* that is used if a value is not specified.

#### Font size

```
Options: 9pt
10pt default
11pt
12pt
```

This option declares the default font size. You may want to use the 12pt option for proofreading:

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

Remember, however, that changing the font size changes the line breaks, so changing the 12pt option back to 10pt may require that you make some adjustments in the text (see Section 2.3).

#### Paper size

Options: letterpaper (8.5 inches by 11 inches) default

legalpaper (8.5 inches by 14 inches) a4paper (210 mm by 297 mm)

#### Equations and equation numbers

A number of options deal with the placement of equations and equation numbers.

Options: leqno default reqno

By default, equation numbers are placed on the left, the default lequo option. The requo option places the equation numbers on the right.

Option: fleqn

This option positions equations a fixed distance from the left margin rather than centering them. The fleqn option is typically used in conjunction with the reqno option. Here is how an equation looks with the fleqn and reqno options:

$$\int_0^\pi \sin x \, dx = 2 \tag{1}$$

typed as

\begin{equation}\label{E:firstInt}
 \int\_{0}^{\pi} \sin x \, dx = 2
\end{equation}

Options: tbtags centertags default

The tbtags option uses *top-or-bottom tags* for a split environment, that is, it places the equation number level with the last line if numbers are on the right, or level with the first line if the numbers are on the left:

(1) 
$$f = (x_1 x_2 x_3 x_4 x_5 x_6)^2$$
$$= (x_1 x_2 x_3 x_4 x_5 + x_1 x_3 x_4 x_5 x_6 + x_1 x_2 x_4 x_5 x_6 + x_1 x_2 x_3 x_5 x_6)^2$$
$$= (x_1 x_2 x_3 x_4 + x_1 x_2 x_3 x_5 + x_1 x_2 x_4 x_5 + x_1 x_3 x_4 x_5)^2$$

The centertags option (the default) vertically centers the equation number in a split subsidiary math environment.

11.5 Options 299

#### Limits

Options: intlimits

nointlimits default

The intlimits option places the subscripts and superscripts of integral symbols above and below the integral symbol rather than on the side in a displayed math formula—with this option you can use the \nolimit command to disable the option for one integral. The nointlimits option positions the subscripts and superscripts of integral symbols on the side.

Options: sumlimits default

nosumlimits

The sumlimits option places the subscripts and superscripts of large operators, such as  $\sum$ ,  $\prod$ ,  $\bigcup$ ,  $\bigotimes$ ,  $\bigoplus$ , above and below the large operator in a displayed math formula. nosumlimits positions them on the side (see Table 7.5 and Section B.7.1).

Options: namelimits default nonamelimits

The namelimits option places the subscripts and superscripts of operators with limits such as det, inf, lim, max, min, and so on, above and below the operator in a displayed math formula. nonamelimits positions them on the side (see Tables 7.2, 7.3, and Section B.7).

#### Two-sided printing

Options: twoside default

oneside

The twoside option formats the output for printing on both sides of the paper. The alternative is the oneside option. This option influences running heads, the placement of page numbers, and so on.

#### Two-column printing

Options: twocolumn

onecolumn default

The twocolumn option typesets the document in two columns.

#### Title page

Options: titlepage

notitlepage default

The titlepage option creates a separate title page including the abstract.

The notitlepage option splits the top matter between the first and last pages of the typeset article.

#### Draft

Options: draft

final default

The draft option prints a slug in the margin next to each line that is too wide. The final option does not. Note that this option is passed on to some packages, such as graphicx.

#### **Fonts**

Option: noamsfonts

With this option, the document class does not load the packages necessary for the use of the AMSFonts font set.

Option: psamsfonts

The psamsfonts option tells LATEX to use the PostScript version of the AMSFonts set.

#### No math

Option: nomath

By default, amsart loads the amsmath package (which, in turn, loads three more math packages). If you want to use the title page and related features without the math features, you can use the nomath option.

# 11.6 The AMS packages

If you follow the recommendation of this book and begin each article with

```
\documentclass{amsart}
\usepackage{amssymb,latexsym}
```

then you can safely ignore most of the information in this section. There are two minor exceptions, the packages amsxtra and upref.

However, if you use a document class that does not load the same packages that amsart loads, then you have to load the packages needed for your work. Typically, you have

```
\usepackage{amsmath,amsfonts,amsthm}
\usepackage{amssymb,latexsym}
```

as a minimum.

The AMS distribution contains many packages that can be loaded together or by themselves.

#### Math enhancements

- amsmath The primary math enhancement package, which loads the four packages, amsgen, amsbsy, amsopn, and amstext.
- amsbsy Provides two commands for the use of bold math symbols, \boldsymbol and \pmb (see Section 8.3.3).
- amscd Commands for creating simple commutative diagrams (see Section 9.8).
- amsgen An auxiliary package that is never invoked directly. It is loaded by all the AMS math packages (except for upref).
- amsopn Provides operator names and also the \DeclareMathOperator command for defining new ones (see Section 7.6).
- amstext Defines the \text command and redefines commands such as \textrm and \textbf to behave like the \text command (see Section 7.4.6).
- amsxtra Provides the "sp" math accents (see Sections 7.7 and B.8) and loads the amsmath package.
- upref Ensures that the \ref command always produces upright numbers.

#### **AMSFonts**

amsfonts Contains the basic commands needed to utilize the AMSFonts. It also defines the \mathfrak command which makes the Euler Fraktur math alphabet available (see Section 8.3.2). If you use the PostScript AMSFonts font set, you should load this package with the option

\usepackage[psamsfonts]{amsfonts}

In addition, if you want to use the 12pt document class option, then you must also load the exscale package (see Section 12.3):

\usepackage{exscale}

amssymb Defines the symbol names for amsfonts. It loads amsfonts.

eucal Replaces the calligraphic math alphabet with the Euler Script math alphabet (see Section 8.3.2). If you load it with the option mathscr, as in

\usepackage[mathscr]{eucal}

then both the \mathscr and the \mathcal commands are available, so you can have both  $\mathcal{CE}$  and  $\mathcal{CE}$ , typed as

\$\mathcal{C}\mathcal{E}\$ and \$\mathscr{C}\mathscr{E}\$

eufrak Defines the Euler Fraktur math alphabet (see Section 8.3.2).

#### Loading packages

amsart contains code to provide more flexible formatting of proclamations and the proof environment (see Sections 6.4.2 and 6.5). By loading the amsthm package you can add this functionality to a non-AMS document class. The amsthm package loads the amsgen package.

amsart loads four packages from the math enhancements group, the amsmath, amsbsy, amstext, amsopn, and amsgen packages, and the amsfonts package from the AMSFonts group.

A typical article using the legacy article document class (see Section 12.1) and the AMS enhancements would normally have

\documentclass{article}

\usepackage{amsmath}% math enhancements

\usepackage{amssymb,latexsym}% AMSFonts and LaTeX symbol names \usepackage{amsthm}% proclamations with style

and perhaps the following:

\usepackage{eucal}% Euler Script

Note that it is not critical for you to remember which packages load others. No harm is done if you type

\usepackage{amsmath}

\usepackage{amsbsy}

The amsbsy package is loaded by the amsmath package, and the

\usepackage{amsbsy}

line is ignored by LATEX.

All the math related options of amsart (see Section 11.5) are also options of the amsmath package. So, for instance, if you want the equation numbers on the right, load amsmath with the requo option:

\usepackage[reqno]{amsmath}

#### Multiple indices

The AMS distribution also contains the package amsmidx for creating multiple indices. This package is discussed in Section 17.5.

# Legacy document classes

Even though the AMS spent a few decades refining the amsart document class, some of the legacy document classes of LATEX are still around. If you want to whip up a quick report or write up a research note, the legacy article or report document classes may serve you well.

In this chapter, we discuss some of the legacy LaTeX document classes. We take up the book document class in Chapter 18.

We do not discuss the slides document class for preparing slides. It is now considered obsolete. Use instead the beamer class which we discuss in Chapter 14 or the FoilTeX class discussed in Section 4.4.

We conclude this chapter with a description of the components of the standard LaTeX distribution.

# 12.1 Articles and reports

The article and report document classes are very similar. There are two substantive differences to remember:

 The report document class provides a separate page for the abstract by default, the article document class does not. 2. The report document class has two additional sectioning commands, \chapter and \part. We discuss these commands in Section 18.1.1.

In the samples folder (see page 4) is the document legacy-article.tex, a variant of the introductory sample article, intrart.tex of Chapter 4. The first page of this is typeset on the following page.

# *12.1.1 Top matter*

For a detailed discussion of the top matter, refer to Chapter 10, in particular Sections 10.1 and 10.3—see also Figure 10.1. Here is the top matter of the legacy article:

There are four commands for the top matter: \title, \author, \thanks, and \date.

#### Rule ■ Top matter for the article document class

- 1. If necessary, break the title into separate lines with \\. Do not put a \\ at the end of the last line.
- 2. \thanks places a footnote at the bottom of the first page. If it is not needed, omit it.
- 3. Separate the lines of the address with \\. Do not put a \\ at the end of the last line.
- 4. Multiple authors are separated by \and. There is only one \author command, and it contains *all the information*—name, address, support—about *all the authors*. There is no \\ command before the \and command.
- 5. If there is no \date command, LaTeX will insert the date on which you typeset the file (\date{\today} will produce the same result). If you do not want *any* date to appear, type \date{}. For a specific date, such as February 21, 2007, type \date{February 21, 2007}.
- 6. The \title command is the only required command. The others are optional.

# A construction of complete-simple distributive lattices

George A. Menuhin\*
Computer Science Department
Winnebago, MN 23714
menuhin@cc.uwinnebago.edu

March 15, 2006

#### Abstract

In this note, we prove that there exist *complete-simple distributive lattices*, that is, complete distributive lattices in which there are only two complete congruences.

# 1 Introduction

In this note, we prove the following result:

**Theorem 1** There exists an infinite complete distributive lattice K with only the two trivial complete congruence relations.

# 2 The $\Pi^*$ construction

The following construction is crucial in the proof of our Theorem:

**Definition 1** Let  $D_i$ , for  $i \in I$ , be complete distributive lattices satisfying condition (J). Their  $\Pi^*$  product is defined as follows:

$$\Pi^*(D_i \mid i \in I) = \Pi(D_i^- \mid i \in I) + 1;$$

that is,  $\Pi^*(D_i \mid i \in I)$  is  $\Pi(D_i^- \mid i \in I)$  with a new unit element.

Notation 1 If  $i \in I$  and  $d \in D_i^-$ , then

$$\langle \dots, 0, \dots, d, \dots, 0, \dots \rangle$$

is the element of  $\Pi^*(D_i \mid i \in I)$  whose i-th component is d and all the other components are 0.

<sup>\*</sup>Research supported by the NSF under grant number 23466.

As you see, the rules for the \date command here differ slightly from the rules for the \date command in the amsart document class. However, the rules for the command \author here are *very different* from the rules for the \author command in the amsart document class.

For two authors use the following template:

```
\author{name1\thanks{support1}\\
   address1line1\\
   address1line2\\
   address1line3
   \and
   name2\thanks{support2}\\
   address2line1\\
   address2line2\\
   address2line3}
```

Note the use of the \and command, which separates the two authors.

One more difference to keep in mind. Place the abstract after the  $\mbox{\tt maketitle}$  command.

## 12.1.2 **Options**

The article and report document classes have a similar range of options. These are listed below.

#### Font size

```
Options: 10pt default 11pt 12pt
```

Each option declares the specified size to be the default font size.

#### Paper size

```
Options: letterpaper (8.5 inches by 11 inches) default legalpaper (8.5 inches by 14 inches) executivepaper (7.25 inches by 10.5 inches) a4paper (210 mm by 297 mm) a5paper (148 mm by 210 mm) b5paper (176 mm by 250 mm)
```

#### Draft

```
Options: draft
```

final default

The draft option places a slug in the margin next to each line that is too wide (see Section 2.3). The final option does not. Note that this option is passed on to some packages, such as graphicx. To prevent this, invoke graphicx with the final option.

## Landscape printing

Option: landscape

The landscape option typesets the document in landscape format, swapping the width and height of the paper.

## Two-sided printing

Options: twoside

oneside default

The twoside option formats the output for printing on both sides of the paper.

## Two-column printing

Options: twocolumn

onecolumn default

The twocolumn option typesets the document in two-column format. This option has many problems. It is better to use the multicol package (see Section 12.3.1).

## Title page

Options: titlepage default for report notitlepage default for article

The titlepage option creates a separate title page and places the abstract on a separate page. The notitlepage option places the title and the abstract together on the first page.

## Equations and equation numbers

Options: leqno

reqno default

The lequo option places any equation number in the document on the left side and requo places them on the right.

Option: fleqn

The fleqn option sets displayed formulas flush left. This option is typically used in conjunction with the reqno option.

[1] Soo-Key Foo.

Lattice Constructions.

PhD thesis, University of Winnebago, Winnebago, MN, December 1990.

[2] George A. Menuhin.

Universal Algebra.

D. Van Nostrand, Princeton, 1968.

[3] Ernest T. Moynahan.

Ideals and congruence relations in lattices. II.

Magyar Tud. Akad. Mat. Fiz. Oszt. Közl., 7:417–434, 1957.

[4] Ernest T. Moynahan.

On a problem of M. Stone.

Acta Math. Acad. Sci. Hungar., 8:455-460, 1957.

[5] Ferenc R. Richardson.

General Lattice Theory.

Mir, Moscow, expanded and revised edition, 1982.

Figure 12.1: The openbib option.

## **Bibliography**

Option: openbib

The openbib option typesets the bibliography in a spread out "open" format (see Figure 12.1).

#### **Combinations**

Of course, these options can be combined with each other and are also used by most legacy document classes. For instance,

\documentclass[12pt,a4paper,twoside,twocolumn]{report}

produces a double-columned, two-sided report on A4 paper, the European standard, at the 12-point font size.

# 12.2 Letters

The letter document class was developed for writing letters. One document can contain any number of letters, each in its own letter environment. In the following example (letter.tex in the samples folder) there is only a single letter:

```
% Sample file: letter.tex
\documentclass{letter}
```

12.2 Letters 309

```
\begin{document}
\address{George Gr\"{a}tzer\\
         Department of Mathematics\\
         University of Manitoba\\
         Winnipeg, MB, R3T 2N2\\
         Canada }
\signature{George Gr\"{a}tzer}
\date{}
\begin{letter}{Prof.~John Hurtig\\
                Computer Science Department/\
                University of Winnebago\\
                Winnebago, Minnesota 23714}
\opening{Dear John,}
Enclosed you will find the first draft of the
five-year plan.
\closing{Friendly greetings,}
\cc{Carla May\\
    Barry Bold}
\encl{Five-year plan}
\ps{P.S. Remember our lunch meeting tomorrow! G.}
\end{letter}
\end{document}
    Figure 12.2 shows the typeset letter.
    The argument of the letter environment is the name and address of the recipient.
It is a required argument and if it is omitted, you get an error message such as
! Incomplete \iffalse; all text was ignored
                                          after line 21.
```

As with all multiline arguments, the lines are separated by \\.

<inserted text>

1.21 \end{letter}

\fi

The arguments of some commands may apply to all the letter environments in the document. Such commands should be placed before the first letter environment. In the example, \signature and \address are so placed.

If the \date command is absent, today's date is typeset. If you want no date, use an empty argument \date{}, as in the example. If you want all the letters in the same document to have the same date, the \date command should precede the first letter environment.

George Grätzer Department of Mathematics University of Manitoba Winnipeg, MB, R3T 2N2 Canada

Prof. John Hurtig Computer Science Department University of Winnebago Winnebago, Minnesota 23714

Dear John,

Enclosed you will find the first draft of the five-year plan.

Friendly greetings,

George Grätzer

cc: Carla May Barry Bold

encl: Five-year plan

P.S. Remember our lunch meeting tomorrow! G.

Figure 12.2: A letter.

Many of the options listed in Section 12.1.2 can also be invoked for the letter document class.

# 12.3 The LATEX distribution

The LATEX distribution contains a number of document classes and packages, most of which you have probably received with your TEX software. If you find that you are missing some files, see Section E.1 on how to get them.

The files of the LATEX distribution on CTAN are grouped in the directory

/pub/tex/macros/latex

into four subdirectories.

base contains all the files necessary to install the system. As a rule, for every package, say, exscale, it contains two files, exscale.ins and exscale.dtx. Typesetting the first gives you exscale.sty and typesetting the second produces the user guide and the commented source code. Since most LATEX implementations install the content of the unpacked directory, this directory is not for the average user.

doc contains LATEX documentation in PDF files and also the LATEX News.

required contains the directories amslatex, babel, cyrillic, graphics, psnfss, tools.

unpacked contains the unpacked LATEX distribution. Since most LATEX implementations install this, you may never need it.

Of the packages and tex files included in the unpacked folder, the following should be of special interest to readers of this book.

latexsym Some symbol definitions (see the tables in Appendix B).

alltt The alltt environment, which is like the verbatim environment except that \, and {, } retain their usual meanings.

exscale Scaled versions of the math extension font.

makeidx Commands for producing indexes (see Chapter 17).

showidx A package to allow you to typeset the index entries in the margin of your typeset document (see Section 17.1).

nfssfont.tex Generates font tables for use with the \symbol command (see Section 5.4.4).

There is also the file fixltx2e.sty in the unpacked directory (and the corresponding fixltx2e.dtx and fixltx2e.ins in the base directory). This file contains fixes to latex.ltx, the main LTEX file, and also some new commands that did not make it into the current release. The last fixltx2e.sty (Dec. 2005) contains two important additions. It complements the \textsuperscript command (see Section C.4) with a \textsubscript command.

More importantly, it introduces a very useful new command \TextOrMath. This command has two arguments and it typesets the first in text and the second in math. For instance, if in newlattice.sty (see 15.3) you define

\newcommand{\Gra}{\TextOrMath{\$\alpha\$\xspace}{\alpha}}

then you can type \Gra in both test and math. Indeed.

this is \Gra in text, and this is \$\Gra - x^2\$ in math

```
typesets as \text{this is } \alpha \text{ in text, and this is } \alpha - x^2 \text{ in math}
```

If you want to use these commands, include the line

```
\usepackage{fixltx2e}
```

in the preamble.

In the required folder there are some major software distributions related to LATEX.

amslatex Discussed in detail in this book, this directory contains the AMS math packages and document classes, while the font-related AMS files are in the directory

```
/tex-archive/fonts/amsfonts/latex/
```

babel For typesetting languages other than American English.

cyrillic For typesetting Cyrillic characters.

graphicx For the inclusion and transformation of graphics and for typesetting in color (see Section 10.4.3). This package requires that you have a suitable printer driver.

psnfss For typesetting with a wide range of PostScript fonts (see Section F.1).

tools A range of tools for managing document production discussed in the next section.

Each of these packages comes with its own documentation. They are also described in *The LATEX Companion*, 2nd edition [46].

## 12.3.1 Tools

Some of these packages are so important that they could well have been incorporated into LATEX proper. Here is a brief listing.

afterpage Implements the \afterpage command. The commands specified in its argument are expanded after the current page is output.

array Contains extended versions of the array and tabular environments with many extra features.

bm Gives access to bold math symbols.

calc Allows algebraic manipulation of lengths and counter values when specifying lengths and counters.

dcolumn Provides alignment on decimal points in tabular entries. It requires the array package.

delarray Adds "large delimiters" around arrays. It requires the array package.

enumerate Provides customized enumerate environments (see Sections 6.2.4 and also Sections 15.2.1, 15.3, 15.4).

fileerr Helps with missing files.

fontsmpl Produces a test file for displaying "font samples".

ftnright Places all footnotes in the right-hand column of documents typeset with the twocolumn document class option.

hhline Provides control over horizontal lines in tables.

indentfirst Indents the first paragraph of each section.

layout Shows the page layout defined by a document class (see Section 10.6).

longtable Helps to create multipage tables. It does not require the array package, but it uses array's extended features if both packages are loaded.

multicol Provides multicolumn typesetting with some advanced features.

rawfonts Preloads fonts using the old font names of LATEX 2.09.

showkeys Selectively prints the labels used by \label, \ref, \cite, and so forth, in the margin (see Section 10.4.2).

somedefs Elective handling of package options. It is used by the rawfonts package.

tabularx Defines a variant of the tabular environment where all the columns are the same width. It requires the array package.

theorem Allows the definition of proclamations in flexible formats. The AMS variant, the amsthm package, is discussed in Section 6.4.2.

trace Tracing help for macro writers.

varioref Provides smart as well as multilingual handling of page references.

verbatim Extends the verbatim environment and provides the comment environment (see Sections 5.5.1 and 6.8).

xr Creates cross-references among documents.

xspace Provides a "smart space" command that helps you avoid the common mistake of missing space after commands. It is mainly used in commands that expand to some text (see Section 15.1.1).

All of these packages are discussed in *The LATEX Companion*, 2nd edition [46].

CHAPTER

# PDF documents

# 13.1 PostScript and PDF

# 13.1.1 PostScript

PostScript is the preeminent platform and device independent page-description and programming language, introduced by Adobe Systems Inc. It describes the placement and shapes of all the elements in the document, including the fonts. Documents placed on the Web in PostScript format can be downloaded to any computer and print identically on all PostScript printers. Until the appearance of PDF, PostScript was the format of choice for sharing Late articles with diagrams or complex forms. There are a number of disadvantages to using PostScript files on the Web:

- The files tend to be very large.
- They cannot be viewed until the whole file has been downloaded.
- If a PostScript file does not include a particular font used in the document and you do
  not have that font installed on your computer, then another font—usually Courier—
  is substituted causing graphically unacceptable rendering.

## 13.1.2 PDF

All of these concerns have been addressed by Adobe's Portable Document Format (PDF). See Adobe Systems' *PDF Reference*, *Version 1.6*, 5th edition [2] for a complete description of this file format.

PDF is based on the PostScript language, with some important differences:

- PDF is much more concise than PostScript. A PDF file is normally about 10 percent of the size of the corresponding PostScript file.
- Missing fonts are usually substituted by fonts with the same metrics, so that the size of the substituted text is the same as that of the original. In particular, there are no incorrect line breaks caused by the substitution.
- PDF files allow *partial inclusion of fonts*. As a result, it is much easier to obtain permission to include proprietary fonts in PDF documents.
- PDF files can be downloaded and viewed in a Web browser one page at a time, without having to wait for the whole file to download first.
- Many LATEX implementations, including the two discussed in Appendix A, produce PDF files.

PDF files and Adobe Acrobat Professional offer many nice features, including:

- Efficient navigational tools
- Searching and indexing capability for documents and even for collections of documents
- Bookmarks
- Thumbnails of pages
- Limited editing
- Annotations (notes, text, and voice) and markups
- Hyperlinks to the same document or to another document or Web site (see Section 13.1.3)
- The inclusion of programs, particularly JavaScript
- The creation of interactive features
- The inclusion of multimedia objects such as video and sound files

If you use a LATEX implementation that produces the typeset file in PDF format, then you already have the file you need. If not, the typeset file will be a DVI file,

and you have to convert it to PDF format. Usually, this is a two step process. First you convert the DVI file to PostScript and then from PostScript to PDF.

On a Mac, just click on a PostScript file and it is converted to PDF.

If you have a PostScript printer, you can "print to file" to create the PostScript version. To convert from Postscript to PDF, you need special software such as Adobe Acrobat Professional—free utilities to do this are also available for all operating systems. When downloaded, a PDF file can be read and printed using Adobe Reader (or some other PDF viewer). Adobe Reader is available from Adobe free of charge for a PC, Mac, and some UNIX variants (see Section E.1 on how to get it).

PDF files can also be used to make legacy documents available on the Internet. For instance, if you go to my home page,

http://www.maths.umanitoba.ca/homepages/gratzer/

and click on Mathematical articles, then 1980-89, in the bottom frame you will find entry 102, which links to a PDF file. I created that PDF file by scanning the pages of the original article, converting them to PDF files (with Adobe Photoshop), and finally stringing them together into a single document (using Adobe Acrobat Professional). The scanned pages totalled 32 MB, the PDF file is 320 KB. The printed version of the PDF file is somewhat lower in quality than the original, but it is still quite satisfactory. See my article [32] on some practical pointers about scanning and PDF files.

# 13.1.3 Hyperlinks

With Adobe Acrobat Professional you can place *hyperlinks* in PDF documents. Clicking on a hyperlink, you jump to another location in the same document, to an electronic document, or to a Web site. For instance, in the table of contents, you can put a hyperlink to Chapter 3, so that clicking on it takes you to Chapter 3. Adobe Acrobat's help system has ample information on how to set up links.

# 13.2 Hyperlinks for LATEX

It is tedious to set hyperlinks one at a time in your PDF file. Would it not be nice if hyperlinks corresponding to cross-references were set automatically? For instance, clicking on <u>Lemma 6</u> in

This follows from  $\underline{\text{Lemma } 6}$  and the relevant definitions.

would cause the display to jump to the page containing Lemma 6.

Sebastian Rahtz's hyperref package (maintained now by Heiko Oberdiek) does just that (see Section E.1 on how to get it).

# 13.2.1 Using hyperref

You invoke the hyperref package with the command

\usepackage{hyperref}

as the *last* \usepackage line in the preamble of your Lagar document. If this does not do the job, try this format, specifying the printer driver:

\usepackage[driver] {hyperref}

The *driver* is one of hypertex, dvips, dvipsone, ps2pdf, tex4ht, pdftex, dvipdf, dvipdfm, dvipdfmx, dviwindo, vtex, textures. If none of these work, you are out of luck.

Figure 13.1 shows a page fragment from a mathematical article with hyperlinks to some sections, theorems, and citations automatically created by hypertex.

The construction of the uniquely complemented lattice representing a given monoid is introduced in Section 4. It is based on V. Koubek and J. Sichler [12]. Section 5 proves that this construct has many simple sublattices. Finally, in Section 6, we put all these pieces together to construct the lattice L for the Main Theorem.

To prove <u>Theorem 1</u>, we need a different construction, which is presented in <u>Section 7</u>.

Figure 13.1: The hyperref package with the \autoref command.

See Section 13.2.4 for the autoref command. To see how hypertex works, look up the sampart-ref.tex article in the samples folder. It is the sample article enhanced with the hyperref package. The article uses the hyperref options

pagebackref, colorlinks, bookmarks=true

See Section 13.2.2 for the pagebackref and colorlinks options. The third option, bookmarks=true is discussed in Section 13.2.3.

Copy sampart-ref.tex into the work folder and typeset it twice. The PDF file created for you has some of the hyperref features, but not all. Open the pdf file with Adobe Reader. Look at the left pane. Bookmarks is a table of contents of the article, with links to the named sections. Pages is a thumbnail sketches of the pages, with links to them.

## 13.2.2 backref and colorlinks

A useful addition to hyperref is David Carlisle's backref package. It is invoked as an option of hyperref:

\usepackage[backref]{hyperref}

The items in your bibliography will be followed by a list of sections in which the bibliographic reference is cited. Each number printed after the cited reference becomes a hyperlink to the relevant section. Alternatively, you can use the pagebackref option, which produces a list of page numbers. Figure 13.2 shows a page fragment from a bibliography displaying lists of section numbers. backref can be used to check if all items in the bibliography have actually been referenced in the article. Any reference that has not been cited does not have a page listed.

```
[10] G. Grätzer and J. Sichler, On the endomorphism semigroup (and category) of bounded lat-
tices, Pacific J. Math. 35 (1970), 639–647. 1, 1
```

Figure 13.2: The hyperref package with the backref option.

Another popular option is colorlinks, which colors the text of the links instead of underlining them.

## 13.2.3 Bookmarks

An important navigational feature of Acrobat is the ability to set and use bookmarks. If you choose View>Navigation Tabs>Bookmarks in Adobe Reader, the navigation pane opens up showing the bookmarks.

For a sophisticated example, in Adobe Reader, view Adobe Reader Help, the menu item Help>Adobe Reader Help.... The bookmarks form a table of contents. Clicking on a chapter title bookmark displays the first page of the chapter or its table of contents in the main pane. Click on the triangle next to the left of the chapter title bookmark. It opens up the chapter title to show the sections within the chapter, which are links to the sections.

The hyperref package option bookmarks=true makes bookmarks from the sectioning commands of the LATEX document, thereby producing a table of contents even if the document had none. You can invoke all these options together:

```
\usepackage[backref,colorlinks,bookmarks=true]{hyperref}
```

Typesetting your LATEX document with the bookmarks=true option produces an out file, which contains entries such as

```
\BOOKMARK [1][-]{section.1}{1. Introduction}{} \BOOKMARK [1][-]{section*.2}{References}{}
```

Once you have produced the final version of your document, you should edit this file to make sure that it contains no LATEX code. Math formulas in titles create havoc. So do

<sup>[11]</sup> \_\_\_\_\_, On the endomorphism monoid of complemented lattices, AMS Abstract 97T-06-98.

<sup>[12]</sup> V. Koubek and J. Sichler, Universality of small lattice varieties, Proc. Amer. Math. Soc. 91 (1984), 19–24. 1, 2, 4, 4.2, 4.3, 4.3, 4.3, 7

<sup>[13]</sup> H. Lakser, Simple sublattices of free products of lattices, Abstract, Notices Amer. Math. Soc. 19 (1972), A 509. 1, 3, 3

accented characters. hyperref does its best to convert internal encodings for accented characters to the encoding used by Acrobat Reader, but it is still best to avoid them. Once this file has been edited, add the line

\let\WriteBookmarks\relax

at the start of the file to prevent it from being overwritten.

## 13.2.4 Additional commands

The hyperref package has dozens of commands and parameters, but we will discuss only four more commands.

## Preventing links

If you do not want a \ref or \pageref command to appear as a link, you can use their \*-ed forms, \ref \* and \pageref \*.

## Long links

An often heard complaint is that in the link Theorem  $\underline{6}$ , only the  $\underline{6}$  can be clicked to activate the link, and it is too short. hyperref provides the \autoref command to help out. Instead of

```
Theorem~\ref{T:new}
you can simply type
\autoref{T:new}
```

and hyperref will provide the word Theorem so that the link becomes <u>Theorem 6</u>. The names supported by the \autoref command are listed in Table 13.2.4.

For my own use, I redefine:

```
\renewcommand{\chaptername}{Chapter}
\renewcommand{\sectionname}{Section}
\renewcommand{\subsectionname}{Section}
\renewcommand{\subsubsectionname}{Section}
```

## External links

External links can be links to websites or other files that are located on the Internet. Use the

```
\href{address}{text}
```

Command	Meaning
\figurename	Figure
\tablename	Table
\partname	Part
\appendixname	Appendix
\equationname	Equation
\Itemname	item
\chaptername	chapter
\sectionname	section
\subsectionname	subsection
\subsubsectionname	subsubsection
\paragraphname	paragraph
\Hfootnotename	footnote
\AMSname	Equation
\theoremname	Theorem

Table 13.1: Redefinable names supported by \autoref.

command to typeset text and make it into a link to the Web address (URL). For instance, in your references, you may have

```
Robert Miner and Jeff Schaefer,
\emph{Gentle intoduction to MathML.}\\
\href{http://www.webeq.com/mathml/gitmml/}
{http://www.webeq.com/mathml/gitmml/}
```

Then the last line of the address becomes a link and clicking on it takes you to the Web site. As an even fancier example, note the top matter command \urladdr (see Section 11.2.2) in sampart-ref.tex:

```
\urladdr{\href{http://math.uwinnebago.edu/menuhin/}
http://math.uwinnebago.edu/homepages/menuhin/}
```

Then, as part of Menuhin's address, you will find

http://math.uwinnebago.edu/menuhin/

Now clicking on the Web address will link to his Web page.

hyperref, of course, offers a lot more than I have presented here. For more detail, see the user manual and *The LATEX Web Companion* [18].

# Presentations

In Section 4.4, we describe how a *presentation* is a PDF file that you open with Adobe Reader. You can put it in full screen mode<sup>1</sup> (View>Full screen), and then project the presentation one page at a time by pressing the space bar or the arrow keys.

Remember overhead transparencies? If we want to see half of what is on the transparency, we cover up the bottom part so that only the top part is projected. This way we have control over what the audience sees and when. We sometimes used overlays: placing another transparency on top of the projected one to modify it by adding text or graphics.

In this chapter, we discuss Till Tantau's beamer package to help you prepare presentations with overlays and with stunning visual effects. beamer relies on other packages such as the hyperref package (see Section 13.2) to establish links, Till Tantau's Portable Graphics Format package for creating graphics, Uwe Kern's xcolor package for coloring, the AMS packages for formatting math formulas and defining declarations, and some others.

The documentation for these packages runs to about a thousand pages. The good news is that you can use beamer "out of the box". You only have to learn about 20

<sup>&</sup>lt;sup>1</sup>If you have Adobe Acrobat Pro, open File>Document Properties and check mark Full Screen Mode. Then the PDF document automatically opens in full screen mode.

commands—this is more than the **one** new command we had to learn in Section 4.4 but still an easily manageable task.

So we set ourselves in this chapter a modest goal, using beamer "out of the box". It is amazing how much you can achieve with a small investment of your time.

**Getting started** First, you need to install beamer. If you installed MikTeX for your PC or TeXShop for your Mac as described in Appendix A, beamer is already installed for you. Otherwise, consult Section E.1 on how to get it.

Second, the tex file created for beamer has to be turned into a PDF file to make it into a presentation. For MikTeX, click on the PDF TeXify icon and for TeXShop, just click on Typeset. For other TeX installations, check the user manual on how to create a PDF output.

# 14.1 Quick and dirty beamer

We convert the article intrart.tex (in the samples folder) to a beamer presentation. We will remove some commands that are appropriate for an article but not for a presentation and add some commands—such as the frame commands—that are specific to presentations. This will not produce a very good presentation. Nevertheless, the conversion is a really quick introduction to some basic beamer concepts.

# 14.1.1 First changes

Open intrart.tex, save it as quickbeamer.tex in the work folder. The converted tex version and the presentation quickbeamer.pdf are both in the samples folder.

Make the following changes in the preamble and top matter:

- Change the first line to
   Introductory beamer presentation: quickbeamer.tex
- 2. Change the document class to beamer.
- 3. Delete the six \usepackage and \newtheorem lines—beamer loads the necessary packages and defines these declarations.
- 4. Change the \address to \institute—this is the beamer command for address.
- 5. Delete the abstract environment—this is not needed for the presentation.

Here is the new version of the preamble and top matter.

```
%Introductory beamer presentation: quickbeamer.tex
\documentclass{beamer}
\begin{document}
\title{A construction of complete-simple\\
```

## 14.1.2 Changes in the body

1. Delete the notation and proof environments, but not the contents, that is, delete the four lines

```
\begin{notation}
\end{notation}
\begin{proof}
\end{proof}
```

Both environments could theoretically stay, but the notation environment is not needed since in the next step we put Notation in the frame title. The proof environment is not suitable for presentations because it can only be used within a frame (see Section 5.3.2).

Cut the presentation into frames (pages, transparencies, foils) with the frame environments. After each \begin{frame} we put a \frametitle command. The argument of the command is the "title" for the frame, displayed prominently at the top of the display.

It would be tedious to give you precise instructions on how to do this, instead refer to the quickbeamer.tex document (in the samples folder) for all the frame environments and \frametitle commands we have added.

3. Cut out the figure environment, except for the line

```
\centering\includegraphics{products}
which should be moved to follow the
\frametitle{Illustrating the construction}
line and accordingly delete (see Figure~\ref{Fi:products}).
```

Now copy over the illustration products from the samples folder to the work folder and typeset. That's it, enjoy your first presentation.

## 14.1.3 Making things prettier

Now you make some small changes to quickbeamer.tex to utilize beamer's power for wonderful effects. Changes 1 and 3 are quite dramatic.

Save quickbeamer.tex with the name quickbeamer1.tex in the work folder. The edited version,quickbeamer1.tex, is in the samples folder along with the presentation quickbeamer1.pdf.

- 1. Add \usetheme{Berkeley} after the documentclass line.
- 2. Change \maketitle to

```
\begin{frame}
  \titlepage
  \end{frame}
```

Make sure that the last (sub)section is followed by a frame, otherwise it will be missing from the table of contents.

3. Add this frame after the titlepage frame:

```
\begin{frame}
\frametitle{Outline}
\tableofcontents[pausesections]
\end{frame}
```

This creates a table of contents frame, with the section titles appearing one at a time.

- 4. Replace all instances of {equation} by {equation\*}. In a presentation a reference to another frame is not recommended so equations should not be numbered. You might as well delete all the \label commands since these are not needed either.
- 5. In the second to last frame there are two references to equation numbers. Replace the text the congruence \eqref{E:cong2} with the congruence, and also replace \eqref{E:comp} with the penultimate equation, or similar.
- 6. Change the bibliographic reference to See also Ernest T. Moynahan, 1957.

Turning quickbeamer1.tex into a PDF file will get you a much prettier presentation. The first four pages of the new presentation are displayed in Figures 14.1 and 14.2—unfortunately, without the pretty colors.

# 14.1.4 Adjusting the navigation

Looking at Figures 14.1 and 14.2, we see that the Berkeley theme turns the sidebar into a navigation device and the section titles produce the table of contents (the Outline frame). Remember to typeset a few times! But a number of problems come to light.

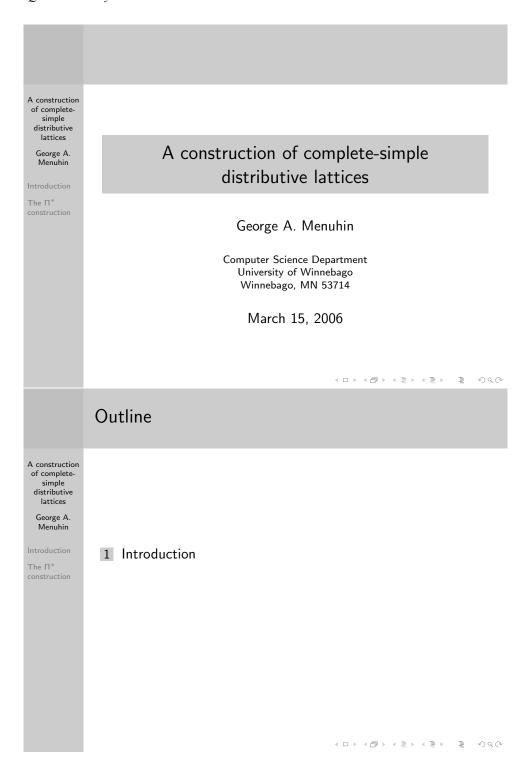


Figure 14.1: quickbeamer1 presentation, pages 1 and 2.

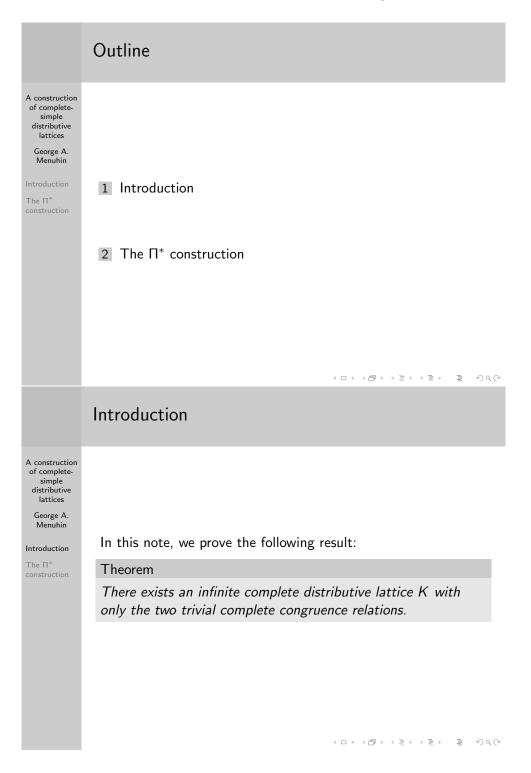


Figure 14.2: quickbeamer1 presentation, pages 3 and 4.

- 1. The title of the presentation is too long for the sidebar, so is the title of the second section.
- 2. There is no need to repeat the author's name in the sidebar.
- 3. It was natural for the article intrart.tex to have only two sections. But sections play a different role in a beamer presentation, they are navigation tools. The sidebar lists all the sections. It also highlights the section we are in. Moreover, by clicking on the name of a section, the presentation jumps there.

To correct these deficiencies, save the file quickbeamer1.tex as quickbeamer2.tex in the work folder. The edited version is in the samples folder along with the PDF file.

1. Change the \title command to

```
\title[Complete-simple distributive lattices]%
{A construction of complete-simple\\
distributive lattices}
and the second \section command to
\section[Construction]{The $\Pi^{*}$$ construction}
```

The bracketed parts are the short versions used in the sidebar.

2. Change the \author command to

```
\author[]{George~A. Menuhin}
```

before the frame of the same name.

The short version of the author command is blank, so the author's name will not be displayed in the sidebar.

3. Add the command

```
\section[Second result]{The second result}
before the frame of the same title and
\section{Proof}
before the proof. We even add
\section{References}
```

Figure 14.3 shows page 7 of the quickbeamer2 presentation—this corresponds to page 4 of the quickbeamer1 presentation; the Outline accounts for the difference. Note how all the deficiencies listed above have been corrected. Compare page 7 of this presentation with the Berkeley theme in Figure 14.3 and with the Warsaw theme in Figure 14.4. Themes are discussed in Section 14.5.

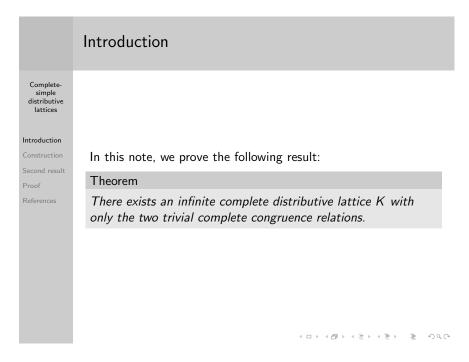


Figure 14.3: quickbeamer2 presentation, page 7 with Berkeley theme.



In this note, we prove the following result:

# Theorem There exists an infinite complete distributive lattice K with only the two trivial complete congruence relations.

《□→《⑦→《意》《意》》 Complete-simple distributive lattices

Figure 14.4: quickbeamer2 presentation, page 7 with Warsaw theme.

# 14.2 Baby beamers

In the previous discussions you may have noticed two interesting features. First, the Outline frame (table of contents) created *two* pages in the quickbeamer1 presentation and *five* pages in the quickbeamer2 presentation. We discuss this in some detail now with the babybeamer presentations. You can find all the babybeamer presentations as tex and PDF files in the samples folder. Second, the sidebar shows some links. More about this in Section 14.2.7.

333

## 14.2.1 Overlays

The outline frame of the quickbeamer2 presentation created five pages in the PDF file. Observe how each page, from the second on, completely overlaps the previous one, making it appear that the previous one stayed put and an additional line is displayed "on top of it". In beamer terminology these pages are *overlays* or *slides*. The five overlays will be referenced as overlay 1, ..., overlay 5. A single frame may create one or many overlays. The subsequent sections discuss many more variants.

beamer has many commands creating overlays. We start with some examples of \pause, then \only, and \onslide.

We introduce overlays with some presentations. The first, babybeamer1, introduces the \pause command to create overlays.

```
% babybeamer1 presentation
\documentclass{beamer}
\begin{document}

\begin{frame}
\frametitle{Some background}

We start our discussion with some concepts.
\pause

The first concept we introduce originates with Erd\H os.
\end{frame}
\end{document}

produces the presentation of Figure 14.5.
```

# Rule ■ The \pause command

- **1.** A frame may have many \pause commands.
- **2.** The \pause command cannot be given in an AMS multiline math environment.

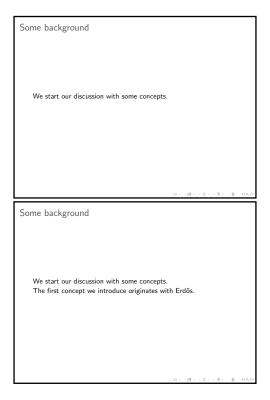


Figure 14.5: babybeamer1 presentation.

You move past a \pause command the same way as you get to the next frame, by pressing the space bar or the forward arrow key.

Using the \pause commands you can create many overlays, each containing a little more material on the overlays. If this is all you need, skip to Section 14.2.7, you do not need the more detailed discussion of overlays in the next few pages.

We could have coded the same presentation with the \only command:

```
% babybeamer2 presentation
\documentclass{beamer}
\begin{document}

\begin{frame}
\frametitle{Some background}

\only<1,2>{We start our discussion with some concepts.}

\only<2>{The first concept we introduce originates
    with Erd\H os.}
```

```
\end{frame}
\end{document}
```

This presentation is slightly different from babybeamer1. Overlay 1 ignores the second \only command and displays the line as appropriate to display one line. Overlay 2 displays the two lines as appropriate to display two lines. As a result, the first line moves slightly up when passing from overlay 1 to overlay 2. The argument of the \only command is typeset only on the overlays specified. On the other overlays, it is ignored.

If instead of the \only command you use the \onslide command (on slide, get it?), as in

```
\onslide<1,2>{We start our discussion with some concepts.}
\onslide<2>{The first concept we introduce originates
    with Erd\H os.}
```

then the first line of overlay 2 completely overlaps the first line of overlay 1, so the first line seems to stay put. The argument of the \onslide command is typeset on the overlays specified and on the other overlays it is typeset but invisible. This is the behavior you would want most often, but you may find that sometimes you prefer \only.

# 14.2.2 Understanding overlays

In Section 14.2.1 we introduced overlays, probably the most important new concept for presentations. LATEX typesets the content of a frame and the typeset material

- appears on all overlays for the parts of the source (maybe all) not modified by any command with an overlay specification;
- appears only on the overlays specified and is ignored on the other overlays for the arguments of the \only commands;
- appears on the overlays specified and is typeset but made invisible on the other overlays for the arguments of the \onslide commands.

More on overlay specifications at the end of this section. Here are some illustrations.

#### Example 1

```
This is a very \only<1>{very, very} important concept. \only<1,2>{To start the definition \dots} will typeset overlay 1 as
```

```
This is a very very, very important concept. To start the definition \dots
and will typeset overlay 2 as
    This is a very important concept. To start the definition . . .
Example 2
What is 2+2? It is \onslide<2>{$4$}.
\only<1>{Can you figure it out?}
\onslide<2>{I hope you all got it right.}
will typeset overlay 1 as
    What is 2 + 2? It is . Can you figure it out?
and will typeset overlay 2 as
    What is 2 + 2? It is 4.
    I hope you all got it right.
    Note that there is room in overlay 1 for the number 4.
Example 3
What is $2+2$?
\onslide<2>{It is {$4$}.}
Can you figure it out?
will typeset overlay 1 as
    What is 2 + 2?
    Can you figure it out?
```

```
and will typeset overlay 2 as

What is 2 + 2?

It is 4.

Can you figure it out?
```

Note that there is room in overlay 1 for the "missing" second line.

## Overlay specifications

The angle brackets contain the *overlay specification*. Here are some more examples:

```
<1-2,4-> means all overlays from 1 to 2, and all overlays from 4 onwards.
```

<-3> means all overlays up to 3.

<2,4,6> means overlays 2, 4, and 6.

In the presentation babybeamer2 we have two overlay specifications: <1,2> and <2>. Maybe, <1-> and <2-> would be better, so that if you add a third overlay you do not have to change these.

The command \pause can only take the simplest overlay specification, a number. \pause<3> takes effect from overlay 3 on.

Note that overlay specifications are attached to commands but the overlays created are overlays of the frame in which the commands appear.

# 14.2.3 More on the \only and \onslide commands

The \only and \onslide commands can accomplish everything the \pause command can and a lot more.

## The basic syntax

The syntax of \only is

```
\only<overlay spec>{source}
```

where overlay spec is the overlay specification and source is the code typeset by LATEX.

A (partial) syntax of \onslide is

```
\onslide<overlay spec>{source}
```

With the same syntax you can give overlay specifications to many commands, including \textbf, \textit, \alert—beamer's alternative to the \emph command—and then the command is in effect only on the overlays specified.

So the babybeamer3 presentation (see Figure 14.6) has two overlays, each with two lines of text. On overlay 1 the first line is bold, on overlay 2 the second line is bold.

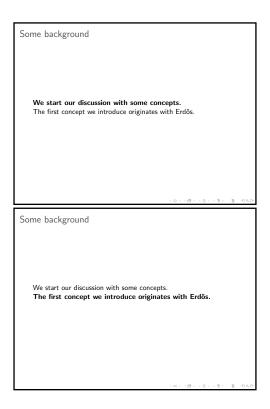


Figure 14.6: babybeamer3 presentation.

## A different syntax

```
The command \only has an alternate syntax:
\only{source} < overlay spec >
So
\only<1>{Can you figure it out?}
and
\only{Can you figure it out?}<1>
accomplish the same.

With this syntax, you can define your own commands that allow overlay specifications. For instance, using the command \color{blue} defined in Section 14.2.9, you can define the command
\newcommand{\myblue}{\only{\color{blue}}}
Then
\myblue<2>{Some more text}
will color the text blue on overlay 2 only.
```

# 14.2.4 Lists as overlays

Lists may be presented one item at a time, for example the babybeamer4 presentation in Figure 14.7 (in the samples folder) shows the four overlays of a list. R. Padmanabhan appears on the first, R. Padmanabhan and Brian Davey appear on the second, and so on. This is accomplished simply by adding the overlay specification <1-> to the item for R. Padmanabhan, the overlay specification <2-> to the item for Brian Davey, and so on.

```
% babybeamer4 presentation
\documentclass{beamer}
\begin{document}

\begin{frame}
\frametitle{Overlaying lists}

We introduce our guests:
\begin{itemize}
\item<1-> R. Padmanabhan
\item<2-> Brian Davey
```

Overlaying lists	
We introduce our guests:	
▶ R. Padmanabhan	
	(0) (8) (8) (8) 8 900
Overlaying lists	
Overlaying lists	
We introduce our guests:	
▶ R. Padmanabhan	
► Brian Davey	
	101151121121 2 990
Overlaving lists	
Overlaying lists	
We introduce our guests:	
We introduce our guests:  ▶ R. Padmanabhan	
We introduce our guests:  ► R. Padmanabhan  ► Brian Davey	
We introduce our guests:  ▶ R. Padmanabhan	
We introduce our guests:  ► R. Padmanabhan  ► Brian Davey	
We introduce our guests:  ► R. Padmanabhan  ► Brian Davey	
We introduce our guests:  ► R. Padmanabhan  ► Brian Davey	
We introduce our guests:  ► R. Padmanabhan  ► Brian Davey	
We introduce our guests:  ► R. Padmanabhan  ► Brian Davey	
We introduce our guests:  ► R. Padmanabhan  ► Brian Davey	
We introduce our guests:  ► R. Padmanabhan  ► Brian Davey	10 (8) (3) (3) 3 98
We introduce our guests:  ▶ R. Padmanabhan  ▶ Brian Davey  ▶ Harry Lakser	. D O E E E Q . Q . Q
We introduce our guests:  ► R. Padmanabhan  ► Brian Davey	· B · · · · · · · · · · · · · · · · · ·
We introduce our guests:  ▶ R. Padmanabhan  ▶ Brian Davey  ▶ Harry Lakser	10 10 10 10 10 10 10 10 10 10 10 10 10 1
We introduce our guests:  ▶ R. Padmanabhan  ▶ Brian Davey  ▶ Harry Lakser	· 0 · · 6 · · 5 · · 5 · 3 · 90.
We introduce our guests:  ▶ R. Padmanabhan  ▶ Brian Davey  ▶ Harry Lakser	· B · · B · · B · · B · · B · · B · · B · · B · · B · · B · · B · · B · · B · · B · · B · · B · · B · · · B · · · B · · · B · · · B · · · B · · · B · · · B · · · · B · · · · B · · · · B ·
We introduce our guests:  ► R. Padmanabhan  ► Brian Davey  ► Harry Lakser  Overlaying lists	. E (8) . 3 . 13 . 3 . 994
We introduce our guests:  ▶ R. Padmanabhan  ▶ Brian Davey  ▶ Harry Lakser  Overlaying lists  We introduce our guests:	1011d1121121 2 90
We introduce our guests:  ▶ R. Padmanabhan  ▶ Brian Davey  ▶ Harry Lakser  Overlaying lists  We introduce our guests:  ▶ R. Padmanabhan	· D · · Ø · · È · · È · · È · · Ø · · Ø ·
We introduce our guests:  ► R. Padmanabhan  ► Brian Davey  ► Harry Lakser  Overlaying lists  We introduce our guests:  ► R. Padmanabhan  ► Brian Davey	· O · · Ø · · 2 · · 2 · · 2 · · 3 · · 3 · ·
We introduce our guests:  ► R. Padmanabhan  ► Brian Davey  ► Harry Lakser  Overlaying lists  We introduce our guests:  ► R. Padmanabhan  ► Brian Davey  ► Harry Lakser	· D · · · Ø · · · 2 · · 2 · · 2 · · 3 · · 3 · · 3 · · 3 · · 3 · · 3 · · 3 · · 3 · · · 3 ·
We introduce our guests:  ► R. Padmanabhan  ► Brian Davey  ► Harry Lakser  Overlaying lists  We introduce our guests:  ► R. Padmanabhan  ► Brian Davey	. E (8) . 3 . 13 . 3 . 994
We introduce our guests:  ► R. Padmanabhan  ► Brian Davey  ► Harry Lakser  Overlaying lists  We introduce our guests:  ► R. Padmanabhan  ► Brian Davey  ► Harry Lakser	10 · 10 · 12 · 13 · 3 · 90
We introduce our guests:  ► R. Padmanabhan  ► Brian Davey  ► Harry Lakser  Overlaying lists  We introduce our guests:  ► R. Padmanabhan  ► Brian Davey  ► Harry Lakser	· · · · · · · · · · · · · · · · · · ·
We introduce our guests:  ► R. Padmanabhan  ► Brian Davey  ► Harry Lakser  Overlaying lists  We introduce our guests:  ► R. Padmanabhan  ► Brian Davey  ► Harry Lakser	10110112122
We introduce our guests:  ► R. Padmanabhan  ► Brian Davey  ► Harry Lakser  Overlaying lists  We introduce our guests:  ► R. Padmanabhan  ► Brian Davey  ► Harry Lakser	· D · · · Ø · · · · · · · · · · · · · ·

Figure 14.7: babybeamer4 presentation.

```
\item<3-> Harry Lakser
\item<4-> Dick Koch
\end{itemize}
\end{frame}
\end{document}
```

Such an overlay structure is used so often that beamer has a shorthand for it, [<+->]. Here it is in babybeamer5.

```
% babybeamer5 presentation
\documentclass{beamer}
\begin{document}

\begin{frame}
\frametitle{Overlaying lists}

We introduce our guests:
\begin{itemize}[<+->]
\item R. Padmanabhan
\item Brian Davey
\item Harry Lakser
\item Dick Koch
\end{itemize}
\end{frame}
\end{document}
```

This shorthand allows adding and reordering items without having to change overlay specifications.

Of course, if you do not want the items to appear in sequence, you have to use overlay specifications.

# 14.2.5 Out of sequence overlays

We now present an example of "out of sequence overlays". Look at Figure 14.8. I want to make this part of my presentation. First, I want to show the theorem, then illustrate it with the diagram at the bottom. Finally, I present the proof in the middle. So I need three overlays.

The theorem is on all three overlays, 1, 2, 3. Its illustration is on overlays 2 and 3, leaving room for the proof that appears only on overlay 3.

This is an example of "out of sequence overlays". We code this in babybeamer6 (in the samples folder).

Since declarations, proofs, and the \includegraphics command may all have overlay specifications, this seems easy to accomplish.

```
% babybeamer6 presentation, first try
\documentclass{beamer}
\begin{document}

\begin{frame}
\frametitle{Overlaying declarations and graphics}
\begin{theorem}<1->
Every finite distributive lattice can be embedded
in a boolean lattice.
\end{theorem}
\begin{proof}<3->
Use join-irreducible elements.
\end{proof}
\includegraphics<2,->{cube}
\end{frame}
\end{document}
```

This does not work too well. On overlay 1 the theorem appears in the middle and then it jumps up to make room for the illustration. This is the same problem we encountered in the babybeamer2 presentation in Section 14.2.1 and the solution is also the same, the use of the \onslide command. Replace the line

\includegraphics<2,->{cube}

with

\onslide<2->{\includegraphics{cube}}

Theorem

Every finite distributive lattice can be embedded in a boolean lattice.

Proof.

Use join-irreducible elements.

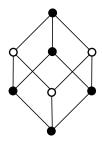


Figure 14.8: The slide to represent.

## 14.2.6 Blocks and overlays

You can think of a theorem in beamer as the contents of the theorem environment with a heading and, optionally, with an overlay specification, and with most themes—see Section 14.5—colorful visual highlighting, see Figures 14.3 and 14.4.

beamer provides the block environment that works the same way except that you name the block. The (partial) syntax of the block environment is

```
\begin{block}<overlay spec>{title}
source
\end{block}
```

Blocks are shaped as theorems. If there is no title, you still need the braces. The overlay specification is optional.

As an example, save babybeamer6.tex as babybeamer6block.tex in the work folder (also in the samples folder along with the PDF file) and replace the theorem environment with

```
\begin{block}<1->{Theorem}
   Every finite distributive lattice can be embedded
in a boolean lattice.
\end{block}
```

If you want a block of LATEX code with an overlay specification but with no title and no visual highlighting, use one of the commands, \onslide and \only.

## 14.2.7 Links

A presentation is a PDF file, so it is not surprising that you can set links of various types in a beamer presentation. Just as the hyperref package helps us with hyperlinks in a PDF file (see Section 13.2), the beamer package allows us to conveniently set links in a presentation.

Some links are automatically provided. If you look closer at Figures 14.1 and 14.2, you see that the section titles are shown in the *sidebar*. In fact, the sidebar is a *navigation bar*. First, it shows which section you are in. Second, clicking on a section title takes you to that section.

Creating a link is a two-step process.

- 1. Name the place you want to link to.
- 2. Create a button with the property that clicking on it jumps you to the designated place.

To illustrate this process, we modify the presentation babybeamer4. Open the file babybeamer4.tex and save it as babybeamer7.tex in the work folder (the edited version is in the samples folder along with the PDF file).

1. Name the frame you want to link to by adding a label to the \begin{frame} line. In babybeamer7, add a label to the frame fourguests:

```
\begin{frame}[label=fourguests]
```

Labels of frames are also useful for selective typesetting of your presentation, see Section 14.6.

2. Add the following line to babybeamer7:

```
\hyperlink{fourguests<3>}%
     {\beamergotobutton{Jump to third guest}}
```

This creates a link to the third overlay of the frame named fourguests, and creates a button, with the text Jump to third guest. Clicking on this button will jump to the third overlay of the frame fourguests.

3. To add variety to linking, include a new first frame:

```
\begin{frame}
\frametitle{First frame with a button}
Button example

Jumping to an overlay of a different frame
\bigskip

\hyperlink{fourguests<3>}%
{\beamergotobutton{Jump to third guest}}
\end{frame}
```

which has a button for jumping to the third overlay of the fourguests frame.

4. We also add a new third frame.

```
\begin{frame}
\frametitle{Third frame with a button}
Button example

Jumping to another frame
\bigskip

\hyperlink{fourguests}%
{\beamergotobutton{Jump to guest list}}
\end{frame}
```

with a button, with the text Jump to guest list. Clicking on this button will jump to the second frame, overlay not specified (defaults to 1).

### 5. Add a fourth frame.

```
\begin{frame}
\frametitle{Hidden link}
\hyperlink{fourguests}{Jumping to the guest list}
\end{frame}
```

introducing another version of the \hyperlink command:

```
\hyperlink{fourguests}{Jumping to the guest list}
```

which typesets the second argument as regular text, making it an *invisible link*. However, you may notice that the cursor changes when it hovers over the link. For instance, you may want to link the use of a concept to its earlier definition, where you also need a button for the return jump.

Here is babybeamer7:

```
% babybeamer7 presentation
\documentclass{beamer}
\begin{document}
\begin{frame}
\frametitle{First frame with a button}
Button example
Jumping to an overlay of a different frame
\bigskip
\hyperlink{fourguests<3>}%
{\beamergotobutton{Jump to third guest}}
\end{frame}
\begin{frame}[label=fourguests]
\frametitle{Overlaying lists}
We introduce our guests:
\begin{itemize}
\item<1-> R. Padmanabhan
\item<2-> Brian Davey
\item<3-> Harry Lakser
\item<4-> Dick Koch
\end{itemize}
```

First frame with a button	
D.,	
Button example Jumping to an overlay of a different frame	
Jump to third guest	
	(B) (B) (2) (2) 2 900
Overlaying lists	
We introduce our guests:  ▶ R. Padmanabhan	
Jump to third guest	
	(a) (b) (2) (2) 2 940
Overlaying lists	
We introduce our guests:	
► R. Padmanabhan ► Brian Davey	
Jump to third guest	
Third frame with a button	(D) (B) (2) (2) 2 VQC
Third frame with a button	(E) (B) (B) (B) (B)
Third frame with a button	101101121131 2 040
Button example	101101121121 2 040
	.aa33. 3 040
Button example Jumping to another frame	.agzz. 2 040
Button example Jumping to another frame	10,10,12,12, 2 040

Figure 14.9: babybeamer7 presentation.

```
\hyperlink{fourguests<3>}%
{\beamergotobutton{Jump to third guest}}
\end{frame}
\begin{frame}
\frametitle{Third frame with a button}
Button example
Jumping to another frame
\bigskip
\hyperlink{fourguests}%
{\beamergotobutton{Jump to guest list}}
\end{frame}
\begin{frame}
\frametitle{Hidden link}
\hyperlink{fourguests}{Jumping to the guest list}
\end{frame}
\end{document}
```

Figure 14.9 shows all these buttons. We do not show overlays 3 and 4 of frame 2 and frame 4, where the button is invisible.

#### 14.2.8 Columns

Often, it is useful to put the display into columns. A simple illustration is given in babybeamer8:

```
% babybeamer8 presentation
\documentclass{beamer}
\begin{document}

\begin{frame}
\frametitle{Columns, top alignment}

\begin{columns}[t]
\begin{column}{2in}
Is it true that there is no new result
on the Congruence Lattice Characterization Problem?
\end{column}
\begin{column}{2in}
```

F. Wehrung found a distributive algebraic lattice that
cannot be represented as the congruence lattice
of a lattice.
\end{column}
\end{columns}
\end{frame}
\end{document}

The environment is columns. It has an optional argument for alignment, t for top, c for center, and b for bottom.

The columns, usually two, are both in the column environment; the width of the column is in the argument; it can be given as a measurement—2in in the example—or relative to the width of the whole frame as 0.4\textwidth.

Figure 14.10 shows the babybeamer8 presentation.

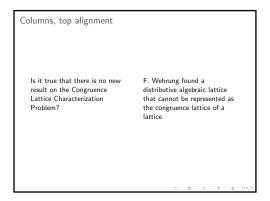


Figure 14.10: babybeamer8 presentation.

# 14.2.9 *Coloring*

LATEX's job is to produce articles and books that contain text, math formulas, and graphics. Such publications—with the exception of textbooks—cannot afford color printing. Presentations are different. If you prepare a color presentation, it will project in color.

Nevertheless, the color commands are of limited use even for presentations. You probably use the color scheme of the chosen theme (see Section 14.5), and have limited opportunity to color things yourself. If you do, be very careful, too much color distracts from the presentation but judicious use of color—say, for highlighting a word or phrase—may be very effective.

beamer uses the sophisticated xcolor package of Uwe Kern. It colors by specifying the color model: rgb (red, green, blue), or cmyk (cyan, magenta, yellow, black), or gray (black and white)—there are many more models to choose from—and how much

of each color you want to mix. So \color[rgb]{0,1,0} paints everything—within its scope—green. You can color some text green with the command

```
\textcolor[rgb]{0,1,0}{This text is green.}
```

There are seventeen predefined colors: red, green, blue, cyan, magenta, yellow, orange, violet, purple, brown, pink, olive, black, darkgray, gray, lightgray, and white. With the proper options, there are hundreds more. So the previous command could also be given as

```
\textcolor{green}{This text is green.}
or as
{\color{green}This text is green.}
```

To pretty thing up, you can use \colorbox{green}{Green box}, which puts the argument in a green box and \fcolorbox{red}{green}{Green box}, which also adds a red frame.

xcolor is automatically loaded by beamer. To make sure that xcolor is loaded with the options desired, you have to include these options in the preamble in the

```
\documentclass{beamer}
```

line. For instance, to have the dvipsnam option for xcolor, invoke beamer with

```
\documentclass[xcolor=dvipsnam]{beamer}
```

You can also mix predefined colors:

```
{\color{green!40!yellow} This text is of what color?}
```

which sets the text 40% green and 60% yellow.

There are commands for defining colors and color sets, as well as for coloring the background, frames, and hyperlinks (see Uwe Kern, *Extending LaTeX's color facilities:* the xcolor package [36]).

Here is a simple illustration:

```
% babybeamer9 presentation
\documentclass{beamer}
\begin{document}

\setbeamercolor{normal text}{bg=yellow!15}
\begin{frame}
\frametitle{Colors}

\begin{columns}[t]
\begin{column}{2in}
```

```
{\color{red}Is it true that there is no new result
on the Congruence Lattice Characterization Problem?}
  \end{column}
    \begin{column}{2in}
{\color{green}F. Wehrung found a distributive
algebraic lattice that cannot be represented
as the congruence lattice of a lattice.}
  \end{column}
\end{columns}
\end{frame}
\setbeamercolor{normal text}{bg=green!15}
\begin{frame}
\frametitle{Colors fading out}
We introduce our guests:
\begin{itemize}
\item {\color{red}R. Padmanabhan}
\item {\color{red!60!white}Brian Davey}
\item {\color{red!40!white}Harry Lakser}
\item {\color{red!20!white}Dick Koch}
\end{itemize}
\end{frame}
\end{document}
    The command
```

\setbeamercolor{normal text}{bg=yellow!15}

sets the background color to light (15%) yellow. In the first column, the text is red, in the second, green. Set the foreground with fg=.

The background of the second frame is light green. The four participants are in lighter and lighter shades of red.

Figure 14.11 shows the frames of the babybeamer9 presentation—unfortunately, not in color.

# 14.3 The structure of a presentation

The structure of your presentation is, by and large, determined by the sectioning commands: \section and \subsection. For a very long lecture there may also be \part commands. The argument of any of these commands may have a short version for the navigational side bar (see Section 14.1.4).

The sectioning commands used in a beamer presentation look the same as they do for articles and books, but they play a different role. They do not display a section

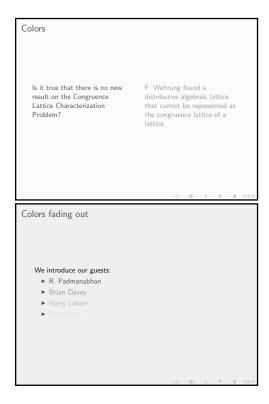


Figure 14.11: babybeamer9 presentation.

title, but they add an entry to the table of contents. They also act as place markers in the sense that if you click on the title of a section in a navigation bar, then you will jump to the *frame following* the section command.

# Rule ■ Sectioning commands

- 1. Sectioning commands can only be placed between frames.
- **2.** There must be a frame following the last sectioning command.
- 3. For a long (sub)section title, use \breakhere to break a line.
- **4.** The optional short versions are for the navigation bar.

These are illustrated with beamerstructure1, see Figure 14.12. The line

\tableofcontents[pausesections, pausesubsections]

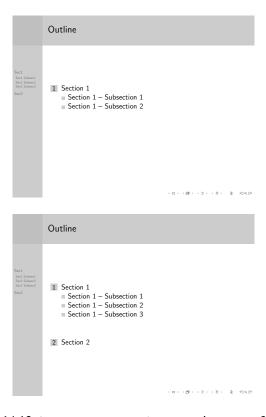


Figure 14.12: beamerstructure1 presentation, pages 3 and 5.

causes the table of contents to appear a line at a time. This command may also be used without an option or only with one, pausesections.

The second page shown in Figure 14.12 is the table of contents. The page is about half filled with only five listed items, so no more than 10 sections and subsections would fit. There should be fewer.

```
% beamerstructure1 presentation
\documentclass{beamer}
\usetheme{Berkeley}
\begin{document}

\begin{frame}
\frametitle{Outline}

\tableofcontents[pausesections, pausesubsections]
\end{frame}
```

```
\section[Sec1]{Section 1}
\begin{frame}
\frametitle{Section 1}
Text of Section 1
\end{frame}
\subsection[Sec1 Subsec1]{Section 1 -- Subsection 1}
\begin{frame}
\frametitle{Section 1\\Subsection 1}
Text of Section 1, Subsection 1
\end{frame}
\subsection[Sec1 Subsec2]{Section 1 -- Subsection 2}
\begin{frame}
\frametitle{Section 1\\Subsection 2}
Text of Section 1, Subsection 2
\end{frame}
\subsection[Sec1 Subsec3]{Section 1 -- Subsection 3}
\begin{frame}
\frametitle{Section 1\\Subsection 3}
Text of Section 1, Subsection 3
\end{frame}
\section[Sec2]{Section 2}
\begin{frame}
\frametitle{Section 2}
Text of Section 2
\end{frame}
\end{document}
```

## 14.3.1 Longer presentations

Longer presentations may need parts and a more complicated table of contents. I will not discuss these topics, but the presentation beamerstructure2 (in the samples folder) illustrates the use of parts and some other features. I added some comments to point these out. See Figure 14.13 for two sample pages of this presentation.

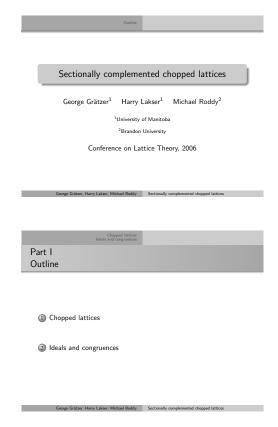


Figure 14.13: beamerstructure2 presentation, pages 1 and 10.

# 14.3.2 Navigation symbols

The more structure you have in a presentation, the more you may appreciate the navigation icons shown by default on each page in the last line on the right. The icons are:

- the slide
- the frame
- the section

14.4 Notes 355

the presentation icons

each surrounded by a left and a right arrow

- the appendix
- the back and forward icons (circular arrows)
- the search icon (a magnifying glass)

If you decide not to have them, as in the presentation beamerstructure2, then give the following command in the preamble:

\setbeamertemplate{navigation symbols}{}

# 14.4 Notes

You can place notes in your presentation to remind yourself of what you want to say in addition to what is being projected. A note is placed in the presentation as the argument of the \note command, as in

```
\note{This is really difficult to compute.}
```

By default, notes are not shown in the presentation. If you invoke beamer with

\documentclass[notes=show]{beamer}

then the notes pages are included. The command

\documentclass[notes=show, trans]{beamer}

produces transparencies with notes, and

\documentclass[notes=only]{beamer}

produces only the note pages, one note page for every overlay of a frame with a note. To avoid this, print the output of

\documentclass[trans, notes=only]{beamer}

In addition to these examples, all the notes placed in a single frame are collected together on one note page. And a note between frames becomes a page on its own.

beamer does an excellent job of producing notes pages, for example, see Figure 14.14. In the upper-left corner, it displays precisely where we are in the structure of the presentation. The upper-right corner shows a small picture of the page to which the notes are attached.

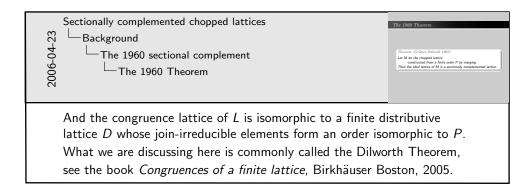


Figure 14.14: A note page.

# 14.5 Themes

If you look carefully at Figures 14.1, 14.2, and 14.13 (even better, if you look at the PDF files of these presentations), you see how every little detail of the presentation is provided by beamer. Figures 14.1 and 14.2 show a presentation style dominated by a dark blue headline and left sidebar, a complete navigation bar in the left sidebar, the name of the author(s) and the title repeated in every overlay, section numbers in colored squares, and so on.

The presentation in Figure 14.13 has no sidebars, section numbers are in colored circles, the navigation elements are in the headline.

The display of lists and theorems (and other similar elements of a presentation) also vary a great deal.

You can achieve such detailed control over your presentation by defining all these elements yourself. beamer places dozens of commands at your disposal to make this possible. Or you can use a *presentation theme* that will do the job for you.

The command to name a presentation theme is \usetheme{}. The presentation beamerstructure2 uses the theme Warsaw (see Figure 14.13), so following the document class line type the command

\usetheme{Warsaw}

quickbeamer1 uses the theme Berkeley (see Figures 14.1 and 14.2) and so does beamerstructure1 (see Figure 14.12).

The presentation themes are in the theme subfolder of the themes folder of beamer. As of this writing, there are 26 of them, named after cities:

#### **Presentation Themes**

Without Navigation Bars default, Bergen, Boadilla, Madrid, AnnArbor, CambridgeUS, Pittsburgh, Rochester

With a Navigation Bar Antibes, JuanLesPins, Montpellier

14.5 Themes 357

With a table of contents Sidebar Berkeley, PaloAlto, Goettingen, Marburg, Hannover

With Mini Frame Navigation Berlin, Ilmenau, Dresden, Darmstadt, Frankfurt, Singapore, Szeged

#### With Section and Subsection Table Copenhagen, Luebeck, Malmoe, Warsaw

How do you choose a presentation theme? After the presentation is finished, try out the various themes. Ask yourself:

- Do sidebars take too much room away from my illustrations?
- Do stronger colors add to the presentation or do they distract?
- Do I want to use a navigation bar?

Answering these questions will narrow your choice.

The presentation theme defines all the colors, but you can alter them with the command \usecolortheme{}. You have a choice of albatross, beetle, crane, fly, and seagull.

For instance,

```
\usetheme{Warsaw}
\usecolortheme{seagull}
```

is a gray version of the Warsaw theme, appropriate for printing in black-and-white. In addition, you can further modify the "inner elements", such as blocks, with

```
\usecolortheme{lily}
```

or orchid, or rose. You can modify the "outer elements", such as headlines and sidebars, with

```
\usecolortheme{whale}
```

or seahorse, or dolphin. So you can have, for instance,

```
\usetheme{Warsaw}
\usecolortheme{lily}
\usecolortheme{whale}
```

This gives you 45 "out of the box" color schemes.

Similarly, font themes can also be specified, modifying the presentation theme, with the command \usefonttheme{}. You have the default and the following options: professionalfonts

```
structurebold
structureitalicserif
structuresmallcapserif.
```

# 14.6 Planning your presentation

- **Step 1** As a rule, your presentation is based on one or more of your articles. Collect them in one folder. Resolve naming conventions as necessary. There should be only one Fig1!
- **Step 2** Rewrite the article(s) to sketch out your presentation. The pages correspond to frames. A page should not have too many words, say, no more than 40. Replace your numbered theorems with named theorems. Never reference another page. Have few sections and subsections. Add a table of contents, which is a readable overview of the new article.
- **Step 3** Base the new presentation on a presentation in the samples folder, a sample presentation in beamer's solution folder, or on one of your own or of a colleague's older presentations. Turn the pages into frames.
- **Step 4** Design your frames and add frame titles. Completely disregard what we wrote in Section 4.3.2 (the idea behind LaTeX is that you should concentrate on what you have to say and let LaTeX take care of the visual design). The new principle is: You are completely responsible for the visual appearance of every frame and overlay.

This is, of course, in addition to brevity and readability. Do not let LATEX break your lines. Do it with the \\ command and keep words that belong together on the same line.

- **Step 5** Write notes to remind yourself what you want to say in your lecture that is not on the slides. Print the notes for your lecture.
- **Step 6** Build in flexibility. For instance, if you have four examples to illustrate a definition, put each one on a different frame or overlay, and add a link to each that skips the rest of the examples. Depending on your audience's understanding, show an example or two, and skip the rest. The same way, you may skip proof ideas and even topics.
- **Step 7** Prepare for the worst—the computer system may fail, but projectors seldom do—so print a set of transparencies for your lecture as a backup by invoking the option trans of the documentclass

\documentclass[trans]{beamer}

To print a *handout*, use the handout option

\documentclass[handout]{beamer}

Open the presentation in Acrobat Reader. In Printer/Page Setup... set landscape and 140% magnification. In the Print dialogue box in Layout choose two pages per sheet and print—assuming, of course, that you have a printer offering these options.

# 14.7 What did I leave out?

Since the beamer reference manual is over 200 pages long, it is clear that this chapter covers maybe 10% of it.

For most presentations, you won't even need most of what I have included. If you read Sections 14.1, 14.2.1 and maybe Section 14.3, you should have enough for most math presentations.

If you are in other fields, or if you are more ambitious, you may need more. For example, a computer scientist will want program listings in a verbatim environment. This is easy. Start your frame with

```
\begin{frame}{fragile}
```

and then you can use the verbatim environment.

If you want to include sounds or movies in your presentation, consult Till Tantau, *User's Guide to the Beamer Class* [59].

You can do very simple animation with what we have covered here. This is illustrated with the babybeamer10 presentation (in the samples folder).

```
% babybeamer10 presentation
\documentclass{beamer}
\begin{document}

\begin{frame}

\includegraphics<1>{basem3-1}

\includegraphics<2>{basem3-2}

\includegraphics<3>{basem3-3}

\includegraphics<4>{basem3-4}
\end{frame}
\end{document}
```

The congruence generated by the dashed red line, see Figure 14.15, spreads in three steps, illustrating an interesting result. The animation is quite effective and instructive.

If you want to place such changing pictures lower in a frame, put them in the overprint environment.

I would recommend that you read Section 5 of Till Tantau, *User's Guide*, which has many good pointers about creating presentations.

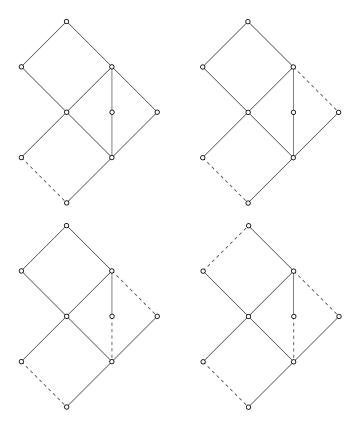


Figure 14.15: The four pictures of babybeamer10.

# 15

# Customizing LATEX

In Section D.1.2, we discuss that Donald E. Knuth designed TEX as a platform on which *convenient work environments* could be built. One such work environment, LATEX, predominates today, and it is indeed convenient.

Nevertheless, LaTeX is designed for all of us, so it is not surprising that we could improve on it for our personal use. There are many reasons to customize LaTeX:

- Goal 1 to enhance the readability of the source file
- Goal 2 to make notational and terminological changes easier
- Goal 3 to redefine names used by LATEX
- **Goal 4** to introduce consistent layouts

There are many techniques to accomplish these.

**Technique 1** Define commands and environments in order to enhance LaTeX to meet your particular needs (see Sections 15.1, 15.1.6, and 15.2).

- **Technique 2** Utilize delimited commands to write LaTeX documents in a more readable fashion (see Section 15.1.8).
- **Technique 3** Collect your frequently used commands into a command file (see Section 15.3).
- **Technique 4** Manipulate *counters*, integers—for instance, equation numbers and section numbers—and *length commands*, distance measurements—the \voffset command is an example (see Section 15.5).
- **Technique 5** Create customized list environments with the list environment (see Section 15.6).

Of course, there are many more reasons to customize and many more techniques to employ. We cover them in detail in this chapter.

We dedicate the last section to the pitfalls of customization (see Section 15.7). While the benefits of customization are great, there are many practices to avoid.

# 15.1 User-defined commands

LATEX provides hundreds of commands. Chances are good, however, that you still have specific needs that are not directly addressed by these commands. By judiciously adding *user-defined commands* (or *macros*) you can make your work more productive.

User-defined commands follow the same rules as regular LATEX commands (see Section 5.3.1).

# 15.1.1 Examples and rules

#### Commands to enhance readability

Let us start with a few examples of user-defined commands as shorthand for longer command(s) or text in order to enhance readability of the source file (Goal 1).

1. If you use the \leftarrow command a lot, you could define

\newcommand{\larr}{\leftarrow}

Then you would only have to type \larr to obtain a left arrow.

2. Instead of

\widetilde{a}

you could simply type \wtilda after defining

\newcommand{\wtilda}{\widetilde{a}}

I show you how to define a generalized version of such a command in Section 15.1.2.

3. If you want to suppress the ligature in iff (see Section 5.4.6), you would normally have to type

```
if\textcompwordmark f
```

By defining a command \Iff,

```
\newcommand{\Iff}{if\textcompwordmark f}
```

you can type  $\backslash$ Iff to get iff. We name this command  $\backslash$ Iff because  $\backslash$ iff is the symbol  $\iff$  (see Section B.4).

4. If you use the construct  $D^{[2]} \times D^{[3]}$  often, you could introduce the \DxD (D times D) command,

```
\label{local_problem} $$\operatorname{D^{[2]}\times D^{[3]}}$
```

and then type \DxD instead of the longer, and hard to read, version throughout your document—serves also Goal 2.

5. If you want to get a backslash in typewriter style, you would normally have to type (see Section 5.4.4)

```
\texttt{\symbol{92}}
```

Instead, you can introduce the \bsl command,

```
\newcommand{\bsl}{\texttt{\symbol{92}}}
```

and \bsl typesets as \.

You can also use commands as a shorthand for text. For instance, if you use the phrase subdirectly irreducible many times in your document, you could define

```
\newcommand{\subdirr}{subdirectly irreducible}
```

\subdirr is now shorthand for subdirectly irreducible, which typesets as subdirectly irreducible.

**Tip** With modern editors, the need to have user-defined commands as shorthand is reduced. Most editors have "command completion" or "phrase completion". For instance, in TeXShop, type the first few letters of a word and hit the escape key. The remaining letters are entered to match the first entry in the completion dictionary. Hitting escape again cycles through all possible completions. To make this feature useful, you have to customize the completion dictionary.

#### **Rule** ■ User-defined commands

- 1. Issue the \newcommand command.
- 2. In braces, type the name of your new command, for example, \subdirr, including the backslash (\).
- 3. In a second pair of braces, define the command, in this example, subdirectly irreducible.
- 4. Use the command as \subdirr\□ or \subdirr{} before a space, before an alphabetical character as \subdirr{}, and \subdirr otherwise.

Examples for Rule 4. For subdirectly irreducible lattice type \subdirr{} lattice or \subdirr\ lattice and not \subdirr lattice. Indeed, typesetting \subdirr lattice results in subdirectly irreduciblelattice. By the first spacing rule, \subdirr\_lattice is not any better (see Section 5.2.1). If you want subdirectly irreducibles, you must use the \subdirr{} form. Indeed, \subdirr{}s typesets as subdirectly irreducibles.

#### Using new commands

It is good practice to place user-defined commands in the preamble of your document or in a command (style) file you load with a \usepackage command (see Section 15.3)—provided that you do not submit to a journal that does not allow this. Then you always know where to look for the command definitions. An exception is a user-defined command that you want to restrict to a part of the document. Delimit the segment with braces and define the user-defined command within those braces (see Section 5.3.2). Instead of a pair of braces, you can use \begingroup and \endgroup, which is easier to see. Section 15.2.5 recommends yet another approach.

#### Tip

- If errors occur, isolate the problem. Comment out the user-defined commands and reintroduce them one at a time.
- LATEX only checks whether the braces match in the command definition. Other mistakes are found only when the command is used.

For instance, if you define a command with a spelling error

\newcommand{\bfA}{\textf{A}}}

then at the first use of \bfA you get the error message

```
! Undefined control sequence.
\bfA ->\textf
{A}
```

Note that LATEX is not complaining about \bfA but about the misspelled \textbf command in the definition of \bfA.

Be careful not to define a user-defined command with a name that is already in use. If you do, you get an error message such as

! LaTeX Error: Command \larr already defined.

To correct the error, replace the command name with a new one. On the other hand, if you need to replace an existing command, you have to *redefine* it. See Section 15.1.5 for how to do so.

**Tip** Use spaces to make your source files more readable, but avoid them in definitions.

For example, you may type

```
D^{ \ \ } = x^{ \ \ \ }
```

This may help you see how the braces match, easily identify relations and operations, and so on. *Do not add these spaces in command definitions* because it may result in unwanted spaces in your typeset document. You may start a new line to increase the readability of a command definition, provided that you terminate the previous line with %. For instance, borrowing an example from page 372:

```
\newcommand{\Xquotphi}[2]{%
  \dfrac{\varphi \cdot X_{n, #1}}%
  {\varphi_{#2}\times \varepsilon_{#1}}}
```

**Tip** In the definition of a new command, command declarations need an extra pair of braces (see Section 5.3.3).

Say you want to define a command that typesets the warning: *Do not redefine this variable!* It is very easy to make the following mistake:

```
\newcommand{\Warn}{\em Do not redefine this variable!}
```

\Warn typesets the warning emphasized, but everything that follows the warning is also emphasized (more precisely, until the end of the \Warn command's scope). Indeed, \Warn is replaced by \em Do not redefine this variable! so the effect of \em goes beyond the sentence to the next closing brace.

The correct definition is

\newcommand{\Warn}{{\em Do not redefine this variable!}}

Even simpler, you could use a command with an argument

\newcommand{\Warn}{\emph{Do not redefine this variable!}}

#### The xspace package

Rule 4 (on page 366) is the source of many annoying problems in LATEX. David Carlisle's xspace package (see Section 12.3.1) helps eliminate such problems. In the preamble, load the package with

\usepackage{xspace}

Whenever you define a command that may have such problems, add the \xspace command to the definition. For instance, define \subdirr as

\newcommand{\subdirr}{subdirectly irreducible\xspace}

Then all the following typesets subdirectly irreducible lattice correctly:

\subdirr\ulattice \subdirr{}ulattice \subdirrulattice

Note that \xspace does not add space if followed by a punctuation mark, so to get

the lattice is subdirectly irreducible.

type
the lattice is \subdirr.

**Tip** Be careful not to use \xspace twice in a definition.

For instance, if you define

then

\newcommand{\tex}{\TeX\xspace}
\newcommand{\bibtex}{\textsc{Bib}\kern-.1em\tex\xspace}% Bad!!!

\bibtex, followed by a comma

```
typesets as

BIBTEX , followed by a comma
```

The correct definitions are

\newcommand{\tex}{\TeX\xspace}

\newcommand{\bibtex}{\textsc{Bib}\kern-.1em\TeX\xspace}% Correct!

Of course, if you want to get TeXbook, you cannot use \xspace variant definition: \tex.

#### Ensuring math

The \ensuremath command is useful for defining commands that work in both text and math mode. Suppose you want to define a command for  $D^{\langle 2 \rangle}$ . If you define it as

```
\newcommand{\Dsq}{D^{\langle2\rangle}}
```

then you can use the command in math mode, but not in text mode. If you define it as

```
\newcommand{\Dsq}{$D^{\langle2\rangle}$}
```

then it works in text mode, but not in math mode. Instead, define this command as

```
\newcommand{\Dsq}{\ensuremath{D^{\langle2\rangle}}}
```

Then \Dsq works correctly in both contexts.

This example also shows the editorial advantages of user-defined commands. Suppose the referee suggests that you change the notation to  $D^{[2]}$ . To carry out the change you only have to change one line:

```
\label{local_prop} $$\operatorname{Dsq}{\operatorname{Dsq}}(D) = \operatorname{D}^{[2]}$$
```

It is hard to overemphasize the importance of this example. You may want to change notation because:

- you found a better notation;
- your coauthor insists;
- your article appears in a conference proceedings, and the editor wants to unify the notation;
- you are reusing the code from this article in another one or in a book, where the notation is different.

See also the discussion of the \TextOrMath command on page 311.

## 15.1.2 Arguments

Arguments of user-defined commands work the same way as for LaTeX commands (see page 69). Define

Then \fsqAB typesets as  $(f^2)^{[[\frac{A^2}{B-1}]]}$  in a math formula. If you want to use \fsqAB in math and also by itself in text, define it with \ensuremath, as

However, if you use this construct for many functions f, then you may need a generalized command, such as

Now \sqAB{g} typesets  $(g^2)^{[[\frac{A^2}{B-1}]]}$ . The form of this \newcommand is the same as before, except that after the name of the command in braces, {\sqAB}, we specify the number of arguments in brackets (in this example, [1]). Then we can use #1 in the definition of the command. When the command is invoked, the argument you provide replaces #1 in the definition. Typing \$\sqAB{q}\$ results in the formula  $(q^2)^{[[\frac{A^2}{B-1}]]}$ , while \$\sqAB{r}\$ gives  $(r^2)^{[[\frac{A^2}{B-1}]]}$ .

Notice how these examples disrupt the normal spacing between lines—a practice to avoid!

A user-defined command may have up to nine arguments, numbered 1–9.

The simplest examples just allow you to invoke an existing command under a new name. For instance, the \eqref command introduced in Section 7.3 to reference equations (the equation number upright, enclosed in parentheses), would also be useful to reference items for the user-defined list environment enumeratei introduced in Section 15.2.1—see Example 3. Indeed, for the enumeratei environment, we want references to items to be typeset upright, enclosed in parentheses. So if the first item has label First, we could reference it with \eqref{First}, which typesets as (i). But \eqref{First} seems awkward and inappropriate; we are referencing an item not an equation.

So define

```
\newcommand{\itemref}[1]{\eqref{#1}}
```

and now we can reference the first item with \itemref{First}, which typesets as (i). Following are some simple examples of user-defined commands with arguments.

1. In the preamble of the source file for this book, I defined

```
\newcommand{\env}[1]{\textnormal{\texttt{#1}}}
```

In this example, the \env command is used to typeset environment names. So the environment name center is typed as

\env{center}

Again the editorial advantage is obvious. If the editor wants the environment names set in sans serif, only one line in the book has to be changed to alter every occurrence of a typeset environment name:

\newcommand{\env}[1]{\textsf{#1}}

2. An argument (e.g., #1) may occur more than once in a definition. A natural example is provided by the \index command (see Section 17.1). Typically, if you wanted to include a phrase, say subdirectly irreducible lattice, in your index, you would have to type

this proves that \$L\$ is a subdirectly irreducible lattice\index{subdirectly irreducible lattice}

You could instead define an "index it" command such as

\newcommand{\indexit}[1]{#1\index{#1}}

The argument of this command is a phrase to be both typeset and included in the index. Using this command, you can type

this proves that \$L\$ is a
\indexit{subdirectly irreducible lattice}

If you want all such index entries to be typeset in italics, then \indexit should be defined as

\newcommand{\indexit}[1]{#1\index{#1@\textit{#1}}}

in which #1 occurs three times. (See Chapter 17 for more information about index commands.)

3. Let us define a command with three arguments for congruences:

\newcommand{\congr}[3]{#1\equiv#2\pod{#3}}

Now type  $\congr{a}{b}{\theta}$  to typeset  $a \equiv b \ (\theta)$ . In Section 15.1.8, I present another command for typesetting congruences.

4. In the sampart.tex article (see Section 11.3), there are a lot of vectors with only one nonzero entry:

$$\langle \dots, 0, \dots, \overset{i}{d}, \dots, 0, \dots \rangle$$

the i above the d indicates that it is the ith component of the vector. A command

\vectsup, a vector with a superscript, producing this symbol can be defined as

\newcommand{\vectsup}[2]{\langle\dots,0,\dots,
\overset{#1}{#2},\dots,0,\dots\rangle}

 $\verb|\vectsup{i}{d}| \text{ in a math formula now produces } \langle \dots, 0, \dots, \stackrel{i}{d}, \dots, 0, \dots \rangle.$ 

5. Formula 20 of the Formula Gallery (Section 7.9),

$$\mathbf{A} = \begin{pmatrix} \frac{\varphi \cdot X_{n,1}}{\varphi_1 \times \varepsilon_1} & (x + \varepsilon_2)^2 & \cdots & (x + \varepsilon_{n-1})^{n-1} & (x + \varepsilon_n)^n \\ \frac{\varphi \cdot X_{n,1}}{\varphi_2 \times \varepsilon_1} & \frac{\varphi \cdot X_{n,2}}{\varphi_2 \times \varepsilon_2} & \cdots & (x + \varepsilon_{n-1})^{n-1} & (x + \varepsilon_n)^n \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \frac{\varphi \cdot X_{n,1}}{\varphi_n \times \varepsilon_1} & \frac{\varphi \cdot X_{n,2}}{\varphi_n \times \varepsilon_2} & \cdots & \frac{\varphi \cdot X_{n,n-1}}{\varphi_n \times \varepsilon_{n-1}} & \frac{\varphi \cdot X_{n,n}}{\varphi_n \times \varepsilon_n} \end{pmatrix} + \mathbf{I}_n$$

is a good candidate for user-defined commands. By defining

\newcommand{\Xquotphi}[2]{%

\dfrac{\varphi \cdot X\_{n, #1}}%

{\varphi\_{#2}\times \varepsilon\_{#1}}}

the two new commands,

١/

\Xquotphi{2}{3} \qquad \exn{n}

 $\backslash$ 

are typeset as

$$\frac{\varphi \cdot X_{n,2}}{\varphi_3 \times \varepsilon_2} \qquad (x + \varepsilon_n)^n$$

With these user-defined commands, you can rewrite Formula 20 as follows:

```
\[
\mathbf{A} =
\begin{pmatrix}
    \Xquotphi{1}{1} & \exn{2} & \cdots & \exn{n - 1}
        & \exn{n}\\[10pt]
    \Xquotphi{1}{2} & \Xquotphi{2}{2} & \cdots
        & \exn{n - 1} & \exn{n}\\
    \hdotsfor{5}\\
    \Xquotphi{1}{n} & \Xquotphi{2}{n} & \cdots &
        \Xquotphi{1}{n} & \Xquotphi{1}{n} \\
    \hdotsfor{5}\\
    \Xquotphi{1}{n} & \Xquotphi{1}{n} \\
    \end{pmatrix}
    + \mathbf{I}_{n}
```

\]

Observe how much shorter this form is than the version shown in the *Formula Gallery* and how much easier it is to read. It is also easier to reuse in a subsequent article.

#### 15.1.3 Short arguments

There are three ways of defining new commands:

```
\newcommand \renewcommand \providecommand
```

We take up the last two in Section 15.1.5. They define commands that can take any number of paragraphs as arguments. The \*-ed versions of these commands define *short* commands (see Section 5.3.3) that take a block of text that contains no paragraph break as an argument. For instance,

```
\newcommand{\bigbold}[1]{{\large\bfseries#1}}

makes its argument large and bold. So
\bigbold{First paragraph.
Second paragraph.
}

prints

First paragraph.
Second paragraph.
as expected. On the other hand, if you define
\newcommand*{\bigbold}[1]{{\large\bfseries#1}}

and then attempt to typeset the previous example, you get the error message
! Paragraph ended before \bigbold was complete.
<to be read again>
\par
```

Short commands are often preferable because of their improved error checking.

#### 15.1.4 Optional arguments

You can define a command whose first argument is *optional*, and provide a *default* value for this optional argument. To illustrate, let us define the command

 $\sum m$  now produces  $a_1 + a_2 + \cdots + a_n$ . Now we change this command so that we can sum from 1 to m if necessary, with n as the default:

```
\mbox{\newcommand{\BetterSum}[1][n]{a_{1}+a_{2}+\dots+a_{\#1}}}
```

 $\Delta a_1 + a_2 + \cdots + a_n$ , but  $\Delta m$  by typesets as  $a_1 + a_2 + \cdots + a_m$ .

A \newcommand may have up to nine arguments, but *only the first* may be optional. The following command has two arguments, one optional:

Now

```
$\BestSum{a}$ typesets as a_1 + a_2 + \cdots + a_n
$\BestSum{b}$ typesets as b_1 + b_2 + \cdots + b_n
$\BestSum[m]{c}$ typesets as c_1 + c_2 + \cdots + c_m
```

# 15.1.5 Redefining commands

ETEX makes sure that you do not inadvertently define a new command with the same name as an existing command (see, for example, page 367). Assuming that you have already defined the \larr command as in Section 15.1.1 (to typeset ←), to redefine \larr, use \renewcommand:

```
\label{larr} $$ \operatorname{now \scriptstyle larr typesets as} = .
```

Tip Use the \renewcommand command sparingly and make sure that you understand the consequences of redefining an existing command. Redefining LATEX commands may cause LATEX to behave in unexpected ways, or even crash.

Blind redefinition is the route to madness.

See also the discussion in Section 15.7.

You can also use \renewcommand to redefine commands defined by LATEX or any package. For instance, the end of proof symbol, \qedsymbol, used by the proof environment, can be changed to the solid black square some people prefer (defined in the amssymb package) with the command

\renewcommand{\qedsymbol}{\$\blacksquare\$}

Even better, define

\renewcommand{\qedsymbol}{\ensuremath{\blacksquare}}

so that you can use \qedsymbol in both text and math mode. Section 15.1.6 has more on redefining names.

\renewcommand has a companion, \providecommand. If the command it defines has already been defined, the original command is left unchanged. Otherwise, the \providecommand command acts exactly like \newcommand. For instance, the \bysame command (see Section 10.5.1, page 266) is defined in some document classes as

```
\newcommand{\bysame}{\makebox[3em]{\hrulefill}\thinspace}
```

If you want to use the \bysame command in your bibliography and include this definition in your document, LATEX generates an error message when you typeset your document using a document class that already defines \bysame (all AMS document classes do). However, if you define \bysame in your document using \providecommand:

```
\providecommand{\bysame}%
{\makebox[3em]{\hrulefill}\thinspace}
```

the \bysame command typesets correctly whether or not the document class defines it.

# 15.1.6 Redefining names

A number of names, such as Table, List of Tables, Abstract, and so on, are typeset in your document by LATEX. You can easily change these names.

For instance, if you are preparing your manuscript for the proceedings of a meeting, and Abstract has to be changed to Summary, you can do so with

```
\renewcommand{\abstractname}{Summary}
```

Table 15.1 lists the commands that define such names in various document classes, along with their default definitions and the major document classes using the commands. It is easy to check whether your document class defines such a command, simply open the appropriate cls file and search for the command.

If your document has photographs rather than figures, you could redefine

```
\renewcommand{\figurename}{Photograph}
\renewcommand{\listfigurename}{List of Photographs}
```

		Defined by
Command	Default Value	Document Class
\abstractname	Abstract	aa, ab, ap, a, p, r
\appendixname	Appendix	aa, ab, ap, a, b, r
\bibname	Bibliography	ab, b, r
\ccname	$\mathrm{Cc}$	1
\chaptername	Chapter	ab, b, r
\contentsname	Contents	aa, ab, ap, a, b, r
\datename	Date	aa, ab, ap
\enclname	Enclosure	1
\figurename	Figure	aa, ab, ap, a, b, r
\headtoname	То	1
\indexname	Index	aa, ab, ap, a, b, r
\keywordsname	Key words and phrases	aa, ab, ap
\listfigurename	List of Figures	aa, ab, ap, a, b, r
\listtablename	List of Tables	aa, ab, ap, a, b, r
\pagename	Page	l, p
\partname	Part	aa, ab, ap, a, b, r
\proofname	Proof	aa, ab, ap
\refname	References	aa, ap, a
\see	see	aa, ab, ap
\seealso	see also	aa, ab, ap
\subjclassname	1991 Mathematics	aa, ab, ap
	Subject	
	Classification	
$\slash$ subjclassname $[2000]$	2000 Mathematics	aa, ab, ap
	Subject	-
	Classification	
\tablename	Table	aa, ab, ap, a, b, r

Document class codes: aa amsart, ab amsbook, ap amsproc, a article, b book, l letter, p proc, and r report

Table 15.1: Redefinable name commands in LATEX.

# 15.1.7 Showing the definitions of commands

If you are defining a new command with \newcommand and an error message informs you that the command name is already in use, then it may be useful to find out the existing definition of the command. For instance, the \vects command is defined in sampartu.tex (in the samples folder and in Section 15.4). If you called this new command \vec, you would get the error message

! LaTeX Error: Command \vec already defined.

You can find out the definition of the \vec command by getting into interactive mode (see Section D.4) and typing

\*\show \vec

LATEX responds with

- > \vec=macro:
- ->\mathaccent "017E .
- <\*> \show \vec

informing you that \vec is a command, and, specifically, a math accent (see Sections 7.7 and B.8). Now try \hangafter (see Section 5.7.2):

- \*\show \hangafter
- > \hangafter=\hangafter.
- <\*> \show \hangafter

The response indicates that \hangafter is a *primitive*, defined by TEX itself. Redefining a primitive is not a good idea.

Try one more command, \medskip (see Section 5.8.2), to find out how large it is:

- \*\show \medskip
- > \medskip=macro:
- ->\vspace \medskipamount .

The third line indicates that the length is stored in \medskipamount. If we use \show to ask what \medskipamount is defined to be:

- \*\show \medskipamount
- > \medskipamount=\skip14.

we do not get a very useful answer. \medskipamount is unlike most of the commands you have seen so far. It is a *length command* (see Section 15.5.2), containing the value of \medskip. You can ask for the value of a length command (or parameter) with the \showthe command:

- \*\showthe \medskipamount
- > 6.0pt plus 2.0pt minus 2.0pt.

So \medskip is a vertical space of 6 points that can stretch or shrink by up to 2 points. LaTeX has many registers that contain numbers:

- counters containing integers, such as 3
- dimensions such as 10.2pt. For example, \textwidth (see Section 10.6)

• lengths, written in the form 6.0pt plus 2.0pt minus 2.0pt, also called a *glue* or a *rubber length* (see Sections 15.5.2 and D.3.2)

Use the \showthe command to display the value for any of these registers.

You can also type the \show and \showthe commands directly into your document rather than go into interactive mode. LaTeX's response appears in the log window, and is saved into the log file.

#### 15.1.8 Delimited commands

You can define new commands in TEX using characters and symbols to delimit arguments. Such *delimited commands* provide a way to write more readable source documents.

First we have to learn how to define a command using TEX's \def command. Type \def, followed by the new command name (not in braces), then the definition in braces. For example, the first command defined in Section 15.1.1,

\newcommand{\larr}{\leftarrow}
could be typed

\def\larr{\leftarrow}

TEX's \def command does not check whether a new command name is already in use, so \def behaves differently from the LATEX's \newcommand, \renewcommand, and \providecommand (see Section 15.1.5). If the \larr command was defined previously, the original definition is overwritten.

It is your responsibility to ensure that your command name is unique when you define a command using \def. LaTeX provides no protection. Use the techniques introduced in Section 15.1.7 to check a name before you define a command with \def.

Now we can start discussing delimited commands with a simple example, defining a command for vectors:

\def\vect<#1>{\langle#1\rangle}

Note that  $\$  is a command with one argument, #1. When invoked, it typesets  $\langle$ , the argument, and then  $\rangle$ .

In the definition of \vect, the argument #1 is delimited by < and >. When the command is invoked, the argument must be delimited the same way. So to typeset the vector  $\langle a,b\rangle$ , we invoke \vect with

\vect<a,b>

This looks somewhat like a vector, and the name \vect serves as a reminder.

You have to be careful with delimited commands because the math spacing rules (see Section 7.2) do not hold in either the definition or the invocation. So if there is a space before #1, in the definition of \vect,

\def\vect<\\_#1>{\langle#1\rangle}

then \$\vect<a,b>\$ results in the error message

- ! Use of \vect doesn't match its definition.
- 1.12 \$\vect<a

,b>\$

which is clear enough. If the space is on the other side of the #1, as in

\def\vect<#1 >{\langle#1\rangle}

the error message is slightly more confusing:

Runaway argument?

a,b>\$

! Paragraph ended before \vect was complete.

<to be read again>

\par

The moral is that if you use delimited commands, you must be very careful that each invocation exactly matches the definition.

In Example 3 of Section 15.1.2, we introduced a command with three arguments for typing congruences:

\newcommand{\congr}[3]{#1\equiv#2\pod{#3}}

 $\comprac{b}{\theta}\$  produces  $a\equiv b\ (\theta)$ . This command is easy to remember, but it does not make the source file more readable. For that, we use a delimited command.

Let us redo the congruence example with a delimited command

\def\congr#1=#2(#3){#1\equiv#2\pod{#3}}

so that  $\congr$  a=b(\theta)\$ produces  $a \equiv b$  ( $\theta$ ). In the source document, the formula \congr a=b(\theta) looks a bit like the typeset congruence and it is easier to read. I included this definition in the newlattice.sty command file (see Section 15.3).

There is only one catch. Suppose you want to typeset the formula

$$x = a \equiv b \quad (\theta)$$

If you type  $\c = a=b(\theta)$ , Let a = b ( $\theta$ ). Indeed, a = b is delimited on the right by the first a = b the first a = b the first a = b is delimited on the right by the first a = b the first a = b

The second argument is delimited by the first = and the left parenthesis, so it is a=b. In such cases, you can help LATEX find the correct first argument by enclosing it in braces:

```
$\congr{x=a}=b(\theta)$
```

Here is our final example. In Section 5.3.1 we discuss the problem of typing a command such as  $\TeX$  (the example there was  $\today$ ) in the form  $\TeX$  is that it is typeset as a separate word. The problem is that if you type  $\TeX$  without the trailing  $\L_U$ ,  $\TeX$  is merged with the next word, and there is no error message to warn you. One solution is to use a delimited command:

```
\def\tex/{\TeX}
```

Now to get  $T_EX$ , type tex/. If a space is needed after it, type  $\text{tex/}_{\sqcup}$ . If you forget the closing /, you get an error message.

A better solution to this problem is the use of the xspace package—provided you do not want to typeset something like TeXbook (see Section 15.1.1). However, many documents use the delimited construct (including the AMS documentation), so you should be familiar with it.

# 15.2 User-defined environments

Most user-defined commands are new commands. *User-defined environments*, as a rule, are built on existing environments. We start with such user-defined environments (Section 15.2.1) and then proceed to investigate

- arguments (Section 15.2.2)
- optional arguments (Section 15.2.3)
- short arguments (Section 15.2.4)

Finally, we discuss how to define brand-new environments (Section 15.2.5).

# 15.2.1 Modifying existing environments

If you do not like the name of the proof environment and would prefer to use the name demo, define

```
\newenvironment{demo}
    {\begin{proof}}
    {\end{proof}}
```

Note that this does not change how the environment is typeset, only the way it is invoked.

To modify an existing environment, oldenv, type

```
\newenvironment{name}
    {begin_text}
    {end_text}
```

where  $begin\_text$  contains the command  $\begin{oldenv} and end\_text contains the command <math>\end{oldenv}$ .

**Tip** Do not give a new environment the name of an existing command or environment.

```
For instance, if you define

\newenvironment{parbox}
{...}
{...}
you get the error message
! LaTeX Error: Command \parbox already defined.
```

If there is an error in such a user-defined environment, the message generated refers to the environment that was modified, not to your environment. For instance, if you misspell proof as prof when you define

```
\newenvironment{demo}
    {\begin{prof}}
    {\end{proof}}

then at the first use of the demo environment you get the message
! LaTeX Error: Environment prof undefined.

1.13 \begin{demo}

If you define

\newenvironment{demo}
    {\begin{proof}\em}
    {\end{prof}}

at the first use of demo you get the message
! LaTeX Error: \begin{proof} on input line 5
        ended by \end{prof}.

1.14 \end{demo}
```

Here are four more examples of modified environments.

1. The command

```
\newenvironment{demo}
    {\begin{proof}\em}
    {\end{proof}}
```

defines a demo environment that typesets an emphasized proof. Note that the scope of \em is the demo environment.

2. The following example defines a very useful environment. It takes an argument to be typeset as the name of a theorem:

```
\newtheorem*{namedtheorem}{\theoremname}
\newcommand{\theoremname}{testing}
\newenvironment{named}[1]{
   \renewcommand{\theoremname}{#1}
   \begin{namedtheorem}}
   {\end{namedtheorem}}

For example,
\begin{named}{Name of the theorem}
Body of theorem.
\end{named}

produces
```

Name of the theorem. Body of theorem.

in the style appropriate for the \newtheorem\* declaration. This type of environment is often used to produce an unnumbered **Main Theorem** (see Section 15.4) or when typesetting an article or book in which the theorem numbering is already fixed, for instance, when publishing a book in LaTeX that was originally typeset by another typesetting system.

3. In Sections 6.2.4 and 12.3.1, we came across the enumerate package, which allows you to customize the enumerate environment. If the enumerate package is loaded, you can invoke the enumerate environment with an optional argument specifying how the counter should be typeset, for instance, with the option [\upshape (i)],

```
\begin{enumerate}[\upshape (i)]
  \item First item\label{First}
\end{enumerate}
items are numbered (i), (ii), and so on.
```

So now we define

and we can invoke the new environment with (see Sections 15.3 and 15.4)

```
\begin{enumeratei}
    \item \label{ }
\end{enumeratei}
```

Reference items in the enumeratei environment with the \itemref command introduced in Section 15.1.2.

4. If you want to define an environment for displaying text that is numbered as an equation, you might try

```
\newenvironment{texteqn}
    {\begin{equation} \begin{minipage}{0.9\linewidth}}
    {\end{minipage} \end{equation}}
```

But there is a problem. If you use this environment in the middle of a paragraph, an interword space appears at the beginning of the first line after the environment. To remove this unwanted space, use the \ignorespacesafterend command, as in

```
\newenvironment{texteqn}
  {\begin{equation} \begin{minipage}{0.9\linewidth}}
  {\end{minipage} \end{equation} \ignorespacesafterend}
```

Examples 2 and 3 are included in the newlattice.sty command file (see Section 15.3). See the sample article, sampartu.tex in Section 15.4, for some instances of their use.

See Section 15.6.3 for custom lists as user-defined environments.

Redefine an existing environment with the \renewenvironment command. It is similar to the \renewcommand command (see Section 15.1.5).

There are some environments you cannot redefine; for instance, verbatim and all the AMS multiline math environments.

# 15.2.2 Arguments

An environment defined by the \newenvironment command can take arguments (see Example 2 in Section 15.2.1), but they can only be used in the begin\_text argument of the \newenvironment command. Here is a simple example. Define a theorem proclamation in the preamble (see Section 6.4), and then define a theorem that can be referenced:

```
\newenvironment{theoremRef}[1]
    {\begin{theorem}\label{T:#1}}
    {\end{theorem}}
```

This is invoked with

```
\begin{theoremRef}{label}
```

The theoremRef environment is a modified environment. It is a theorem that can be referenced (with the \ref and \pageref commands, of course) and it invokes the theorem environment when it defines T: label to be the label for cross-referencing.

# 15.2.3 Optional arguments with default values

The first argument of an environment created with the \newenvironment command may be an *optional argument with a default value*. For example,

```
\newenvironment{narrow}[1][3in]
    {\noindent\begin{minipage}{#1}}
    {\end{minipage}}
```

creates a narrow environment. By default, it sets the body of the environment in a 3-inch wide box, with no indentation. So

```
\begin{narrow} This text was typeset in a \texttt{narrow}
environment, in a 3-inch wide box, with no indentation.
\end{narrow}
```

typesets as

This text was typeset in a narrow environment, in a 3-inch wide box, with no indentation.

You can also give an optional argument to specify the width. For example, \begin{narrow} [3.5in]

This text was typeset in a \texttt{narrow} environment, in a 3-inch wide box, with no indentation. \end{narrow}

which produces the following false statement:

This text was typeset in a narrow environment, in a 3-inch wide box, with no indentation.

#### 15.2.4 Short contents

We have discussed two commands that define new environments,

```
\newenvironment and \renewenvironment
```

These commands allow you to define environments whose contents (begin\_text and end\_text; see page 381) can include any number of paragraphs. The \*-ed versions of these commands define short environments whose contents cannot contain a paragraph break (a blank line or a \par command).

#### 15.2.5 Brand-new environments

Some user-defined environments are not modifications of existing environments. Here are two examples:

A command remains effective only within its scope (see Section 5.3.2). Now suppose that you want to make a change, say redefining a counter, for only a few paragraphs. You could simply place braces around these paragraphs, but they are hard to see. So define

```
\newenvironment{exception}
    {\relax}
    {\relax}
and then
\begin{exception}
    new commands
    body
\end{exception}
```

The environment stands out better than a pair of braces, reminding you later about the special circumstances. The \relax command does nothing, but it is customary to include a \relax command in such a definition to make it more readable.

2. In this example, we define a new environment that centers its body vertically on a new page:

For \vspace, see Section 5.8.2 and for \fill, see the last subsection in Section 15.5.

# 15.3 A custom command file

User-defined commands, of course, are a matter of individual need and taste. I have collected some commands for writing papers in lattice theory in the newlattice.sty file, which you can find in the samples folder (see page 4). I hope that this model helps you to develop a command file of your own. Please remember that everything we discuss in this section is a reflection of *my* work habits. Many experts disagree with one or another aspect of the way I define the commands, so take whatever suits your needs. And keep in mind the dangers of customization discussed in Section 15.7.

**Tip** Some journals do not permit the submission of a separate custom command file. For such journals, just copy the needed user-defined commands into the preamble of the article.

This file is named newlattice.sty. It can be loaded with \usepackage. This has a number of advantages.

Your command names should be mnemonic. If you cannot easily remember a command's name, rename it. The implication here is that your command file should not be very large unless you have an unusual ability to recall abbreviations.

Here are the first few lines of the newlattice.sty command file:

\NeedsTeXFormat{LaTeX2e}[2005/12/01]

The line

gives an error message if a document loading the newlattice package is typeset with LaTeX 2.09 or with an older version of the standard LaTeX. The next line provides information that is written in your log file.

The next seven lines declare what packages are required. If some of these packages have not yet been loaded, then the missing packages are loaded. A package loaded

with \RequirePackage is not read in again.

Being able to specify the packages we need is one of the great advantages of command files. When I write a document, the packages are there if I need them.

You may want some justification for the inclusion of two of these packages in this list. The verbatim package is on the list so that I can use the comment environment to comment out large blocks of text (see Section 5.5.1), which is useful for finding errors and typesetting only parts of a longer document—but do not forget to remove your comments before submission. The enumerate package is on the list because the enumerate and enumeratea environments, defined in newlattice.sty, require it.

If you start your article with

```
\documentclass{amsart}
\usepackage{newlattice}
```

then the \listfiles command (see Section D.3.4) produces the following list when your document is typeset:

```
*File List*
  amsart.cls
                2004/08/06 v2.20
 amsmath.sty
                2000/07/18 v2.13 AMS math features
 amstext.sty
                2000/06/29 v2.01
                1999/11/30 v2.0
  amsgen.sty
  amsbsy.sty
               1999/11/29 v1.2d
  amsopn.sty
                1999/12/14 v2.01 operator names
    umsa.fd
               2002/01/19 v2.2g AMS font definitions
amsfonts.sty
                2001/10/25 v2.2f
newlattice.sty
                  2006/03/15 New commands for lattices v1.2
 amssymb.sty
                2002/01/22 v2.2d
enumerate.sty
                 1999/03/05 v3.00 enumerate
                                  extensions (DPC)
                1999/02/16 v1.0f Enhanced LaTeX
graphicx.sty
                                 Graphics (DPC, SPQR)
  keyval.sty
                1999/03/16 v1.13 key=value
                                 parser (DPC)
                1999/03/16 v1.09 sin cos tan (DPC)
    trig.sty
                2005/02/03 v1.3 graphics configuration
graphics.cfg
                    of teTeX/TeXLive
                2002/06/19 v0.03k graphics/color
  pdftex.def
                                      for pdftex
    umsa.fd
               2002/01/19 v2.2g AMS font definitions
    umsb.fd
               2002/01/19 v2.2g AMS font definitions
    ueuf.fd
               2002/01/19 v2.2g AMS font definitions
 ******
```

Now we continue with newlattice.sty. After the introductory section dealing with LATEX and the packages, we define some commands for writing about lattices and sets:

```
% Lattice operations
\newcommand{\jj}{\vee}% join
\newcommand{\mm}{\bigvee}% meet
\newcommand{\MM}{\bigvee}% big join
\newcommand{\MM}{\bigwedge}% big meet
\newcommand{\JJm}[2]{\JJ(\,#1\mid#2\,)}% big join with a middle
\newcommand{\MMm}[2]{\MM(\,#1\mid#2\,)}% big meet with a middle
% Set operations
\newcommand{\uu}{\cup}% union
\newcommand{\\ii}{\cap}% intersection
\newcommand{\\UU}{\bigcup}% big union
\newcommand{\\UU}{\bigcap}% big intersection
\newcommand{\\UU}{\\invextrm{UU}}{\bigcap}% big intersection
\newcommand{\\UUm}[2]{\\UU(\,#1\mid#2\,)}% big union with a middle
\newcommand{\\IIm}[2]{\\II(\,#1\mid#2\,)}
% big intersection with a middle
```

#### % Sets

```
\newcommand{\contd}{\subseteq}% contained in
\newcommand{\ncontd}{\nsubseteq}% not \contd
\newcommand{\scontd}{\subset}% strictly contained in
\newcommand{\contg}{\supseteq}% containing with equality
\newcommand{\ncontg}{\nsupseteq}% not \contg
\newcommand{\nin}{\notin}% not \in
\newcommand{\empset}{\varnothing}% the empty set
\newcommand{\set}[1]{\{#1\}}% set
\newcommand{\setm}[2]{\{\,#1\mid#2\,\}}% set with a middle
\def\vect<#1>{\langle#1\rangle}% vector
```

So  $a \neq b$  produces  $a \vee b$  and  $a \neq b$  contd B\$ produces  $a \subseteq B$ , and so on. The original commands are not redefined, so if a coauthor prefers  $a \neq b$  to  $a \neq b$ , the \vee command is available.

The commands with a "middle" are exemplified by \setm:

```
\sum x^2 \le x^2 \le 2
typesets as \{x \in R \mid x^2 \le 2\}.
```

Using the \set command, we can type the set  $\{a,b\}$  as  $\star \{a,b\}$ , which is easier to read than  $\{a,b\}$ . Similarly, we type  $\star \{a,b\}$  for the vector  $\langle a,b\rangle$ ,

so it looks like a vector.

Next in newlattice.sty I map the Greek letters to easy to remember commands. For some, I prefer to use the variants, but that is a matter of individual taste. It is also a matter of taste whether or not to change the commands for the Greek letters at all, and how far one should go in changing commonly used commands.

```
% Greek letters
\newcommand{\Gra}{\alpha}
\newcommand{\Grb}{\beta}
\newcommand{\Grc}{\chi}
\newcommand{\Grd}{\delta}
\renewcommand{\Gre}{\varepsilon}
\newcommand{\Grf}{\varphi}
\renewcommand{\Grg}{\gamma}
\newcommand{\Grh}{\eta}
\newcommand{\Gri}{\iota}
\newcommand{\Grk}{\kappa}
\newcommand{\Grl}{\lambda}
\newcommand{\Grm}{\mu}
\newcommand{\Grn}{\nu}
\newcommand{\Gro}{\omega}
\newcommand{\Grp}{\pi}
\newcommand{\Grq}{\theta}
\newcommand{\Grr}{\varrho}
\newcommand{\Grs}{\sigma}
\newcommand{\Grt}{\tau}
\newcommand{\Gru}{\upsilon}
\newcommand{\Grv}{\vartheta}
\newcommand{\Grx}{\xi}
\newcommand{\Gry}{\psi}
\newcommand{\Grz}{\zeta}
\newcommand{\GrG}{\Gamma}
\newcommand{\GrD}{\Delta}
\newcommand{\GrF}{\Phi}
\newcommand{\GrL}{\Lambda}
\newcommand{\GrO}{\Omega}
\newcommand{\GrP}{\Pi}
\newcommand{\GrQ}{\Theta}
\newcommand{\GrS}{\Sigma}
\newcommand{\GrU}{\Upsilon}
\newcommand{\GrX}{\Xi}
\newcommand{\GrY}{\Psi}
```

I also introduce some new names for text font commands by abbreviating text to t (so that \textbf becomes \tbf) and for math font commands by abbreviating math to m (so that \mathbf becomes \mbf).

```
% Font commands
\newcommand{\tbf}{\textbf}% text bold
\newcommand{\tit}{\textit}% text italic
\newcommand{\tsl}{\textsl}% text slanted
\newcommand{\tts}{\textsc}% text small cap
\newcommand{\ttt}{\texttt}% text typewriter
\newcommand{\ttm}{\textrm}% text roman
\newcommand{\trm}{\textrm}% text sans serif
\newcommand{\tsf}{\textsf}% text sans serif
\newcommand{\tup}{\textup}% text upright
\newcommand{\mbf}{\mathbf}% math bold
\providecommand{\mbf}{\mathbf}% math italic
\newcommand{\msf}{\mathsf}% math sans serif
\newcommand{\mrm}{\mathrm}% math roman
\newcommand{\mrm}{\mathrm}% math typewriter
```

The math alphabets are invoked as commands with arguments: \Bold for bold, \Cal for calligraphic, \DD for blackboard bold (double), and \Frak for fraktur (German Gothic) (see Section 8.3.2). Notice that \Cal and \Euler are different because of the option mathscr of the eucal package (see Section 8.3.1).

```
\newcommand{\Bold}[1]{\boldsymbol{#1}}
    % Bold math symbol, use as \Bold{\alpha}
\newcommand{\Cal}[1]{\mathcal{#1}}
    % Calligraphics - only caps, use as \Cal{A}
\newcommand{\DD}[1]{\mathbb{#1}}
    % Doubled - blackboard bold - only caps, use as \DD{A}
\newcommand{\Euler}[1]{\mathscr{#1}}
    % Euler Script - only caps, use as \Euler{A}
\newcommand{\Frak}[1]{\mathfrak{#1}}% Fraktur, use as \Frak{a}
```

 $\Bold{A}$  typesets bold italic A, A; to get upright bold, use  $\mbox{mathbf}{A}$ , which typesets as A. Here are some commands of importance in lattice theory:

```
% Constructs
\DeclareMathOperator{\Id}{Id}
\DeclareMathOperator{\Fil}{Fil}
\DeclareMathOperator{\Con}{Con}
\DeclareMathOperator{\Aut}{Aut}
\DeclareMathOperator{\Sub}{Sub}
```

```
\DeclareMathOperator{\Pow}{Pow}
\DeclareMathOperator{\Part}{Part}
\DeclareMathOperator{\Ker}{Ker}
\newcommand{\Ji}[1]{\tup{J}(#1)} %join irreducible
\newcommand{\Mi}[1]{\tup{M}(#1)} %meet irreducible
% Generated by
\newcommand{\con}[1]{\tup{con}(#1)}
\newcommand{\sub}[1]{\tup{sub}(#1)}
\mbox{\newcommand}(id)[1]{\tup{id}(#1)}
\label{limits} $$\operatorname{mand}\left(fil\right)[1]_{\sup\{f\{\}il\}(\#1)\}$}
\newcommand{\Downg}{\downarrow\!}% down-set generated by
Here are a few more commands and environments:
% Miscellaneous
\newcommand{\newl}{\newline}
\newcommand{\overl}[1]{\overline{#1}}
\newcommand{\underl}[1]{\underline{#1}}
\providecommand{\bysame}{\makebox[3em]%
                         {\hrulefill}\thinspace}
\newcommand{\iso}{\cong}% isomorphic
\def\congr#1=#2(#3){#1\equiv#2\pod{#3}}
   %congruence, use it as \congr a=b(\theta)%
\newcommand{\itemref}[1]{\eqref{#1}}
\newenvironment{enumeratei}{\begin{enumerate}%
               [\upshape (i)]}{\end{enumerate}}
   %produces (i), (ii), etc. Reference with \itemref
\newenvironment{enumeratea}{\begin{enumerate}}%
               [\upshape (a)]}{\end{enumerate}}
   %produces (a), (b), etc. Reference with \itemref
\theoremstyle{plain}
\newtheorem*{namedtheorem}{\theoremname}
\newcommand{\theoremname}{testing}
\newenvironment{named}[1]{\renewcommand{\theoremname}{#1}}
   \begin{namedtheorem}}
   {\end{namedtheorem}}
   %use it as \begin{named}{Name of theorem}
              %Body of theorem \end{named}
\endinput
For the \congr command see Section 15.1.8. The enumeratei and named environ-
```

For the \congr command see Section 15.1.8. The enumeratei and named environments are discussed in Section 15.2.1. The enumeratea environment is similar.

This command file, like all command files, is terminated with the \endinput command. In Section 18.3.2, we discuss the same rule for files that are \include-d.

My newlattice.sty evolves with time. I keep a copy in the folder of every article I write. This way, even years later, with the command file much changed, I can typeset the article with no problem.

The \TextOrMath command (see Section 12.3) is very useful for command files. For instance, we can use it to define our Greek letters, such as

```
\newcommand{\Gra}{\TextOrMath{$\alpha$}{\alpha}}
```

Then we can use \Gra both in text and math to produce  $\alpha$ .

Read the discussion in Sections A.1.6 and A.2.6 where to put your custom command file.

# 15.4 The sample article with user-defined commands

In this section, we look at the sampartu.tex sample article (also in the samples folder), which is a rewrite of the sampart.tex sample article (see Section 11.3 and the samples folder) utilizing the user-defined commands collected in the command file newlattice.sty (see Section 15.3 and the samples folder).

```
% Sample file: sampartu.tex
% The sample article
% with user-defined commands and environments
\documentclass{amsart}
\usepackage{newlattice}
\theoremstyle{plain}
\newtheorem{theorem}{Theorem}
\newtheorem{corollary}{Corollary}
\newtheorem{lemma}{Lemma}
\newtheorem{proposition}{Proposition}
\theoremstyle{definition}
\newtheorem{definition}{Definition}
\theoremstyle{remark}
\newtheorem*{notation}{Notation}
\numberwithin{equation}{section}
% product with a middle
```

```
% product * with a middle
\newcommand{\vectsup}[2]{\vect<\dots,0,\dots,%</pre>
\overset{#1}{#2},\dots,0,\dots>}% special vector
\newcommand{\Dsq}{D^{\langle2\rangle}}
\begin{document}
\title[Complete-simple distributive lattices]
      {A construction of complete-simple\\
       distributive lattices}
\author{George~A. Menuhin}
\address{Computer Science Department\\
        University of Winnebago\\
        Winnebago, Minnesota 23714}
\email{menuhin@ccw.uwinnebago.edu}
\urladdr{http://math.uwinnebago.edu/homepages/menuhin/}
\thanks{Research supported by the NSF under
    grant number~23466.}
\keywords{Complete lattice, distributive lattice,
   complete congruence, congruence lattice}
\subjclass[2000]{Primary: 06B10; Secondary: 06D05}
\date{March 15, 2006}
\begin{abstract}
   In this note we prove that there exist
   \emph{complete-simple distributive lattices,} that is,
   complete distributive lattices in which
   there are only two complete congruences.
\end{abstract}
\maketitle
\section{Introduction}\label{S:intro}
In this note we prove the following result:
\begin{named}{Main Theorem}
   There exists an infinite complete distributive lattice
   $K$ with only the two trivial complete
   congruence relations.
\end{named}
\section{The $\Dsq$ construction}\label{S:Ds}
For the basic notation in lattice theory
and universal algebra, see Ferenc~R.
Richardson \cite{fR82} and George A. Menuhin \cite{gM68}.
```

We start with some definitions:

```
\begin{definition}\label{D:prime}
   Let $V$ be a complete lattice, and let
   {\rm p} = [u, v] be an interval of $V$. Then
   $\Frak{p}$ is called \emph{complete-prime} if the
   following three conditions are satisfied:
   \begin{enumeratei}
      \item $u$ is meet-irreducible but $u$ is \emph{not}
         completely meet-irreducible;\label{m-i}
      \item $v$ is join-irreducible but $v$ is \emph{not}
         completely join-irreducible;\label{j-i}
      \item $[u, v]$ is a complete-simple lattice.\label{c-s}
   \end{enumeratei}
\end{definition}
Now we prove the following result:
\begin{lemma}\label{L:Dsq}
   Let $D$ be a complete distributive lattice satisfying
   conditions \itemref{m-i} and \itemref{j-i}.
   Then $\Dsq$ is a sublattice of $D^{2}$; hence $\Dsq$
   is a lattice, and $\Dsq$ is a complete distributive
   lattice satisfying conditions
   \itemref{m-i} and \itemref{j-i}.
\end{lemma}
\begin{proof}
   By conditions \itemref{m-i} and \itemref{j-i}, $\Dsq$ is a
   sublattice of $D^{2}$. Hence, $\Dsq$ is a lattice.
   Since $\Dsq$ is a sublattice of a distributive
   lattice, $\Dsq$ is a distributive lattice. Using the
   characterization of standard ideals in
   Ernest~T. Moynahan~\cite{eM57},
   $\Dsq$ has a zero and a unit element, namely,
   \color=0, 0> and \color=0, 1>. To show that \color=0, 1>
   is complete, let $\empset \ne A \contd \Dsq$, and let
   a = \J A in D^{2}. If a \in \Dsq, then
   $a = \JJ A$ in $\Dsq$; otherwise, $a$ is of the form
   \ vect<b, 1>$ for some $b \in D$ with $b < 1$. Now
   JJ A = \vect<1, 1>$ in $D^{2}$, and
```

```
the dual argument shows that $\MM A$ also exists in
   $D^{2}$. Hence $D$ is complete. Conditions \itemref{m-i}
   and \itemref{j-i} are obvious for $\Dsq$.
\end{proof}
\begin{corollary}\label{C:prime}
   If $D$ is complete-prime, then so is $\Dsq$.
\end{corollary}
The motivation for the following result comes from
Soo-Key Foo~\cite{sF90}.
\begin{lemma}\label{L:ccr}
   Let $\GrQ$ be a complete congruence relation of $\Dsq$
   such that
   \begin{equation}\label{E:rigid}
      \congr \vect<1, d>=\vect<1, 1>(\GrQ),
   \end{equation}
   for some d \in D with d < 1. Then GrQ = Gri.
\end{lemma}
\begin{proof}
   Let $\GrQ$ be a complete congruence relation of $\Dsq$
   satisfying \left(E:rigid\right). Then \left(GrQ = Gri\right).
\end{proof}
\section{The $\Grp^{*}$ construction}\label{S:P*}
The following construction is crucial to our proof of the
Main~Theorem:
\begin{definition}\label{D:P*}
   Let $D_{i}$, for $i \in I$, be complete distributive
   lattices satisfying condition~\itemref{j-i}. Their
   $\Grp^{*}$ product is defined as follows:
   ١/
     \Pr D_{i} \}_{i \in I} =
                   \Pr \{ D_{i}^{-} \} \{ i \in I \} + 1;
   \]
   that is, {\displaystyle D_{i} } = I  is
   Prodm\{D_{i}^{-}\}\{i \in I\} with a new unit element.
\end{definition}
```

```
\begin{notation}
   If i \in I and d \in D_{i}^{-}, then
   1/
      \vectsup{i}{d}
   \1
   is the element of \scriptstyle D_{i} \ whose
   $i$-th component is $d$ and all the other
   components are $0$.
\end{notation}
See also Ernest~T. Moynahan~\cite{eM57a}. Next we verify:
\begin{theorem}\label{T:P*}
   Let $D_{i}$, for $i \in I$, be complete distributive
   lattices satisfying condition \itemref{j-i}. Let $\GrQ$
   be a complete congruence relation on
   \scriptstyle prodsm{ D_{i} }{i} \in I}. If there exist
   i \in I and d \in D_{i} with d < 1_{i} such
   that for all d \le c < 1_{i},
   \begin{equation}\label{E:cong1}
      \congr\vectsup{i}{d}=\vectsup{i}{c}(\GrQ),
   \end{equation}
   then \GrQ = \Gri.
\end{theorem}
\begin{proof}
   Since
   \begin{equation}\label{E:cong2}
      \congr\vectsup{i}{d}=\vectsup{i}{c}(\GrQ),
   \end{equation}
   and $\GrQ$ is a complete congruence relation, it
   follows from condition \itemref{c-s} that
   \begin{equation}\label{E:cong}
   \begin{split}
       &\langle \dots, \overset{i}{d}, \dots, 0,
        \dots \rangle\\
       &\equiv \bigvee ( \langle \dots, 0, \dots,
        \overset{i}{c},\dots, 0,\dots \rangle \mid d
          \leq c < 1) \geq 1 \leq C
   \end{split}
   \end{equation}
```

```
Let $j \in I$, for $j \neq i$, and let
  a\in D_{j}^{-}\. Meeting both sides of the congruence
  \itemref{E:cong} with $\vectsup{j}{a}$, we obtain
  \begin{equation}\label{E:comp}
      \begin{split}
          0 &= \displaystyle \sum_{i}{d} \m \displaystyle \int_{j}{a}\
           &\equiv \vectsup{j}{a}\pod{\GrQ}.
    \end{split}
  \end{equation}
 Using the completeness of $\GrQ$ and \itemref{E:comp},
 we get:
  \begin{equation}\label{E:cong3}
       \congr{0=\Jm{\vectsup{j}{a}}{ a \in D_{j}^{-} }}
       =\{1\}(\GrQ),
  \end{equation}
  hence \GrQ = \Gri.
\end{proof}
\begin{theorem}\label{T:P*a}
  Let $D_{i}$, for $i \in I$, be complete distributive
  lattices satisfying
  conditions \itemref{j-i} and \itemref{c-s}. Then
  Prodsm{ D_{i} }{i \in I} \ also satisfies
  conditions \itemref{j-i} and \itemref{c-s}.
\end{theorem}
\begin{proof}
  Let $\GrQ$ be a complete congruence on
  Prodsm{D_{i}}{i} \in I. Let $i \in I$. Define
  \begin{equation}\label{E:dihat}
     \widehat{D}_{i} = \setm{ \vectsup{i}{d} }
       \{ d \in D_{i}^{-} \} \subseteq \left\{1\right\}.
  \end{equation}
  Then \hat{D}_{i}\ is a complete sublattice of
  Prodsm{D_{i}}{i} \in I}, and \phi_{i}
  is isomorphic to D_{i}\. Let \CrQ_{i}\ be the
  restriction of $\GrQ$ to $\widehat{D}_{i}$. Since
  $D_{i}$ is complete-simple, so is $\widehat{D}_{i}$,
  hence $\GrQ_{i}$ is $\Gro$ or $\Gri$. If
  \GrQ_{i}=\Gros, for all $i\in Is, then $\GrQ = \Gros.
  If there is an i \in I, such that \c GrQ_{i} = Gri,
  then \congr0=1(\GrQ), and hence \GrQ = \Gri.
\end{proof}
```

```
The Main Theorem follows easily from Theorems~\ref{T:P*}
and ref{T:P*a}.
\begin{thebibliography}{9}
   \bibitem{sF90}
      Soo-Key Foo, \emph{Lattice Constructions},
     Ph.D. thesis, University of Winnebago,
     Winnebago, MN, December, 1990.
   \bibitem{gM68}
      George A. Menuhin, \emph{Universal algebra}. D. Van
     Nostrand, Princeton, 1968.
   \bibitem{eM57}
      Ernest~T. Moynahan,
      \emph{On a problem of M. Stone},
      Acta Math. Acad. Sci. Hungar. \tbf{8} (1957),
      455--460.
   \bibitem{eM57a}
     \bysame, \emph{Ideals and congruence relations in
     lattices}.~II, Magyar Tud. Akad. Mat. Fiz. Oszt.
     K'''\{0\}z1. \tbf\{9\} (1957), 417--434 (Hungarian).
   \bibitem{fR82}
      Ferenc~R. Richardson,
      \emph{General Lattice Theory}.
     Mir, Moscow, expanded and revised ed.,
      1982 (Russian).
\end{thebibliography}
\end{document}
```

# 15.5 Numbering and measuring

Let TeX stores integers in *counters*. For example, the section counter contains the current section number. Distance measurements are saved in *length commands*. For instance, the \textwidth command contains the width of the text. For this book, \textwidth is set to 345.0 points.

In this section, we take a closer look at counters and length commands.

#### 15.5.1 Counters

Counters may be defined by LATEX, by document classes, by packages, or by the user.

#### Standard LATEX counters

Let EX automatically generates numbers for equations, sections, theorems, and so on. Each such number is stored in a *counter*. Table 15.2 shows the standard Let EX counters. Their names are more or less self-explanatory. In addition, for every proclamation *name*, there is a matching counter called name (see Section 6.4).

#### **Setting counters**

The command for setting a counter's value is \setcounter. When LaTeX generates a number, it first increments the appropriate counter, so if you want the next chapter to be numbered 3, you should set the chapter counter to 2 by typing

\setcounter{chapter}{2}

before the \chapter command. The only exception to this rule is the page number, which is first used to number the current page, and then incremented. If you wanted to set the current page number to 63, you would include the command

\setcounter{page}{63}

somewhere in the page.

LATEX initializes and increments its standard counters automatically. Sometimes you may want to manipulate them yourself. To typeset only chapter3.tex, the third chapter of your book, start with

\setcounter{chapter}{2}
\include{chapter3}

and when chapter3.tex is typeset, the chapter is properly numbered. You can also type

\setcounter{page}{63}

equation	part	enumi
figure	chapter	enumii
footnote	section	enumiii
${\tt mpfootnote}$	subsection	enumiv
page	subsubsection	
table	paragraph	
	subparagraph	

Table 15.2: Standard LATEX counters.

if the first page of this chapter is supposed to be 63. Of course, the preferred way to typeset parts of a larger document is with the \includeonly command (see Section 18.3.2).

**Tip** If you need to manipulate counters, always look for solutions in which L≜T<sub>E</sub>X does the work for you.

## Defining new counters

You can define your own counters. For example,

\newcounter{mycounter}

makes mycounter a new counter. In the definition, you can use an optional argument, the name of another counter:

\newcounter{mycounter}[basecounter]

which automatically resets mycounter to 0 if basecounter changes value. This command has the same form as the command LATEX uses internally for tasks such as numbering theorems and subsections within sections.

# **Rule** ■ New counters

New counters should be defined in the preamble of the document. They should not be defined in a file read in with an \include command (see Section 18.3.2).

Let us suppose that you define a new counter, mycounter, in chapter5.tex, which is made part of your whole document with an \include command. When you typeset your document with \includeonly commands not including chapter5.tex, you get an error message, such as

! LaTeX Error: No counter 'mycounter' defined.

## Counter styles

The value of counter can be displayed in the typeset document with the command

\thecounter

If you want to change the counter's appearance when typeset, issue the command

\renewcommand{\the counter} { new\_style }

Style	Command	Sample
Arabic	$\arabic{counter}$	1, 2,
Lowercase Roman	$\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ $	i, ii,
Uppercase Roman	$\Roman\{counter\}$	I, II,
Lowercase Letters	$\alph{counter}$	$a, b, \ldots, z$
Uppercase Letters	$\Alph{counter}$	$A,B,\ldots,Z$

Table 15.3: Counter styles.

where *new\_style* specifies the counter modified as shown in Table 15.3. The default style is arabic. For instance, if you give the command

\renewcommand{\thetheorem}{\Alph{theorem}}

then the theorems appear as Theorem A, Theorem B, ...

Here is a more complicated example for a book:

```
\renewcommand{\thechapter}{\arabic{chapter}}
\renewcommand{\thesection}{\thechapter-\arabic{section}}
\renewcommand{\thesubsection}%
    {\thechapter-\arabic{section}.\arabic{subsection}}
```

With these definitions, Section 1 of Chapter 3 is numbered in the form 3-1 and Subsection 2 of Section 1 of Chapter 3 is numbered in the form 3-1.2.

The \pagenumbering command is a shorthand method for setting the page numbering in a given style. For instance, \pagenumbering{roman} numbers pages as i, ii, and so on.

The subequations environment (see Section 8.5) uses parentequation as the counter for the whole equation group and it uses equation as the counter for the subequations. To change the default format of the equation numbers from (2a), (2b), and so forth, to (2i), (2ii), and so on, type the following line inside the subequations environment

#### Counter arithmetic

The \stepcounter{counter} command increments counter and sets all the counters that were defined with the optional argument counter to 0. The variant

\refstepcounter{counter}

does the same, and also sets the value for the next \label command.

You can do some arithmetic with the command

\addtocounter{counter}{n}

where n is an integer. For example,

\setcounter{counter}{5}

\addtocounter{counter}{2}

sets counter to 7.

The value stored in a counter can be accessed using the \value command, which is mostly used with the \setcounter or \addtocounter commands. For instance, you can set counter to equal the value of another counter, oldcounter, by typing

\setcounter{counter}{\value{oldcounter}}

Here is a typical example of counter manipulation. You might want a theorem (invoked in a theorem environment) to be followed by several corollaries (each in a corollary environment) starting with Corollary 1. In other words, Theorem 1 should be followed by Corollary 1, Corollary 2, and so forth and so should Theorem 3. By default, LaTeX numbers the next corollary as Corollary 3, even if it follows another theorem. To tell LaTeX to start numbering the corollaries from 1 again, issue the command

\setcounter{corollary}{0}

after each theorem. But such a process is error-prone, and goes against the spirit of LATeX.

Instead, follow my advice on page 400, and let LaTeX do the work for you. In the preamble, type the proclamations

\newtheorem{theorem}{Theorem}

\newtheorem{corollary}{Corollary}[theorem]

We are almost there. Theorem 1 now is followed by Corollary 1.1, Corollary 1.2 and Theorem 3 by Corollary 3.1. If we redefine \theorem1 becorollary,

\renewcommand{\thecorollary}{\arabic{corollary}}

then Theorem 1 is followed by Corollary 1 and Corollary 2, and Theorem 3 is also

followed by Corollary 1.

If you need to perform more complicated arithmetic with counters, use Kresten K. Thorup and Frank Jensen's calc package (see Section 12.3.1). This package is discussed in Section A.3.1 of *The LATEX Companion*, 2nd edition [46].

#### Two special counters

The secnumdepth and tocdepth counters control which sectional units are numbered and which are listed in the table of contents, respectively. For example,

```
\setcounter{secnumdepth}{2}
```

sets secnumdepth to 2. As a result, chapters—if they are present in the document class—sections, and subsections are numbered, but subsubsections are not. This command must be placed in the preamble of the document. tocdepth is similar.

## 15.5.2 Length commands

While a counter contains integers, a length command contains a *real number* and a *dimensional unit*.

LATEX recognizes many different dimensional units. We list five absolute units:

- cm centimeter
- in inch
- pc pica (1 pc = 12 pt)
- pt point (1 in = 72.27 pt)
- mm millimeter

and two relative units:

- em, approximately the width of the letter M in the current font
- ex, approximately the height of the letter x in the current font

LATEX defines many length commands. For instance, Section 4.1 of *The LATEX Companion*, 2nd edition [46] lists 17 length commands for page layout alone. You can find some of them in Figure 10.4. A list environment sets about a dozen additional length commands (see Figure 15.2). Length commands are defined for almost every aspect of LATEX's work, including displayed math environments—a complete list would probably contain a few hundred. Many are listed in Leslie Lamport's LATEX: A Document Preparation System, 2nd edition [43] and in *The LATEX Companion*, 2nd edition [46]. Many more are hidden in packages such as amsmath.

The most common length commands are:

- \parindent, the amount of indentation at the beginning of a paragraph
- \parskip, the extra vertical space inserted between paragraphs
- \textwidth, the width of the text on a page

A more esoteric example is \marginparpush, the minimum vertical space between two marginal notes. Luckily, you do not have to be familiar with many length commands because LATEX and the document class set them for you.

#### Defining new length commands

You can define your own length commands. For example,

```
\newlength{\mylength}
```

makes \mylength a new length command with a value of 0 points. Note that while you have to type

\newcounter{counter}

to get a new counter, typing

\newlength{mylength}

results in an error message such as

! Missing control sequence inserted.

<inserted text>

\inaccessible

1.3 \newlength{mylength}

# Setting length

The \setlength command sets or resets the value of a length command. So

```
\setlength{\textwidth}{3in}
```

creates a very narrow page. The first argument of \setlength must be a length command, not simply the command name, that is

```
\setlength{textwidth}{3in} % Bad
```

is incorrect. The second argument of \setlength must be a real number with a dimensional unit, for instance, 3in, and *not simply a real number*. In other words,

```
\setlength{\textwidth}{3} % Bad
```

is also incorrect.

**Tip** A common mistake is to type a command such as

\setlength{\marginpar}{0}

Instead, type

\setlength{\marginpar}{0pt}

Always be sure to include a dimensional unit.

The \addtolength command adds a quantity to the value of a length command. For instance,

\addtolength{\textwidth}{-10pt}

narrows the page width by 10 points.

If you define

\newlength{\shorterlength}
\setlength{\shorterlength}{\mylength}
\addtolength{\shorterlength}{-.5in}

then \parbox{\shorterlength}{...} always typesets its second argument in a box 1/2 inch narrower than the parboxes set to be of width \mylength.

When LaTeX typesets some text or math, it creates a box. Three measurements are used to describe the size of the box:

- the width
- the height, from the baseline to the top
- the depth, from the baseline to the bottom

as illustrated in Figure 15.1. For instance, the box typesetting "aa" has a width of 10.00003 pt, a height of 4.30554 pt, and a depth of 0 pt. The box typesetting "ag" has

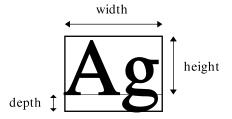


Figure 15.1: The measurements of a box.

the same width and height, but a depth of 1.94444 pt. The box "Ag" (see Figure 15.1) has a width of 12.50003 pt, a height of 6.83331 pt, and a depth of 1.94444 pt.

The commands

\settowidth \settoheight \settodepth

each take two arguments. The first argument is a length command, the second is text (or math) to be measured by LaTeX. The corresponding measurement of the box in which the second argument is typeset is assigned to the length command in the first argument. For example, if \mylength is a length command, then

```
\settowidth{\mylength}{Ag}
```

assigns 12.50003 pt to \mylength. It should be clear from this example how the \phantom and \hphantom commands (see Section 5.8.1) are related to this command.

To perform more complicated arithmetic with length commands, use the calc package.

#### Rubber lengths

In addition to rigid lengths, such as 3in, LaTeX can also set *rubber lengths*, that is, lengths that are allowed to stretch and shrink. Here is an example:

```
\setlength{\stretchspace}{3in plus 10pt minus 8pt}
```

Assuming that \stretchspace is a length command, this command assigns it a value of 3 inches that can stretch by 10 points or shrink by 8 points, if necessary. So a box of width \stretchspace is 3 inches wide, plus up to 10 points, or minus up to 8 points.

Stretchable vertical spaces are often used before and after displayed text environments. LATEX adjusts these spaces to make the page look balanced. An example can be found in Section 15.1.7. \medskipamount is defined as

```
6.0pt plus 2.0pt minus 2.0pt
```

See Section 15.6.3 for more examples.

The \fill command is a special rubber length that can stretch any amount. The stretching is done evenly if there is more than one \fill present. See the second example of brand-new environments in Section 15.2.5.

# 15.6 Custom lists

Although there are three ready-made list environments provided by LaTeX (see Section 6.2), it is often necessary to create one of your own using LaTeX's list environment. In fact, LaTeX itself uses the list environment to define many of its standard environments, including:

15.6 Custom lists 407

- The three list environments (Section 6.2)
- The quote, quotation, and verse environments (Section 6.8)
- Proclamations (Section 6.4)
- The style environments center, flushleft, and flushright (Section 6.3)
- The thebibliography environment (Section 10.5.1)
- The theindex environment (Section 10.5.2)

## 15.6.1 Length commands for the list environment

The general layout of a list is shown in Figure 15.2. It uses six horizontal measurements and three vertical measurements. I now list these length commands.

## Vertical length commands

\topsep is most of the vertical space between the first item and the preceding text, and also between the last item and the following text. This space also includes \parskip, the extra vertical space inserted between paragraphs, and optionally, \partopsep, provided that the list environment starts a new paragraph.

\parsep is the space between paragraphs of the same item.

\itemsep is the space between items. Like \topsep, the actual gap is the sum of \itemsep and \parsep.

All of these vertical length commands are rubber lengths (see Section 15.5.2).

#### Horizontal length commands

By default, the margins of a list environment are the same as the margins of the surrounding text. If the list is nested within a list, the margins are wider and so the text is narrower.

The \leftmargin and \rightmargin length commands specify the distance between the edge of the item box and the left and right margins of the page.

The label is the text provided by the optional argument of an \item command or provided as a default in the definition of the list environment. It is typeset in a box of width \labelwidth, which is indented \itemindent units from the left margin, and separated by a space of \labelsep units from the text box. If the label is too wide to fit in the box, it is typeset at its full natural width, and the first line in the text box is indented.

The second and subsequent paragraphs of an item are typeset with their first lines indented by \listparindent units.

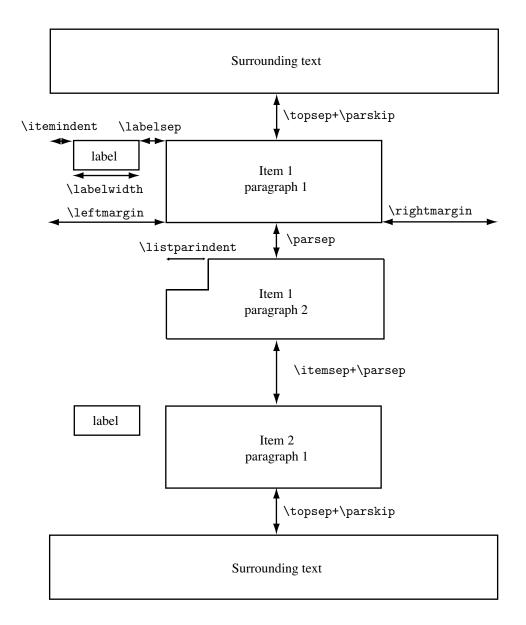


Figure 15.2: The layout of a custom list.

15.6 Custom lists 409

#### 15.6.2 The list environment

Custom lists are created with the list environment, which is invoked as follows:

```
\begin{list}{default_label}{declarations}
  \item item1
  \item item2
  ...
\end{list}
```

The arguments are

- default\_label, the label for any items that do not specify their own, similar to the optional argument of the \item command
- declarations, the vertical and horizontal length commands and any other required parameters for the list

Here is a very simple example:

Here are the most important LaTeX rules about spaces in text, sentences, and paragraphs:

- ♦ Rule 1: Two or more spaces in text are the same as one.
- ♦ Rule 2: A blank line (that is, two end-of-line characters separated only by blanks and tabs) indicates the end of a paragraph.

Rules 1 and 2 make typing and copying very convenient.

I have used the  $\diamondsuit$  math symbol (\$\diamondsuit\$) as a default label, and I set the item box 0.5 inch from either margin. So this example is typed as follows:

```
\noindent Here are the most important \LaTeX\ rules about
spaces in text, sentences, and paragraphs:
\begin{list}{$\diamondsuit$}{\setlength{\leftmargin}{\.5in}}
\item \textbf{Rule 1:} Two or more spaces in text
are the same as one.
\item \textbf{Rule 2:} A blank line (that is, two
end-of-line characters separated only by blanks and tabs)
indicates the end of a paragraph.
\end{list}
Rules 1 and~2 make typing and copying very convenient.
```

Here is a second variant:

Here are the most important LATEX rules about spaces in text, sentences, and paragraphs:

Rule 1: Two or more consecutive spaces in text are the same as one.

Rule 2: A blank line (that is, two end-of-line characters separated only by blanks and tabs) indicates the end of a paragraph.

Rules 1 and 2 make typing and copying very convenient.

In this example, I dropped the optional  $default\_label$  and typed Rule 1: and Rule 2: as (optional) arguments of the \item commands:

For further simple examples, you can look at various document class files to see how standard environments such as verse, quote, and so on, are defined.

#### Using counters

It is not very LaTeX-like to provide the numbers for the rules in the examples above. It would be more logical for LaTeX to do the numbering. The following is a more LaTeX-like coding of the second example:

15.6 Custom lists 411

characters separated only by blanks and tabs)
 indicates the end of a paragraph.\label{Li:blankline}
\end{list}
Rules \ref{Li:Twoor} and~\ref{Li:blankline} make typing

and copying very convenient.

Note that

1. I declared the counter before the list environment with the line

\newcounter{spacerule}

2. I defined the default\_label as

\textbf{Rule \arabic{spacerule}:} item In the declarations, I specified that the list should use the spacerule counter with the command

\usecounter{spacerule}

# 15.6.3 Two complete examples

In the previous examples, I set the values of \leftmargin and \rightmargin. The other length commands were not redefined, so their values remained the values set by the document class. In the following examples, I set the values of many more length commands.

**Example 1** To get the following list,

Here are the most important  $\LaTeX$  rules about spaces in text, sentences, and paragraphs:

- Rule 1: Two or more consecutive spaces in text are the same as one.
- Rule 2: A blank line—that is, two end-of-line characters separated only by blanks and tabs—indicates the end of a paragraph.

Rules 1 and 2 make typing and copying very convenient.

we type
\noindent Here are the most important \LaTeX\ rules about
spaces in text, sentences, and paragraphs:
\newcounter{spacerule}

\begin{list}{\upshape\bfseries Rule \arabic{spacerule}:}

```
{\setlength{\leftmargin}{1.5in}
             \setlength{\rightmargin}{0.6in}
             \setlength{\labelwidth}{1.0in}
             \setlength{\labelsep}{0.2in}
             \setlength{\parsep}{0.5ex plus 0.2ex
                                 minus 0.1ex}
             \setlength{\itemsep}{0ex plus 0.2ex
                                  minus Oex}
             \usecounter{spacerule}
             \itshape}
   \item Two or more consecutive spaces in text are the
   same as one.\label{Li:Twoor}
   \item A blank line---that is, two end-of-line
    characters separated only by blanks and
                           tabs---indicates
    the end of a paragraph.\label{Li:blankline}
\end{list}
Rules \ref{Li:Twoor} and \ref{Li:blankline} make typing
and copying very convenient.
```

Note that

- 1. I declared the counter as in the previous example.
- The last item in declarations is \itshape, which typesets the entire list in italics.
- 3. The default\_label is defined as

```
\upshape\bfseries Rule \arabic{spacerule}
```

My first attempt was to define it as

```
\bfseries Rule \arabic{spacerule}
```

which typesets Rule in bold italics (because in Step 2 we set the whole list in italics). To force the label to be typeset upright, I start the  $default\_label$  with the \upshape command.

4. The left margin is set to 1.5 inches and the right margin to 0.6 inches:

```
\setlength{\leftmargin}{1.5in}
\setlength{\rightmargin}{0.6in}
```

5. Next I set the width of the label to 1 inch, and the space between the label and the item to 0.2 inches:

15.6 Custom lists 413

```
\setlength{\labelwidth}{1.0in} \setlength{\labelsep}{0.2in}
```

6. Finally, I set the paragraph separation to 0.5 ex, allowing stretching by 0.2 ex and shrinking by 0.1 ex, and the item separation to 0 ex, allowing stretching by 0.2 ex and no shrinking, by

```
\setlength{\parsep}{0.5ex plus 0.2ex minus 0.1ex}
\setlength{\itemsep}{0ex plus 0.2ex minus 0ex}
```

The actual amount of item separation is calculated by adding the values specified for \parsep and \itemsep.

A complicated list such as this should be defined as a new environment. For example, you could define a myrules environment:

```
\newenvironment{myrules}
   {\begin{list}
      {\upshape \bfseries Rule \arabic{spacerule}:}
      {\setlength{\leftmargin}{1.5in}
        \setlength{\rightmargin}{0.6in}
        \setlength{\labelwidth}{1.0in}
        \setlength{\labelsep}{0.2in}
        \setlength{\parsep}{0.5ex plus 0.2ex minus 0.1ex}
        \setlength{\itemsep}{Oex plus 0.2ex minus Oex}
        \usecounter{spacerule}
        \itshape} }
   {\end{list}}
and then use it anywhere, as in
\begin{myrules}
   \item Two or more consecutive spaces in text are the
    same as one.\label{Li:Twoor}
   \item A blank line---that is, two end-of-line
    characters separated only by blanks and
    tabs---indicates the end of a paragraph.
                        \label{Li:blankline}
\end{myrules}
Rules \ref{Li:Twoor} and \ref{Li:blankline} make typing
and copying very convenient.
which typesets as the first example shown on page 411.
```

**Example 2** In Section 5.7.2, we discussed the formatting of the following type of glossary:

**sentence** is a group of words terminated by a period, exclamation point, or question mark.

paragraph is a group of sentences terminated by a blank line or by the \par command.

Now we can create the glossary as a custom list:

```
\begin{list}{}
    {\setlength{\leftmargin}{30pt}
     \setlength{\rightmargin}{0pt}
    \setlength{\itemindent}{14pt}
    \setlength{\labelwidth}{40pt}
    \setlength{\labelsep}{5pt}
    \setlength{\parsep}{0.5ex plus 0.2ex minus 0.1ex}
    \setlength{\itemsep}{0ex plus 0.2ex minus 0ex}}
    \item[\textbf{sentence}\hfill] is a group of words
    terminated by a period, exclamation point,
    or question mark.
    \item[\textbf{paragraph}\hfill] is a group of sentences
        terminated by a blank line or by the \com{par} command.
\end{list}
```

There is nothing new in this example except the \hfill commands in the optional arguments to left adjust the labels. With the long words in the example this adjustment is not necessary, but it would be needed for shorter words.

See Section 3.3 of *The LATEX Companion*, 2nd edition [46] on how to customize the three standard list environments and also for more complicated custom lists.

#### 15.6.4 The trivlist environment

LATEX also provides a trivlist environment, meant more for programmers than users. The environment is invoked in the form

```
\begin{trivlist}
  body
\end{trivlist}
```

It is similar to the list environment except that there are no arguments, and all the length commands are trivially set, most to 0 points, except for \listparindent and \parsep, which are set to equal \parindent and \parskip, respectively. For instance, LATEX defines the center environment as follows:

\begin{trivlist}
 \centering \item[]
\end{trivlist}

# 15.7 The dangers of customization

We can customize LaTeX in so many ways. We can add packages to expand its power and define new commands that better suit our work habits. These enhance LaTeX and make it easier to work with. But they also introduce difficulties. Let us start with the obvious.

Whoever introduced the command \textcompwordmark knew that—even if we use command completion—we are not going to type

if\textcompwordmark f

to avoid having a ligature (see Section 5.4.6). It is a lot of typing, and the source file becomes hard to read. This cries out for a user-defined command, say, \Iff, which is short and *readable* (see Section 15.1.1).

When introducing user-defined commands, watch out for the following traps.

# **Trap 1** ■ Redefining a command that is a necessary part of LaTeX.

This is easy to avoid. As discussed in Section 15.1.7, you can easily find out whether a command is already in use. If it is, do not redefine it unless you really know what you are doing.

# **Trap 2** ■ Defining too many commands.

This creates two problems. Your editor has a hard time making changes in your source file. And a few years later, when you want to reuse the material, you have a difficult time understanding all those clever commands.

**Trap 3** ■ Your contribution appears in a volume with many other authors and your user-defined commands create conflicts.

As your article appears in a publication, some parts of it are used for the whole volume. The title and maybe even the section titles are used in the table of contents. The abstracts may be collected for the whole volume or there may be a joint bibliography.

With the advent of the internet, there are now collections of thousands of math articles; PlanetMath.org is one example. Write your articles so that even the editors of PlanetMath.org can use it.

**Rule 1** ■ Do not use your own commands in the title of the article, in the abstract, in section titles, in the bibliography, or in captions of figures and tables.

**Trap 4** ■ You submit the article to a journal that does not permit a separate custom command file.

For such journals, just copy the needed user-defined commands into the preamble of your article. Go through the list and **delete those user-defined commands that are not used in this article**. This helps the editor to look up your commands from a shorter list.

**Rule 2** ■ Introduce judiciously user-defined commands with very short names.

Introducing one-letter commands—for instance, using \C for the complex field—is dangerous because many one-letter commands are reserved by LATEX.

Two-letter user-defined commands are not quite this bad. Of the 2,500 or so possibilities only a few dozen are used by LaTeX. The danger here is, of course, conflict with other authors and confusion for the editor. My command file has about 15 two-letter commands. For instance \jj, part of the \jj, \JJ, \JJm family. Also \Id, because Id is the standard notation for ideal lattices. Some editors may think that this is 15 too many.

**Rule 3** ■ Do not use \def to define your commands, with the exception of a very few delimited commands.

Using \def means giving up LaTeX's built in defense. In the editorial office of my journal, about half the submitted articles that we cannot typeset violate this rule.

**Rule 4** ■ Do not redefine length commands, especially, if you do not know what other length commands are computed based on the ones you change.

The page layout diagram, Figure 10.4, should provide examples. Even simpler, *Do not redefine length commands*. Let the document class define them for your article.

**Rule 5** ■ Make sure that the packages you use are compatible.

For instance, the popular psfrag and epsfig packages cause problems if used with the AMS packages.

Be cautious when you use packages that redefine a lot of LaTeX commands, such as hyperref (see Section 13.2).

You can read more about the plight of authors in the hands of incompetent editors in my article [31] and the difficult job of editors with articles violating the above rules in Enrico Gregorio [16].

CHAPTER

# BIBTEX

The BIBTEX application, written by Oren Patashnik, assists LATEX users in compiling bibliographies, especially long ones. Short bibliographies can easily be placed in the document directly (see Section 10.5.1).

It takes a little effort to learn BIBTeX. But in the long run, the advantages of building bibliographic databases that can be reused and shared outweigh the disadvantage of a somewhat steep learning curve.

The *bibliographic database files*, the bib files, contain the *bibliographic entries*. We discuss the format of these entries in Section 16.1, and then describe how to use BIBTEX to create bibliographies in Section 16.2.

BIBTEX uses a style, called a *bibliographic style*, or bst file, to format entries. On the next two pages we show the bibliography of the sampartb.tex sample article typeset with six different style files.

To simplify our discussion, in the rest of this chapter I discuss only one style, the AMS plain style, amsplain.bst, version 2.0. All of the examples shown are in this style, and several of the comments I make are true only for the AMS plain style. If you choose to use a different style, you should check its documentation for special rules.

- Soo-Key Foo. Lattice Constructions. PhD thesis, University of Winnebago, Winnebago, MN, December 1990.
- [2] George A. Menuhin. Universal Algebra. D. van Nostrand, Princeton, 1968.
- [3] Ernest T. Moynahan. Ideals and congruence relations in lattices. II. Magyar Tud. Akad. Mat. Fiz. Oszt. Közl., 7:417–434, 1957.
- [4] Ernest T. Moynahan. On a problem of M. Stone. Acta Math. Acad. Sci. Hungar., 8:455–460, 1957
- [5] Ferenc R. Richardson. General Lattice Theory. Mir, Moscow, expanded and revised edition, 1982.

# plain.bst

- [Foo90] Soo-Key Foo. Lattice Constructions. PhD thesis, University of Winnebago, MN, December 1990.
- [Men68] George A. Menuhin. Universal Algebra. D. van Nostrand, Princeton, 1968.
- [Moy57a] Ernest T. Moynahan. Ideals and congruence relations in lattices. II. Magyar Tud. Akad. Mat. Fiz. Oszt. Közl., 7:417–434, 1957.
- [Moy57b] Ernest T. Moynahan. On a problem of M. Stone. Acta Math. Acad. Sci. Hungar., 8:455–460, 1957.
- [Ric82] Ferenc R. Richardson. General Lattice Theory. Mir, Moscow, expanded and revised edition, 1982.

## alpha.bst

- Soo-Key Foo, Lattice constructions, Ph.D. thesis, University of Winnebago, Winnebago, MN, December 1990.
- 2. George A. Menuhin, *Universal algebra*, D. van Nostrand, Princeton, 1968.
- Ernest T. Moynahan, Ideals and congruence relations in lattices. II, Magyar Tud. Akad. Mat. Fiz. Oszt. Közl. 7 (1957), 417–434 (Hungarian).
- 4. \_\_\_\_\_\_, On a problem of M. Stone, Acta Math. Acad. Sci. Hungar. 8 (1957), 455–460.
- Ferenc R. Richardson, General lattice theory, expanded and revised ed., Mir, Moscow, 1982 (Russian).

## amsplain.bst

- [Foo90] Soo-Key Foo, Lattice constructions, Ph.D. thesis, University of Winnebago, Winnebago, MN, December 1990.
- [Men68] George A. Menuhin, *Universal algebra*, D. van Nostrand, Princeton, 1968.
- [Moy57a] Ernest T. Moynahan, Ideals and congruence relations in lattices. II, Magyar Tud. Akad. Mat. Fiz. Oszt. Közl. 7 (1957), 417–434 (Hungarian).
- [Moy57b] Ernest T. Moynahan, On a problem of M. Stone, Acta Math. Acad. Sci. Hungar. 8 (1957), 455–460.
- [Ric82] Ferenc R. Richardson, General lattice theory, expanded and revised ed., Mir, Moscow, 1982 (Russian).

#### amsalpha.bst

16.1 The database 423

 S.-K. Foo, Lattice Constructions, PhD thesis, University of Winnebago, Winnebago, MN, Dec. 1990.

- [2] G. A. Menuhin, *Universal Algebra*, D. van Nostrand, Princeton, 1968.
- [3] E. T. MOYNAHAN, Ideals and congruence relations in lattices. II, Magyar Tud. Akad. Mat. Fiz. Oszt. Közl., 7 (1957), pp. 417–434.
- [4] ——, On a problem of M. Stone, Acta Math. Acad. Sci. Hungar., 8 (1957), pp. 455–460.
- [5] F. R. RICHARDSON, General Lattice Theory, Mir, Moscow, expanded and revised ed., 1982.

#### siam.bst

- [1] F. R. Richardson, General Lattice Theory. Moscow: Mir, expanded and revised ed., 1982.
- [2] G. A. Menuhin, Universal Algebra. Princeton: D. van Nostrand, 1968.
- [3] E. T. Moynahan, "On a problem of M. Stone," Acta Math. Acad. Sci. Hungar., vol. 8, pp. 455–460, 1957.
- [4] S.-K. Foo, Lattice Constructions. PhD thesis, University of Winnebago, Winnebago, MN, Dec. 1990.
- [5] E. T. Moynahan, "Ideals and congruence relations in lattices. II," Magyar Tud. Akad. Mat. Fiz. Oszt. Közl., vol. 7, pp. 417–434, 1957.

#### ieeetr.bst

# 16.1 The database

A BIBTEX database is a text file containing bibliographic entries. To use BIBTEX, you first have to learn how to assemble a database. This section explains how to do that.

There may be special tools available for your computer system that assist you in building and maintaining your bibliographic data. Such tools make compiling the data easier and may minimize formatting errors.

You can find all the examples in this section in the template.bib file in the samples folder (see page 4).

# 16.1.1 Entry types

A bibliographic entry is given in pieces called *fields*. The style (see Section 16.2.2) specifies how these fields are typeset. Here are two typical entries:

```
@BOOK{gM68,
    author = "George A. Menuhin",
    title = "Universal Algebra",
    publisher = "D.~Van Nostrand",
    address = "Princeton",
    year = 1968,
    }
```

```
@ARTICLE{eM57,
author = "Ernest T. Moynahan",
title = "On a Problem of {M. Stone}",
journal = "Acta Math. Acad. Sci. Hungar.",
pages = "455-460",
volume = 8,
year = 1957,
}
```

The start of an entry is indicated with an at sign (@) followed by the *entry type*. In the first example, the entry type is BOOK, while in the second, it is ARTICLE. The entry type is followed by a left brace ({}). The matching right brace ({}) indicates the end of the entry. BIBTEX also allows you to use parentheses as delimiters for an entry. In this book, however, we use braces to enclose an entry.

The string @BOOK{ is followed by a *label*, gM68, which designates the name of the entry. Refer to this entry in your document with \cite{gM68}. The label is followed by a comma and a series of fields. In this example, there are five fields, author, title, publisher, address, and year. Each field starts with the field name, followed by = and the value of the field enclosed in double quotes ("). Be sure to use " and *not* LATEX double quotes (' or '). Alternatively, BIBTEX also allows you to use braces to enclose the field value. In this book, we use double quotes to enclose a field.

Numeric field values, that is, fields consisting entirely of digits, do not need to be enclosed in double quotes or braces, for instance, year in the examples above, volume in the second example, and number in some of the examples that follow. Page ranges, such as 455-460, are not numeric field values since they contain -, so they must be enclosed in double quotes or braces.

There *must* be a comma before each field. The comma before the first field is placed after the label.

There are many standard entry types, including

ARTICLE an article in a journal or magazine

BOOK a book with an author (or editor) and a publisher

BOOKLET a printed work without a publisher

INBOOK a part of a book, such as a chapter or a page range that, in general, is not titled or authored separately

INCOLLECTION a part of a book with its own title and perhaps author

INPROCEEDINGS an article in a conference proceedings with its own title and author

MANUAL technical documentation

16.1 The database 425

MASTERSTHESIS a master's thesis

MISC an entry that does not fit in any other category

PHDTHESIS a Ph.D. thesis

PROCEEDINGS the proceedings of a conference

TECHREPORT a report published by a school or institution

UNPUBLISHED an unpublished paper

Each entry includes a number of fields from the following list:

address	institution	pages
author	journal	publisher
booktitle	key	school
chapter	language	series
crossref	month	title
edition	note	type
editor	number	volume
howpublished	organization	year

The style you choose determines which of the fields within an entry are actually used. All the others are ignored. You may also add fields for your own use. For example, you may want to add a mycomments field for personal comments. Such fields are ignored unless you have a bibliography style that uses them.

Commonly used examples of new field names include URL, abstract, ISBN, keywords, mrnumber, and so on. The language field is used by the AMS styles but not by any of the other styles mentioned in this chapter.

## Tip

- 1. BIBTeX does not care whether you use uppercase or lowercase letters (or mixed) for the names of entry types and fields. In this book, the entry types are shown in uppercase and field names in lowercase.
- Placing a comma after the last field is optional. I recommend that you put it there so that when you append a new field to the entry, the required comma separating the fields is present.

For each entry type there are both required and optional fields. Later in this section, I give two examples of each entry type. The first example of an entry type uses a small set of fields, while the second example is a maximal one, showing a large number of optional fields.

## 16.1.2 Typing fields

Make sure you type the field names correctly. If you misspell one, BIBTEX ignores the field. BIBTEX also warns you if a required field is missing.

The author and editor fields require a name.

## Rule Names

- 1. Most names can be typed as usual, "Ernest T. Moynahan" or "Moynahan, Ernest T.", with one comma separating the family name from the given names.
- 2. Type two or more names separated by and. For instance,

```
author= "George Blue and Ernest Brown and Soo-Key Foo",
```

- 3. The family name of Miguel Lopez Fernandez is Lopez Fernandez, so type it as "Lopez Fernandez, Miguel". This informs BIBTEX that Lopez is not a middle name.
- 4. Type Orrin Frink, Jr. as "Frink, Jr., Orrin".

Rules 3 and 4 are seldom needed. In a bibliography of about 1,500 items, I found fewer than 10 names that could not be typed as usual. Note that you can type John von Neumann as "John von Neumann" or "von Neumann, John". Because BIBTEX knows about von, it handles the name properly.

There are a few rules concerning the title field.

## Rule Title

- 1. You should not put a period at the end of a title. The style supplies the appropriate punctuation.
- 2. Many styles, including the AMS styles, convert titles, except for the first letter of the title, to lowercase for all entry types. If you want a letter to appear in uppercase, put it—or the entire word—in braces. The same rule applies to the edition field. Some other styles only do this conversion for the titles of non-book-like entries.
- 3. To maximize the portability of your database, you should type titles with each important word capitalized:

```
title = "On a Problem of {M. Stone}",
```

The style used in this book, amsplain.bst, converts Problem to problem, so it

16.1 The database 427

makes no difference, but some styles do not. To be on the safe side, you should capitalize all words that may have to be capitalized.

For the record, here are the complete rules for titles: Capitalize (1) the first word; (2) the first word in a subtitle (BIBTeX assumes that a subtitle follows a colon, so it capitalizes the first word after a colon—a colon not introducing a subtitle should be typed in braces); (3) all other words except articles, unstressed conjunctions, and unstressed prepositions. Words that should never be converted to lowercase, for example proper names such as Hilbert, should be enclosed in braces to prevent them from being converted to lowercase. In the example above, two letters in the title should not be converted to lowercase, so we enclosed M. Stone in braces. We could also have typed {M. S}tone or {M.} {S}tone.

BIBTEX and the style automatically handle a number of things for you that you would have to handle yourself when typing text.

1. You do not have to mark periods in abbreviations, as .  $\setminus$  in the names of journals (see Section 5.2.2). So

```
journal = "Acta Math. Acad. Sci. Hungar.",
```

typesets correctly.

2. You can type a single hyphen for a page range instead of the usual -- in the pages field (see Section 5.4.2). So

```
pages = "455-460",
```

typesets correctly with an en dash.

3. You do not have to type nonbreakable spaces with ~ in the author or editor fields (see Section 5.4.3):

```
author = "George A. Menuhin",
```

is correct. Normally you would type George A. Menuhin.

Finally, we state a rule about accented characters.

## Rule Accents

Put accented characters in braces: {\"{a}}.

This rule means that

```
author = "Paul Erd\H{o}s",
```

is not recommended. Instead, type

```
author = "Paul Erd{\H{o}}s",
```

This rule is, again, about portability. Some styles, e.g., alpha and amsalpha, create a citation for an article from the first three letters of the name and the last two digits of the year.

```
author = "Kurt G(\To)del",
year = 1931,
```

creates the citation: [Göd31]. The accent is used only if the accents rule has been followed

The downside of this rule is that the braces suppress kerning.

## 16.1.3 Articles

Entry type ARTICLE

Required fields author, title, journal, year, pages

Optional fields volume, number, language, note

Examples:

1. Ernest T. Moynahan, On a problem of M. Stone, Acta Math. Acad. Sci. Hungar. 8 (1957), 455–460.

2. Ernest T. Moynahan, On a problem of M. Stone, Acta Math. Acad. Sci. Hungar. 8 (1957), no. 5, 455–460 (English), Russian translation available.

typed as

```
@ARTICLE{eM57,
   author = "Ernest T. Moynahan",
   title = "On a Problem of {M. Stone}",
   journal = "Acta Math. Acad. Sci. Hungar.",
   pages = "455-460",
   volume = 8,
   year = 1957,
   }

@ARTICLE{eM57a,
   author = "Ernest T. Moynahan",
   title = "On a Problem of {M. Stone}",
   journal = "Acta Math. Acad. Sci. Hungar.",
   pages = "455-460",
```

16.1 The database 429

```
volume = 8,
number = 5,
year = 1957,
note = "Russian translation available",
language = "English",
}
```

#### 16.1.4 Books

Entry type BOOK

Required fields author (or editor), title, publisher, year

Optional fields edition, series, volume, number, address, month, language, note

Examples:

1. George A. Menuhin, *Universal algebra*, D. Van Nostrand, Princeton, 1968.

2. George A. Menuhin, *Universal algebra*, second ed., University Series in Higher Mathematics, vol. 58, D. Van Nostrand, Princeton, March 1968 (English), no Russian translation.

typed as

@BOOK{gM68,

```
author = "George A. Menuhin",
   title = "Universal Algebra",
   publisher = "D.~Van Nostrand",
   address = "Princeton",
   year = 1968,
   }
@BOOK{gM68a,
   author = "George A. Menuhin",
   title = "Universal Algebra",
   publisher = "D.~Van Nostrand",
   address = "Princeton",
   year = 1968,
   month = mar,
   series = "University Series in Higher Mathematics",
   volume = 58,
   edition = "Second",
   note = "no Russian translation",
   language = "English",
   }
```

Abbreviations, such as mar, are discussed in Section 16.1.9.

A second variant of book has an editor instead of an author:

```
15. Robert S. Prescott (ed.), Universal algebra, D. Van Nostrand, Princeton, 1968.

typed as

@BOOK{rP68,
   editor = "Robert S. Prescott",
   title = "Universal Algebra",
   publisher = "D.~Van Nostrand",
   address = "Princeton",
   year = 1968,
   }
```

## 16.1.5 Conference proceedings and collections

Entry type INPROCEEDINGS

Required fields author, title, booktitle, year

Optional fields address, editor, series, volume, number,

organization, publisher, month, note, pages, language

#### Examples:

- 7. Peter A. Konig, *Composition of functions*. Proceedings of the Conference on Universal Algebra, 1970.
- 8. Peter A. Konig, Composition of functions. Proceedings of the Conference on Universal Algebra (Kingston, ON) (G. H. Birnbaum, ed.), vol. 7, Canadian Mathematical Society, Queen's Univ., December 1970, available from the Montreal office, pp. 1–106 (English).

typed as

```
@INPROCEEDINGS{pK69,
  author = "Peter A. Konig",
  title = "Composition of Functions".
  booktitle = "Proceedings of the Conference on
     Universal Algebra",
  year = 1970,
}
```

*16.1 The database* 431

```
@INPROCEEDINGS{pK69a,
  author = "Peter A. Konig",
  title = "Composition of Functions".
  booktitle = "Proceedings of the Conference on
      Universal Algebra",
  address = "Kingston, ON",
  publisher = "Queen's Univ.",
  organization = "Canadian Mathematical Society",
  editor = "G. H. Birnbaum",
  pages = "1-106",
  volume = 7,
  year = 1970,
  month = dec,
  note = "available from the Montreal office",
  language = "English",
  }
```

The address field provides the location of the meeting. The address of the publisher should be in the publisher field and the address of the organization in the organization field.

Entry type INCOLLECTION

Required fields author, title, booktitle, publisher, year
Optional fields editor, series, volume, number, address,
edition, month, note, pages, language

Examples:

- 1. Henry H. Albert, *Free torsoids*, Current Trends in Lattices, D. Van Nostrand, 1970.
- 2. Henry H. Albert, *Free torsoids*, Current Trends in Lattices (George Burns, ed.), vol. 2, D. Van Nostrand, Princeton, January 1970, new edition is due next year, pp. 173–215 (German).

is typed as

```
@INCOLLECTION{hA70,
   author = "Henry H. Albert",
   title = "Free Torsoids",
   booktitle = "Current Trends in Lattices".
   publisher = "D.~Van Nostrand",
   year = 1970,
}
```

```
@INCOLLECTION{hA70a,
    author = "Henry H. Albert",
    editor = "George Burns",
    title = "Free Torsoids",
    booktitle = "Current Trends in Lattices".
    publisher = "D.~Van Nostrand",
    address = "Princeton",
    pages = "173-215",
    volume = 2,
    year = 1970,
    month = jan,
    note = "new edition is due next year",
    language = "German",
}
```

The address field contains the address of the publisher.

## Cross-referencing

If your database has several articles from the same conference proceedings and collections, you may prefer to make an entry for the entire volume, and cross-reference individual articles to that entry. For instance,

```
@PROCEEDINGS{UA69,
   title = "Proceedings of the Conference on,
      Universal Algebra",
   booktitle = "Proceedings of the Conference on
      Universal Algebra",
   address = "Kingston, ON",
   publisher = "Canadian Mathematical Society",
   editor = "G. H. Birnbaum",
   volume = 7,
   year = 1970,
may be the entry for the proceedings volume as a whole, and
@INPROCEEDINGS{pK69a,
   author = "Peter A. Konig",
   title = "Composition of Functions",
   booktitle = "Proceedings of the Conference on
      Universal Algebra",
   pages = "1-106",
   crossref = "UA69",
   }
```

16.1 The database 433

is the cross-referencing entry for a specific article. These two entries produce the following:

1. G. H. Birnbaum (ed.), *Proceedings of the conference on universal algebra*, vol. 7, Kingston, ON, Canadian Mathematical Society, 1970.

2. Peter A. Konig, Composition of functions, in Birnbaum [1], pp. 1–106.

## **Rule** ■ Cross-references

- 1. All the required fields of the cross-referencing entry must appear in either that entry or in the cross-referenced entry.
- 2. The cross-referenced entry should have both a title and a booktitle field.
- 3. The cross-referenced entry must appear in the bib file later than any entry that cross-references it.

## 16.1.6 Theses

Entry type MASTERSTHESIS or PHDTHESIS
Required fields author, title, school, year
Optional fields type, address, month, note, pages

Examples:

- Soo-Key Foo, Lattice constructions, Ph.D. thesis, University of Winnebago, 1990.
- Soo-Key Foo, Lattice constructions, Ph.D. dissertation, University of Winnebago, Winnebago, MN, December 1990, final revision not yet available, pp. 1–126.

is typed as

```
@PHDTHESIS{sF90,
    author = "Soo-Key Foo",
    title = "Lattice Constructions",
    school = "University of Winnebago",
    year = 1990,
    }
```

```
@PHDTHESIS{sF90a,
    author = "Soo-Key Foo",
    title = "Lattice Constructions",
    school = "University of Winnebago",
    address = "Winnebago, MN",
    year = 1990,
    month = dec,
    note = "final revision not yet available",
    type = "Ph.D. dissertation",
    pages = "1-126",
}
```

If the type field is present, its content takes the place of the phrase Ph.D. thesis (or Master's thesis).

## 16.1.7 Technical reports

Entry type TECHREPORT
Required fields author, title, institution, year
Optional fields type, number, address, month, note

Examples:

Г

- 1. Grant H. Foster, Computational complexity in lattice theory, tech. report, Carnegie Mellon University, 1986.
- 2. Grant H. Foster, Computational complexity in lattice theory, Research Note 128A, Carnegie Mellon University, Pittsburgh, PA, December 1986, in preparation.

is typed as

```
@TECHREPORT{gF86,
   author = "Grant H. Foster",
   title = "Computational Complexity in Lattice Theory",
   institution = "Carnegie Mellon University",
   year = 1986,
   }

@TECHREPORT{gF86a,
   author = "Grant H. Foster",
   title = "Computational Complexity in Lattice Theory",
   institution = "Carnegie Mellon University",
   year = 1986,
```

16.1 The database 435

```
month = dec,
type = "Research Note",
address = "Pittsburgh, PA",
number = "128A",
note = "in preparation",
}
```

## 16.1.8 Manuscripts and other entry types

Entry type UNPUBLISHED

 $\begin{tabular}{ll} \textbf{Required fields} & \textbf{author}, \textbf{title}, \textbf{note} \\ \end{tabular}$ 

Optional fields month, year

## Examples:

1. William A. Landau, Representations of complete lattices, manuscript, 55 pages.

2. William A. Landau, Representations of complete lattices, manuscript, 55 pages, December 1975.

is typed as

```
@UNPUBLISHED{wL75,
    author = "William A. Landau",
    title = "Representations of Complete Lattices",
    note = "manuscript, 55~pages",
    }

@UNPUBLISHED{wL75a,
    author = "William A. Landau",
    title = "Representations of Complete Lattices",
    year = 1975,
    month = dec,
    note = "manuscript, 55~pages",
    }
```

Other standard entry types include

Entry type BOOKLET Required field title

Optional fields author, howpublished, address, month, year, note

Entry type INBOOK

Required fields author or editor, title, chapter or pages, publisher,

year

Optional fields series, volume, number, type, address,

edition, month, pages, language, note

Entry type MANUAL Required field title

Optional fields author, organization, address, edition, month, year,

note

Entry type MISC

**Required field** at least one of the optional fields must be present

Optional fields author, title, howpublished, month, year, note, pages

Entry type PROCEEDINGS
Required fields title, year

Optional fields editor, series, volume, number, address,

organization, publisher, month, note

#### 16.1.9 Abbreviations

You may have noticed the field month = dec in some of the examples. This field uses an abbreviation. Most BIBTeX styles, including the AMS styles, include abbreviations for the months of the year: jan, feb, ..., dec. When an abbreviation is used, it is not enclosed in quotes (") or braces ({ }). The style defines what is actually to be typeset. Most styles typeset dec as either Dec. or December.

The name of the abbreviation, such as dec, is a string of characters that starts with a letter, does not contain a space, an equal sign (=), a comma, or any of the special characters listed in Section 5.4.4.

You may define your own abbreviations using the command @STRING. For example,

```
@STRING{au = "Algebra Universalis"}
```

A string definition can be placed anywhere in a bib file, as long as it precedes the first use of the abbreviation in an entry.

The AMS supplies the mrabbrev.bib file containing the standard abbreviations for many mathematical journals. Find it at ams.org, under Reference Tools, click on MR Serials Abbreviations for BibTeX. Based on this file, you can make your own abbrev.bib file containing entries for all the journals you reference with whatever abbreviations you find easiest to remember. You should pare down the file, mrabbrev.bib, because it is too large for some systems to handle.

If you use this scheme, the command you use to specify the bib files may look like

```
\bibliography{abbrev,...}
```

Section 16.2.1 explains the \bibliography command.

# 16.2 Using BIBT<sub>E</sub>X

In Section 16.1, you learned how to create database files. The sample bib files are template.bib and sampartb.bib in the samples folder (see page 4). In this section, you learn how to use BIBTEX to process these files to create a bibliography. We illustrate the process of working with BIBTEX with the sampartb sample article.

We use the amsplain style. To obtain all six examples of different styles shown on pages 422–423, just change amsplain to the appropriate style name in your document and typeset it.

One BIBTEX style behaves differently. The apacite style of the American Psychological Association requires that the preamble of your document include the line

```
\usepackage{apalike}
```

in addition to using the style file. The package can also be modified by a large number of options.

## 16.2.1 Sample files

Type the following two lines to replace the thebibliography environment in the sampart.tex sample document:

```
\bibliographystyle{amsplain}
\bibliography{sampartb}
```

Save the new sample article as sampartb.tex. The first line specifies the bst file, amsplain.bst, which is part of the AMS distribution (see Section 11.6). The second line specifies the database files used. In this case there is only one, sampartb.bib.

The contents of the sampartb.bib bibliographic database file are as follows:

```
@BOOK{gM68,
    author = "George A. Menuhin",
    title = "Universal Algebra",
    publisher = "D.~Van Nostrand",
    address = "Princeton",
    year = 1968,
    }
```

```
@BOOK{fR82,
   author = "Ferenc R. Richardson",
  title = "General Lattice Theory",
   edition = "Expanded and Revised",
   language = "Russian",
  publisher = "Mir",
   address = "Moscow",
   year = 1982,
   }
@ARTICLE{eM57,
   author = "Ernest T. Moynahan",
  title = "On a Problem of {M. Stone}",
   journal = "Acta Math. Acad. Sci. Hungar.",
  pages = "455-460",
  volume = 8,
  year = 1957,
   }
@ARTICLE{eM57a,
   author = "Ernest T. Moynahan",
  title = "Ideals and Congruence Relations in
      Lattices. ~\textup{II}",
   journal = "Magyar Tud. Akad. Mat. Fiz. Oszt. K{\"{o}}zl.",
   language = "Hungarian",
  pages = "417-434",
  volume = 7,
  year = 1957,
   }
@PHDTHESIS{sF90,
   author = "Soo-Key Foo",
  title = "Lattice Constructions",
   school = "University of Winnebago",
   address = "Winnebago, MN",
  year = 1990,
  month = dec,
   }
```

Type sampartb.bib or copy it from the samples folder to your work folder.

## 16.2.2 Setup

Before you start BIBTeX, make sure that everything is set up properly as described in this section.

439

To list database entries in the bibliography, use the \cite command. Refer to Section 10.5.1 for details on how to use citations. If you want to have a reference listed in the bibliography without a citation in the text, then use the \nocite command. For example,

```
\cite{pK57}
```

includes the reference in the bibliography and cites the entry with label pK57, whereas

```
\nocite{pK57}
```

includes the reference in the bibliography but does not cite the entry. In either case, one of the bib files specified in the argument of the \bibliography command must contain an entry with the label pK57. The \nocite{\*} command includes *all* the entries from the bibliographic databases you've specified.

Your document must specify the bibliography style and must name the bib files to be used. For instance, the sampartb.tex sample article contains the lines

```
\bibliographystyle{amsplain}
\bibliography{sampartb}
```

The \bibliographystyle command specifies amsplain.bst as the style and the \bibliography command specifies the database file sampartb.bib. To use several database files, separate them with commas, as in

```
\bibliography{abbrev,gg,lattice,sampartb}
```

where

- abbrev.bib contains user-defined abbreviations
- gg.bib contains personal articles
- lattice.bib contains lattice theory articles by other authors
- sampartb.bib contains additional references needed for sampartb.tex

It is important to make sure that the bst file, the bib file(s), and the LATEX document(s) are in folders where BIBTEX can find them. If you are just starting out, you can simply copy all of them into one folder. Later, you may want to look for a more permanent solution by keeping the files abbrev.bib and lattice.bib in one "central" location, while placing sampartb.bib in the same folder as its corresponding LATEX document.

440 Chapter 16 BIBT<sub>E</sub>X

## 16.2.3 Four steps of BibTeXing

The following steps produce a typeset bibliography in your LATEX document. We use the sampartb.tex sample article as an example.

**Step 1** Check that BIBTeX, your LATeX document, and the bib files are placed in the appropriate folders.

Step 2 Typeset sampartb.tex to get a fresh aux file. This step is illustrated in Figure 16.1.

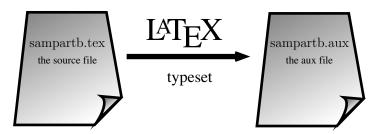


Figure 16.1: Using BIBTEX, step 2.

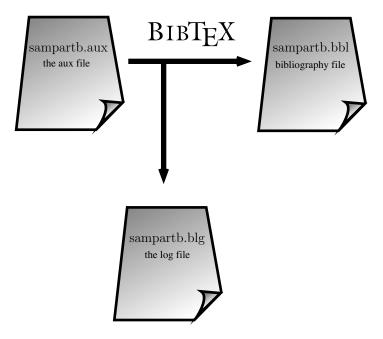


Figure 16.2: Using BIBTEX, step 3.

**Step 3** Run BIBTEX on the sampartb.aux file in one of the following three ways:

- by invoking it with the argument sampartb
- by starting the application and then opening sampartb.aux
- by running it by choosing it as a menu option of your editor or GUI front end or by clicking on an icon

If BIBTEX cannot find a crucial file, for example, the bst file, it stops. The reason it stopped is shown in the log window and also written to a blg (bibliography log) file, sampartb.blg. Correct the error(s) and go back to step 2. A successful run creates a bbl (bibliography) file, sampartb.bbl, in addition to sampartb.blg. This step is illustrated in Figure 16.2.

Step 4 Typeset the LATEX document sampartb.tex twice.

BIBTEX uses and creates a number of files when it is run. To illustrate this process, complete the four steps using sampartb.tex.

- **Step 1** Start fresh by deleting the aux, blg, and bbl files, if they are present.
- Step 2 Typeset the article sampartb.tex to get an aux file (see Figure 16.1). Notice that the log file contains warnings about missing references and a number of other lines not relevant to the current discussion. The lines in the aux file containing bibliographic information are

```
\citation{fR82}
\citation{gM68}
\citation{eM57}
\citation{sF90}
\citation{eM57a}
\bibstyle{amsplain}
\bibdata{sampartb}
```

Each \citation command in this file corresponds to a \cite or \nocite command in the article. The lines

```
\bibliographystyle{amsplain}
\bibliography{sampartb}
in sampartb.tex are written as
\bibstyle{amsplain}
\bibdata{sampartb}
in the sampartb.aux file.
```

Step 3 Now run BIBTEX on the sampartb. aux file (see Figure 16.2). How we do this, depends on the LATEX installation you have. In UNIX installations, you type

bibtex intrarti

at the command line. In newer user interfaces, BIBTEX is represented by an icon, and you drop intrarti.aux into it. In modern installations, your editor also runs BIBTEX. In WinEdt (see Section A.1.2), run BIBTEX by clicking on the BIBTEX button. In TeXShop (see Section A.2.1), change the LaTeX button to BibTeX and click on the Typeset button. Now change the BibTeX button back to LaTeX. Click on the Typeset button, and you have the typeset article with the bibliography.

BIBTeX generates two new files: sampartb.blg and sampartb.bbl. Look at sampartb.blg:

```
This is BibTeX, C Version 0.99c
The top-level auxiliary file: sampartb.aux
The style: amsplain.bst
Database file #1: sampartb.bib
```

On some systems, this file may be much longer than the one I show here. At present, this blg file does not contain much important information. If there were any warnings or errors, they would be listed in this file.

The sampartb.bbl file, in which BIBTEX created a thebibliography environment (see Section 10.5.1) is more interesting:

```
\providecommand{\bysame}{\leavevmode%
\hbox to3em {\hrulefill}\thinspace}
\begin{thebibliography}{1}
```

```
\bibitem{sF90}
Soo-Key Foo, \emph{Lattice constructions},
Ph.D. thesis, University of Winnebago,
Winnebago, MN, December 1990.
```

```
\bibitem{gM68}
George~A. Menuhin, \emph{Universal algebra},
D.~Van Nostrand, Princeton, 1968.
```

```
\bibitem{eM57a}
Ernest~T. Moynahan, \emph{Ideals and congruence
relations in lattices.~\textup{II}},
Magyar Tud. Akad. Mat. Fiz. Oszt. K{\"{o}}zl.
\textbf{7} (1957), 417-434 (Hungarian).
```

```
\bibitem{eM57}
\bysame, \emph{On a problem of {M. Stone}}, Acta
Math. Acad. Sci. Hungar. \textbf{8} (1957),
455-460.
\bibitem{fR82}
Ferenc~R. Richardson, \emph{General lattice theory},
expanded and revised ed., Mir, Moscow,
1982 (Russian).
\end{thebibliography}
```

Observe that the nonbreakable spaces (ties) and the \bysame command have been provided in the author fields.

**Step 4** Now typeset sampartb.tex again. The typeset version now has a REFER-ENCES section, constructed from the bbl file, but the new log file has warnings about missing entries. The new aux file contains five interesting new lines:

```
\bibcite{sF90}{1}
\bibcite{gM68}{2}
\bibcite{eM57a}{3}
\bibcite{eM57}{4}
\bibcite{fR82}{5}
```

These lines identify the cross-reference label sF90 (see the first line shown—the symbol designates Foo's thesis in sampartb.bib) with the number 1, and so on. Now typeset sampartb.tex again, and all the citations are correctly placed in the typeset article.

#### Observe:

- 1. The crucial step 3, running the BIBTEX application, gives different error messages and obeys different rules from LATEX—see Section 16.2.4.
- 2. The sampartb.bbl file was created by BIBTEX. It is not changed by running LATEX.

## 16.2.4 BibT<sub>E</sub>X rules and messages

## Rule ■ BIBT<sub>E</sub>X and %

You cannot comment out a field with an \%.

For example, the entry

```
@ARTICLE{eM57,
   author = "Ernest T. Moynahan",
   title = "On a Problem of {M. Stone}",
   journal = "Acta Math. Acad. Sci. Hungar.",
   \% pages = "455-460",
   volume = 8,
   year = 1957,
   }
causes BIBTEX to generate the error message
You're missing a field name
                 line 23 of file sampartb.bib
      % pages = "455-460",
(Error may have been on previous line)
I'm skipping whatever remains of this entry
Warning--missing year in eM57
Warning--missing pages in eM57
(There was 1 error message)
```

Recall that BIBTEX ignores field names it cannot recognize. So changing the field name pages, for example to pages-comment, does not give an error message. However, doing so removes a required field, so you get the warning message

Warning--missing pages in eM57

## Rule ■ BIBT<sub>E</sub>X field names

Do not abbreviate field names.

For instance, if you abbreviate volume to vol, as in

```
@ARTICLE{eM57,
   author = "Ernest T. Moynahan",
   title = "On a Problem of {M. Stone}",
   journal = "Acta Math. Acad. Sci. Hungar.",
   pages = "455-460",
   vol = 8,
   year = 1957,
}
```

the vol field is simply ignored. This entry is typeset as

3. Ernest T. Moynahan, On a problem of M. Stone, Acta Math. Acad. Sci. Hungar. (1957), 455–460.

instead of

3. Ernest T. Moynahan, On a problem of M. Stone, Acta Math. Acad. Sci. Hungar. 8 (1957), 455–460.

## **Rule** ■ BIBT<sub>E</sub>X field terminations

Make sure that every field of an entry, except possibly the last, is terminated with a comma.

If you drop a comma before a field, you get an error message such as

## **Rule** ■ BIBT<sub>E</sub>X field value terminations

Make sure that the field value is properly terminated.

You should be careful not to drop a double quote or brace. If you drop the closing quote on line 11 of the bib file,

If, instead, you drop the opening double quote in the same line, you get the error message

```
Warning--string name "general" is undefined
--line 11 of file sampartb.bib

I was expecting a ',' or a '}'
line 11 of file sampartb.bib

: title = general
: Lattice Theory",

I'm skipping whatever remains of this entry
Warning--missing title in fR82
Warning--missing publisher in fR82
Warning--missing year in fR82
(There was 1 error message)
```

BIBTEX assumed that general was an abbreviation, since it was not preceded by a ".

The obvious conclusion is that you have to be very careful about typing your bibliographic entries for BIBTeX. If you have access to special tools for maintaining your bibliographic data, use them. Otherwise, refer to the template.bib file that contains templates of often-used entry types.

## 16.2.5 Submitting an article

If you submit an article to a journal that provides you with a BIBTEX style file, then you can submit the article and the BIBTEX database file, pared down of course. If this is not the case, create the bbl file with amsplain.bst and copy and paste the content into the thebibliography environment in the article. Then the journal's editor can edit the bibliography.

## 16.3 Concluding comments

There is a lot more to BIBTEX than what has been covered in this chapter. For example, BIBTEX's algorithm to alphabetize names is fairly complicated. Some names create additional difficulties. Where should John von Neumann be placed, under the "v"-s or the "N"-s? It depends on the style. How do we handle names where the first word is the family name, as in Ho Chi Minh or Grätzer György? Again, it depends on the style.

Oren Patashnik's *BIBT<sub>E</sub>Xing* [52] has many helpful hints. It includes a clever hack to order entries correctly even when the style does not do so. Chapter 13 of *The LAT<sub>E</sub>X Companion*, 2nd edition [46] has a long discussion of BIBT<sub>E</sub>X. It also contains a long list of styles.

There are many tools to make BIBTEXing easier. *BibDesk* for the Mac is an excellent graphical BIBTEX-bibliography manager. For Windows, there is *BibTexMng*. For UNIX, there is *pybibliographer* and if you are an Emacs user, there is *Ebib*. Written in

Java, so available on most platforms, is JBibtexManager.

There are many BIBTEX databases. The largest one may be "The Collection of Computer Science Bibliographies" with more than two million references.

You can easily build your own mathematical databases with MathSciNet from the AMS. Do a search. When the result page comes up, go to the pull down menu next to Batch Download and select Citations (BibTeX). Now you can check mark the items you want by clicking on the little squares and then click on Retrieve Marked next to the pull down menu or click on Retrieve First 50. For the latter to work well, before your search, click on the Preferences button and click on the circle next to 50, so you get at most 50 items per result page. Then Retrieve First 50 retrieves them all.

Finally, after many years of development, the AMS released amsrefs, the kid brother of BIBTeX, at its annual meeting in January 2002. The presentation was made by Michael Downes, who designed and coded the package. I was very excited to hear his lecture—bibliographic management was the last block needed to complete the rebuilding of LATeX. It turned out that amsrefs is not simply a BIBTeX replacement. It has a number of very important new features.

- 1. You can, with amsrefs, enter the marked up bibliographic entries into the document. This means that the document class of the journal publishing the paper can format your bibliography.
- 2. amsrefs is a LaTeX package. Therefore, you do not have to learn (another) esoteric language to control the formatting of your bibliography. Developing a format for a journal is very easy.
- 3. The bibliographic data files are also LaTeX files, so you can print them within LaTeX, making it easy to maintain them.

After Michael Downes passed away, David Jones took over the project, and released version 2.0 in June of 2004.

Unfortunately, unlike the BIBTEX and its bbl file, amsrefs directly creates the typeset file. So if the journal you want to submit your article to does not have an amsrefs style file—and today only the AMS journals have them—then you have to manually convert the amsrefs entries into the format the journal would accept. There is no option to set in amsrefs to produce a LATEX source file for the bibliographic entries. Therefore, unless you know that you intend to submit to an AMS journal—and you know that it will accept your article for publication—you should not use amsrefs.

There is a second obstacle. There is no BibDesk or BibTexMng for amsrefs. But I believe that if amsrefs overcomes the first obstacle, then the second obstacle would resolve itself fast.

There is a new development which shares some of Michael Downes' goals. It is Philipp Lehman's biblatex package, now in version 0.6. It works with (some) BIBTEX databases and uses LATEX to format the bibliography.

# **MakeIndex**

Pehong Chen's *MakeIndex* application, described in Pehong Chen and Michael A. Harrison's *Index preparation and processing* [10], helps LaTeX users create long indexes. For short indexes, you can easily do without it (see Section 10.5.2).

In Section 17.1, we show you by an example how to prepare an article for indexing. We introduce formally the index commands in Section 17.2. In Section 17.3, we describe how Lagrange and *MakeIndex* process the index entries. The rules are stated in Section 17.4.

Multiple indexes are almost as easy as single indexes. They are described in Section 17.5. We conclude with glossaries in Section 17.6.

Indexing is a difficult task. For an extensive discussion on how to create a useful index, consult *The Chicago Manual of Style*, 15th edition [11].

# 17.1 Preparing the document

LATEX provides the theindex environment (see Section 10.5.2). Within this environment, it provides the \item, \subitem, and \subsubitem commands to typeset entries, subentries, and subsubentries, respectively, and the \indexspace command for adding vertical space between alphabetical blocks, see Figure 17.1 for an example.

The makeidx package provides the \index command for specifying the index entry at a particular point in the document, which becomes a page reference for the entry in the typeset index.

Making an index entry with *MakeIndex* is easy. You simply place the index commands in your source file, and then let LaTeX and *MakeIndex* do the work of gathering the entries and the page numbers for the entries, sorting them, and formatting the type-set index.

There are three steps:

1. In the preamble of your LATEX document, include the line

\makeindex

If you do not use an AMS document class, include the two lines

\usepackage{makeidx}
\makeindex

#### 2. Type the line

\printindex

at the point in your document where you want the index to appear, usually as part of the back matter (see Section 10.5).

3. Mark all entries in your document with \index commands.

We illustrate this procedure with the intrarti.tex article, which modifies the article intrart.tex by inserting a number of index entries (both intrart.tex and intrarti.tex are in the samples folder; see page 4).

We now add a dozen \index commands to intrart.tex.

#### Command 1

```
Retype the line
```

\begin{theorem}

to read

\begin{theorem}\index{Main Theorem}

#### Commands 2 and 3

Type the commands

```
\index{pistar@$\Pi^{*}$ construction}%
\index{Main Theorem!exposition|(}%
after the line
```

\section{The \$\Pi^{\*}\$ construction}\label{S:P\*}

#### Command 4

```
Retype the line
See also Ernest~T. Moynahan~\cite{eM57a}.
as follows:
See also Ernest~T.
\index{Moynahan, Ernest~T.}%
Moynahan~\cite{eM57a}.
Commands 5 to 7
Type the three index items
\index{lattice|textbf}%
\index{lattice!distributive}%
\index{lattice!distributive!complete}%
before the line
\begin{theorem}\label{T:P*}
Command 8
Type
\index{Main Theorem!exposition|)}
after the line
hence $\Theta = \iota$.
Command 9
Retype the line
\bibitem{sF90}
as follows:
\bibitem{sF90}\index{Foo, Soo-Key}%
Command 10
Retype the line
\bibitem{gM68}
as follows:
\bibitem{gM68}\index{Menuhin, George~A.}%
```

#### Command 11

```
Retype the line
\bibitem{eM57}
as follows:
\bibitem{eM57}\index{Moynahan, Ernest~T.}%

Command 12

Retype the line
\bibitem{eM57a}
as follows:
\bibitem{eM57a}\index{Moynahan, Ernest~T.}%
```

These \index commands produce the index for the intrarti.tex article shown in Figure 17.1. Notice that although you typed 12 index commands, only 11 entries appear in the index. The last two entries for Moynahan (commands 11 and 12) occur on the same typeset page, so only one page number shows up in the index.

INDEX

```
Foo, Soo-Key, 2
lattice, 1
distributive, 1
complete, 1

Main Theorem, 1
exposition, 1–2
Menuhin, George A., 2
Moynahan, Ernest T., 1, 2
Π* construction, 1
```

Figure 17.1: A simple index.

The showidx package (see Section 12.3) lists all the index items of a page in a top corner on the margin. The top of the first page of the typeset intrarti.tex is shown in Figure 17.2.

17.2 Index commands 453

# A CONSTRUCTION OF COMPLETE-SIMPLE DISTRIBUTIVE LATTICES

GEORGE A. MENUHIN

ABSTRACT. In this note, we prove that there exist *complete-simple distributive lattices*, that is, complete distributive lattices with only two complete congruences.

Main Theorem
pistar@\$"Pi"\*\$
construction
Main
Theorem!exposition—(
Moynahan, Ernest"T.
lattice—textbf
lattice!distributive
lattice!distributivelcomplete

Figure 17.2: Using showidx.

## 17.2 Index commands

There are a few major forms of \index commands. They are discussed in this section, illustrated by the commands shown in Section 17.1.

```
Simple \index commands
```

```
The index entry

Foo, Soo-Key, 2

was created by command 9,

\index{Foo, Soo-Key}

This entry is an example of the simplest form of an index command:
\index{entry}

The entry

lattice, 2

was created as command 5,

\index{lattice|textbf}

Ignore, for the time being, the |textbf part. This entry has a subentry,

lattice, 2

distributive, 2

which was created by command 6,
```

```
\index{lattice!distributive}
There is also a subsubentry,
lattice, 2
    distributive, 2
      complete, 2
which was created by command 7,
\index{lattice!distributive!complete}
The form of the \index command for subentries is
\index{entry!subentry}
and for subsubentries it is
\index{entry!subentry!subsubentry}
Modifiers
Command 5
\index{lattice|textbf}
produces a bold page number in the entry lattice.
    The command whose name follows the symbol | (in this case, the command name
is textbf) is applied to the page number. For instance, if you want a large bold page
number, then define the command \LargeBold as
\newcommand{\LargeBoldB}[1]{\textbf{\Large #1}}
and type the \index command as
\index{entry | LargeBold}
    You can also modify \index commands to indicate page ranges:
Main Theorem, 1
  exposition, 1-2
The latter index entry has a page range. It was created with commands 3 and 8:
\index{Main Theorem!exposition|(}
\index{Main Theorem!exposition|)}
```

17.2 Index commands 455

Separate an entry from its modifier with 1, open the page range with (, and close it with ).

Modifiers can also be combined. The index commands

```
\index{Main Theorem!exposition|(textbf}\index{Main Theorem!exposition|)textbf}
produce a bold page range.
```

## Sorting control

Observe the \index command

```
\index{pistar@$\Pi^{*}$ construction}
```

This produces the entry

```
\Pi^* construction, 1
```

To place this entry in the correct place in the index, use a *sort key*. The general form of an \index command with a sort key is

```
\index{sortkey@entry}
```

In this example, the sortkey is pistar. When the entries are sorted, the *sortkey* is used to sort the entry. A few typical examples follow:

## Example 1 An \index command for G.I. Žitomirskii,

```
\label{lem:continuous} $$ \left( v_{Z} \right) = \left( u_{i}, G.I. \right) $$ sorts $\check{Z}$ itomirskii with the $Z$ entries. $$ If you used the command $$ \left( v_{Z} \right) = \left( u_{i}, G.I. \right) $$$ for $i \in \mathbb{N}$. $$
```

Žitomirskiĭ would be sorted with the v's.

## Example 2 An \index command for the Örmester lemma,

```
\index{Ormester@\H{O}rmester lemma}
would sort Őrmester lemma with the O entries.
If you used the command
\index{\H{O}rmester lemma}
Őrmester lemma would be sorted with the H's.
```

**Example 3** An \index command for *truncated* lattice,

```
\index{truncated lattice@\emph{truncated} lattice}
sorts truncated lattice with the t entries.
If you use the command
\index{\emph{truncated} lattice}
this would sort truncated lattice with the e's.
```

**Example 4** We want to place the symbol Truncat f, typed as \Trunc f (see Section 7.6.2) in the index, sorted as Trunc.

## Sorting control and subentries

If you want to place a subentry under an entry with a sort key, you must include the sort key part of the entry as well:

```
\index{sortkey@entry!subentry}
For instance,
\index{Zitomirskii@\v{Z}itomirski\u{\i}, G.I.!education}
   You can also use a sort key for subentries (and subsubentries), such as
\index{lattice!weakly distributive@
        \emph{weakly} distributive}
or, a more complicated example,
\index{Zitomirskii@\v{Z}itomirski\u{\i}, G.I.!elementary
```

education@\textbf{elementary} education}

17.2 Index commands 457

## Special characters

Since the !, @, and | characters have special meanings within an \index command, you need to *quote* those characters if you want them to appear as themselves. *MakeIndex* uses the double quote character (") for this purpose: "!, "@, and "|.

Because this usage makes the double quote a special character itself, it also has to be quoted if you need to use it in an \index command: "".

**Example 1** To produce the entry Start here!, type the \index command as

```
\index{Start here"!}
```

**Example 2** To produce the entry @ symbol, type the \index command as

```
\index{"@ symbol}
```

**Example 3** To produce the entry |A|, type the \index command as

```
\index{"|A"|@$"|A"|$}
```

## Cross-references

It is easy to make a cross-reference to another index entry. For instance, to list distributive lattice by cross-referencing it to lattice, distributive, the command is

For non-AMS document classes, seeonly should be see. A command of this form can be placed anywhere in the document.

**Tip** Put all cross-referencing \index commands in one place in your document, so they are easy to keep track of.

## Placement of \index commands

The principle is simple.

## Rule ■ Placement of \index commands

An \index command should:

- 1. Reference the correct page
- 2. Not introduce unwanted space into the typeset document

For example, you should avoid placing \index commands as shown here:

```
Let $L$ be a distributive lattice \index{lattice} \index{distributive lattice} that is strongly complete.
```

This placement may result in unwanted extra space following the word lattice:

Let L be a distributive lattice that is strongly complete.

Note the placement of the \index commands in Section 17.1. In each case I have placed them as close to the referenced item as I could. If you place an index entry on a separate line, use % to comment out unwanted spaces including the end-of-line character (see Section 5.5.1), as in

```
Let $L$ be a distributive lattice \index{lattice}% \index{distributive lattice}% that is strongly complete.
```

Read also Section 18.5 on page breaks and index entries.

#### Listing the forms of the \index command

We have discussed the following forms:

```
\index{entry}
\index{entry!subentry}
\index{entry!subentry!subsubentry}
\index{entry|modifier}
\index{entry|open/close modifier}
\index{sortkey@entry}
```

```
\index{sortkey@entry!subentry}
\index{sortkey@entry!subsortkey@subentry}
```

Of course, more combinations are possible; the following may be the longest form:

```
\index{sortkey@entry!subsortkey@subentry%!subsubsortkey@subsubentry|open/close modifier}
```

# 17.3 Processing the index entries

Once you are satisfied with the \index commands, the index is ready to be created.

```
Step 1 Typeset intrarti.tex (see Figure 17.3).
```

**Step 2** Run the *MakeIndex* application on intrarti.idx (see Figure 17.4).

```
Step 3 Typeset intrarti.tex again.
```

You find the index on page 3 of the typeset document.

Let us look at this process in detail. In step 1 (see Figure 17.3), LATEX creates the intrarti.idx file:

```
\indexentry{Main Theorem}{1}
\indexentry{pistar@$\Pi^{*}$ construction}{1}
\indexentry{Main Theorem!exposition|(){1}
\indexentry{Moynahan, Ernest~T.}{1}
\indexentry{lattice|textbf}{1}
\indexentry{lattice!distributive}{1}
\indexentry{lattice!distributive!complete}{1}
\indexentry{Main Theorem!exposition|)}{2}
\indexentry{Foo, Soo-Key}{2}
\indexentry{Menuhin, George~A.}{2}
\indexentry{Moynahan, Ernest~T.}{2}
\indexentry{Moynahan, Ernest~T.}{2}
```

In step 2 (see Figure 17.4), *MakeIndex* processes intrarti.idx and creates the index file intrarti.ind, which contains a theindex environment with all the index entries:

```
\begin{theindex}
  \item Foo, Soo-Key, 2
  \indexspace
```

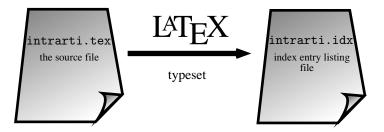


Figure 17.3: Using MakeIndex, step 1.

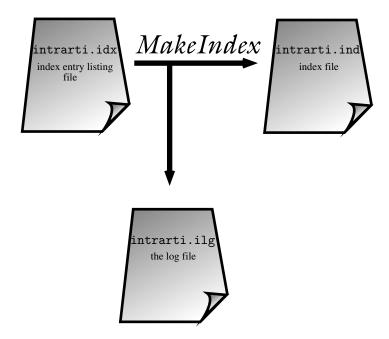


Figure 17.4: Using MakeIndex, step 2.

\item lattice, \textbf{1}
 \subitem distributive, 1
 \subsubitem complete, 1

## \indexspace

\item Main Theorem, 1
\subitem exposition, 1--2
\item Menuhin, George~A., 2

```
\item Moynahan, Ernest~T., 1, 2
\indexspace
\item $\Pi^{*}$ construction, 1
\end{theindex}
```

The \printindex command reads intrarti.ind during the next typesetting cycle.

\*MakeIndex\* also produces the index log file intrarti.ilg:

```
This is makeindex, version 2.14 [02-Oct-2002] (kpathsea + Thai support).

Scanning input file intrarti.idx....done (12 entries accepted, 0 rejected).

Sorting entries....done (43 comparisons).

Generating output file intrarti.ind....done (22 lines written, 0 warnings).

Output written in intrarti.ind.

Transcript written in intrarti.ilg.
```

It is important to understand that in step 1, LaTeX does not process the index entries, it simply writes the arguments of the \index commands in the source file to the idx file as arguments of \indexentry commands verbatim (that is, with no change). *MakeIndex* then processes the idx file by removing the double quote marks for the special characters, sorting the entries, and collating the page numbers. The resulting ind file is a normal LaTeX source file (you can edit it, if necessary) that is included in the original document by the \printindex command the next time you run LaTeX.

In Step 2, we run the *MakeIndex* application on intrarti.idx. How we do this depends on the LaTeX installation you have. In UNIX installations, you type

#### MakeIndex intrarti

at the command line. In newer user interfaces, <code>MakeIndex</code> is represented by an icon, and you drop intrarti.idx into it. In modern installations, your editor also runs <code>MakeIndex</code>. In <code>WinEdt</code> (see Section A.1.2), run <code>MakeIndex</code> by clicking on the <code>MakeIndex</code> button. In <code>TeXShop</code> (see Section A.2.1), change the <code>LaTeX</code> button to <code>MakeIndex</code> with <code>Typeset>MakeIndex</code> and click on the <code>Typeset</code> button. Now change the <code>MakeIndex</code> button back to <code>LaTeX</code> with <code>Typeset>LaTeX</code>. Click on the <code>Typeset</code> button, and you have the typeset article with the index.

## 17.4 Rules

There are some simple rules to keep in mind when entering index items.

## Rule ■ Spaces in \index

Do not leave unnecessary spaces in the argument of an \index command.

 $\displaystyle \lim_{i\to\infty}, \displaystyle \lim_{i\to\infty}, and \displaystyle \lim_{i\to\infty}$ 

produces three different entries.

There are options that instruct *MakeIndex* to ignore such spaces, but you are better off typing the \index commands correctly in the first place.

## **Rule** ■ Spacing rules for *MakeIndex*

LATEX's text spacing rules (Section 5.2.1) do not apply. *MakeIndex* does not follow these rules when it sorts the index items. While LATEX ignores spaces, *MakeIndex* does not.

## Rule ■ Sort keys

In \index{sortkey@item}, the sortkey is both space and case sensitive.

For instance,

\index{alpha@\$\alpha\$}

 $\displaystyle \sum_{Alpha@}\alpha$$ 

\index{ALPHA@\$\alpha\$}

represent three different items.

## Rule Braces

In every entry, the braces must be balanced.

Normally, balancing braces is not a problem. The braces within a math formula or a TEX expression should always be balanced. However, the \index command that creates the entry for { with the sort key leftbrace cannot be typed as

 $\inf\{0\setminus\{\}$ 

because LATEX would give the error message

```
Runaway argument?
{leftbrace@\{}
! Paragraph ended before \@wrindex was complete.

There are many ways to correct this \index command. Perhaps the simplest is to define
\newcommand{\printleftbrace}{\{}

and rewrite the \index command
\index{@\printleftbrace}

This produces the entry

{, 1
```

There is, of course, a lot more to *MakeIndex* than what we have discussed in this short introduction, but what we have covered here should do for most documents. See Pehong Chen and Michael A. Harrison's *Index preparation and processing* [10] for more detail. Chapter 12 of *The LATEX Companion*, 2nd edition [46] covers *MakeIndex* in great detail, including the customization of indexes.

## 17.5 Multiple indexes

To split your index file into two parts, the first with all names and the second with the other entries, include the following three lines in the preamble:

```
\usepackage{amsmidx}
\makeindex{names}
\makeindex{others}

For the package amsmidx, see Section 11.6.
     Now enter each index command in the form
\index{names}{}

or
\index{others}{}

So you would enter
\index{Moynahan, Ernest~T.}

as
\index{names}{Moynahan, Ernest~T.}
```

and

\index{Main Theorem}

as

\index{others}{Main Theorem}

Where you want the two indexes to appear in the typeset article, enter the commands

```
\Printindex{names}{Contributors}
\Printindex{others}{Index}
```

Of course, instead of Contributors and Index you may enter any titles for the two indexes.

## 17.6 Glossary

Using the glossary commands is very similar to using the corresponding index commands.

Instead of the \index and \makeindex commands, use the \glossary and \makeglossary commands, respectively. Glossary entries are written in the glo file, which corresponds to the idx file. LATEX gives you no further assistance in making a glossary file. There is no \printglossary command, theglossary environment, or MakeGlossary application. There is, however, Thomas Henlich's makeglos package (see Section E.1).

## 17.7 Concluding comments

Style files are available in a very limited form also for MakeIndex. Google

makeindex style

for an up-to-date listing.

Indexing is a very complex process, so it is not surprising that there are many index packages available. CTAN lists a number of them in the index directory. The best known is xindy, described in detail in *The LATEX Companion*, 2nd edition [46].

# Books in LATEX

Since the introduction of LaTeX, the visual quality of articles published in mathematical journals has improved dramatically. Unfortunately, the same cannot be said of books published using LaTeX. A record number of very ugly books have appeared.

It is easy to understand why. While amsart has been designed to produce highquality printed output, the standard book document classes do not produce attractive books without additional work.

LATEX provides the book and the amsbook document classes to serve as foundations for well-designed books. Better quality books have to use document classes designed by professionals. We provide some sample pages from a book using Springer's symono.cls document class. We briefly discuss logical and visual design in Section 4.3.2.

So this chapter is not about how to produce a finished book using LaTeX. Our goal is much more modest, how to prepare a book manuscript for your publisher. In Section 18.1 we describe the book document classes book and amsbook. The table of contents and lists of figures and tables are discussed in Section 18.2.

Typesetting a book involves dozens of files. Section 18.3.3 gives some tips on how to organize them. Section 18.4 covers logical design. Section 18.5 deals with the final preparation of your edited manuscript for your publisher. Finally, Section 18.6

suggests a few more things to do if you typeset your book yourself.

## 18.1 Book document classes

In this section, we briefly discuss the way in which book and amsbook, the two standard book document classes, differ from the corresponding article document classes. We also show a few pages from a book that was typeset with Springer Verlag's document class for monographs: symono.cls.

## 18.1.1 Sectioning

Book document classes have chapters, invoked with the \chapter command and *parts*, invoked with \part. The \part command is generally used to group chapters in longer documents, for instance in this book. Parts have no effect on the numbering of chapters, sections, and so on, so Chapter 1 of Part I is not numbered as I.1 but as 1.

Both \chapter and \part take a title as an argument, but the \chapter command also has an optional argument:

```
\chapter[short_title]{title}
```

The optional  $short_title$  argument is used in the running head. You may need to protect any fragile commands in title and  $short_title$  with the \protect command (see Section 5.3.3).

Here is the whole hierarchy:

```
\part
```

```
\chapter
\section
\subsection
\subsubsection
\paragraph
\subparagraph
```

Book document classes, as a rule, do not number subsubsections or any of the sectioning divisions below that level.

## Equations in chapters

By default, equations are numbered from 1 within chapters. So in Chapter 1 as well as in Chapter 3, the equations are numbered (1), (2), and so forth. If you have the

```
\numberwithin{equation}{chapter}
```

command in the preamble, then equations in Chapter 2 are numbered as (2.1), (2.2), and so on.

## 18.1.2 Division of the body

The book document classes formalize the division of the body into three parts.

Front matter The material that appears in the front of the document, including the title pages (normally four), table of contents, preface, introduction, and so on. LATEX numbers these pages using roman numerals. The front matter is introduced with the \frontmatter command.

Main matter The main part of the book, including the appendices if any. Page numbering starts from 1 using arabic numerals. The main matter is introduced with the \mainmatter command.

**Back matter** Material that appears in the back of the book, including the bibliography, index, and various other sections, such as the colophon, afterword, and so on. The back matter is introduced with the \backmatter command.

For the book document class—and the document classes built on it—in the front and back matter, the \chapter command does not produce a chapter number but the title is listed in the table of contents. So you can start your introduction with

\chapter{Introduction}

Within such a chapter, you should use the \*-ed forms of the sectioning commands \section, \subsection, and so on, otherwise you have sections with numbers such as 0.1.

In the main matter, the \appendix command marks the beginning of the appendices. Each subsequent chapter becomes a new appendix. For example,

\appendix

\chapter{A proof of the Main Theorem}\label{A:Mainproof}

produces an appendix with the given title.

Note that appendices may be labeled and cross-referenced. In Appendix A, sections are numbered A.1, A.2, and so on, subsections in A.1 are numbered A.1.1, A.1.2, and so on. The precise form these numbers take depends, of course, on the document class, packages, and user-specific changes (see Section 15.5.1).

See Section 18.3.1 for a detailed example.

For the amsbook document class—and the document classes built on it—the \chapter and \chapter\* commands always produce a title listed in the table of contents.

The following two questions are frequently asked:

My book has only one appendix. How can I get it to be called just "Appendix", not "Appendix A"?

The single appendix in my book is being labeled "Appendix A". How can I change this to just "Appendix"? This appendix has a title, so the answer to the preceding question doesn't apply.

These questions are answered in the author FAQ of the AMS, go to

http://www.ams.org/authors/author-faq.html

## 18.1.3 Document class options

The options and defaults for the book document classes are the same as those of other document classes (see Sections 11.5 and 12.1.2) with a few exceptions.

#### Two-sided printing

Options: twoside default

oneside

The twoside option formats the output for printing on both sides of a page.

#### Titlepage

Options: titlepage default

notitlepage

The titlepage option creates a separate title page. The notitlepage option creates no separate pages.

#### Chapter start

 $Options: \quad {\tt openright} \quad \textit{default}$ 

openany

A chapter always starts on a new page.

The book document class—and the document classes built on it—use the option openright to start each chapter on an odd page, while the option openany starts each chapter on the first available new page. If you use the default option, end each chapter with the command

\cleardoublepage

Then if a chapter ends on an odd page, a blank page is added with no header or page number. The \cleardoublepage command is correctly coded if you use amsbook. Otherwise, use the package cleardoublepage.sty (in the samples folder).

The amsbook document class—and the document classes built on it—automatically clears to a right-hand page and leaves a totally blank page if needed.

## 18.1.4 Title pages

The book document class supports the commands: \title, \author, \date, and \maketitle (see Section 12.1.1). The amsbook document class supports the same commands as amsart (see Section 11.2).

You can design your own title page within the titlepage environment, which does not require the use of the \maketitle command. Title pages for books, of course, should be created by a book designer for the publisher.

## 18.1.5 Springer's document class for monographs

We choose symono.cls, Springer's document class for monographs, to demonstrate the sophisticated appearance of a book typeset with a professionally designed document class. On the next three pages, I display the title page, the first Table of Contents page, and the first page of Chapter 1 of Claudio Procesi's book on Lie groups.

## Claudio Procesi

Università di Roma La Sapienza

## Lie Groups

An Approach through Invariants and Representations



## **Contents**

	Introduction x			xix
	Conventional Notations			
1	Ge	enera	l Methods and Ideas	1
	1	Gro	ups and Their Actions	1
		1.1	Symmetric Group	1
		1.2	Group Actions	2
	2	Orb	its, Invariants and Equivariant Maps	4
		2.1	Orbits	4
		2.2	Stabilizer	5
		2.3	Invariants	7
		2.4	Basic Constructions	7
		2.5	Permutation Representations	8
		2.6	Invariant Functions	10
		2.7	Commuting Actions	11
	3		ear Actions, Groups of Automorphisms, Commuting Groups	11
		3.1	Linear Actions	11
		3.2	The Group Algebra	13
		3.3	Actions on Polynomials	15
		3.4	Invariant Polynomials	16
		3.5	Commuting Linear Actions	17
2	Symmetric Functions			19
	1	Symmetric Functions		19
		1.1	Elementary Symmetric Functions	19
		1.2	Symmetric Polynomials	21
	2	Res	ultant, Discriminant, Bézoutiant	22
		2.1	Polynomials and Roots	22

1

## **General Methods and Ideas**

**Summary.** In this chapter we will develop the formal language and some general methods and theorems. To some extent the reader is advised not to read it too systematically since most of the interesting examples will appear only in the next chapters. The exposition here is quite far from the classical point of view since we are forced to establish the language in a rather thin general setting. Hopefully this will be repaid in the chapters in which we will treat the interesting results of Invariant Theory.

## 1 Groups and Their Actions

#### 1.1 Symmetric Group

In our treatment groups will always appear as transformation groups, the main point being that, given a set X, the set of all bijective mappings of X into X is a group under composition. We will denote this group S(X) and call it *the symmetric group* of X.

In practice, the full symmetric group is used only for X a finite set. In this case it is usually more convenient to identify X with the discrete interval  $\{1, \ldots, n\}$  formed by the first n integers (for a given value of n). The corresponding symmetric group has n! elements and it is denoted by  $S_n$ . Its elements are called *permutations*.

In general, the groups which appear are subgroups of the full symmetric group, defined by special properties of the set *X* arising from some extra structure (such as from a topology or the structure of a linear space, etc.). The groups of interest to us will usually be symmetry groups of the structure under consideration. To illustrate this concept we start with a definition:

**Definition.** A partition of a set X is a family of nonempty disjoint subsets  $A_i$  such that  $X = \bigcup_i A_i$ .

A partition of a number n is a (non-increasing) sequence of positive numbers:

$$m_1 \ge m_2 \ge \dots \ge m_k > 0 \text{ with } \sum_{j=1}^k m_j = n.$$

## 18.2 Tables of contents, lists of tables and figures

A long document, as a rule, has a table of contents. It may also include a list of figures and a list of tables.

## 18.2.1 Tables of contents

What goes into the table of contents?

For the amsbook document class—and the document classes built on it—all titles, not the short titles, of the sectioning commands, whether \*-ed or not, subject only to the value of the tocdepth counter, as described in the last subsection of Section 15.5.1. For instance, if tocdepth is set to 2, the default, then the titles of chapters, sections, and subsections are included in the table of contents, and subsubsections are excluded.

This leaves us with the problem, what do we do if the title is too long? You cannot break the line with \\, because this would the appear in table of contents. The AMS coded the following solution: enter the line break in the form

\except{toc}{\linebreak}

For the book document class—and the document classes built on it—the title or optional argument of the sectioning commands, subject to the value of the tocdepth counter, with the following exceptions:

- In Section 10.4.1 we discuss the \*-ed versions of sectioning commands. They are excluded from the table of contents.
- If the sectioning command has a short title, then it is the short title that is utilized. The example in Section 11.2 shows why this is important. If you have \\ in the title, you must have a short title without it, otherwise the linebreak would show up in the running head and the table of contents.

When you typeset your document with a table of contents, LATEX creates a file with the toc extension. The next time the document is typeset, the toc file is typeset too and included in your typeset document at the point where the command

\tableofcontents

appears in the source file, normally in the front matter. If your source file is named myart.tex, the toc file is named myart.toc. This file lists all the sectioning units as well as their titles and page numbers.

If you already have a toc file, the \tableof contents command typesets a table of contents using the previously created toc file and creates a new toc file.

LATEX adds a line to the table of contents, formatted like a section title, if you include the command

\addcontentsline{toc}{section}{text\_to\_be\_added}

in your source file. There are three arguments:

- 1. The first argument informs LaTeX that a line, the third argument, should be added to the toc file.
- The second argument specifies how the line should be formatted in the table of contents. In our example, the second argument is section, so the line is formatted as a section title in the table of contents. The second argument must be the name of a sectioning command.
- 3. The third argument is the text to be added.

You can add an unformatted line to the table of contents with the command

```
\addtocontents{toc}{text_to_be_added}
```

Such a command can also be used to add vertical spaces into the table of contents. For instance, if you want to add some vertical space before a part, you should insert the following line before the sectioning command for the part:

```
\addtocontents{toc}{\protect\vspace{10pt}}
```

The toc file is easy to read. The following are typical lines from the table of contents file for a document using the book document class:

```
\contentsline{section}{\numberline {5-4.}Top matter}{119}
\contentsline{subsection}{\numberline {5-4.1.}
Article info}{119}
\contentsline {subsection}{\numberline {5-4.2.}
Author info}{121}
```

Section 15.5.1 explains how you can specify which levels of sectioning appear in the table of contents. Section 2.3 of *The LATEX Companion*, 2nd edition [46] lists the style parameters for the table of contents. It also shows you how to define new toc-like files and use multiple tables of contents in a single document, for instance, adding a mini table of contents for each chapter.

**Tip** You may have to typeset the document three times to create the table of contents and set the numbering of the rest of the document right.

- 1. The first typesetting creates the toc file.
- 2. The second inserts the table of contents with the old page numbers into the typeset document, re-records in the aux file the page numbers, which may have changed as a result of the insertion, and cross-references in the aux file, and generates a new toc file with the correct page numbers.

3. The third typesetting uses these new aux and toc files to typeset the document correctly and creates a new toc file.

Fragile commands in a movable argument, such as a section (short) title, must be \protect-ed (see Section 5.3.3). Here is a simple example using the table of contents. If the document contains the \section command

```
\section{The function \( f(x^{2}) \)}
the section title is stored in the toc file as
\contentsline {section}{\numberline
{1}The function\relax $ f(x^{2}) \relax \GenericError { }
{LaTeX Error: Bad math environment delimiter}{Your
command was ignored.\MessageBreak Type I <command>
<return> to replace it with another command,\MessageBreak
or <return> to continue without it.}}{1}
and the log file contains the message
! LaTeX Error: Bad math environment delimiter.
...
1.1 ...continue without it.}}{1}
```

Error messages usually refer to a line in the source file, but in this case the error message refers to a line in the toc file.

The correct form for this section title is

```
\label{the function protect(f(x^{2}) protect)} $$ or, even simpler, $$ \end{The function $f(x^{2})$} $$
```

Note that this example is merely an illustration of unprotected fragile commands in movable arguments. As a rule, avoid using formulas in (sectioning) titles.

## 18.2.2 Lists of tables and figures

If you place a \listoftables command in the document, LATEX stores information for the list of tables in a lot file. The list of tables is inserted into the body of your document at the point where the command appears, normally in the front matter, following the table of contents.

A list of figures, similar to a list of tables, can be compiled with the command \listoffigures. This command creates an auxiliary file with the extension lof. An optional argument of the \caption commands in your tables and figures can replace the argument in the list of tables and figures. Typically, the optional argument is used to specify a shorter caption for the list of tables or list of figures. There are other uses. For instance, you may notice that, as a rule, captions should be terminated by periods. If in the list of tables or list of figures, your book style fills the space between the text and the page number with dots, the extra period looks bad. This problem goes away if you use the following form of the \caption command:

```
\caption[title]{title.}
```

There are analogs of the table of contents commands for use with tables and figures. The command

```
\addtocontents{lot}{line_to_add}
```

adds a line to the list of tables or to the list of figures with the first argument lof.

#### 18.2.3 Exercises

For exercises, amsbook provides the xcb environment. It is used for a series of exercises at the end of a section or chapter. The argument of the environment specifies the phrase (such as Exercises) to begin the list:

```
\begin{xcb}{Exercises}
\begin{enumerate}
\item A finite lattice $L$ is modular if{f} it does not
contain a pentagon.\label{E:pent}
\item Can the numbers of covering pairs in\label{E:incr}
Exercise~\ref{E:pent} be increased?\label{E:incr}
\end{enumerate}
\end{xcb}
which typesets as
```

#### **Exercises**

- (1) A finite lattice L is modular iff it does not contain a pentagon.
- (2) Can the numbers of covering pairs in Exercise 1 be increased?

## 18.3 Organizing the files for a book

An article is typically one tex file and maybe some EPS and/or PDF files for the illustrations. On the other hand, a book, like this one, is composed of hundreds of files. In this section, I describe how the files for this book are organized.

There are three commands that help with the organization:

\include \includeonly \graphicspath We discuss these commands in this section.

## 18.3.1 The folders and the master document

All the files for this book are in a folder MiL4 and in this folder the most important document is MiL4.tex, the *master document*.

The master document, MiL4.tex reads, in a somewhat simplified form, as follows:

```
%MiL4 master document
\documentclass[leqno]{book}
\usepackage{MiL4}
\usepackage{makeidx}
\makeindex
\usepackage{cleardoublepage}
\includeonly{
%frontmatter,
%intro,
%Chapter1,% terminology
Chapter18,% books
%appA,% install
}
\begin{document}
\frontmatter
\include{frontmatter}
\tableofcontents
\listoftables\listoffigures
\include{intro}%Intro
\mainmatter
\include{Chapter1}%Setting up
\include{Chapter18}% writing books
\appendix
\include{AppendixA}%install
\backmatter
\printindex
\end{document}
```

Some parts of the master file deserve comment, for example, the third line,

\usepackage{MiL4}

loads the command file

MiL4.sty

which contains all the commands defined for the book and the code for the book style. Since the book style is based on book.cls, in line 5, we load the makeidx package and print the index with \printindex (see Section 17.1).

Line 7 states

\usepackage{cleardoublepage}

This creates blank pages after chapters that end on an odd page number (see Section 18.1.3). For the three ...matter commands, see Section 18.1.2.

#### 18.3.2 Inclusion and selective inclusion

This book is pieced together by the \include commands in the master document. For example,

\include{Chapter18}

inserts the contents of the file Chapter18.tex, starting on a new page, as though its contents had been typed at that place in the document. The master document for this book has 29 \include commands.

## **Rule** ■ File termination

Terminate every file you \include with an \endinput command.

If you terminate an \include-ed file with \end{document}, LMEX gives a warning such as:

(\end occurred when \iftrue on line 6 was incomplete) (\end occurred when \ifnum on line 6 was incomplete)

If you use \include commands in the master file, as in the example in Section 18.3.1, then you can use the \includeonly command for selective inclusion. The lines of the \includeonly command parallel the \include commands. Block comment all the lines of the argument of the \includeonly command, and uncomment the chapter you are working on. In the example above, I am working on this chapter.

The argument of the \includeonly command is a list of files separated by commas. If you want to typeset the whole book, uncomment all the lines.

## 18.3.3 Organizing your files

The MiL4 folder, containing the files of this book, contains the master document, MiL4.tex, the command file MiL4.sty, and all the tex files listed in the master document, that is, the chapters, the frontmatter, the introduction, the appendices, and of course, all the auxiliary files that LATEX creates.

This book contains about 300 illustrations in a subfolder Graphics of the folder MiL4.tex. We have to tell LATEX to look for the illustrations in this folder. We do this with the command

```
\graphicspath{{Graphics\}}
```

in the preamble. If you have two folders, Illustr1 and Illustr2 for illustrations, the \includegraphics command takes the form

```
\graphicspath{{Illustr1\}{Illustr2\}}
```

Even if you have more than one folder for the illustrations, you must make sure that each graphics file has a unique name.

We place the \graphicspath command in MiL4.sty.

In the above commands, \ is appropriate for Mac and UNIX computers. For a PC, use / instead.

If you submit a dvi file, you cannot use the \graphicspath command.

## 18.4 Logical design

The discussion of logical and visual design in Section 4.3.2 applies to books even more than to articles. Since books are long and complex documents, errors in the logical design are much harder to correct.

Let us review some common-sense rules.

**Rule 1** ■ Stick with the sectioning commands provided by the document class. Define the non-standard structures you wish to use as environments.

\vspace{18pt}
\noindent \textbf{Theorem 1.1.}
\textit{This is bad.}
\vspace{18pt}

Here is an example which is obviously bad:

And a good way to achieve the same result:

```
\begin{theorem}\label{T:Goodtheorem}
This is a good theorem.
\end{theorem}
```

The bad example creates a number of difficulties.

- You have to number the theorems yourself. Adding, deleting, and rearranging theorems becomes difficult and updating cross-references is even harder.
- It is difficult to keep such constructs consistent.
- If the publisher decides to increase the white space before and after the theorems to 20 points, finding and changing all the appropriate commands becomes a tedious and error prone task.

## **Rule 2** ■ Define frequently used constructs as commands.

```
Rather than

\textbf{Warning! Do not exceed this amount!}

define

\newcommand{\important}[1]{\textbf{#1}}

and type your warnings as
\important{Warning! Do not exceed this amount!}

You or your editor can then change all the warnings to a different style with ease.
```

## **Rule 3** ■ Avoid text style commands.

```
If you use small caps for acronyms, do not type 
\textsc{ibm}
but rather define
\newcommand{\ibm}{\textsc{ibm}}
and then
```

```
\ibm
or more generally
\newcommand{\acronym}[1]{\textsc{#1}}
and then
\acronym{ibm}
```

## **Rule 4** ■ Avoid white space commands.

paragraph 2

Occasionally, you may feel that there should be some white space separating two paragraphs, so you do the following:

```
paragraph 1
\medskip

paragraph 2
It would be better to define a new command, say \separate, as \newcommand{\separate}{\medskip}
and type the previous example as 
paragraph 1
\separate
```

Now such white space can be adjusted throughout the entire document by simply redefining one command. Note that redefining \medskip itself may have unintended side effects:

- Many environments depend on LATEX's definition of \medskip.
- You may have used \medskip in other situations as well.

Here is a short list of commands you should avoid:

```
\bigskip
          \hfil
                   \hspace
                              \parskip
                                           \vfill
                                                   \vspace
          \hfill
\break
                   \kern
                              \smallskip
                                          \vglue
\eject
                                          \vskip
          \hglue
                   \medskip
                             \vfil
```

## 18.5 Final preparations for the publisher

Throughout this book, there are a number of "don'ts". Most are practices you should avoid while writing articles. When writing a book, it is even more important not to violate these rules.

When the editors, including the copy editor, are finished with your manuscript and you have the document class designed for the book, then you can start on the final preparations.

## **Step 1** ■ Eliminate all T<sub>E</sub>X commands.

TEX commands, that is, Plain TEX commands that are not part of LATEX (not listed as LATEX commands in the index of this book) may interfere with LATEX in unexpected ways. They may also cause problems with the style file that is created for your book.

**Step 2** ■ Collect all your user-defined commands and environments together in one place, preferably in a separate command file (see Section 15.3).

**Step 3** ■ Make sure that user-defined commands for notations and user-defined environments for structures are used consistently throughout your document.

This book uses the command \doc for document names, so intrart is typed as \doc{intrart}. Of course, \texttt{intrart} gives the same result, but if you intermix \doc{intrart} and \texttt{intrart} commands, you lose the ability to easily change the way document names are displayed.

#### **Step 4** ■ Watch out for vertical white space adding up.

- Do not directly follow one displayed math environment with another. Multiple adjacent lines of displayed mathematics should all be in the same environment.
- If your style file uses interparagraph spacing, avoid beginning paragraphs with displayed math.

For instance,

\[ x=y \]

is wrong. Use, instead, an align or gather environment.

**Step 5** ■ If possible, do not place "tall" mathematical formulas inline. All formulas that might change the interline spacing, as a rule, should be displayed.

You can find examples on pages 23 and 370. Here is one more example, double hat accents used inline:  $\hat{A}$ .

## Step 6 ■ Read the log file.

- Watch for line-too-wide warnings (see Section 2.3).
- Check for font substitutions (see Section 5.6.7).

If you find lines that are too wide:

- Fix wide lines by rewording the sentence or adding optional hyphens (see Section 5.4.9).
- Break displayed formulas so that they fit comfortably within the line.

Adobe Acrobat Professional has a preflight utility in the Advanced menu. It will check whether the PDF version of your typeset document has all the fonts it requires.

Step 7 ■ Do not assume that gray boxes or color illustrations appear when published exactly the way that they look on your monitor or printer.

Color work requires calibration of monitors and printers. It is often best left to the experts at the publisher.

**Step 8** ■ Do not assume that the application that created your EPS files (see Section 10.4.3) can create high-quality EPS files.

Many applications can create EPS files or convert files to EPS format. Very few do it right. Ask your publisher what applications they recommend.

Font substitutions can also cause problems:

- A font that was used in typesetting the document may not be the font you intended.
   Missing fonts are substituted and the substitute fonts are rarely satisfactory.
- A special trap: Your publisher may have more, or maybe fewer, fonts than you do! As a result, the font substitutions on your publisher's system may be different from those on yours. Make sure that the fonts you use are not substituted.

## 18.6 If you create the PDF file for your book

Many publishers take your manuscript, prepared as described in Section 18.5, and guide it through the final steps for printing. Some books, however, are prepared by the authors for printing using a custom document class for books and submitted to the publisher as PDF files. If your book falls into this category, there are a few more things you should do before you create the final PDF file for your book.

## Adjust the pages

Make sure that you are satisfied with the way the document is broken into pages by LATEX and with the placement of the figure and table environments (see Section 10.4.3). If necessary, you should make last-minute changes to adjust page breaks. You may find the \enlargethispage command (see Section 5.7.3) very helpful at this stage. Just be sure to apply it on both facing pages.

To ensure that

- Page numbers in the index are correct
- \pageref references (see Section 10.4.2) are correct
- Marginal comments (see Section 5.9.4) are properly placed
- Tables and figures are properly placed

insert page breaks where necessary. Where pages break, add the three commands \linebreak, \pagebreak, and \noindent. Here is an example. The bottom of page 3 and the top of page 4 of my book *General Lattice Theory* [28] are shown in Figure 18.1.

Now let us assume that we have to manually do this page break because some index items attached to this paragraph generate incorrect page numbers. The paragraph split by the page break is

In other words, lattice theory singles out a special type of poset for detailed investigation. To make such a definition worthwhile, it must be shown that this class of posets is a very useful class, that there are many

such posets in various branches of mathematics (analysis, topology, logic, algebra, geometry, and so on), and that a general study of these posets will lead to a better understanding of the behavior of the examples.

This was done in the first edition of G.~Birkhoff's \emph{Lattice Theory} \cite{gB40}. As we go along, we shall see many examples, most of them in the exercises. For a general survey of lattices in mathematics, see G.~Birkhoff \cite{gB67} and H.~H.~Crapo and G.-C.~Rota \cite{CR70}.

When typesetting this paragraph, LATEX inserts a page break following

This was done in the first edition of G.~Birkhoff's.

So we edit four lines as follows:

understanding of the behavior of the examples. This was done in the first edition of G.~Birkhoff's \linebreak

\pagebreak

\noindent \emph{Lattice Theory} \cite{gB40}. As we go
along, we shall see many examples, most of them in the

This change does not affect the appearance of the typeset page, but now pages 3 and 4

In other words, lattice theory singles out a special type of poset for detailed investigation. To make such a definition worthwhile, it must be shown that this class of posets is a very useful class, that there are many such posets in various branches of mathematics (analysis, topology, logic, algebra, geometry, and so on), and that a general study of these posets will lead to a better understanding of the behavior of the examples. This was done in the first edition of G. Birkhoff's

#### 4 I. First Concepts

Lattice Theory [1940]. As we go along, we shall see many examples, most of them in the exercises. For a general survey of lattices in mathematics, see G. Birkhoff [1967] and H. H. Crapo and G.-C. Rota [1970].

Figure 18.1: A page break.

are separated by a \pagebreak. Make sure that any \index or \label commands are moved to the appropriate half of the paragraph. Now all index commands generate the correct page numbers.

Of course, if the page break is between paragraphs, only the \pagebreak command is needed. If the break occurs in the middle of a word, use \-\linebreak to add a hyphen.

This method works about 95 percent of the time. Occasionally, you have to drop either the \linebreak or the \pagebreak command.

## Check for missing fonts and other defects

Open the PDF file of your book in Adobe Reader (or even better, in Adobe Acrobat Pro). Under File, go to Properties... and click on the Fonts tab. You will find a long list of fonts. Each one should be marked Embedded Subset.

If all your fonts are embedded, you are in good shape.

Adobe Acrobat Pro has an excellent set of utilities to check whether your PDF file is ready for printing. You find them under Advanced>Preflight.... In the Preflight window, choose Digital printing (B/W)—unless your book will print in color, in which case choose Digital printing (color). Click on Execute. Adobe Acrobat Pro will correct all the mistakes it finds in the file and presents a detailed report.

Adobe Acrobat Pro also comes to the rescue if some fonts are not embedded. In the Preflight window, expand the PDF analysis group and select List text using non-embedded fonts and click on Execute. The report will list all pages with fonts missing and if you select a page, Snap view will show you the trouble spot.

In the help system of Adobe Acrobat Pro, search for Customize Adobe PDF settings and Embed fonts using the TouchUp Text tool for detailed instructions on how to embed the missing fonts.

## Other adjustments

- Move the figure and table environments (see Section 10.4.3) physically close to where they appear in the typeset version, and change the optional argument of the figure and table environments to !h.
- Balance the white space on each page as necessary.
- Generate the index only after the page breaks are fixed.

## Polish the auxiliary files

■ Typeset the document one last time and then place the \nofiles command in the preamble (see Section D.3.4) to make sure that the auxiliary files are not overwritten.

Normally, you should not have to edit the table of contents (toc) file or the lot and lof files (see Section 18.2) and your style file should take care of the formatting. Sometimes, however, an unfortunate page break makes editing necessary. In an appropriate place, you may want to add to the text the command

\addtocontents{toc}{\pagebreak}

to avoid such edits.

■ Create the index (ind) file from the new aux file, as described in Section 17.3. The Chicago Manual of Style, 15th edition [11] has a section on bad breaks, remedies, and Continued lines in the index. Break the ind file into pages. To minimize bad breaks, use the \enlargethispage command where necessary (see Section 5.7.3). Add any Continued entries.

# A

## Installation

In case you do not already have a LaTeX installation, in Sections A.1 and A.2, we describe how to install LaTeX on your computer, a PC or a Mac. The installation is much easier if you obtain TeX Live 2007 (or later) from the TeX Users Group, TUG (see Section E.2). It contains both the TeX implementations we discuss.

No installation is given for UNIX computers. The attraction of UNIX to its users is the incredibly large number of options, from the UNIX dialect, to the shell, the editor, and so on. A typical UNIX user downloads the code and compiles the system. This is obviously beyond the scope of this book. Nevertheless, TeX Live 2007 (or later) from the TeX Users Group supplies the compiled (binaries) of LaTeX for a number of UNIX variants.

First read Chapter 1, so that in this Appendix you recognize the terminology we introduce there. I will assume that you become sufficiently familiar with your LaTeX distribution to be able to perform the editing cycle with the sample documents.

## A.1 LATEX on a PC

On a PC, most mathematicians use MiKTeX and the editor WinEdt. So it seems appropriate that we start there.

## A.1.1 Installing MiKTeX

If you made a donation to MikTeX or if you have the TeX Live 2007 (or later) from the TeX Users Group, then you have a CD or DVD with the MikTeX installer. Installation then is in one step and very fast. In case you do not have this CD or DVD, we show how to install from the Internet. To begin, go to the MikTeX home page:

http://miktex.org

and under the Download/Install click on the version you want to install.<sup>1</sup> You are directed to the MiKTeX download page, where you click on Download MikTeX Net Installer. This takes you to a list of the download sites, called "mirrors". Choose one geographically close to you and click Download next to your pick. You are asked whether to Run or Save the installer application. Choose Save to save and now you have the setup application on your computer.

Run setup and the MiKTeX Setup Wizard should start automatically. Then click Next and choose the task, Download only. Click Next again to choose the size of the download and choose Complete MikTeX. Again you have to choose a download site, and click Next a few more times, then Start, and the download starts. When it is complete, almost 35,000 files later, click Close. Now you have the files you need in the next step.

The next task is installation. Run setup again, and up comes the Wizard. Click Next, and the task Install MikTeX is selected for you. Click Next, make sure you select Complete MikTeX. Click Next a few more times, select the default paper size, click Start, and the installation starts. When it is finished, click Close.

## A.1.2 Installing WinEdt

You can download WinEdt from its Web site and use it for 30 days before you pay the license fee. We now install WinEdt from the CD you are sent after you pay the license fee. Go to License and Registration at

http://www.winedt.com

Put the WinEdt installer CD in the DVD drive. The WinEdt Setup Wizard starts automatically. After accepting the licence, click Next a few times until WinEdt is installed and then click Finish.

After installation, the WinEdt Configuration Wizard

<sup>&</sup>lt;sup>1</sup>We follow the instructions for MiKTeX 2.5. Hopefully, this will also assist you with later versions.

starts automatically. Click on the File Associations tab and click on Modify file type associations... under Current User, which is down the right side of the window, and then click OK. This gives all TeX files a lion icon and automatically associates them with WinEdt so that double clicking a TeX file automatically opens it in WinEdt. Clicking OK to close the Wizard.

WinEdt's claim to fame is its incredible customizability. Once you become familiar with the basic operations, you can make WinEdt behave the way you like.

## A.1.3 The editing cycle

In Section 1.2 you created the work folder for your work files. Start WinEdt by double clicking the WinEdt icon and open the file note1.tex in work, see the top half of Figure A.1. Observe:

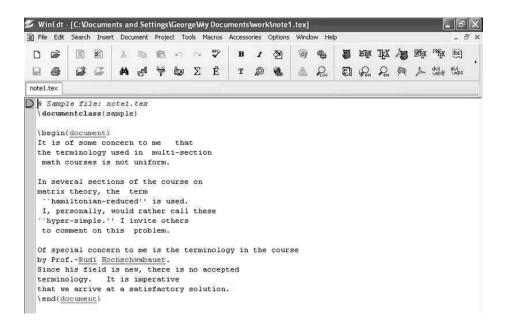
- In the right-hand corner, under the X button, the close application button, there is a small black x. All windows of WinEdt have such an x, this is the *close window* button.
- There are two rows of icons. The seventh from the right in the first row, a darkened lion's head, is the TeXify button, use it to typeset your LaTeX file. If you are not sure what an icon represents, let the cursor hover over it, and a brief description appears.
- A blue arrow in the left margin points at the line where the cursor is.

Click on the TeXify icon. MiKTeX typesets note1.tex and produces another file, note1.dvi. The new file is displayed by the application Yap, which was automatically installed for you with MiKTeX. Rearrange the WinEdt and Yap windows. You should get an arrangement similar to the bottom half of Figure A.1.

## A.1.4 Making a mistake

WinEdt tells you if there is a mistake in your source file. To see what happens, click on the WinEdt window, and add a \ in line 11 of note1.tex, so that personally reads \personally. This makes \personally a command, which is a mistake (see Chapter 2). Click on the TeXify icon. We get the TeXify ... window, as in the top part of Figure A.2. At the ? prompt, type x for "exit" and press Return. You now see three windows, as shown in the bottom half of Figure A.2. The Yap window is mostly covered up. There is a new window, note1.log, the log window, in which the information from the TeXify ... window is recorded. In the WinEdt window, the blue arrow line pointer on the left indicates the offending line, and the mistake, \personally, is highlighted in red. Correct the mistake by deleting \, click on TeXify, and you are back in business.

<sup>&</sup>lt;sup>2</sup>The user, recorded on Figure A.2, typed s for "scroll mode". L⁴TEX then completes the typesetting without stopping for errors (see Section D.4).



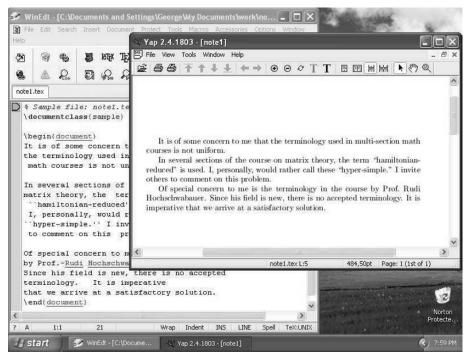


Figure A.1: note1.tex opened in WinEdt and typeset.



Figure A.2: The mistake identified and localized (showing the log window).

## A.1.5 Three productivity tools

Now we see how the three productivity tools introduced in Section 1.4 are implemented in WinEdt and MiKTeX.

**Synchronization** This is known as *inverse search* in WinEdt and MiKTeX. To set it up, open Yap, for example, by Texifying the document note1.tex. Choose the menu item View>Options>Inverse DVI Search. A list now displays the editors detected. Select WinEdt, click Apply, and click OK. You are done.

- To jump from the typeset file in Yap to the source file in WinEdt, double click a word in the typeset file.
- To jump from the source file to the typeset file, click on the DVI Search icon, the magnifying glass with the green leaf attached to the handle. You then jump to the typeset file, where a marker indicates the beginning of the typeset version of the source line the cursor is on.

**Block comment** Select a number of lines in a source document and choose the menu option Edit>Move/Fill>Insert comment. Block uncomment is done with Edit>Move/Fill>Remove comment.

Go to line This is done with Search>Go to Line...

The icons and menu options all have keyboard equivalents. For instance, Go to line is Ctrl+G and TeXify is Ctrl+Shift and then press x.

## A.1.6 An important folder

When using MikTeX, where do you put new style files and packages?

You can always place these files in your working folder. This is the simplest, but they will not be available when working with files outside that folder.

If you want these files accessible everywhere (from all folders), then make a new folder in the LocalTeXFM folder tree, say

C:\LocalTeXMF\MyStyles

and place these files there. In order for MiKTeX to find these files, you now need to update the MiKTeX FileName Database. Do this:

All Programs>MikTeX>MikTeX Options>Refresh FNDB

or access it directly via the drop down menus from within WinEdt:

Accessories>MikTeX Options

The best way to install new packages from CTAN is via the Package Manager, which is accessed via

#### All Programs>MikTeX>Package Manager

The Package Manager downloads the files from a CTAN mirror of your choice, then installs all files in their correct folders and updates MikTeX's filename database.

It is a good idea to run the MiKTeX Update Wizard on a regular basis to keep your system up to date:

All Programs>MikTeX>MikTeX Update Wizard

## A.2 LATEX on a Mac

#### A.2.1 Installations

For the Mac, we install MacTeX,<sup>3</sup> which consists of the TUG's TeX Live and Richard Koch's TeXShop. If you have TeX Live (see Section E.2), put the DVD in your computer's DVD drive and follow the simple instructions. In a few minutes you are done. Otherwise, go to

http://www.tug.org/mactex/

and in the Downloading section, click on MacTeX-2007. After downloading about 700 MBs, you get the MacTeX-2007 "disk image" that contains the mactex installer package. The disk image should open and the application MacTeX-2007.mpkg should start automatically. A few more clicks—as in all Mac installations—and you are done.

## The spelling checker

Finally, get the spell checker cocoAspell by Anton Leuski by going to

http://people.ict.usc.edu/~leuski/cocoaspell/home.html

and clicking on the download link, cocoAspell. This downloads the disk image cocoAspell.dmg, containing the installation package cocoAspell.mpkg. Follow the same process as above to mount this. Then double click on the installer package and follow the instructions.

In the Apple menu, choose System Preferences..., where you find a new one, Spelling. Double click on it, and choose a dictionary. I use the dictionary English(United States). You should also select the filters you need. They are explained on the page you obtain by clicking on the Filter button. I selected Texinfo and TeX/LaTeX. You may have to restart the computer for the spelling checker to work.

To invoke the spelling checker, select a word and press Command+Shift and :. It suggests a correct spelling. You can also add words to the dictionary.

To learn more about the dictionaries, read the documents in

/Library/Application Support/cocoAspell/ aspell6-en-6.0-0/doc/

<sup>&</sup>lt;sup>3</sup>We follow the instructions for MacTeX-2007. Hopefully, this will also assist you with later versions.

## A.2.2 Working with TeXShop

#### Custom settings

In due course, you can fully customize TeXShop as an advanced user. But to begin, there are just a few things to do. In the TeXShop menu choose Preferences... to open the TeXShop Preferences. To set the default font for the source files in TeXShop, click on the Document tab. Under Document Font click Set..., which brings up the Font window. Choose a font and size for the source files that is easy on your eyes. I use Courier and 12. Close the Font window.

Make sure that under Editor all items except Auto Complete are selected.

Now click the Preview tab and in the Preview Window Magnification enter a number for the magnification to be used for viewing the typeset version—I use 150. Once you type in the number, press Set. For Default Mouse Mode, choose Select Text. For Default Page Style, choose Multi-Page.

Under After Window Resize, choose Fixed Magnification. Then click on OK. Close the TeXShop Preferences window.

When you become more familiar with TeXShop, you may want to revisit these settings.

#### Changing a document for TeXShop

If

- you use the graphicx package, see intrart.tex in the samples folder as an example, and
- your document contains illustrations that have been saved as EPS graphics and included with the \includegraphics command,

then add the line

\usepackage{epstopdf}

in the preamble below the line

\usepackage{graphicx}

If you have many illustrations, it is preferable to open all the illustrations with TeXShop or Preview and save them in PDF format. Also, make sure that the extensions are not given in the \includegraphics commands, that is,

```
\usepackage{graphicx}
\includegraphics{products.eps}
is changed to
\usepackage{graphicx}
\includegraphics{products}
```



Figure A.3: The document note1.tex: the source and the typeset version.

### A.2.3 The editing cycle

In your Document folder, you created the work folder (see page 4). We are going to work with the document note1.tex in the work folder.

To start TeXShop, double click on TeXShop.app in the Applications folder, select the menu File>Open..., and navigate to the folder

Documents/work/note1.tex

Open the document.

In the upper left corner of the source window, click the Typeset button. A second window opens, the *preview window*, showing note1.pdf, the typeset version of note1.tex. Unlike WinEdt, discussed in Section A.1, which produces a file called note1.dvi, TeXShop produces a PDF file, note1.pdf.

Figure A.3 shows the two windows. At the top, you see TeXShop's seven menus. For this introduction we ignore all but two menu options. You should use the Help menu to learn more and the Macros Help in the Help window along with the Macro Editor (open it with Macros>Open Macro Editor...) to become more productive.

### A.2.4 Making a mistake

TeXShop tells you if there is a mistake in your source file. Open note1.tex again and introduce a silly error, say, in the line \documentclass{amsart}, delete the closing brace, so it reads \documentclass{amsart. A new window—the third!—pops up, called note1 console, see Figure A.4. This is the log window (see Section 1.3). Click on the button Goto Error and the cursor is placed in the source document pretty close to the error. Now you can correct the error and typeset again.

### A.2.5 Three productivity tools

Now we see how the three productivity tools introduced in Section 1.4 are implemented in TeXShop.

Synchronization Command-click on a word in the source window. The preview window shows the corresponding typeset phrase circled in red. Similarly, command-click on a word in the preview window and the corresponding source phrase is highlighted in yellow—it helps to click on text with no LaTeX commands close by.

**Block comment** Select a number of lines in a source document, and choose the menu option Format>Comment. All the lines, the whole block, are commented out. The reverse is done with Format>Uncomment.

Go to line This is done with Edit>Line Number...

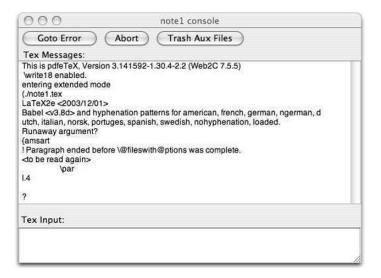


Figure A.4: The note1.tex console (log window).

Buttons and menu options all have keyboard equivalents. For instance, Block comment is  $Command + \{ and Go to line is Command + L. \}$ 

### A.2.6 An important folder

Create the texmf folder in the Library folder of your home folder—not the other Library folder, which is in the same folder as Applications. In texmf, create the tex folder, wherein you create the latex folder. Put all your personal (see Section 15.3) and additional sty files here.



# Math symbol tables

# **B.1** Hebrew and Greek letters

### Hebrew letters

Type	Typeset
\aleph	×
\beth	コ
\daleth	٦
\gimel	נ

502 Appendix B

### Greek letters

### Lowercase

Туре	Typeset	Type	Typeset	Type	Typeset
\alpha	$\alpha$	\iota	$\iota$	\sigma	$\sigma$
\beta	eta	\kappa	$\kappa$	\tau	au
\gamma	$\gamma$	\lambda	$\lambda$	\upsilon	v
\delta	$\delta$	\mu	$\mu$	\phi	$\phi$
\epsilon	$\epsilon$	\nu	$\nu$	\chi	$\chi$
\zeta	ζ	\xi	ξ	\psi	$\psi$
\eta	$\eta$	\pi	$\pi$	\omega	$\omega$
\theta	$\theta$	\rho	ho		
\varepsilon	arepsilon	\varpi	$\overline{\omega}$	\varsigma	ς
\vartheta	$\vartheta$	\varrho	$\varrho$	\varphi	$\varphi$
	\digamma	F	\varkappa	×	

# Uppercase

Туре	Typeset	Туре	Typeset	Type	Typeset
\Gamma	$\Gamma$	\Xi	Ξ	\Phi	$\Phi$
\Delta	$\Delta$	\Pi	П	\Psi	$\Psi$
\Theta	$\Theta$	\Sigma	$\Sigma$	\Omega	$\Omega$
\Lambda	$\Lambda$	\Upsilon	Υ		
\varGamma	$\Gamma$	\varXi	Ξ	\varPhi	$\Phi$
\varDelta	$\Delta$	\varPi	П	\varPsi	$\Psi$
\varTheta	$\Theta$	\varSigma	$\Sigma$	\varOmega	$\Omega$
\varLambda	$\Lambda$	\varUpsilon	$\Upsilon$		

# **B.2** Binary relations

Туре	Typeset	Туре	Typeset
<	<	>	>
=	=	:	:
\in	$\in$	\ni or \owns	$\ni$
$\leq or \leq o$	$\leq$	\geq or \ge	$\geq$
\11	«	\gg	>>
\prec	$\prec$	\succ	$\succ$
\preceq	$\preceq$	\succeq	$\succeq$
\sim	$\sim$	\approx	$\approx$
\simeq	$\simeq$	\cong	$\cong$
\equiv	≡	\doteq	Ė
\subset	$\subset$	\supset	$\supset$
\subseteq	$\subseteq$	\supseteq	⊇
\sqsubseteq		\sqsupseteq	$\supseteq$
\smile	$\smile$	\frown	$\overline{}$
\perp	$\perp$	\models	⊨
\mid		\parallel	
\vdash	$\vdash$	\dashv	$\dashv$
\propto	$\propto$	$\agnumber \agnumber \agn$	$\approx$
\bowtie	$\bowtie$		
\sqsubset		\sqsupset	
\Join	$\bowtie$		

Note the **\colon** command used in  $f \colon x \to x^2$ , typed as

f \colon x \to x^2

504 Appendix B

### More binary relations

Type	Typeset	Type	Typeset
\leqq	$\leq$	\geqq	$\geq$
\leqslant	$\leq$	\geqslant	$\geqslant$
\eqslantless	<	\eqslantgtr	≽
\lesssim	$\lesssim$	\gtrsim	$\gtrsim$
\lessapprox	≨	\gtrapprox	≷
\approxeq	$\approxeq$		
\lessdot	⋖	\gtrdot	≽
\111	<b>***</b>	\ggg	<b>&gt;&gt;&gt;</b>
\lessgtr	≶	\gtrless	$\geq$
\lesseqgtr	$\stackrel{\leq}{>}$	\gtreqless	$\geq$
\lesseqqgtr		\gtreqqless	N
\doteqdot	÷	\eqcirc	===
\circeq	<u>•</u>	\triangleq	$\triangleq$
$\rightarrow$ risingdotseq	≓	\fallingdotseq	≒
\backsim	$\sim$	\thicksim	~
\backsimeq	<u>~</u>	\thickapprox	≈
\preccurlyeq	$\preccurlyeq$	\succcurlyeq	≽
\curlyeqprec	$\curlyeqprec$	\curlyeqsucc	$\succcurlyeq$
\precsim	$\stackrel{\scriptstyle \sim}{\scriptstyle \sim}$	\succsim	$\succeq$
\precapprox	$\stackrel{\scriptstyle \sim}{\approx}$	\succapprox	₩
\subseteqq	$\subseteq$	\supseteqq	$\supseteq$
\Subset	$\subseteq$	\Supset	∋
$\vartriangleleft$	$\triangleleft$	$\vartriangleright$	$\triangleright$
$\trianglelefteq$	$\leq$	$\trianglerighteq$	$\trianglerighteq$
\vDash	F	\Vdash	⊩
\Vvdash	II⊢		
\smallsmile	$\smile$	\smallfrown	$\overline{}$
\shortmid	1	\shortparallel	11
\bumpeq	<u></u>	\Bumpeq	≎
\between	Ŏ	\pitchfork	ф
\varpropto	$\propto$	\backepsilon	Э
\blacktriangleleft	<b>◄</b>	\blacktriangleright	•
\therefore	<i>:</i> .	\because	<u>:</u>

# Negated binary relations

Type	Typeset	Type	Typeset
\neq or \ne	<i>≠</i>	\notin	∉
\nless	≮	\ngtr	*
\nleq	≰	\ngeq	≱
\nleqslant	≰	\ngeqslant	*
\nleqq	≨	\ngeqq	≱
\lneq	≤	\gneq	$\geq$
\lneqq	$\leqq$	\gneqq	$\geq$
\lvertneqq	$\leq$	\gvertneqq	$\geq$
\lnsim	$\lesssim$	\gnsim	$\gtrsim$
\lnapprox	≨	\gnapprox	⋧
\nprec	$ \prec$	\nsucc	$\neq$
\npreceq	$\not\preceq$	\nsucceq	$\not\succeq$
\precneqq	$\not\equiv$	\succneqq	<del>\</del>
\precnsim	$\not \supset$	\succnsim	$\succeq_{\!$
\precnapprox	$\widetilde{pprox}$	\succnapprox	<b>≿</b> ≋
\nsim	~	\ncong	≇
\nshortmid	<b>†</b>	\nshortparallel	Ħ
\nmid	†	\nparallel	#
\nvdash	¥	\nvDash	¥
\nVdash	$\mathbb{H}$	\nVDash	⊭
$\n$		\ntriangleright	$\not\triangleright$
\ntrianglelefteq	⊉	$\n$	⋭
\nsubseteq	⊈	\nsupseteq	$ ot \geq$
\nsubseteqq	≨	\nsupseteqq	$\not\supseteq$
\subsetneq	$\subsetneq$	\supsetneq	$\supseteq$
\varsubsetneq	≨	\varsupsetneq	⊋
\subsetneqq	$\subseteq$	\supsetneqq	$\supseteq$
$\varsubsetneqq$	≨	\varsupsetneqq	$ \supseteq $

506 Appendix B

# **B.3** Binary operations

Type	Typeset	Type	Typeset
+	+	-	_
\pm	$\pm$	\mp	Ŧ
\times	×	\cdot	
\circ	0	\bigcirc	$\bigcirc$
\div	÷	\bmod	$\operatorname{mod}$
\cap	$\cap$	\cup	$\cup$
\sqcap	П	\sqcup	$\sqcup$
\wedge or \land	$\wedge$	\vee or \lor	$\vee$
\triangleleft	◁	$\$ triangleright	$\triangleright$
\bigtriangleup	$\triangle$	\bigtriangledown	$\nabla$
\oplus	$\oplus$	\ominus	$\ominus$
\otimes	$\otimes$	\oslash	$\oslash$
\odot	$\odot$	\bullet	•
\dagger	†	\ddagger	‡
\setminus	\	\smallsetminus	\
\wr	}	\amalg	П
\ast	*	\star	*
\diamond	$\Diamond$		
\lhd	$\triangleleft$	\rhd	$\triangleright$
\unlhd	$\leq$	\unrhd	$\trianglerighteq$
\dotplus	÷	\centerdot	
\ltimes	×	\rtimes	$\rtimes$
\leftthreetimes	$\rightarrow$	\rightthreetimes	/
\circleddash	$\bigcirc$	\uplus	$\oplus$
\barwedge	$\overline{\wedge}$	\doublebarwedge	$\overline{\wedge}$
\curlywedge	人	\curlyvee	Υ
\veebar	$\underline{\vee}$	\intercal	Т
\doublecap or \Cap	$\bigcap$	\doublecup or \Cup	U
\circledast	*	\circledcirc	0
\boxminus	$\Box$	\boxtimes	$\boxtimes$
\boxdot		\boxplus	$\blacksquare$
\divideontimes	*	\vartriangle	Δ
\And	&		

*B.4 Arrows* 507

### **B.4** Arrows

Туре	Typeset	Туре	Typeset
\leftarrow	<b>←</b>	\rightarrow or \to	$\rightarrow$
\longleftarrow	←	\longrightarrow	$\longrightarrow$
\Leftarrow	$\Leftarrow$	\Rightarrow	$\Rightarrow$
\Longleftarrow	$\Leftarrow$	\Longrightarrow	$\Longrightarrow$
\leftrightarrow	$\leftrightarrow$	\longleftrightarrow	$\longleftrightarrow$
\Leftrightarrow	$\Leftrightarrow$	\Longleftrightarrow	$\iff$
\uparrow	<b>↑</b>	\downarrow	$\downarrow$
\Uparrow	$\uparrow$	\Downarrow	$\Downarrow$
\updownarrow	$\uparrow$	\Updownarrow	<b>\$</b>
\nearrow	7	\searrow	\
\swarrow	/	\nwarrow	_
\iff	$\iff$	\mapstochar	ı
\mapsto	$\mapsto$	\longmapsto	$\longmapsto$
\hookleftarrow	$\leftarrow$	\hookrightarrow	$\hookrightarrow$
\leftharpoonup	_	\rightharpoonup	$\rightarrow$
\leftharpoondown	_	\rightharpoondown	$\rightarrow$
\leadsto	$\sim$		
\leftleftarrows	otin	\rightrightarrows	$\Rightarrow$
\leftrightarrows	$\stackrel{\longleftarrow}{\Longrightarrow}$	\rightleftarrows	$\rightleftharpoons$
\Lleftarrow	<b></b>	\Rrightarrow	$\Rightarrow$
\twoheadleftarrow	<del>~~</del>	\twoheadrightarrow	$\longrightarrow$
\leftarrowtail	$\leftarrow$	\rightarrowtail	$\longrightarrow$
\looparrowleft	$\leftarrow$ P	\looparrowright	$\rightarrow$
\upuparrows	$\uparrow\uparrow$	\downdownarrows	$\downarrow \downarrow$
\upharpoonleft	1	\upharpoonright	1
\downharpoonleft	1	\downharpoonright	ļ
\leftrightsquigarrow	<del>~~</del>	\rightsquigarrow	<b>~</b> →
\multimap	<b>-</b> 0		
\nleftarrow	↔	\nrightarrow	$\rightarrow \rightarrow$
\nLeftarrow	#	\nRightarrow	<b>⇒</b>
\nleftrightarrow	$\leftrightarrow$	\nLeftrightarrow	<b>⇔</b>
\dashleftarrow	<b>←</b>	\dashrightarrow	<b></b> →
\curvearrowleft	$ \leftarrow $	\curvearrowright	$\curvearrowright$
\circlearrowleft	Q	\circlearrowright	Ö
$\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ $	$\leftrightharpoons$	\rightleftharpoons	$\rightleftharpoons$
\Lsh	4	\Rsh	Γ,

508 Appendix B

# **B.5** Miscellaneous symbols

Type	Typeset	Type	Typeset
\hbar	$\hbar$	\ell	$\ell$
\imath	$\imath$	\jmath	Ĵ
\wp	Ø	\partial	$\partial$
\Im	$\Im$	\Re	$\Re$
$\infty$	$\infty$	\prime	1
\emptyset	Ø	\varnothing	Ø
\forall	$\forall$	\exists	∃
\smallint	$\int$	\triangle	$\triangle$
\top	Τ	\bot	$\perp$
\P	$\P$	<b>\</b> S	\$ ‡ 4
\dag	†	\ddag	‡
\flat	b	\natural	Ц
\sharp	#	\angle	_
\clubsuit	*	\diamondsuit	$\Diamond$
\heartsuit	$\Diamond$	\spadesuit	<b>^</b>
\surd	$\sqrt{}$	\nabla	$\nabla$
\pounds	$\pounds$	\neg or \lnot	$\neg$
\Box		\Diamond	$\Diamond$
\mho	Ω		
\hslash	$\hbar$	\complement	C
\backprime	1	\nexists	∄
\Bbbk	k		
\diagup	/	\diagdown	
\blacktriangle	<b>A</b>	\blacktriangledown	▼
\triangledown	$\nabla$	\eth	3
\square		\blacksquare	
\lozenge	$\Diamond$	\blacklozenge	<b>♦</b>
\measuredangle	4	\sphericalangle	⋖
\circledS	S	\bigstar	*
\Finv	F	\Game	G

B.6 Delimiters 509

# **B.6** Delimiters

Name	Туре	Typeset
left parenthesis	(	(
right parenthesis	)	)
left bracket	[ or \lbrack	[
right bracket	] or \rbrack	]
left brace	\{ or \lbrace	{
right brace	<pre>\} or \rbrace</pre>	}
backslash	\backslash	\
forward slash	/	/
left angle bracket	\langle	<
right angle bracket	\rangle	$\rangle$
vertical line	or \vert	
double vertical line	\  or \Vert	
left floor	\lfloor	Ĺ
right floor	\rfloor	
left ceiling	\lceil	ſ
right ceiling	\rceil	]
upward	\uparrow	$\uparrow$
double upward	\Uparrow	$\uparrow$
downward	\downarrow	$\downarrow$
double downward	\Downarrow	$\Downarrow$
up-and-down	\updownarrow	$\uparrow$
double up-and-down	\Updownarrow	<b>\$</b>
upper-left corner	\ulcorner	Г
upper-right corner	\urcorner	٦
lower-left corner	\llcorner	L
lower-right corner	\lrcorner	_

510 Appendix B

# **B.7** Operators

## "Pure" operators, with no limits

Type	Typeset	Type	Typeset	Type	Typeset	Type	Typeset
\arccos	arccos	\cot	cot	\hom	hom	\sin	sin
$\arcsin$	arcsin	\coth	$\coth$	\ker	ker	$\sinh$	$\sinh$
\arctan	arctan	\csc	csc	\lg	lg	\tan	$\tan$
\arg	arg	\deg	$\deg$	$\ln$	$\ln$	\tanh	tanh
\cos	cos	\dim	$\dim$	\log	$\log$		
\cosh	$\cosh$	\exp	exp	\sec	sec		

### Operators with limits

Туре	Typeset	Туре	Typeset
\det	det	\limsup	$\limsup$
\gcd	$\operatorname{gcd}$	\max	max
\inf	$\inf$	\min	$\min$
\lim	$\lim$	\Pr	Pr
\liminf	$\lim\inf$	\sup	$\sup$
\injlim	inj lim	\projlim	$\operatorname{projlim}$
\varliminf	$\underline{\lim}$	\varlimsup	$\overline{\lim}$
\varinjlim	$\underset{\longrightarrow}{\lim}$	\varprojlim	lim ←

B.7 Operators 511

**B.7.1** Large operators

Туре	Inline	Displayed
\int_{a}^{b}	$\int_a^b$	$\int_a^b$
$\int_{a}^{a}$	$\oint_a^b$	$\oint_a^b$
$\int_{a}^{a}^{b}$	$\iint_a^b$	$\iint_a^b$
$\left( \frac{a}^{b} \right)$	$\iiint_a^b$	$\iiint_a^b$
\iiiiint_{a}^{b}	$\iiint_a^b$	$\iiint_a^b$
\idotsint_{a}^{b}	$\int \cdots \int_a^b$	$\int \cdots \int_a^b$
\prod_{i=1}^{n}	$\prod_{i=1}^{n}$	$\prod_{i=1}^{n}$
$\coprod_{i=1}^{n}$	$\coprod_{i=1}^{n}$	$\coprod_{i=1}^n$
$\bigcap_{i=1}^{n}$	$\bigcap_{i=1}^n$	$\bigcap_{i=1}^{n}$
$\bigcup_{i=1}^{n}$	$\bigcup_{i=1}^{n}$	$\bigcup_{i=1}^{i=1}$
$\big( i=1 \right)^{n}$	$\bigwedge_{i=1}^{n}$	$\bigwedge_{i=1}^{i=1}$
\bigvee_{i=1}^{n}	$\bigvee_{i=1}^{n}$	$\bigvee_{i=1}^{i=1}$
\bigsqcup_{i=1}^{n}	$\bigsqcup_{i=1}^{n}$	$\prod_{i=1}^{n}$
\biguplus_{i=1}^{n}	$\biguplus_{i=1}^n$	$\biguplus_{i=1}^{n}$
$\bigotimes_{i=1}^{n}$	$\bigotimes_{i=1}^n$	$\bigotimes_{i=1}^{i-1}$
\bigoplus_{i=1}^{n}	$\bigoplus_{i=1}^n$	$\bigoplus_{i=1}^{i-1}$
\bigodot_{i=1}^{n}	$\bigcirc_{i=1}^n$	$\bigcup_{i=1}^{i-1}$
\sum_{i=1}^{n}	$\sum_{i=1}^{n}$	$\sum_{i=1}^{i=1}$

512 Appendix B

# B.8 Math accents and fonts

### Math accents

		amsxtra	
Туре	Typeset	Туре	Typeset
\acute{a}	á		
\bar{a}	$\bar{a}$		
\breve{a}	$reve{a}$	\spbreve	U
$\check{a}$	$\check{a}$	\spcheck	V
$\det\{a\}$	$\dot{a}$	\spdot	•
\ddot{a}	$\ddot{a}$	\spddot	
\dddot{a}	$\ddot{a}$	\spdddot	•••
\ddddot{a}	$\ddot{a}$		
\grave{a}	$\grave{a}$		
\hat{a}	$\hat{a}$		
\widehat{a}	$\widehat{a}$	\sphat	^
$\mathbf{mathring}\{a\}$	$\mathring{a}$		
$\tilde{a}$	$\tilde{a}$		
	$\widetilde{a}$	\sptilde	~
\vec{a}	$\vec{a}$		

### Math fonts

Type	Typeset
IAT <sub>E</sub> X	
\mathbf{A}	$\mathbf{A}$
\mathcal{A}	${\cal A}$
\mathit{A}	A
\mathnormal{A}	A
\mathrm{A}	A
$Mathsf\{A\}$	Α
\mathtt{A}	Α
\boldsymbol{\alpha}	$\alpha$
\mathbb{A}	$\mathbb{A}$
$Mathfrak\{A\}$	$\mathfrak{A}$
\mathscr{a}	$\mathcal{A}$

\mathscr requires the eucal package with the mathscr option

# **B.9** Math spacing commands

Name	Width	Short	Long
1 mu (math unit)	ı	\mspace{1mu}	
thinspace	Ш	١,	\thinspace
medspace	Ш	\:	\medspace
thickspace	П	\;	\thickspace
interword space	П	\_	
1 em			
2 em			\qquad
Negative space			
1 mu	I		\mspace{-1mu}
thinspace	И	<b>\!</b>	\negthinspace
medspace	Ш		\negmedspace
thickspace	Ш		\negthickspace



# Text symbol tables

# C.1 Some European characters

Name	Type	Typeset	Type	Typeset
a-ring	\aa	å	\AA	Å
aesc	\ae	æ	\AE	Æ
ethel	\oe	œ	\0E	Œ
eszett	\ss	ß	\SS	SS
inverted question mark	?'	i		
inverted exclamation mark	!'	i		
slashed L	\1	ł	\L	Ł
slashed O	\0	Ø	\0	Ø

516 Appendix C

### C.2 Text accents

Name	Type	Typeset	Name	Туре	Typeset
acute	\'{o}	ó	macron	\={o}	ō
breve	\u{o}	ŏ	overdot	\.{g}	ġ
caron/haček	\v{o}	ŏ	ring	$\r\{u\}$	ů
cedilla	\c{c}	Ç	tie	\t{oo}	oo
circumflex	\^{o}	ô	tilde	\~{n}	$\tilde{\mathrm{n}}$
dieresis/umlaut	\"{u}	ü	underdot	$\d{m}$	ṃ
double acute	\H{o}	ő	underbar	\b{o}	Ō
grave	\'{o}	ò			
dotless i	\i	1	dotless j	<b>\</b> j	J
	\'{\i}	í		\v{\j}	ď

# C.3 Text font commands

### C.3.1 Text font family commands

Command with Argument	Command Declaration	Switches to the font family
	{\normalfont}	document
	{\em}	emphasis
	{\rmfamily}	roman
	{\sffamily}	sans serif
	{\ttfamily}	typewriter style
	{\upshape}	upright shape
	{\itshape}	$italic\ shape$
	{\slshape}	slanted shape
	{\scshape}	SMALL CAPITALS
	{\bfseries}	bold
	{\mdseries}	normal weight and width

# C.3.2 Text font size changes

Command	L <sup>A</sup> T <sub>E</sub> X sample text	AMS sample text
\Tiny	[not available]	sample text
\tiny	sample text	sample text
\SMALL or \scriptsize	sample text	sample text
\Small or \footnotesize	sample text	sample text
\small	sample text	sample text
\normalsize	sample text	sample text
\large	sample text	sample text
\Large	sample text	sample text
\LARGE	sample text	sample text
\huge	sample text	sample text
\Huge	sample text	sample text

518 Appendix C

# C.4 Additional text symbols

Name	Туре	Typeset
ampersand	\&	&
asterisk bullet	\textasteriskcentered	*
backslash	\textbackslash	\
bar (caesura)	\textbar	
brace left	\{	{
brace right	\}	}
bullet	\textbullet	•
circled a	\textcircled{a}	(a)
circumflex	\textasciicircum	^
copyright	\copyright	©
dagger	\dag	†
double dagger (diesis)	\ddag	‡
dollar	\\$	\$
double quotation left	\textquotedblleft or ''	"
double quotation right	\textquotedblright or ''	"
em dash	\textemdash or	_
en dash	\textendash or	_
exclamation down	\textexclamdown or !'	i
greater than	\textgreater	>
less than	\textless	<
lowline	\_	-
midpoint	\textperiodcentered	
octothorp	\#	#
percent	\%	%
pilcrow (paragraph)	<b>\</b> P	$\P$
question down	\textquestiondown or ?'	i
registered trademark	\textregistered	®
section	\S	§

### Additional text symbols, continued

Name	Type	Typeset
single quote left	\textquoteleft or '	4
single quote right	\textquoteright or '	,
sterling	\pounds	£
superscript	\textsuperscript{a}	a
tilde	\textasciitilde	~
trademark	\texttrademark	TM
visible space	\textvisiblespace	u

For the \textsubscript command, see Section 12.3.

# C.5 Additional text symbols with T1 encoding

### An accent

Name	Type	Typeset
Ogonek	\k{e}	ę

### European characters

Name	Type	Typeset	Type	Typeset
Eth	\dh	ð	\DH	Ð
Dyet	\dj	đ	\DJ	Ð
Eng	\ng	ŋ	\NG	$\mathcal{D}$
Thorn	\th	þ	\TH	Þ

### Quotation marks

Name	Type	Typeset	Type	Typeset
Single Guillemet	\guilsinglleft	<	\guilsinglright	>
Double Guillemet	\guillemotleft	«	$\guillemotright$	>>
Single Quotation	\quotesinglbase	,	quoteright	,
Double Quotation	\quotedblbase	"	\textquotedbl	"

520 Appendix C

# C.6 Text spacing commands

Name	Width	Short command	Long command
Positive Space			
Normal	varies	П	
Intersentence	varies	\@.⊔	
Interword	varies	\_	
Italic Corr.	varies	$\bigvee_{\sqcup}$	
Tie	varies	~	
Thinspace	Ш	١,	\thinspace
Medspace	Ш	<b>\</b> :	\medspace
Thickspace	Ш	\;	\thickspace
1 em	ш		
2 em			\qquad
Negative Space			
Thinspace	Ш	\!	\negthinspace
Medspace	Ш		\negmedspace
Thickspace	Ш		\negthickspace

# APPENDIX

# Some background

In this book we define LaTeX as the foundation TeX, the work platform LaTeX, and the superstructure AMS packages rolled into one. While you do not need to know anything about LaTeX's detailed structure and history to use it, such knowledge may help you understand how and why LaTeX works the way it does.

In Section D.1, we present a short history of LaTeX, where it has come from and where it is going. Section D.2 provides a description of the structure of LaTeX. Appendix D.3 provides a description of how LaTeX works. In Appendix D.4, the various prompts are defined and Appendix D.5 discusses the separation of visual and logical design elements.

# D.1 A short history

### D.1.1 $T_{EX}$

Donald E. Knuth's multivolume work, *The Art of Computer Programming* [37], caused its author a great deal of frustration because it was very difficult to keep the volumes typographically uniform. To solve this problem, Knuth decided to create his own type-setting language. The result is described in *The TeXbook* [38].

A mathematical typesetting language takes care of the multitude of details that are so important in mathematical typesetting, including

- Spacing formulas properly
- Breaking text into pleasingly typeset lines and paragraphs
- Hyphenating words where necessary
- Providing hundreds of symbols for typesetting mathematics

LATEX does all this and more on almost any computer: PC, Mac, UNIX, workstation, or mainframe. You can write your document on a PC and e-mail it to a coworker who makes corrections on a Mac. The final manuscript might be sent to a publisher who uses a UNIX computer to prepare the document for printing.

Knuth realized that typesetting is only half the solution to the manuscript production problem. You also need a style designer—a specialist who determines what fonts to use, how large a vertical space to put before and after a theorem, and numerous other design issues.

### D.1.2 LATEX 2.09 and AMS-TEX

Knuth also realized that typesetting a complex document in TEX requires a very knowledgeable user. So TEX was designed as a platform on which *convenient work environments*—macro packages—could be built, more suitable for the average user to work with. It is somewhat unfortunate that *two* such platforms were made available to the mathematical community in the early 1980s, AMS-TEX and LATEX.

 $\mathcal{A}_{\mathcal{M}}\mathcal{S}$ -TEX was written by Michael D. Spivak for the American Mathematical Society, whereas LATEX was developed by Leslie Lamport. The strengths of the two systems were somewhat complementary.  $\mathcal{A}_{\mathcal{M}}\mathcal{S}$ -TEX provided many features needed by mathematical articles, including

- Sophisticated math typesetting capabilities
- Extensive options for formatting multiline formulas
- Flexible bibliographic references

LATEX also provided many features, including

- The use of logical units to separate the logical and the visual design of an article
- Automatic numbering and cross-referencing
- Bibliographic databases

Both  $A_MS$ -TeX and LATeX became very popular, causing a split in the mathematical community as some chose one system over the other.

D.1 A short history 523

### D.1.3 LATEX3

When Lamport decided not to develop Lambar Englishment and further, the Lambar took over with the aim of actively supporting, maintaining, and updating Lambar.

The goals for LATEX3 are very ambitious. LATEX3 will

- Provide high-quality typesetting for a wide variety of document types and typographic requirements
- Support direct formatting commands for editors and designers, which are essential to the fine-tuning of document layout and page design
- Process complex structured documents and support a document syntax that allows automatic translation of documents conforming to the international document-type definition standard SGML (Standard Generalized Markup Language, ISO 8879)
- Provide a common foundation for a number of incompatible LaTeX variants that have been developed, including the old LaTeX 2.09, LaTeX with the New Font Selection Scheme, and AMS-LaTeX

See two articles by Frank Mittelbach and Chris Rowley,  $\LaTeX$  2.09  $\rightarrow$   $\LaTeX$  [47], 1992, and  $\LaTeX$  Project [49], 1994, for a statement of goals. Go to The LaTeX3 project at

http://www.latex-project.org/latex3.html

for more up-to-date articles and reports.

A number of LATEX3 projects have already been completed and are part of LATEX, including:

The New Font Selection Scheme LaTeX uses Knuth's Computer Modern fonts. The New Font Selection Scheme, NFSS, of Frank Mittelbach and Rainer Schöpf, written in 1989, allows the *independent changing* of font attributes and the integration of new font families into LaTeX. With the proliferation of PostScript fonts and printers, more and more users want to use PostScript fonts in their LaTeX documents.

New and improved environments Frank Mittelbach wrote a new multicolumn environment and Rainer Schöpf improved the verbatim and comment environments. There have also been several improvements made to the tabular and array environments. The extremely important graphicx package by David Carlisle and Sebastian Rahtz was released.

<sup>&</sup>lt;sup>1</sup>A talented group of mathematicians and programmers, Frank Mittelbach, Chris Rowley, and Rainer Schöpf. The group has since expanded with the addition of Johannes Braams, David Carlisle, Michael Downes, Denys Duchier, Robin Fairbairns, Alan Jeffrey, and Martin Schröder; many volunteers have also contributed to the project. The current l⁴TEX3 project team personnel are: Johannes Braams, David Carlisle, Robin Fairbairns, Frank Mittelbach, Chris Rowley, Rainer Schöpf, Thomas Lotze, Morten Høgholm, and Javier Bezos.

### The first interim solution

In 1990, the AMS released  $\mathcal{A}_{M}S$ -LATEX, version 1.0—see Rainer Schöpf's *Foreword* to this book for a personal account. This release contained

- AMS-TEX recoded to work with LATEX
- The NFSS styles for proclamations
- The new verbatim environment

 $\mathcal{A}_{M}S$ -PTeX, version 1.0, is a PTeX *dialect*. It was incompatible with the then current PTeX—version 2.09.

While the LaTeX3 team wanted to unify the mathematical community, this first attempt by the AMS split it even further apart. Many  $\mathcal{A}_{\mathcal{M}}\mathcal{S}$ -TeX users simply refused to switch. Even today, 17 years later, many mathematicians cling to  $\mathcal{A}_{\mathcal{M}}\mathcal{S}$ -TeX. Even the LaTeX community was split into users of the old LaTeX, those whose LaTeX incorporated the NFSS, and  $\mathcal{A}_{\mathcal{M}}\mathcal{S}$ -LaTeX users.

### The second interim solution

When it became obvious that the goals of LaTeX3 could not be fulfilled any time soon, the LaTeX3 team decided to issue a new version of LaTeX, version 2e (also called LaTeX  $2_{\varepsilon}$ ) in June of 1994. This version replaced LaTeX 2.09, see the two Mittelbach and Rowley articles cited above. This interim release accomplished some of LaTeX3's goals, including the projects listed previously. Since then, LaTeX  $2_{\varepsilon}$  (called LaTeX today) has become accepted as the standard LaTeX.

In February of 1995, the AMS released version 1.2 of  $\mathcal{A}_{MS}$ -LATEX (which I call the AMS packages in this book) built on top of the new LATEX. Michael Downes was the project leader.

The changes in  $\mathcal{A}_{\mathcal{M}}\mathcal{S}$ -LeTeX were substantial. The align environment, for example, was completely rewritten by David M. Jones. The recoded  $\mathcal{A}_{\mathcal{M}}\mathcal{S}$ -TeX had now become a LeTeX package, amsmath.

It is extremely important to note that while  $\mathcal{A}_{M}\mathcal{S}$ -LETEX 1.0 and 1.1 were monolithic structures, versions 1.2 and 2.0 (see Section D.1.4) are just collections of packages that fit nicely into the LETEX model. You can use one AMS package or all, by themselves or mixed with other LETEX packages. This book was typeset using the LETEX document class (book) and the AMS packages, version 2.13, along with a number of other LETEX (non-AMS) packages.

### D.1.4 More recent developments

Since 1996, changes to LaTeX have been minor. A few new symbols have been added. Much work has been done on character encoding and LM (Latin Modern) fonts by

D.2 Structure 525

Bogusław Jackowski and Janusz M. Nowacki to extend L<sup>A</sup>T<sub>E</sub>X to languages other than American English (see Appendixes F and G).

In 1999, the American Mathematical Society released version 2.0 of the AMS packages and in 2004, version 2.2. About the same time, a consortium (made up of the AMS, Blue Sky Research, and Y&Y) released free PostScript versions of the CM and AMS fonts. These PostScript fonts are now part of any LATEX distribution.

Interestingly, there are still those who argue that the AMS packages are not part and parcel of LaTeX and typesetting math. In life, almost everything is a compromise, in software design, even more so. Using the AMS packages to typeset math is an exception. It costs you nothing—if you do not need their features for a document, then you don't have to use them. You need not sacrifice anything in order to have the power of the AMS packages available when you need them. This is why, in this book, by LaTeX we mean LaTeX with the AMS packages.

### D.2 Structure

LATEX's core is a programming language called TeX, created by Donald E. Knuth, which provides low-level typesetting instructions. TeX comes with a set of fonts called *Computer Modern* (CM). The CM fonts and the TeX programming language form the foundation of a typical TeX system.

TEX is extensible—new commands can be defined in terms of more basic ones. LATEX is one of the best known extensions of TEX.

The visual layout of a LATEX document is primarily determined by the *document class*, such as amsart, article for articles, amsbook, book for books. Many journals, publishers, and schools have their own document classes for formatting articles, books, and theses.

Extensions of LaTeX are called *packages*. They provide additional functionality by adding new commands and environments, or by changing the way previously defined commands and environments work. It is essential that you find the packages that make your work easier. *The LaTeX Companion*, 2nd edition [46] discusses a large number of the most useful packages.

The structure of LaTeX is illustrated in Figure D.1. This figure suggests that in order to work with a LaTeX document, you first have to install TeX and the CM fonts, then LaTeX, and finally specify the document class and the necessary packages. The packages must include amsmath, amsthm, and so on. The AMSFonts font set is very useful, but not absolutely necessary. Of course, chances are that your LaTeX installation already includes all of these.

### D.2.1 Using LATEX

Figure D.2 on page 527 illustrates the steps in the production of a typeset document.

You start by opening an existing LaTeX source file or creating a new one with a

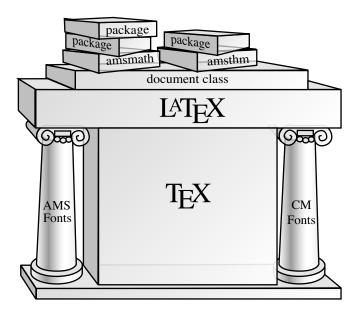


Figure D.1: The structure of LATEX.

text editor. For this discussion, the source file is called myart.tex. Once the source file is ready, you typeset it. Depending on the document class options you choose and the packages the document loads, you end up with at least three additional files:

- 1. myart.dvi or myart.pdf The typeset article in machine-readable format—DVI stands for DeVice Independent—or in PDF format.
- 2. myart.aux The auxiliary file, used by LATEX for internal bookkeeping, including cross-references and bibliographic citations.
- 3. myart.log The log file. LATEX records the typesetting session in the log file, including any warnings and error messages that appear on your monitor in the log window.

Your computer uses a *video driver* to display the typeset article on your monitor and a *printer driver* to print the typeset article on a printer. The video and printer drivers are computer and LATEX implementation dependent.

It should be emphasized that of the three applications used, only one is the same for all computers and all implementations.

D.2 Structure 527

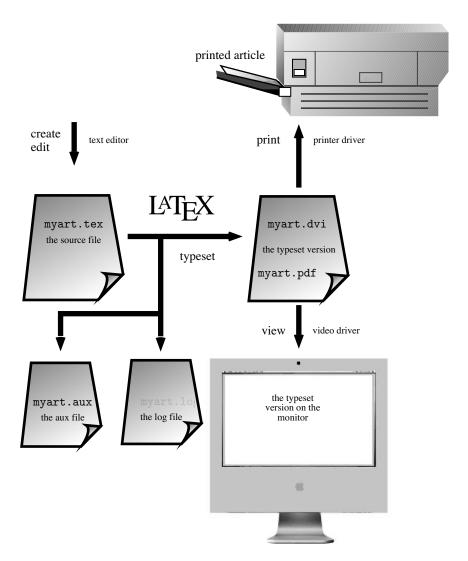


Figure D.2: Using LATEX.

### D.2.2 AMS packages revisited

The AMS enhancements to LATEX fall into three groups: the AMS math enhancements, the document classes, and the AMSFonts. They consist of several packages.

An AMS document class automatically loads a number of AMS packages (see Section 11.6 for a more detailed discussion) including:

- amsmath, the main AMS math package
- amsfonts, commands for math alphabets
- amsbsy, bold symbol commands

The AMS document classes do not automatically load the amssymb package, which provides math symbol names. This package and other AMS or LATEX packages can be loaded as needed.

## D.3 How LATEX works

In this section, I present a very simplified overview of the inner workings of LATEX.

### D.3.1 The layers

TEX and LATEX consist of many layers. These include:

virtex T<sub>F</sub>X's core, containing about 350 primitive commands such as

```
input accent hsize
```

virtex can also read *format files*, which are precompiled sets of commands. LATEX is nothing more than virtex reading in a large set of commands, built layer upon layer.

plain.tex The most basic layer built on virtex. It adds about 600 commands to virtex. When you invoke the TeX command, virtex loads the plain format, which is the default. The core TeX commands combined with the commands defined by the plain format are called Plain TeX.

Plain TEX is described in detail in Appendix B of Knuth's *The TeXbook* [38]. You can also read plain.tex, a text file in the LATEX distribution. Plain TEX is powerful enough that you could do all your work in it. This approach is advocated by many, including Michael Doob in his book, TEX *Starting from* [1] [12].

virtex cannot build (compile) format files. For that you need another version of TEX called initex, which loads the most basic information a format needs, such as the hyphenation tables and plain.tex, and creates a format file.

### LATEX

LATEX is a format file containing a compiled set of commands written by Leslie Lamport and others. It provides tools for logical document design, automatic numbering and cross-referencing, tables of contents, and many other features. The new LATEX we are using is under the control of the LATEX3 group.

### Document classes

The document class forms the next layer. You may choose

- amsart, amsbook, or amsproc, provided by the AMS
- article, book, letter, proc, report, or slides, the legacy classes
- or any one of a large (and growing) number of other document classes provided by publishers of books and journals, universities, and other interested parties

### **Packages**

The next layer is made up of the packages loaded by the document. You can use standard LaTeX packages, AMS packages, or any of hundreds of other packages in the LaTeX universe, mixed together as necessary. Any package may require other packages, or may automatically load other packages.

### **Documents**

At the top of this hierarchy sit your documents, with their user-defined commands and environments, utilizing all the power derived from the layers below.

### D.3.2 Typesetting

When typesetting, LaTeX uses two basic types of files, the source files and the font metric files.

A font metric file is designed to hold the information for a font of a given size and style. Each LATEX font metric file, called a tfm file, contains the size of each character, the kerning (the space placed between two adjacent characters), the length of the italic correction, the size of the interword space, and so on. A typical tfm file is cmr10.tfm, which is the LATEX font metric file for the font cmr (CM roman) at 10-point size.

LATEX reads the source file one line at a time. It converts the characters of each line into a *token sequence*. A token is either a character—together with an indication of what role the character plays—or a command. The argument of a command is the token following it unless a group enclosed in braces follows it, in which case the contents of the group becomes the argument.<sup>2</sup> An example of this behavior can be seen when you

<sup>&</sup>lt;sup>2</sup>Delimited commands work somewhat differently (see Section 15.1.8).

specify an exponent. LaTeX looks for the next token as the exponent unless a group enclosed in braces follows the ^ symbol. This explains why \$2^3\$ and \$2^\alpha\$ work, but \$2^\mathfrak{m}\$ does not. Indeed, 3 and \alpha each become a single token but \mathfrak{m} becomes more than one, four, in fact. Of course, if you always use braces, as in

```
$ 2^{3}$, $2^{\alpha}$, $2^{ \mathfrak{m} }$
```

then you never have to think about tokens to type such expressions.

After tokenizing the text, LATEX hyphenates it and attempts to split the paragraph into lines of the required width. The measurements of the characters—also called glyphs—are absolute, as are the distances between characters—called kerning. The spaces, interword space, intersentence space, and so on, are made of *glue* or rubber length (see Section 15.5.2). Glue has three parameters:

- the length of the space
- stretchability, the amount by which it can be made longer
- shrinkability, the amount by which it can be made shorter

LATEX stretches and shrinks glue to form lines of equal length.

LATEX employs a formula to measure how much stretching and shrinking is necessary in a line. The result is called badness. A badness of 0 is perfect, while a badness of 10,000 is very bad. Lines that are too wide are reported with messages such as

```
Overfull \hbox (5.61168pt too wide) in paragraph at lines 49--57
```

The badness of a line that is stretched too much is reported as follows:

```
Underfull \hbox (badness 1189) in paragraph at lines 93--93
```

Once enough paragraphs are put together, LATEX composes a page from the typeset paragraphs using vertical glue. A short page generates a warning message such as

```
Underfull \vbox (badness 10000) has occurred while \output is active
```

The typeset file is stored as a dvi (Device Independent) file or a PDF file.

### D.3.3 Viewing and printing

Viewing and printing LATEX's typeset output are not really part of LATEX proper, but they are obviously an important part of your work environment. The printer driver prints the dvi and PDF files, and the video driver lets you view them on your monitor.

### D.3.4 LATEX's files

### Auxiliary files

LATEX is a *one-pass compiler*, that is, it reads the source file once only for typesetting. As a result, LATEX must use auxiliary files to store information it generates during a run. For each typesetting run, LATEX uses the auxiliary files compiled during the *previous* typesetting run. This mechanism explains why you have to typeset twice or more (see Section 18.2) to make sure that changes you have made to the source files are reflected in the typeset document. Such an auxiliary file has the same base name as the source file, the extension indicates its type.

The most important auxiliary file, the aux file, contains a great deal of information about the document, most importantly, the data needed for symbolic referencing. Here are two typical entries:

```
\newlabel{struct}{{5}{2}}
\bibcite{eM57a}{4}
```

The first entry indicates that a new symbolic reference was introduced on page 2 of the typeset document in Section 5 using the command

```
\label{struct}
```

The command  $\ref{struct}$  produces 5, while  $\passes 2$ .

The second entry indicates that the bibliographic entry with label eM57a has been assigned the number 4, so \cite{eM57a} produces [4].

There is an aux file for the source file being processed, and another one for each file included in the main file by an \include command.

No auxiliary file is written if the \nofiles command is given. The message

```
No auxiliary output files.
```

in the log file reminds you that \nofiles is in effect.

The log file contains all the information shown in the log window during the typesetting. The dvi file contains the typeset version of the source file.

There are five auxiliary files that store information for special tasks. They are written only if that special task is invoked by a command and there is no \nofiles command. The additional auxiliary files are

glo Contains the glossary entries produced by \glossary commands. A new file is written only if there is a

```
\makeglossary
```

command in the source file (see Section 17.6).

lof Contains the entries used to compile a list of figures. A new file is written only if there is a

\listoffigures

command in the source file (see Section 10.4.3).

lot Contains the entries used to compile a list of tables. A new file is written only if there is a

\listoftables

command in the source file (see Section 10.4.3).

toc Contains the entries used to compile a table of contents. A new file is written only if there is a

\tableofcontents

command in the source file (see Section 18.2).

For information about the auxiliary files created by BIBTEX and *MakeIndex*, see Sections 16.2.3 and 17.3, respectively. Some classes and packages create additional auxiliary files (see Section 13.2.3 for an example).

### Versions

A complete LaTeX distribution consists of hundreds of files, all of which interact in some way. Since most of these files have had many revisions, you should make sure that they are all up-to-date and compatible with each other. You can check the version numbers and dates by reading the first few lines of each file in a text editor or by checking the dates and version numbers that are shown on the list created by the command \listfiles, which I discuss later in this section.

LaTeX has been updated every year. While writing this book, I used the version of LaTeX that was issued on December 1, 2005.

When you typeset a LATEX document, LATEX prints its release date in the log file with a line such as

LaTeX2e <2005/12/01>

If you use a LaTeX feature that was introduced recently, you can put a command such as the following into the preamble of your source file:

\NeedsTeXFormat{LaTeX2e}[2004/12/01]

This command specifies the date of the oldest version of LATEX that may be used to typeset your file. If someone attempts to typeset your file with an older version, LATEX generates a warning.

The AMS math package amsmath is at version 2.13, the document classes at version 2.26, and the AMSFonts set is at version 2.2d. See Section E.1 for more information on obtaining updated versions.

If you include the \listfiles command in the preamble of your document, the log file contains a detailed listing of all the files used in the typesetting of your document. Here are the first few (truncated) lines from such a listing:

```
*File List*
    book.cls
                1999/01/07 v1.4a Standard LaTeX document class
                1998/08/17 v1.1c Standard LaTeX option
   leqno.clo
                   (left equation numbers)
    bk10.clo
                2005/09/16 v1.4f Standard LaTeX file
                   (size option)
                2006/09/15 Commands for MiL4
 MiL4.sty
                2000/07/18 v2.13 AMS math features
 amsmath.sty
 amstext.sty
                2000/06/29 v2.01
  amsgen.sty
                1999/11/30 v2.0
  amsbsy.sty
                1999/11/29 v1.2d
  amsopn.sty
                1999/12/14 v2.01 operator names
  amsthm.sty
                2004/08/06 v2.20
verbatim.sty
                2003/08/22 v1.5q LaTeX2e package for
                   verbatim enhancements
                1999/11/15 v1.2c
 amsxtra.sty
   eucal.sty
                2001/10/01 v2.2d Euler Script fonts
 amssymb.sty
                2002/01/22 v2.2d
amsfonts.sty
                2001/10/25 v2.2f
               1999/05/25 v2.5h Standard LaTeX
 omxcmex.fd
                     font definitions
latexsym.sty
                1998/08/17 v2.2e Standard LaTeX package
                    (lasy symbols)
   amscd.sty
                1999/11/29 v1.2d
   alltt.sty
                1997/06/16 v2.0g defines alltt environment
  xspace.sty
                2006/02/12 v1.11 Space after command
                   names (DPC,MH)
graphicx.sty
                1999/02/16 v1.0f Enhanced LaTeX Graphics
                    (DPC, SPQR)
  keyval.sty
                1999/03/16 v1.13 key=value parser (DPC)
graphics.sty
                2006/02/20 v1.0o Standard LaTeX Graphics
                    (DPC,SPQR)
                1999/03/16 v1.09 sin cos tan (DPC)
    trig.sty
```

This list looks quite up-to-date (in fact, it is completely up-to-date). To confirm

this, open the file alltt.sty in the latest LATEX distribution. You find the lines

```
\ProvidesPackage{alltt} [1997/06/16 v2.0g defines alltt environment]
```

that explain the date found in the listing.

# D.4 Interactive LATEX

If LaTeX cannot carry out your instructions, it displays a *prompt* and possibly an error message (see Section 4.3.1) in the log window.

- The \*\* prompt means that LaTeX needs to know the name of a source file to typeset. This usually means that you misspelled a file name, you are trying to typeset a document that is not located in LaTeX's current folder, or that there is a space in the name of your source file.
- The ? prompt indicates that LATEX has found an error in your source file, and wants you to decide what to do next. You can try to continue typesetting the file by pressing
  - Return
  - q to typeset in quiet mode, not stopping for errors. Depending on the nature of the error, LATEX may either recover or generate more error messages
  - x to stop typesetting your file
  - h to get advice on how to correct the error
- If you have misspelled the name of a package in a \usepackage command, or if LATEX cannot find a file, it displays a message similar to the following:

```
! LaTeX Error: File 'misspelled.sty' not found.

Type X to quit or <RETURN> to proceed,
or enter new name. (Default extension: sty)
```

Enter file name:

You can either type the correct name of the file at the prompt, or type x to quit LATEX.

■ The \* prompt signifies that LaTeX is in *interactive mode* and is waiting for instructions. To get such a prompt, comment out the line

```
\end{document}
```

in a source file, then typeset the file. Interactive instructions, such as \show and \showthe (see Section 15.1.7) may be given at the \* prompt. To exit, type

\end{document}

at the \* prompt, and press Return.

■ If you get the \* prompt and no error message, type \stop and press Return.

# D.5 Separating form and content

In Section 4.3.2, we discuss logical and visual design and how LaTeX allows you to concentrate on the logical design and takes care of the visual design.

LATEX uses four tools to separate the logical and visual design of a document:

**1. Commands** Information is given to LATEX in the arguments of commands. For instance, title page information is given in this form. The final organization and appearance of the title page is completely up to the document class and its options.

A more subtle example is the use of a command for distinguishing a term or notation. For instance, you may want to use an \env command for environment names. You may define \env as follows:

```
\newcommand{\env}[1]{\texttt{#1}}
```

This gives you a command that typesets all environment names in typewriter style (see Section 5.6.2). Logically, you have decided that an environment name should be marked up. Visually, you may change your decision any time. By changing the definition to

```
\newcommand{\env}[1]{\textbf{#1}}
```

all environment names are typeset in bold (see Section 5.6.5).

The following, more mathematical, example is taken from sampartu.tex (see Section 11.3 and the samples folder). This article defines the construct  $D^{\langle 2 \rangle}$  with the command

```
\newcommand{\Dsq}{D^{\langle 2 \rangle}}
```

If a referee or coauthor suggests a different notation, editing this *one line* changes the notation throughout the entire article.

**2. Environments** Important logical structures are placed within environments. For example, list items are typed within a list environment (see Section 6.2) and formatted accordingly. If you later decide to change the type of the list, you can do so by simply changing the name of the environment.

- **3. Proclamations** You can change the style or numbering scheme of any proclamation at any time by changing that proclamation's definition in the preamble. See the typeset sampart article on pages 286–288 for examples of proclamations typeset with different styles.
- **4. Numbering and cross-referencing** Theorems, lemmas, definitions, sections, and equations are logical units that can be freely moved around. LaTeX automatically recalculates the numbers and cross-references.

You write articles to communicate your ideas. The closer you get to a separation of logical and visual design, the more you are able to concentrate on that goal. Of course, you can never quite reach this ideal. For instance, a line too wide warning (see Sections 2.3 and 5.7.1) is a problem of visual design. When a journal changes the document class in an article you submitted, unless the new document class retains the same fonts and line width of the document class you used, new line too wide problems arise. LaTeX is successful in automatically solving visual design problems well over 95% of the time. That is getting fairly close to the ideal.

# IATEX and the Internet

While LaTeX is pretty stable, the rest of the world around us is changing very fast and the Internet plays an ever larger role in our lives. This appendix deals with the Internet as a useful source of LaTeX information.

The Internet is clearly the main repository of all matters LaTeX, and the Comprehensive TeX Archive Network (CTAN) is the preeminent collection of TeX-related material. Section E.1 discusses how and where to find the LaTeX distribution, AMS and LaTeX packages, and the sample files for this book on CTAN.

Various international TEX user groups (especially TUG, the TEX Users Group) and the American Mathematical Society play a significant role in supporting LATEX. I discuss some of the major user groups in Section E.2.

Finally, you find a great deal of useful information on the Internet concerning LATEX. I provide some pointers in Section E.3.

# E.1 Obtaining files from the Internet

Say you are interested in using Piet van Oostrum's fancyhdr package mentioned in Section 10.6. Chances are you can go ahead and use it, your LaTeX installation already has it. In this age of gigantic hard disks, your LaTeX installation places pretty much

everything on your computer. But what if your version of fancyhdr needs updating or you need a new package. How you go about getting it?

We discuss below the proper way of doing this, with an FTP client or a Web browser. But maybe the simplest approach is to google fancyhdr. The first line of the first entry of the complete list of 82,100 responses is

```
The TeX Catalogue OnLine, Entry for fancyhdr, Ctan Edition
```

Clicking on it takes you to a page describing the package. You can get the package by clicking on Download. It is this simple.

In general, there are two types of Internet sites from which you can download files:

- FTP sites (using the file transfer protocol)
- Web sites (using the HTTP protocol)

To access them, use a *client* application on your computer to connect to a *server* on another machine. Today, most *Web browsers*, which are designed to connect to Web sites, also handle FTP transfers.

All operating systems include a browser and an FTP client as part of the system.

#### The Comprehensive T<sub>F</sub>X Archive Network

The Comprehensive TEX Archive Network (CTAN) is the preeminent collection of TEX-related material on the Internet. There are three main CTAN hosts:

```
    U.S.
```

```
- FTP address: ftp://tug.ctan.org/
```

- Web address: http://www.ctan.org/

U.K.

```
- FTP address: ftp://ftp.tex.ac.uk/
```

- Web address: http://www.tex.ac.uk/

Germany

```
- FTP address: ftp://ftp.dante.de/
```

- Web address: http://www.dante.de/

If you go to a CTAN site, at the very root you find README.structure, a very important file. It describes the bottom of the archive tree.

• biblio Systems for maintaining and presenting bibliographies within documents typeset using LATEX

- digests Collections of TeX mailing list digests, TeX-related 'electronic magazines', and indexes, etc., of printed publications
- dviware Printer drivers and previewers, etc., for DVI files
- fonts Fonts written in Metafont, and support for using fonts from other sources (e.g., those in Adobe Type 1 format)
- graphics Systems and T<sub>E</sub>X macros for producing graphics
- help FAQs and similar direct assistance, the catalogue
- indexing Systems for maintaining and presenting indexes of documents typeset using T<sub>F</sub>X.
- info Manuals and extended how-to information, errata for TEX-related publications, collections of project (e.g., LATEX and NTS) documents, etc.
- languageSupport for various languages
- macros TeX macros. Several directories have significant sub-trees:
  - macros/context The Context distribution
  - macros/generic Macros that work in several environments
  - macros/latex The LATEX distribution and contributed matter
  - macros/plain Donald Knuth's example macro set
- nonfree Material which is not freely-usable
- obsolete Material which is now obsolete, including all of LATEX 2.09
- support TEX support environments and the like
- systems TeX systems. Organized by operating environment, but also including:
  - systems/knuth Donald Knuth's current distribution
  - systems/generic Complete systems that can potentially operate in more than one operating environment
- tds The T<sub>E</sub>X Directory Structure standard
- tools Tools of use for the archive maintainers
- usergrps Information supplied by TEX User Groups
- web 'Literate Programming' tools and systems

All of these have many subdirectories, for instance, info has the examples subdirectory that contains the sample files for this book. This is a rather new subdirectory, older sample files are in info proper.

So if you are interested in BIBTEX, you go to biblio/, and so on. The explanations are clear. All matters LATEX are in macros/latex/, which has a number of subdirectories, including

- base—the current LATEX distribution
- required—packages that all LaTeX installations should have, such as the AMS packages, the LaTeX tools, Babel, graphics, and PSNFSS for using PostScript fonts
- contrib—user-contributed packages
- unpacked—the base LaTeX distribution in a form that can be downloaded and placed directly in your TeX input folder

There are many *full mirrors*, exact duplicates, of CTAN and many *partial mirrors*. At the root of CTAN you find the README.mirrors file listing them all. To reduce network load, you should try to use a mirror located near you.

Many CTAN sites now have easy search access with Web browsers. For instance, point your browser to

```
http://tug.ctan.org/search.html
```

In the search field, type fancyhdr, and you get a long list of links. Click on

```
macros/latex/contrib/fancyhdr.zip
```

and you are done. If you type gratzer, you get the links to the help files of my various books—in info/and info/examples/.

#### The AMS packages

Chances are that you received the AMS packages with your LATEX distribution. If you did not, or if you want to update them, go to a CTAN site:

- /tex-archive/fonts/amsfonts/latex/
- | /tex-archive/macros/latex/required/amslatex/

or to the AMS site:

http://www.ams.org/tex/amslatex.html

#### The sample files

The sample files for this book, introduced in Section 1.2 on page 4, live on CTAN in the directory

```
/info/examples/Math_into_LaTeX-4
```

You can go to /info/examples/ and download it, or you can search for the directory name Math\_into\_LaTeX-4. If you forget these, just search for gratzer.

You can also find the Short Course (Part I) on CTAN:

/info/Math\_into\_LaTeX-4/Short\_Course.pdf

# E.2 The T<sub>E</sub>X Users Group

The TEX Users Group (TUG) does a tremendous job of supporting and promoting TEX, by publishing a journal, *TUGboat*, three times a year and organizing an annual international conference. TUG also helps support the LATEX3 team in maintaining LATEX and developing LATEX3.

Consider joining TUG if you have an interest in LATEX. TUG's contact information is:

1466 NW Naito Parkway Suite 3141 Portland, OR 97209–2820

Telephone: (503) 223-9994
E-mail: office@tug.org
Web page: http://www.tug.org/

If you are a member, you receive every year a brand new TEX Live DVD, which contains everything you need to install LATEX as described in Appendix A.

### International T<sub>E</sub>X users groups

There are also many TEX users groups that are geographic or linguistic in nature. Some of the main groups include

- Dante in Germany www.dante.org
- GUTenberg in France www.gutenberg.eu.org
- NTG in the Netherlands www.ntg.nl
- UK TUG in the U.K. uk.tug.org

Click on User groups on the home page of TUG.

#### The American Mathematical Society

The AMS provides excellent technical advice for using the AMS packages and AMS-Fonts. You can reach the AMS technical staff by e-mail at tech-support@ams.org, or by telephone at (800) 321-4267 or (401) 455-4080. You can also find a great deal of helpful TFX information on the AMS Web site in the Author Resource Center.

# E.3 Some useful sources of LATEX information

You may find useful the Frequently Asked Questions (FAQ) documents maintained on CTAN in the /tex-archive/help/ directory. The U.K. TEX Users Group maintains its own FAQ list at

http://www.tex.ac.uk/cgi-bin/texfaq2html?introduction=yes

The AMS FAQ is at

http://www.ams.org/authors/author-faq.html

You can also ask most  $T_EX$ -related questions in the Usenet newsgroup comp.text. tex.

Most LATEX implementations have discussion groups. For the MiKTeX discussion group go to MiKTeX.org and for the WinEdt editor/frontend go to WinEdt.org. On the Mac side, go to

http://www.esm.psu.edu/mac-tex/

or to the TeXShop user forum at

http://www.apfelwiki.de/forum/viewforum.php?f=6

Another useful place is Sebastian Rahtz's Interesting TeX-related URLs

http://www.tug.org/interest.html

containing many links to many other useful sites.

# PostScript fonts

In the late 1990s, as we mentioned in Section D.1.4, a consortium (the AMS, Blue Sky Research, and Y&Y) released a free PostScript version of the CM and AMS fonts, so everyone could switch to PostScript fonts, a tremendous advance for LATEX users.

The Computer Modern fonts were originally "hardwired" into LaTeX. Many users liked LaTeX but disliked the Computer Modern font, and with the spread of personal computers and PostScript laser printers, it was imperative that more PostScript fonts be integrated into LaTeX. In Section F.1, I describe how easy it is to use standard PostScript fonts, such as Times. In Section F.2, I show you how to replace the CM and AMS fonts in a LaTeX document with the Lucida Bright fonts.

And now an apology. "PostScript font" is the terminology that lay people, like me, use. The proper terminology is *Adobe Type 1 format font*. PostScript has provision for a wide range of fonts including Type 3 and Type 1 (as well as Type 42 and Type 5, and so on). The Type 3 font category is very general and includes bitmap fonts, grayscaled fonts, and so on. Type 1 fonts are tightly constrained *outline* fonts, which can be accurately rendered at almost any resolution, and have a special purpose code that deals only with Type 1 fonts.

## F.1 The Times font and MathTime

In this section, we step through the process of incorporating the Adobe Times font into a LATEX document to replace the Computer Modern text fonts, and, optionally, of using the *MathTime Pro 2* math fonts to replace the Computer Modern math fonts. To do so, we use the PSNFSS packages (see Section 12.3).

A document class specifies three standard font families (see Section 5.6.2):

- A roman (or serif) font family
- A sans serif font family
- A typewriter style font family

The times package in the PSNFSS distribution makes Times the roman font family, Helvetica the sans serif font family, and Courier the typewriter style font family.

#### **Setting up Times**

First, install the Adobe Times, Helvetica, and Courier PostScript fonts and their T<sub>E</sub>X font metric files.

Now typeset the psfonts.ins file—in the PSNFSS distribution. This produces sty files for the standard PostScript fonts. The Times style file is called times.sty. If you do not already have it, copy it into a folder LATEX can access (see Sections A.1.6 and A.2.6).

To use the times package, you must have the *font definition* (fd) files for the fonts specified. By checking the times.sty file, you see that you need three files for the three fonts: Times, Helvetica, and Courier. In the times package these are named ptm, phv, and pcr, respectively. The three file names, each comprising three characters, are the font names in the naming scheme devised by Karl Berry. In ptm, p stands for the foundry's name (in this case, Adobe), tm stands for Times, hv for Helvetica, and cr for Courier. The corresponding font definition files are named ot1ptm.fd, ot1phv.fd, and ot1pcr.fd, respectively. OT1 designates the old TeX font encoding scheme, which is not discussed here. You can get these files from CTAN (see Section E.1). If you do not already have it, copy it into a folder LaTeX can access (see Sections A.1.6 and A.2.6).

#### **Using Times**

In the preamble of your document, type

\usepackage{times}

after the \documentclass line. Then Times becomes the roman, Helvetica the sans serif, and Courier the typewriter style document font family. That is all there is to it.

Using the times package changes the document font family throughout your document. To switch to Times only occasionally, type

```
{\fontfamily{ptm}\selectfont phrase}
The text preceding and following this construct is not affected. For example,
{\fontfamily{ptm}\selectfont
This text is typeset in the Times font.}

typesets as

This text is typeset in the Times font.

Similarly,
\fontfamily{ptm}\selectfont
This text is typeset in the Times font.
\normalfont.
```

also typesets the same phrase in Times. Recall that the \normalfont command restores the document font family (see Section 5.6.2).

#### Setting up MathTime

Looking at a mathematical article typeset with the Times text font, you may find that the Computer Modern math symbols look too thin. To more closely match Times and other PostScript fonts, Michael Spivak modified the CM math symbols, calling these modified fonts *MathTime Pro 2*. You can purchase these fonts from Personal TeX.

```
http://store.pctexstore.com/
```

Install the *MathTime Pro 2* PostScript fonts and the T<sub>E</sub>X font metric files. If you do not already have them, copy from PSNFSS the files

```
mathtime.ins mathtime.dtx mtfonts.fdd
```

into a folder LATEX can access (see Sections A.1.6 and A.2.6).

Typeset  $\mathtt{mathtime.ins}$  to produce the necessary fd files and the  $\mathtt{mathtime.sty}$  file.

#### Using MathTime

If you want to use Times as the document font family and *MathTime* as the default math font, specify

in the preamble of your document.

The mathtime package has many options. See its documentation for more information; typeset mathtime.dtx to get it.

## F.2 Lucida Bright fonts

Another alternative to Computer Modern fonts is *Lucida Bright* for both text and math fonts. You can purchase the Lucida Bright fonts from TUG.

Copy the files

```
lucidabr.ins, lucidabr.dtx,
lucidabr.fdd,lucidabr.yy
```

into your TEX input folder (see Sections A.1.6 and A.2.6). Typeset lucidabr.yy, producing the lucidabr.sty file and a large number of fd files.

Now add the lines

in the preamble of your document. The lucidabr package has many options. See its documentation—typeset lucidabr.dtx to get it.

# F.3 More PostScript fonts

You can obtain PostScript fonts from a wide variety of sources. There are many free PostScript fonts on CTAN. Table F.1 is a short list of the more prominent commercial vendors.

See also the Web page at http://www.microsoft.com/typography/ for a lot of useful information and links.

Foundry	URL
Adobe	www.adobe.com/type/
Agfa/Monotype	www.agfamonotype.com/
Berthold	www.bertholdtypes.com/
Bitstream	www.bitstream.com/
Coniglio	www.conigliotype.com/
Emigre	www.emigre.com/
Hoefler	www.typography.com/
ITC	www.itcfonts.com/
Linotype	www.linotype.com/
Monotype	www.fonts.com/
Scriptorium	www.fontcraft.com/
Vintage	www.vintagetype.com/

Table F.1: Some type foundries on the Internet.

# LATEX localized

If the language in which you write articles is not American English and/or your key-board is not the standard American keyboard, you may find it annoying and sometimes difficult to use standard LaTeX. The annoyance may start with finding out how to type ~ for a nonbreakable space, to LaTeX's inability to properly hyphenate Gr\"{a}tzer, and LaTeX's inability to use a different alphabet.

Many of the improvements to LaTeX in recent years have been to localize LaTeX, that is, to adapt LaTeX for use with languages other than American English and keyboards other than standard American keyboards. The

babel fontenc inputenc

packages are the major players, along with new font-encoding schemes, including the T1 encoding. You find these packages as part of the LATEX distribution (see Section 12.3).

The babel package is described in detail in Johannes Braams, *Babel, a multilingual package for use with LATEX's standard document classes* [7] and in Chapter 9 of *The LATEX Companion*, 2nd edition [46].

If you are interested in using a localized LaTeX, you should turn to the TeX user group for that linguistic group to find out what is available. You should also consult

the babel user guide.

At a minimum, a supported language has translated redefinable names (see Table 15.1), and a localized variant of the \today command. Two very advanced language adaptations are German and French.

We first illustrate the use of the babel package with the German language, which gives you a rich set of features, including

- Allows you to type "a for \"{a}
- Introduces "s for sharp s (eszett)

\documentclass{article}

■ Introduces "ck for a ck that becomes k-k when hyphenated

Type the following test file: (german.tex in the samples folder):

```
\usepackage[german]{babel}
\usepackage[T1]{fontenc}

\begin{document}
\section{H"ullenoperatoren}

Es sei $P$ eine teilweise geordnete Menge. Wir sagen,
dass in $P$ ein \emph{H"ullenoperator} $\lambda$
```

erkl"art ist, wenn sich jedem \$a \in P\$ ein eindeutig bestimmtes \$\lambda(a) \in P\$ zuordnen l"a"st, so dass die folgenden Bedingungen erf"ullt sind.

And here it is typeset:

### 1 Hüllenoperatoren

Es sei P eine teilweise geordnete Menge. Wir sagen, dass in P ein  $H\ddot{u}llenoperator$   $\lambda$  erklärt ist, wenn sich jedem  $a \in P$  ein eindeutig bestimmtes  $\lambda(a) \in P$  zuordnen läßt, so dass die folgenden Bedingungen erfüllt sind.

The second example uses the following options for the packages:

```
\usepackage[T2A] {fontenc}
\usepackage[koi8-u] {inputenc}
\usepackage[ukrainian] {babel}
```

The encoding koi8-u is appropriate for Ukrainian.

And here is the typeset Ukrainian sample file:

# Поняття теорії ігор

#### Віктор Анякін

31 липня 2006 р.

Логічною основою теорії ігор є формалізація трьох понять, які входять в її визначення і є фундаментальними для всієї теорії:

- Конфлікт,
- Прийняття рішення в конфлікті,
- Оптимальність прийнятого рішення.

Ці поняття розглядаються в теорії ігор у найширшому сенсі. Їх формалізації відповідають змістовним уявленням про відповідні об'єкти.

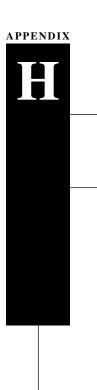
Змістовно, конфліктом можна вважати всяке явище, відносно якого можна казати про його учасників, про їхні дії, про результати явищ, до яких призводять ці дії, про сторони, які так чи інакше зацікавлені в таких наслідках, і про сутність цієї зацікавленості.

Якщо назвати учасників конфлікту коаліціями дії (позначивши їхню множину як  $\Re_D$ , можливі дії кожної із коаліції дії — її стратегіями (множина всіх стратегій коаліції дії K позначається як S), результати конфлікту — ситуаціями (множина всіх ситуацій позначається як S; вважається, що кожна ситуація складається внаслідок вибору кожної із коаліцій дії деякої своєї стратегії, так, що  $S \subset \prod_{K \in \Re} S_K$ ), зацікавлені сторони — коаліціями

iнтересів (їх множина —  $\Re_I$ ) і, нарешті, говорити про можливі переваги для кожної коаліції інтересів Kоднієї ситуації s' перед іншою s'' (цей факт позначається як  $s' \prec s''$  ), то конфлікт в цілому може бути описаний як система

$$\Gamma = \langle \Re_D, \{S_K\}_{K \in \Re_D}, S, \Re_I, \{ \prec \}_{K \in \Re_I} \rangle$$

Така система, яка представляє конфлікт, називається *грою*. Конкретизації складових, які задають гру, призводять до різноманітних класів ігор.



# Final thoughts

In this final appendix, I will outline some of the material I did not discuss and suggest some additional reading to learn more about LATEX, typesetting, and writing. We conclude by looking at some projects that may come to fruition soon.

# H.1 What was left out?

The mission statement in the introduction stated that my goal for this book was to provide you with a good foundation in LATEX including the AMS packages, and that we would not cover programming or visual design. As a result, I have omitted a great deal of material.

### H.1.1 LATEX omissions

LATEX has some additional features that I have not discussed in this book:

- 1. The picture environment allows you to draw simple pictures with lines and circles.
- 2. The array, tabular, and tabbing environments have a number of additional features.

- 3. LaTeX makes the style parameters of a document and of most LaTeX constructs available to the user for modification. Very few of these parameters have been mentioned in this book.
- 4. Low-level NFSS commands provide finer control over fonts.

The following are some pointers to additional information on these topics:

1. Drawing with the picture environment has the advantage of portability. This environment is described in Leslie Lamport's LATEX: A Document Preparation System, 2nd edition [43]. A very advanced internal drawing system is TikZ by Till Tantau, see

http://sourceforge.net/projects/pgf/

However, I believe that the best approach is to use a drawing application that can save your illustrations in EPS or PDF format so that you can include them in your document using the graphicx package (see Section 10.4.3).

- 2. The tabbing, tabular, and array environments—and their extensions—are described in detail in Leslie Lamport's *LATEX: A Document Preparation System*, 2nd edition [43] and Chapter 5 of *The LATEX Companion*, 2nd edition [46].
- 3. The style parameters for LATEX are set by the document class. When a publisher changes the document class loaded by your document, the style parameters are changed to its specifications. If you explicitly change style parameters in your document, a publisher will have trouble getting your source file to conform to their publishing style. If you must change any basic style parameters, be sure to explain what you did with comments.
- 4. There are two types of commands defined in the NFSS, high-level and low-level commands. The latter are, by and large, meant for style designers and package writers. Nevertheless, anyone who wants to use fonts other than Computer Modern (the default) would do well to read Chapter 7 of *The LATEX Companion*, 2nd edition [46].

Low-level NFSS commands are briefly mentioned in Section 5.6.9 and are used in Appendix F.

### H.1.2 T<sub>E</sub>X omissions

Almost all discussion of Plain TeX was omitted from this book. TeX is a powerful programming language, allowing you to design any page layout or formula. Remember, however, that to change any design feature, you should be knowledgeable not only about TeX, but also about document design. Also keep in mind that making such changes may make it difficult or impossible for a publisher to make your document conform to its own specifications.

Much documentation is included with the LATEX and the AMS distributions and many third-party packages are also well documented. You will also find a great deal of documentation on CTAN.

553

As you have no doubt noticed, there are many references to *The LATEX Companion*, 2nd edition [46] in this book. While it is not a beginner's book, it is indispensable for advanced LATEX users with special needs. It is also the best overview of more than a hundred important packages. For package writers and students of NFSS, it is *the* basic textbook. For graphics work, read *The LATEX Graphics Companion* [17], and on Web publishing *The LATEX Web Companion* [18].

Learning TeX is a bit more complicated than learning LaTeX. You may want to start with Wynter Snow's TeX for the Beginner [57]. It introduces many of TeX's basic concepts in a very relaxed style with many examples. The notes on LaTeX make the book especially useful, and the author gives many examples of writing macros. The use of TeX as a programming language is not discussed.

Raymond Seroul and Silvio Levy's *A Beginner's Book of TeX* [56] is another good introduction. This book also includes a chapter on TeX programming. Donald E. Knuth's *The TeXbook* [38] provides an easy introduction to TeX, as long as you avoid the difficult parts marked by dangerous bend signs. Paul W. Abrahams, Karl Berry, and Kathryn A. Hargreaves' *TeX for the Impatient* [1] explains many TeX commands, grouped by topic. This book has a very useful, nonsequential approach. Finally, Victor Eijkhout's *TeX by Topic: A TeXnician's Reference* [14] is an excellent reference book on TeX, mainly for experts. For many tutorial examples, see the articles and columns in *TUGboat* (see Section E.2).

For advice to authors of mathematical articles and books, see *Mathematics into Type* [58] by Ellen Swanson (updated by Arlene Ann O'Sean and Antoinette Tingley Schleyer). You may find it interesting to see how many of the rules in Swanson's book have been incorporated into LATeX. The definitive book on style (in North America) is *The Chicago Manual of Style*, 15th edition [11]. Two other views on copy editing are presented in Judith Butcher's *Copy Editing: The Cambridge Handbook* [9] and *Hart's Rules for Compositors and Readers at the University Press, Oxford* by Horace Hart [35], updated in R. M. Ritter's *New Hart's Rules: The Handbook of Style for Writers and Editors* [54]. The special problems of writing about math and computer science are admirably dissected in Lyn Dupré's *BUGS in Writing: A Guide to Debugging Your Prose*, 2nd edition [13].

Most people who write math have little or no background in typography, the art of printing with type. But when you become a typesetter, it can be useful to learn a little bit about typography. I would highly recommend Robert Bringhurst's *The Elements of Typographic Style* [8]. See also Ruari McLean's *The Thames and Hudson Manual of Typography* [44] and Alison Black's *Typefaces for Desktop Publishing: A User Guide* [6].

Harley Hahn's *A Student's Guide to Unix* [34] provides an excellent introduction to UNIX.

### H.3 What's coming

I do not have a very good record forecasting what important projects will be completed in the near future. In 1995, when I completed my second big LATEX book, I thought that LATEX3 was just around the corner. Now, more than a decade later, I am still hopeful. There seems to be some movement. In 2000, I thought that the new version of BIBTEX is just around the corner ...

Today, maybe most progress is happening with *Unicode*, a character encoding standard developed by the Unicode Consortium in cooperation with W3C and ISO, specifically, with ISO/IEC/JTC 1/SC2/WG2, which is responsible for refining the specification and expanding the character set of ISO/IEC 10646. The goal of Unicode is to provide a uniform encoding for all the characters we need in all human languages, collectively, in addition to the thousands of symbols used in science, in particular, in mathematics. The project, *STIX*, which started more than 10 years ago, may see the light of day before this year is out. STIX will provide fonts that include thousands of mathematical symbols encoded in Unicode.

A number of important projects were and are undertaken to develop a Unicode based LaTeX, namely, Omega, Aleph, and XaTeX.

The first of these, *Omega*, was developed as an extension of T<sub>E</sub>X, to use with multilingual texts. While Omega showed a lot of promise in the mid-1990s, its development stopped. The second of these, *Aleph*, merged e-TeX with the Omega codebase. In 2006, Omega<sub>2</sub> has emerged, to continue the work.

The most promising project is X<sub>T</sub>T<sub>E</sub>X from Jonathan Kew who works for SIL International. X<sub>T</sub>T<sub>E</sub>X is a typesetting system that extends T<sub>E</sub>X to work with Unicode and modern font technologies such as OpenType. X<sub>T</sub>T<sub>E</sub>X was originally developed for Mac OS X, but is now available on a variety of operating systems including Windows and Linux.

X<sub>3</sub>T<sub>E</sub>X is approaching version 1, and is considered very solid. For more information, see the X<sub>3</sub>T<sub>E</sub>X home page

http://scripts.sil.org/xetex

There are a number of promising attempts to bring TeX into the 21st century. LuaTeX, see at

http://luatex.org/documentation.html

has an ambitious set of goals and a tight timetable. A similar project,  $\varepsilon_{\chi}$ TeX, see at

http://extex.org/

is based on the New Typesetting System that was started in 1992. It reached alpha stage

H.3 What's coming 555

in 2000. Many parts of the system are ready and we may soon see an alpha release.

Another very important area of development is *OpenType*, a successor font format of TrueType by Apple computer and the Type 1 font format of Adobe. It became an ISO standard "Open Font Format" in 2006. Microsoft's Vista operating system uses Open Type. The TeX fonts are not yet available in this format.

- [1] Paul W. Abrahams, Karl Berry, and Kathryn A. Hargreaves, *T<sub>E</sub>X for the Impatient*. Addison-Wesley, Reading, MA, 1990.
- [2] Adobe Systems, PDF Reference, Version 1.6. 5th edition. Adobe Press, 2004.
- [3] American Mathematical Society, AMSFonts, Version 2.2 User's Guide. Providence, RI, 1997.
- [4] \_\_\_\_\_, User's Guide for the amsmath Package (version 2.0). Providence, RI, 1999. (Revised 2002.)
- [5] \_\_\_\_\_, Using the amsthmpackage (version 2.20). Providence, RI, 2004.
- [6] Alison Black, Typefaces for Desktop Publishing: A User Guide. Architecture Design and Technology Press, London, 1990.
- [7] Johannes Braams, Babel, a multilingual package for use with LATEX's standard document classes. 2005, on CTAN.
- [8] Robert Bringhurst, The Elements of Typographic Style. Hartley & Marks Publishers, 2004.
- [9] Judith Butcher, Caroline Drake, Maureen Leach, Butcher's Copy-editing: The Cambridge Handbook for Editors, Copy-editors and Proofreaders. 4th edition. Cambridge University Press, London, 2006.
- [10] Pehong Chen and Michael A. Harrison, *Index preparation and processing*. Software Practice and Experience **19** (9) (1988), 897–915.
- [11] The Chicago Manual of Style. 15th edition. University of Chicago Press, Chicago, 2003.
- [12] Michael Doob, *T<sub>E</sub>X Starting from* 1 . Springer-Verlag, New York, 1993.
- [13] Lyn Dupré, BUGS in Writing. A Guide to Debugging Your Prose. 2nd edition. Addison-Wesley Professional, Reading, MA, 1998.
- [14] Victor Eijkhout, T<sub>E</sub>X by Topic: A T<sub>E</sub>Xnician's Reference. Addison-Wesley, Reading, MA, 1991. Free download at http://www.eijkhout.net/tbt/

[15] Michel Goossens, Frank Mittelbach, and Alexander Samarin, The LTEX Companion. Addison-Wesley, Reading, MA, 1994.

- [16] Enrico Gregorio, Horrors in LaTeX: How to misuse LaTeX and make a copy editor unhappy, TUGboat 26 (2005), 273–279.
- [17] Michel Goossens, Sebastian Rahtz, and Frank Mittelbach, The LATEX Graphics Companion. Addison-Wesley, Reading, MA, 1997.
- [18] Michel Goossens and Sebastian Rahtz (with Eitan Gurari, Ross Moore, and Robert Sutor), The LATEX Web Companion: Integrating TeX, HTML and XML. Addison-Wesley, Reading, MA, 1999.
- [19] George Grätzer, *Math into TeX: A Simple Introduction to AMS-LATeX*. Birkhäuser Boston, 1993.
- [20] \_\_\_\_\_, AMS-LATEX. Notices Amer. Math. Soc. 40 (1993), 148–150.
- [21] \_\_\_\_\_\_, Advances in T<sub>E</sub>X implementations. I. PostScript fonts. Notices Amer. Math. Soc. **40** (1993), 834–838.
- [22] \_\_\_\_\_\_, Advances in T<sub>E</sub>X implementations. II. Integrated environments. Notices Amer. Math. Soc. **41** (1994), 106–111.
- [23] \_\_\_\_\_\_, Advances in TeX implementations. III. A new version of LATeX, finally. Notices Amer. Math. Soc. 41 (1994), 611–615.
- [24] \_\_\_\_\_, Advances in TeX. IV. Header and footer control in LaTeX. Notices Amer. Math. Soc. 41 (1994), 772–777.
- [25] \_\_\_\_\_, Advances in TeX. V. Using text fonts in the new standard LaTeX. Notices Amer. Math. Soc. 41 (1994), 927–929.
- [26] \_\_\_\_\_, Advances in TeX. VI. Using math fonts in the new standard LeTeX. Notices Amer. Math. Soc. 41 (1994), 1164–1165.
- [27] \_\_\_\_\_, Math into LATEX: An Introduction to LATEX and AMS-LATEX. Birkhäuser Boston, 1996. 2nd printing, 1998.
- [28] \_\_\_\_\_, General Lattice Theory. 2nd edition. Birkhäuser Verlag, Basel, 1998. xix+663 pp.
- [29] \_\_\_\_\_, First Steps in LATEX. Birkhäuser Boston, Springer-Verlag, New York, 1999.
- [30] \_\_\_\_\_\_, Math into LTEX. 3rd edition. Birkhäuser Verlag, Boston, Springer-Verlag, New York, 2000. xl+584 pp. ISBN: 0-8176-4131-9; 3-7643-4131-9
- [31] \_\_\_\_\_\_, Turbulent transition, TUGboat **21** (2001), 111–113.
- [32] \_\_\_\_\_, Publishing legacy document on the Web, TUGboat **22** (2001), 74–77.
- [33] James Hafner, FoilT<sub>E</sub>X. A LAT<sub>E</sub>X 2<sub>E</sub> class for overhead transparencies. 2002.
- [34] Harley Hahn, Harley Hahn's Student's Guide to Unix. 2nd edition. McGraw-Hill, New York, 1993.

[35] Horace Hart, *Hart's Rules For Compositors and Readers at the University Press, Oxford.* Oxford University Press, Oxford, 1991.

- [36] Uwe Kern, Extending LaTeX's color facilities: the xcolor package. December 21, 2005. http://www.ukern.de/tex/xcolor.html
- [37] Donald E. Knuth, *The Art of Computer Programming*. Volumes 1–3. Addison-Wesley, Reading, MA, 1968–1998.
- [38] \_\_\_\_\_, The T<sub>E</sub>Xbook. Computers and Typesetting. Vol. A. Addison-Wesley, Reading, MA, 1984, 1990.
- [39] \_\_\_\_\_, T<sub>E</sub>X: The Program. Computers and Typesetting. Vol. B. Addison-Wesley, Reading, MA, 1986.
- [40] \_\_\_\_\_\_, The METAFONTbook. Computers and Typesetting. Vol. C. Addison-Wesley, Reading, MA, 1986.
- [41] \_\_\_\_\_\_, METAFONT: The Program. Computers and Typesetting. Vol. D. Addison-Wesley, Reading, MA, 1986.
- [42] \_\_\_\_\_\_, Computer Modern Typefaces. Computers and Typesetting. Vol. E. Addison-Wesley, Reading, MA, 1987.
- [43] Leslie Lamport, ETeX: A Document Preparation System. 2nd edition. Addison-Wesley, Reading, MA, 1994.
- [44] Ruari McLean, The Thames and Hudson Manual of Typography. Thames and Hudson, London, 1980.
- [45] Frank Mittelbach, An extension of the LATEX theorem environment. TUGboat 10 (1989), 416–426.
- [46] Frank Mittelbach and Michel Goosens (with Johannes Braams, David Carlisle, and Chris Rowley), *The LaTeX Companion*. 2nd edition. Addison-Wesley, Reading, MA, 2004.
- [47] Frank Mittelbach and Chris Rowley, *LETEX 2.09* → *LETEX3. TUGboat* **13** (1) (1992), 96–101.
- [48] \_\_\_\_\_, LATeX—A new version of LATeX. TeX and TUG NEWS 2 (4) (1993), 10–11.
- [49] \_\_\_\_\_, *The LATEX3 project*. Euromath Bulletin **1** (1994), 117–125.
- [50] \_\_\_\_\_, LATEX3 in '93. TEX and TUG NEWS 3 (1) (1994), 7–11.
- [51] Frank Mittelbach and Rainer Schöpf, The new font family selection—user interface to standard LaTeX. TUGboat 11 (1990), 297–305.
- [52] Oren Patashnik, BIBTEXing. Document in the BIBTEX distribution.
- [53] \_\_\_\_\_, BIBT<sub>E</sub>X 1.0. TUGboat **15** (1994), 269–273.
- [54] R. M. Ritter, New Hart's Rules: The Handbook of Style for Writers and Editors, Oxford. Oxford University Press, Oxford, 2005.

[55] Rainer Schöpf, A new implementation of the LTEX verbatim and verbatim\* environments. TUGboat 11 (1990), 284–296.

- [56] Raymond Seroul and Silvio Levy, A Beginner's Book of TeX. Springer-Verlag New York, 1995.
- [57] Wynter Snow, TeX for the Beginner. Addison-Wesley, Reading, MA, 1992.
- [58] Ellen Swanson, *Mathematics into Type*. Updated edition. Updated by Arlene Ann O'Sean and Antoinette Tingley Schleyer. American Mathematical Society, Providence, RI, 1999.
- [59] Till Tantau, *User's Guide to the Beamer Class.* 2005. http://latex-beamer.sourceforge.net

# Index

*Italic* numbers indicate figures or tables, *bold* numbers indicate definitions. Special symbols are placed at the end of the Index.

```
math, 25, 176-178, 183, 185, 301, 377, 483
A
a4paper (doc. class opt.), 298, 306
                                                                  double, 177
                                                               text, 9, 15, 69, 79, 79-80, 516, 519
a5paper (doc. class opt.), 306
\AA (Å), 81, 515
                                                           accents (pack.), 178
\aa (å), 81, 515
                                                          acronyms, using small caps for, 91, 480
abbreviations
                                                          acute ( ' acute text accent), 79, 516
     in bibliographic entries, 436-437
                                                           \acute (\acute{x} math accent), 177, 512
       defining, 436
                                                           \addcontentsline (table of contents com.)
     periods in, 66-67
                                                                and lists of figures and tables, 476
     using small caps for, 91, 480
                                                                arguments of, 473, 476
     using ties (~) with, 66
                                                           adding lines
Abrahams, Paul W., 553, 557
                                                               to lists of figures and tables, 476
absolute
                                                               to tables of contents, 473-474
                                                           addition, 22, 63, 157
     names for equations, 201
     units, 12, 15, 89, 93, 95, 96, 105, 107, 111,
                                                           \address (top matter com.), 54, 296, 326
          308, 403
                                                               in letters, 309
abstract (text env.), 36, 68, 251, 285
                                                               optional arguments of, 277
     in beamer document class, 326
                                                               rules for using, 277
     in report document class, 303
                                                                with multiple authors, 281
     placement of, 251, 285
                                                           address (BIBTEX database field), 424, 425
abstract (bibl. com.), 425
                                                           addresses
\abstractname (redef. name), 375
                                                               in letters, 309
abstracts, 36, 251, 326
                                                               of authors in articles, 44, 277, 281, 296
     in AMS document classes, 285
                                                           \addtocontents (table of contents com.)
     in presentations, 53–55
                                                                and lists of figures and tables, 476
     in report document class, 303
                                                                arguments of, 474, 476
     separate page for, 249, 299
                                                           \addtocounter (counter incr. com.), 402
accents
                                                           \addtolength (counter setting com.), 405
     European, 15, 79, 79–80, 519
                                                           adjusted
     hyphenation of words with, 82
                                                               columns, 210, 231-242
     in bibliographies, 427
                                                               formulas, 210, 231-242
     in hyperref titles, 322
                                                                  flush left and right, 214
```

adjusting	of formulas, see also under adjusted,
interline spacing, 95, 98–99	219–231
placement of root with \sqrt, 162	annotated, 32, 209
Adobe	commands for, 214
Acrobat Professional, 318, 319, 321, 325,	flush left and right, 209
483	multiline, 30–33, <b>217–219</b>
converting from Postscript to PDF, 319	simple, 31, 30–31
placing hyperlinks in documents, 319	of large symbols, 229–230
Portable Document Format (PDF), see	of text, <b>8</b> , 68, 106, <b>124</b> , 134, 227, 407
under PDF	centering, 8, 14, 54, 124, 124, 134, 137,
	227, 327, 414
PostScript (PS), see PS	
Reader, 53, 321, 325, 358, 486	command declarations for, <b>124</b> , 137
Adobe Systems, 317–319, 557	flush left, 8, 14, 124
\AE Aesc (Æ), $81, 515$	flush right, 8, 14, 106, 124
\ae aesc ( $\alpha$ ), 81, 515	with trivlist environments, 414
\afterpage (delay com.), 312	of text boxes, vertical, 111
afterpage (pack.), 312	point
afterwords, of books, 467	for annotations (&&), 32
\aleph (ℵ Hebrew char.), 501	for subformulas (&), 30, 31, 33, 216,
\alert (beamer text style com.), 337	218, 221
align (math align. env.), 30–31, 33, 208, 209,	within text boxes, 107, 111
210, <b>219–224</b> , 230, 483, 524	allowdisplaybreaks (display break com.),
annotated, 209	242
page breaks in, 242	and subsidiary math environments, 243
align* (math align. env.), 31, 221, 226	optional argument of, 243
alignat (math align. env.), 31, 221, 226 alignat (math align. env.), 208, 210, <b>224–226</b>	alltt (disp. text env.), 159, 311
argument of, 226	
E .	alltt (pack.), 147, 311, 534
aligned	\Alph (uppercase letter counter style com.), 401
formulas, <b>30–32</b> , 207–211, 219–226,	\alph (lowercase letter counter style com.), 401
230–232, 242, 298, 524	\alpha ( $\alpha$ Greek char.), 502
text in, 226–227	alpha (BIBTEX style), 428
math environments, 242	alphabets (counter styles), 401
align, 30-32, 208, 210, <b>219-224</b> , 230,	alphabets, math, 196, <b>195–196</b>
242	blackboard bold, 181, <b>197</b> , 390, 512
alignat, 208, 210, <b>224-226</b>	calligraphic, 185, <b>197</b> , 301, 390, <i>512</i>
and \verb commands, 148	Euler Fraktur, 180, 182, 197, 301, 302,
eqnarray, 222	390, 512
flalign, 208, 210, <b>221</b>	Euler Script, <b>301</b> , 302, 390, 512
inserting lines of text in, 226	Greek, 197
intercolumn space in, 209	symbol, <b>197–199</b>
subsidiary math environments, 227–231	alphanumeric keys, 8–9
aligned, 211, 227-230	\amalg (II math op.), 506
alignedat, 227-230	American Standard Code for Information
•	
split, 208, 211, <b>230–231</b> , 298	Interchange, see ASCII
aligned (subsid. math align. env.), 211,	ampersand (&)
227–230	as alignment point
and \allowdisplaybreaks commands,	for annotations, 32, 33
243	for subformulas, 30, 31, 216, 218, 221
alignedat (subsid. math align. env.), 227-230	as column separator, 25, 135, 220, 221
and \allowdisplaybreaks commands,	text symbol, 77, 81, 518
243	AMS (American Mathematical Society), xxix,
alignment	525, 543
of columns in tabular environments, 135,	AMSFonts, see AMSFonts
136, 313	article templates, 294–297
	bibliographies
	0.0.108.49.1100

database files, 437	PostScript versions of, 300, 301, 524, 525,
fields, 425	533
sample files, 437, <b>437–438</b>	technical support for, 542
styles, <b>266</b> , <b>421</b> , <i>421</i> , 426, 437–438	updates to, 533
distribution, 271, <b>300–302</b> , 380, 436, 437,	amsfonts (pack.), 301-302, 528
521, 528, 553	options, 301
document classes, see document classes	amsgen (pack.), 301, 302
environments, see displayed math	amslatex (LATEX distr. directory), 311, 312,
environments, subsidiary math	540
environments, <i>and</i> text environments front matter, <i>see</i> front matter	amsmath (pack.), xxvi, 53, 231, <b>300</b> , 301, 302, 403, 524, 525, 528, 533
packages, see packages	document class options affecting, 299
sample files, see under sample files	options, 299
subject classifications, 279	amsmath.sty (AMS distr. file), 387
technical support provided by, 542	amsmidx (pack.), 302
top matter, see also under top matter	\AMSname (hyperref redef. name), 323
AMS specific information, 279–281	amsopn (pack.), 301, 302
article information, 273–275	amsplain (BIBT <sub>E</sub> X style), 421, 437, 439, 441
author information, 275–279	amsplain.bst (BIBTEX style file), 421, 421,
commands, <b>273–285</b> , 296	426, 437, 439, 446
examples of, 282–285	amsproc (doc. class), 273, 376, 529
rules for, 275–279	amsproc.template (AMS sample template
with multiple authors, 281	file), 297
Web site, 280, 542	amsrefs, 447
$\AmS$ ( $A_{\mathcal{M}}S$ logo com.), 80	creating typeset bibliography, 447
AMS package distribution, 271, <b>300–302</b> , 325,	amssymb (pack.), 37, 180, 294, 300, 301, 374,
380, 417, 436, 437, 521, 528, 553	528
$\mathcal{A}_{\mathcal{M}}\mathcal{S}$ -I $^{\perp}$ T $_{\mathcal{E}}$ X, 523, 524	amstext (pack.), 301, 302
history of, 521-525	amsthm (pack.), 302, 525
version 1.0, 524	amsxtra (pack.), 176, 177, 300, 301
version 1.1, 524	\And (& math op.), 506
two-letter font commands, 94	\and, top matter command, 304, 306
version 1.2, 524	and, in bibliographies, 426
version 2.0, 524	\angle ( $\angle$ math sym.), 508
$A_{\mathcal{M}}S$ -T <sub>E</sub> X, <b>522</b> , 524	annotations
history of, 521-525	alignment of, 32, 32
amsalpha (BIBT <sub>E</sub> X style), 428	alignment point for (&&), 32
amsart (doc. class), 36, 82, 125, 249-251, 254,	of formulas, 225
<b>271–302</b> , 465, 469, 525, 529, 536	apalike (pack.), 437
and numbered lists, 118	apostrophe ('), 11, 62
front matter of, 285	key, 23, 194
sample article, 125, 129, 131, 230, 266,	appendices, 255, 467
273, <b>285–293</b> , 294, 371, 376, 383,	numbering of, 255, 467
<b>392–398</b> , 421, 437, <b>437–443</b> , 535,	\appendix (struct. com.), 255, 467
536	\appendixname (redef. name), 376
top matter of, 251	and hyperref package, 323
amsart.tpl (sample file), 294	\approx ( $\approx$ binary rel.), 503
amsbook (doc. class), xxxii, 253, 376, 465,	\approxeq ( $\approxeq$ binary rel.), 504
<b>466–473</b> , 525, 529	\arabic (numeric counter style com.), 401,
for exercises, 476	401, 411
amsbsy (pack.), 301, 302, 528	\arccos (arccos math op.), 172, 510
amscd (pack.), 301	\arcsin (arcsin math op.), 172, 510
AMSFonts, 300, <b>301–302</b> , 525, 528	\arctan (arctan math op.), 172, 510
document class options for, 300	\arg (arg math op.), 172, 510

arguments	arguments of, 236, 237
and tokens, 529	array (pack.), 312
empty ({ }), 39, 55, 70, 159, 179, 188, 189,	arrays, 25–26, 236–238
194, 204, 279, 309	\arraystretch (table com.), 139 adjusting vertical spacing with, 139
errors in, <i>see</i> error messages long, <b>73</b>	arrow keys, 53
movable, 74, 475	arrows, math, 179, 187, 240, 507
negative, 102, 162 of commands, see also under specific	as delimiters, <i>167</i> , <b>168</b> , <i>509</i> ARTICLE (bibl. entry type), 424, 428
commands, 327, 335, 349, 350, 355	article (doc. class), 249, 251, 273, 302, 303,
of commutative diagram symbols, 240	
of environments, see also under specific	<b>303–308</b> , <i>376</i> , 525, 529
environments	anatomy of, 35–43 bibliographies in, 263, 265
of top matter commands, see also top	sectioning commands provided by, 254
matter, 272, 273, 279, 281, 284	articles
of user-defined commands, 370–373	bibliographic entries in, 40–41
	· .
multiple, 370, 371	bibliographies in, 47–48, <b>261–267</b> , 423, 436, <b>437–438</b> , 446
optional, 374	
short, 373–374 of user-defined environments	creating templates for, 44–45, 294–297 in BIBTEX database files, 428–429, 436
	E .
optional, 380, 382, 384	sectioning of, 46, <b>252–255</b> top matter information, 44–46
short, 385	
optional, 15, 71, 98, 100, 112, 113, 115,	AMS specific, 273–285 AMS subject classifications, 279
125, 162, 179, 233, 242, 250	author addresses, 44, 277, 281, 296
multiple, 70 of commands, 120, 122, 123, 127, 200,	author names, 46, 276, 296
201, 264, 266, 276–279, 348, 400,	contributor, 276 current addresses, 277, 281
402, 407, 409, 410, 414, 475	
of environments, <b>69</b> , 125, 128, 132, 135, 229, 243, 260, 384, 486	dedications, 275 e-mail addresses, 278, 281, 296
of sectioning commands, 253, 473 of structural commands, 255, 466	Internet addresses, 278, 281, 296 keywords, 280, 297
of top matter commands, 273–281	research support, 44, 279, 281, 296, 304
use square brackets ([]), 15, 27, <b>69–70</b> ,	title, 44, 273, 297
· · · · · · · · · · · · · · · · · · ·	ASCII (American Standard Code for Information
123, 132, 135, 285 required, 111, 112, 179, 194, 272, 273, 535	Interchange), see also plain text, 9
*	\ast (* math op.), 506
multiple, 19, 70, 137, 192, 194, 268, 311, 379, 404–406	asterisk (* text symbol), 81, 518
of commands, 19, <b>69</b> , 137, 192, 194,	· · · · · · · · · · · · · · · · · · ·
257, 268, 280, 404, 473, 478, <i>516</i>	\asymp (\pop binary rel.), 503
of environments, <b>69</b> , 135, 136, 224, 226,	at sign (@) in BIBTEX database (bib) files, 424
236, 237, 263–264, 266, 309,	in \index commands, 455, 456
<b>383–385</b> , 476	\author (top matter com.), 37, 54, 249, 304,
use braces ({ }), 8, 14, 19, <b>69</b> , 70, 530	306, 331, 469
	multiple authors in, 46, 304
short, 73 single character, 69	optional arguments of, 276, 331
spacing within, 19, 85, 107, 154, 163, 181,	author (BIBT <sub>F</sub> X database field), 424
192. 462	authors
specifying zero in, 114	information about, 46
arithmetic	in AMS top matter, 275–279, 281
operations, 22–23, 157–159	multiple, 46
with counters, 312, <b>402–403</b>	in AMS documents, 281
with length commands, 312, 405	in bibliographies, 426
array (subsid. math env.), 208, 210, 229, 232,	in documents, 304
<b>236–238</b> , 312, 313, 523, 551, 552	iii documento, 504

names of	bar, vertical (   text symbol), 81, 518
in articles, 46, 276, 296	\barwedge ( $\overline{\wedge}$ math sym.), 506
in running heads, 276	base (LATEX distr. directory), 310, 311, 540
automatic	packages in, 310
loading of packages, 53	base names (of files), 531
numbering, 28, 30, 37, 46, 119, 125, 231,	baseline, of text, 95, 108
252	adjusting with setspace, 99
renumbering, 28, 536	\baselineskip (length com.), 95, 101
\autoref (hyperref cross-ref. com.), 320,	\baselinestretch (length com.), 99
320, 322	\Bbbk (k math sym.), 508
names supported by, 323	bbl (proc. bibl. files), <b>441</b> , 443, 446, 447
aux (aux. files), 440–443, 474, 487, <b>526</b>	beamer (doc. class), see also under
symbolic references recorded in, 531	presentations, 325–359
auxiliary files, 475, 486, see also aux, bbl, bib,	abstracts in, 326
blg, bst, glo, idx, ilg, ind, lof,	color in, 348
log, lot, out, and toc, 531	commands
names of, 531	\beamergotobutton, 344
polishing, 486–487	\breakhere, 351
polishing, 100 107	\color, 339, 349
В	\colorbox, 349
\b (_ underscore text accent), 79, 516	\fcolorbox, 349
b5paper (doc. class opt.), 306	\frametitle, 327, 328, 344
babel (LATEX distr. directory), 311	\hyperlink, 344
. 2	
babel (pack.), 312, 547–548	\institute, 326
options, 548	\note, 355
babybeamer1.pdf (sample file), 333–335	\only, 333-335, <b>337-339</b> , 343
babybeamer2.tex (sample file), 334	\onslide, 333, 335, <b>337-339</b> , 342, 343
babybeamer3.tex (sample file), 338	\pause, 333, <b>333</b> , 334, 337
babybeamer4.tex (sample file), 343	\setbeamercolor, 350
babybeamer5.tex (sample file), 341	\setbeamertemplate, 355
babybeamer6.tex (sample file), 343	\tableofcontents, 328
babybeamer6block.tex (sample file), 343	\textcolor, 349
babybeamer7.tex (sample file), 343, 345–347	\usecolortheme, 357
babybeamer8.tex (sample file), 347	\usefonttheme, 357
babybeamer9.tex (sample file), 349	\usetheme, 328, 356
babybeamer10.tex (sample file), 359	documentation for, 325, 358
back matter, 249, <b>261–268</b> , 467	installation of, 326
bibliographies in, 249	options
index in, 450	handout, 358
numbering of chapters in, 467	notes=only, 355
\backepsilon () binary rel.), 504	notes=show, 355
\backmatter (struct. com.), 467	trans, 355, 358
\backprime (\math sym.), 508	xcolor=dvipsnam, 349
backref (pack.), 320	preamble in, 326–327
backref (opt. of hyperref pack.), 321	sections in, 328
\backsim (∽ binary rel.), 504	sidebars, 331
\backsimeq (≤ binary rel.), 504	sidebars in, 328
\backslash (\ math delimiter), 167, 509	table of contents in, 328
backslash (\ text symbol), 81, 518	themes, 328, <b>356–357</b>
badness, 530	top matter in, 326–327
balancing	\beamergotobutton (beamer com.), 344
braces, 72, 77	beamerstructure.tex (sample file), 352, 354
errors with, 72–73	\because (∵ binary rel.), 504
in \index commands, 462	\begin (start of env.), 67, <b>68</b> , 72
inline math delimiters, 153	Berkeley (beamer theme), 328, 331, 332, 356
math delimiters, 168, 217	
\bar ( $\bar{x}$ math accent), 25, 177, 177, 185, 512	

Berry, Karl, 544, 553, 557	bibliographies, 29, 36, see also under BIBTEX,
font-naming scheme, 544	47–48, <b>261–267</b>
\beta ( $\beta$ Greek char.), 502	AMS support for, 436, <b>437–438</b>
\beth (☐ Hebrew char.), 501	appear in back matter, 249
\between (() binary rel.), 504	citing references from, 29, 47, <b>264</b> , <b>439</b> ,
Bezos, Javier, 178, 523	441
\bf (obs. LATEX 2.09 font com.), 94, 95	as hyperlinks in PDF files, 321
\bfseries (font weight com. dec.), 71, 73, 90,	with BIBT <sub>E</sub> X, 439
<b>93</b> , 94, 95, 123, <i>516</i>	commands for, 437, 439
bfseries (font weight env.), 123	conventions, for labels, 48
bib (BIBT <sub>E</sub> X database files), 421, <b>423–437</b> , 440	defining, 29, 40–41, 48, 66, <b>261–267</b> , 375,
accents in, 427	407, <b>423–437</b> , 442
AMS, 436, <b>437–438</b>	document class options affecting, 308, 308
commas (,) in, 424, 425, 445	entries made in auxiliary files for, 441,
comments in, 443	443, 531
cross-referencing within, 432-433	examples of, <b>40–41</b> , <b>43</b> , 47, <b>261–263</b> ,
delimited with parentheses (( )), 424	421–423
delimiters in, 424	in articles, see also bibliographies, sample
double quote (") in, <b>424</b> , 445, 446	files for, <b>40–41</b> , 423, 436, 446
en dashes (–) in, 427	multiple, in a document, 267
entries	numbering of, 48, <b>264</b>
abbreviations in, 436–437	portability of, 426, 428
capitalization in, 427	processed files, see bbl
Jr. in, 426	sample files for, 423, 437, <b>437–438</b> , 446
multiple authors in, 426	styles, 421, 422, 437
von in, 426	AMS, <b>266</b> , <i>421</i> , <i>426</i> , <i>437</i> , <i>439</i>
entry types, 423–437	templates, 261
case-sensitivity of, 425	with amsrefs, 447
start with 0, 424	\bibliography (bibl. com.), 69, 437, <b>439</b>
equals signs (=) in, 424	\bibliographystyle (bibl. com.), 437, 439
fields in, 425, 431–434, 436	\bibname (redef. name), 267, 376
adding your own, 425	\bibstyle (aux. file com.), 441
case-sensitivity of, 425	ВівТех, 421–447
optional, 425, 428–436	AMS support for, 436
required, 425, 428–436	citing references with, 439
rules for typing, 426–437	commands, <b>436</b> , 439
termination of, 445	in auxiliary files, 441
used by AMS bibliography styles, 425	database files, see bib
location of, 439	log files, see blg
number ranges in, 427	processed bibliography files, see bbl
numbers in, 424	running, 437–446
periods (.) in, 426	sample files for, 423, 437, <b>437–438</b>
portability of, 426	style files, see bst
samples of, 423, 437, 446	styles, 421, 422, 426, 437, 439
ties (unbreakable spaces) in, 427	BIBT <sub>E</sub> X 1.0 (Patashnik), 559
\bibcite (aux. file com.), 443, 531	BIBT <sub>E</sub> Xing (Patashnik), 446
\bibdata (aux. file com.), 441	\Big (math delim. size com.), 168
\bibitem (bibl. com.), 29, 47, 263	\big (math delim. size com.), 168
commas in, 266	\bigcap (\) large math op.), 175, 511
labels for, 263	\bigcirc (\( \) math op.), 506
optional argument of, 266	\bigcup (
spaces in, 266	\Bigg (math delim. size com.), 168
bibl.tpl (sample file), 47	\bigg (math delim. size com.), 168
biblatex (pack.), 447	\Biggl (math delim. size com.), 169
(puen.), 111	\biggl (math delim. size com.), 169, 184
	,00- ( see size coiii.), 107, 107

\biggm (math delim., as binary rel. size com.), 170	\blacktriangleright (▶ binary rel.), 504 blank
\Biggr (math delim. size com.), 169	lines
\biggr (math delim. size com.), 169, 184 \Bigl (math delim. size com.), 169	in displayed math environments, 51, 153, 157, 215
\bigl (math delim. size com.), 169	in inline math environments, 153
\bigm (math delim., as binary rel. size com.),	in text environments, 118
170	in top matter commands, 273
\bigodot ( large math op.), 175, 511	in verbatim environments, 146
\bigoplus (\infty large math op.), 175, 511	terminating paragraphs with, 11, 64, 99,
\bigotimes (\infty large math op.), 175, 511	118, 144
\Bigr (math delim. size com.), 169	math delimiters, 168, 182
\bigr (math delim. size com.), 169	math symbol for commutative diagrams
\bigskip (spacing com.), 104	(@), 240
\bigsqcup (   large math op.), 175, 511	blg (BIBT <sub>E</sub> X log files), 441, <b>442</b>
\bigstar (★ math sym.), 508	block (beamer env.), 343
\bigtriangledown ( $\nabla$ math op.), 506	block comment, see comments
\bigtriangleup ( $\triangle$ math op.), 506	Blue Sky Research, 525, 543
\biguplus (+ large math op.), 175, 511	blue spaces, see also tie, unbreakable spaces,
\bigvee (\sqrt{large math op.}), 175, 511	nonbreakable spaces, 76
bigwedge (\(\lambda\) large math op.), 175, 511	bm (pack.), 312
binary operations, 188, 195, 506	Bmatrix (subsid. math env.), 235
+ and - rule, 191, 213, 216	bmatrix (subsid. math env.), 235
adding white space around, 155	\bmod (mod math op.), 173, 174, 506
and alignment of displayed formulas, 218	body
and breaking displayed formulas, 213, 216,	of books, 467
217	of documents, 11, 36, 37, 41, 68, 164,
created with \overset, 193	248–268
created with \underset, 183	of environments, 68
defining, 195	of page, 268
and subformulas, 216	of presentations, 327
for congruences, 173	of theorem environment, 46
binary relations, <b>170</b> , 181, 188, <b>189</b> , 191, <i>503</i> ,	bold
504	font weight, 14, 89, 90, <b>93</b> , 94, 95, <b>123</b> ,
adding white space around, 155	163, 184, <b>196</b> , <i>196</i> , 197, 301, 390, <i>516</i>
and alignment of displayed formulas, 218	math symbols, <b>197–199</b> , 301, 312
and breaking displayed formulas, 217	\boldsymbol (math font weight com.), 184,
created with \overset, 183, 193	197, <b>198</b> , 301, <i>512</i>
defining, 195	BOOK (bibl. entry type), 424, <b>429–430</b>
delimiters as, 170	book (doc. class), xxxii, 253, 376, 465,
math delimiters as, 170	<b>466–473</b> , 474, 524, 525, 529
negated, 181, <b>194</b> , 505	BOOKLET (bibl. entry type), 424, <b>435</b>
\binom (math com.), 23, 159	bookmarks=true (opt. of hyperref pack.),
binomial coefficients, 23, 159–160	320
in inline and displayed math environments,	bookmarks, in PDF documents, 321
160	books
bitmap fonts, 543	bodies of, 467
Black, Alison, 553, 557	document classes for, 253, 465, <b>466–473</b> ,
blackboard bold (math alphabet), 181, <b>197</b> , 390	474, 476, 524, 525, 529
\blacklozenge (♦ math sym.), 508	options of, 468
\blacksquare (■ math sym.), 508	final preparation of, 482–487
\blacktriangle (▲ math sym.), 508	in BIBT <sub>E</sub> X database files, 429–430
\blacktriangledown (▼ math sym.), 508	logical design of, 479–481
\blacktriangleleft (◀ binary rel.), 504	numbering of structures in, 466
(Second Languetor of Wolliary 101.), 307	sectioning of, <b>466–467</b> , 479

books (continued) structure of, 467 top matter of, 251 writing with LaTeX, 465–487 booktabs (pack.), 140 booktitle (BIBTeX database field), 425, 433 \bot (⊥ math sym.), 508 bottoms, of text boxes, 405 \bowtie (⋈ binary rel.), 503 \Box (□ math sym.), 508 \boxdot (⊡ math op.), 506 boxes, 107–115 and length commands, 405 around formulas, 205–206 commands for measuring, 406 invisible, see struts multiline, 107 paragraph, 110–112 solid, 113–114, see also struts	brackets, square ([]), 8, 62 as math delimiters, 24, 167, 509 breaking formula lines within, 217 enclose optional arguments, 15, 27, 69–70, 123, 132, 135, 166, 331 with \newcommand, 370 \breakhere (beamer com.), 351 breaking formulas, see under formulas lines, see under lines pages, see under pages paragraphs, see under paragraphs breve (* text accent), 79, 516 \breve (*\vec{x}\$ math accent), 177, 512 Bringhurst, Robert, 67, 553, 557 browsers, see under Internet bst (BiBTEX style files), 421, 421, 422, 426, 437, 439 determine use of fields, 425
text, 107–115 alignment of contents in, 107, 111 behave as single characters, 107	form of citations created by, 428 location of, 439 \bullet (• math op.), 506
commands for, xxvi, 27, 33, 83, 99, <b>107</b> , 107–115, 138, 140, 154, 162–163, 181, 206, 241, 301 environments for, 107, 109, 112, 383, 384 fine tuning placement of, 115 framed, <b>109–110</b>	bullet (• text sym.), 81, 518 bulleted lists, 119 \Bumpeq (\$\times\$ binary rel.), 504 \bumpeq (\$\times\$ binary rel.), 504 Butcher, Judith, 553, 557 \bysame (bibl. com.), <b>266</b> , 375, 391, 442, 443
measurements of, 405 single line, 107–109, 163 vertical alignment of, 111, 115 vertical alignment of, 111 \boxminus (⊟ math op.), 506 \boxplus (⊞ math op.), 506	C \c (\( \c \) cedilla text accent), 79, 516 \( \cappa \) (copyright text sym.), 81, 518 \( \cappa \) calc (pack.), 312, 403, 406 \( \cappa \) calligraphic (math alphabet), 185, <b>197</b> , 301, 390, 512
\boxtimes (\( \) math op.), 506 Braams, Johannes, xxxiii, 523, 547, 557, 559 braces must be balanced, 72, 77, 87, 166, 462 special, 18, 49, 72, 73, 152, 153, 157 cannot overlap, 72–73 environments act as, 72 stretchable horizontal, 178–179	\Cap (⋒ math op.), 506 \cap (∩ math op.), 506 capitalization, in bibliographic databases, 266 \caption, 39, 52 in figures, 259 in tables, 259 optional argument of, 476 captions, 134, 476
braces, curly ({ }), 8, 14, 19, 23, 69–71, 158, 159, 180, 181, 188–190, 204, 216, 217, 279, 285, 366, 379 and command declarations, 367 as math delimiters, 167, 509 define scope, 71–73 in BIBTEX entries, 424, 426, 427, 436 in \index commands, 462 in text ({ }), 77, 81, 518, 530 unbalanced, 21, 77 with \def, 378	in figures, 259 in lists, <b>120</b> , 476 in tables, 259 multiple, 259 caret (^), 77 Carlisle, David, xxxiii, 123, 136, 257, 259, 320, 368, 523, 559 caron (´ text accent), 79, 516 case-sensitivity of B1bTEX fields and entry types, 425 of command names, 14, <b>69</b> of environment names, <b>69</b>

-6\7-1-7	
of \label arguments, 257	treating text boxes as, 107
of sort keys in \index commands, 462	\check (x math accent), 177, 512
cases (subsid. math env.), 33, 208, 210, <b>239</b>	checkers, spelling, 48, 495
page breaks in, 242	Chen, Pehong, 449, 463, 557
\ccname (redef. name), 376	\chi ( $\chi$ Greek char.), 502
CD (subsid. math env.), 240–242	\circ (\circ math op.), 506
\cdot (· math op.), 23, <b>158</b> , 506	\circeq (\(\delta\) binary rel.), 504
\cdots (centered ellipsis), <b>160</b> , 186	\circlearrowleft (5 math arrow), 507
cedilla (ç text accent), 79, 516	\circlearrowright (*) math arrow), 507
ceiling math delimiters, 167, 509	\circledast (*) math op.), 506
center (text align. env.), <b>8</b> , 106, <b>124</b> , 134, 227,	\circledcirc (\overline{o} math op.), 506
407	\circleddash (\( \circ \) math op.), 506
breaking lines in, 124	\circledS (\subseteq math sym.), 508
LATEX definition of, 414	circumflex (^)
\centerdot (• math op.), 506	text accent, 79, 516
centered ellipses, <b>24</b> , 160	text symbol, 81, 518
\centering (alignment com. declaration), 54,	\citation (aux. file com.), 441
<b>124</b> , 227, 327	citations, bibliographic, 29, 47, 255, <b>263</b> , <b>439</b> ,
centering text, 8, 14, 124	441
in columns in tabular environments, 135	created by BIBTEX styles, 428, 439
in presentations, 54, 327	hyperlinks in PDF files, 321
in tables, 134, 137	showing in margins, 257
centertags (doc. class opt.), 298	\cite (bibliographic com.), 29, 47, 255, <b>263</b> ,
centimeter (cm abs. unit), 12, 15, 105, 107, 111,	441
403	multiple citations, 264
\cfrac (math com.), 200	optional argument of, 264
\chapter (struct. com.), 253, 255, 304, 466	showing contents, in margin, 313
arguments of, 466	showing labels in margins, 257
numbering of	spaces in, 264
equations in, 466	with BIBT <sub>E</sub> X, 439
in front and back matter, 467	classes, document, see document classes
chapter (counter), 399, 399	classification of math symbols, 188–189, 195
chapter (BIBT <sub>E</sub> X database field), 425	\cleardoublepage (page breaking com.), 101
\chaptername (redef. name), 376	cleardoublepage.sty (sample file), 101
and hyperref package, 323	\clearpage (page breaking com.), 101, 261
chapters	clients
document class options to set start pages	e-mail, 65
for, 468	FTP, 538
grouping into parts, 466	\cline (table com.), 137, 137-138, 138
in BIBTEX database files, 436	cls (doc. class files), 250, 375, 410
in books, 466	\clubsuit (♣ math sym.), 508
numbering of, in front and back matter, 467	CM (Computer Modern) fonts, see Computer
characters, see also glyphs	Modern fonts
accented, 9, 15, 62, 69, <b>79–80</b> , 82,	cm (centimeter abs. unit), 12, 15, 105, 107, 111,
<b>176–178</b> , 183, 322, 416, 427	403
European, 15, <b>79–80</b> , 515–516	cmr10.tfm (TeX font metric file), 529
following verbatim environments, 146	coefficients, binomial, see binomial coefficients
Greek, 181, 389–390, 502	collections, in BIBT <sub>F</sub> X database files, 431–432
Hebrew, 501	\colon (: math com.), 63, <b>191</b>
invalid, 9, 63	colophons, of books, 467
line ending, see line ending characters	\color (beamer com.), 339, 349
math, 17, 63	color, in presentations, 348–350
special, 9, 63, 76–78	\colorbox (beamer com.), 349
accessing with \symbol, 77, 311	colorlinks (opt. of hyperref pack.), 320,
in \index commands, 457	321
,	column (beamer env.), 348
	(

columns	fragile, 74
double	protecting, 74, 252, 253, 466, 475
document class options for, 299, 307	generalized, see user-defined commands
figures spanning, 259	global, see under scope
footnotes in, 313	in preamble, see under preamble
tables spanning, 259	length, see length commands
in presentations, 347–348	local, see under scope
math	logical design using, 52–53
adjusted, 231–242	long, 73
adjusting with flalign environment,	math, see math commands
221	names of, 68
in aligned formulas, 219–231	case-sensitivity of, 14, 69
specifying in matrix subsidiary	primitive, see primitive commands
environments, 233	providing, 375
multiple, <b>101</b> , 313, 523	redefining, 374–375
separator (&), 25, 135, 220, 221	scope of, see under scope
width of, in tabular environments, 136	sectioning, see structural commands
columns (beamer env.), 348	short, <b>73</b> , 90, 273, 284
combining	defining, 373–374
document class options, 308	spacing, see spacing commands
encapsulators in \index commands, 455	start with  8, 14, <b>68</b>
command declarations, 73, 90, 124, 137, 227	structural, see structural commands
affecting multiple paragraphs, 90	terminating, 19, 69, 154
do not take arguments, 73	T <sub>E</sub> X, see under T <sub>E</sub> X
for fonts, see font command declarations	text style, see text style commands
scope of, <b>90</b> , <b>367–368</b> , 382	to avoid using, 94, 481
using in user-defined commands, 90,	top matter, see under top matter
367–368	types of, 73–74
command files, see also sty files and packages,	user-defined, see user-defined commands
250, <b>366</b> , <b>386–392</b>	commas (,), 9, 62
commands in, 386	and italic correction, 92
terminating, 392	in \bibitem commands, 266
commands, 67–74	in B <sub>IB</sub> T <sub>E</sub> X databases, 424, 425, 445
*-ed form, 46, <b>69</b> , 98, 101, 103, 105, 129,	use in formulas, 155
130, 148, 173, 195, 196, 242, 253,	comment (comment env.), <b>86-87</b> , 313, 387, 523
322, 373, 382, 385, 439, 467, 473	locating errors with, 87
arguments of, see under arguments or	nesting, 86
specific commands, 327	comments, <b>10</b> , 85–87
as tokens, 529	block comment, <b>6</b> , 50, 51, 86, 478, 494,
defining, see user-defined commands	498
delimited, see delimited commands	keyboard equivalents, 499
for boxes, see under boxes	block uncomment, <b>6</b> , 494, 498
for dates and times, see time commands	creating with % characters, 6, 21, 85, 86,
for expanding values, <b>80</b> , 87, 113, 400	141, 294
for figures, see under figures or floats	creating with comment environments,
for filling horizontal space, <b>106</b> , 113, 126,	86–87
186, 233, 235, 414	finding errors using, 6, 19, 86, 366, 387
for floats, see under floats	in B <sub>IB</sub> T <sub>E</sub> X database files, 86, 443
for fonts, see font commands	inserted using kill command, 141
for graphics, see under graphics	marginal, <b>112–113</b> , 484
for indexing, see under indexing	in double-sided documents, 112
for presentations, <i>see under</i> presentations,	in equations, 112
beamer, and FoilT <sub>E</sub> X	
0 . 1 1 2 2 2	in multiline math environments, 112
for tables, see under tables or floats	in multiline math environments, 112 space between, 404 width of paragraph box for, 113

removing end-of-line characters with, 84,	counters, 123, 233, 377, <b>399–403</b>
85, 458	and \include commands, 400
commutative diagrams, 240-242, 301	and \label commands, 402
comp.text.tex (newsgroup), 542	and proclamations, 399
\complement (C math sym.), 508	arithmetic with, 312, <b>402–403</b>
components	defined in preamble, 400
building formulas from, 164–166	defining, 400
of formulas, 22–27, 157–166	incrementing, 402
of pages, 268	LAT <sub>E</sub> X, 399
Comprehensive TEX Archive Network, see	linking with other counters, 400, 401
CTAN	names of, 128
computer, see Mac, PC, and UNIX	store numbers, 399
Computer Modern (CM) fonts, 89, <b>89</b> , 93, 544,	styles for, 87, 123, 382, 401, <b>400–401</b> , 411
545	values of, 87, 400
bold extended, 89	printing, <b>80</b> , 113, <b>400</b>
ligatures in, 79	setting, 399–400, 402
math bold italic, 196	with list environments, 411
math italic, 196	Courier, in LATEX documents, 544
PostScript versions of, 523, 525, <b>543</b>	cross-referencing, 47–48, <b>255–258</b> , <b>267</b> , 322
roman, 89, 196, 529	among multiple documents, 313
sans serif, 89	and automatic renumbering, 28, 536
	entries made in auxiliary files for, 443, 531
typewriter, 78, 78, 89	in indexes, 457
conference proceedings, in BIBTEX database	
files, 424, 430–432	in proof environment titles, 132
\cong ( $\cong$ binary rel.), 503	inside presentations, 328
congruences, 24, 173	labels for, 28, 31, 46, 50–51, 202, 215,
as binary operations, 173	231, 252, <b>255</b> , 259, 267, 402
consecutive numbering, of proclamations,	of equations, <b>28</b> , 27–29, 31, 156, 202, 203,
127–128	219, 256
contents, table of, see under tables	groups of, 218–219
\contentsline (toc file com.), 473	in multiline math environments, 215
\contentsname (redef. name), 376	of list items, 119, 123
context, affects style of emphasized text, 91	of tables, 134
continued fractions, 200	page numbers, 28, 31, 202, <b>258</b> , 267, 484,
\contrib (top matter com.), 276	531
contrib (IATEX distr. directory), 540	with varioref package, 313
controls, float, 134, <b>260–261</b>	section numbers, 28, 31, 46, 123, 132, 134,
conventions for labels	156, 202, 215, 252, <b>255</b> , 301, 531
in bibliographies, 48	using ties (~) with, 28, <b>66</b> , 257
of equations, 28	within BIBT <sub>E</sub> X databases, 432–433
of sections, 46	crossref (BIBTEX database field), 425
converting	\csc (csc math op.), 172, 510
files	CTAN (Comprehensive TEX Archive Network),
from DVI to PostScript, 318	310, 537, <b>538–540</b> , 542, 544, 546, 553
from PostScript to PDF, 319	catalogue, 539
from articles to presentations, <b>53</b> , 326	LATEX distribution on, 539
\coprod ( $\coprod$ large math op.), 175, 511	mirrors of, 540
\copyright (© copyright), 81, 518	packages on, 464, 540
corner math delimiters ( $\bot$ , $\bot$ , $\sqcap$ , $\urcorner$ ), 167, 509	\URLs for, 538
corollaries, see proclamations	\Cup (⊎ math op.), 506
correction, italic, see italic correction	\cup ( $\cup$ math op.), 506
\cos (cos math op.), 172, 510	\curlyeqprec ( $\preceq$ binary rel.), 504
\cosh (cosh math op.), 172, 510	\curlyeqsucc (≥ binary rel.), 504
\cot (cot math op.), 172, 510	\curlyvee (\gamma\text{ math op.}), 506
\coth (coth math op.), 172, 510	\curlywedge (A math op.), 506

\curraddr (top matter com.), 2/8	\ddot (x math accent), $177$ , $512$
rules for using, 277	
\curvearrowleft (\sigma math arrow), 507	\ddots ( · · diagonal ellipsis), 161, 235
\curvearrowright (→ math arrow), 507	decimals, alignment on, 136, 313
customizing	declarations, command, see command
article templates, 44–45	declarations
for AMS document classes, 294-297	\DeclareMathOperator (op. def. com.), 173,
preambles of, 44, 294	195, 196, 198, 250, 301
top matter of, 44, 294	\DeclareMathOperator* (op. with limits def.
indentation of text, 103	com.), 173, 195
LAT <sub>E</sub> X, 363–417	declaring, types of math symbols, 195
dangers of, 415–417	\dedicatory (top matter com.), 275
lists	\def (T <sub>E</sub> X com.), 416
and counters, 411	defining commands with, 378
defining new, 406–415	overwriting previously defined commands
theorem styles, 131	with, 378
cyrillic (LATEX distr. directory), 311	definition (procl. style), <b>129</b> , 129-131
cyrillic (pack.), 312	definitions, see proclamations
	\deg (deg math op.), 172, 510
D	delarray (pack.), 313
\d ( underdot text accent), 79, 516	delimited commands, 378–380
\dag († dagger)	invoking, 378
math symbol, 508	delimiters
text symbol, 81, 518	for displayed math environments, 18
\dagger († math op.), 506	for inline math environments, 18, 74,
\daleth(\(\bar{\}\)Hebrew char.), 501	152–153
Dante (German T <sub>F</sub> X user group), 541	for \verb commands, 147
dashes, 62	in BIBT <sub>E</sub> X database files, 424
em dash (—), <b>14</b> , <b>75</b> , <i>81</i> , <i>518</i>	math, see math delimiters
en dash (-), <b>14</b> , <b>75</b> , <i>81</i> , <i>518</i>	\Delta ( $\Delta$ Greek char.), 502
in BIBTEX databases, 427	\delta ( $\delta$ Greek char.), 502
\dashleftarrow (+ math arrow), 507	depth
\dashrightarrow (→ math arrow), 507	of tables of contents, 403
\dashv (⊢ binary rel.), 503	of text boxes, 108, 111, 405, 405
databases, BIBT <sub>E</sub> X, see also bib, 421, <b>423–437</b> ,	\depth (length com.), 108, 108, 111
440	description (text list env.), 118, 120-121
\date (top matter com.), 37, 44, 80, 87, 249,	design
275, 304, 469	logical, 52–53
with letter document class, 309	of books, 479–481
\datename (redef. name), 376	of document classes, 522
dates	visual, 52-53, 268-270, 358
commands for, see also \date and time	\det (det math op.), 172, 510
commands, 14, 37, 44, 70, <b>80</b> , 275,	device independent files, see DVI files
548	\dfrac $\binom{x}{-}$ , 158, <b>186</b> , 200
IATEX release, 86, 251, 532	V DII (Eth Ever short) 510
of packages, 533	\DH (Eth Eur. char.), 519
\day (time com.), 80	\dh (eth Eur. char.), 519
\dbinom (display-style binomial com.), 160	\diagdown (\ math sym.), 508
dcolumn (pack.), 136, 313	diagonal ellipses, 235
\ddag (‡ dagger)	diagrams, commutative, see commutative
math symbol, 508	diagrams
text symbol, 81, 518	\diagup ( / math sym.), 508
\ddagger (\pmath op.), 506	\Diamond (\phi math sym.), 508
\dddot ( $x$ math accent), 177, 512	\diamond (\diamond math op.), 506
\ddot( $\ddot{x}$ math accent), 177, 512	\diamondsuit ( $\diamondsuit$ math sym.), 508

dieresis, see umlaut	displaymath (disp. math env.), 152, 153, 156,
diesis (‡)	157, 231
math symbol, 506, 508	\displaystyle (math font size com.), 199,
text symbol, 81, 518	204
\digamma(F Greek char.), 502	dissertations, in BIBTEX database files, 433-434
\dim (dim math op.), 172, 510	distributions
dimensions, see also measurements	AMS packages, 271, <b>300–302</b> , 325, 380,
units for measuring, 12, 15, 89, 93, 95, 96,	417, 436, 437, 521, 528, 553
105, 107, 111, <i>190</i> , 308, 403, <i>513</i>	LATEX, 78, 86, 257, 303–308, <b>310–313</b> ,
with length commands, 404	489, 525, 528, <b>529</b> , 532, 534, 539,
directories, see under AMS and LATEX	540, 547, 553
distributions	PSNFSS, 544–545
\displaybreak (display break com.), 242, 243	TEX, 528
optional argument of, 243	\div (÷ math op.), <b>158</b> , 506
displayed formulas, see displayed math	\divideontimes (* math op.), 506
environments	division, 22, 63, 158, 191, 506
displayed fractions, see under fractions	\DJ (Dyet Eur. char.), 519
displayed math environments, 17, 25, 27–33,	\dj (dyet Eur. char.), 519
152	doc (LATEX distr. directory), 311
\[ (start math mode), 18, <b>152</b>	document (text env.), 11, 37, 41, 68, 164, 248
Visual Guide to, <b>207</b> , 208	document class options
\] (end math mode), 18, <b>152</b>	9pt, <b>297</b>
act as special braces, 152	10pt, <b>104</b> , <b>297</b> , <b>306</b>
align, 30-31, 33, 208, 210, <b>219-224</b> , 230,	11pt, 297, 306
242	12pt, 93, 297, 306
align*, 31, 221, 226	a4paper, 298, 306
alignat, 208, 210, <b>224–226</b>	a5paper, 306
blank lines in, 51	are passed on to packages, 250
breaking pages in, 242–243	b5paper, 306
displaymath, 152, 153, 156, 157, 231	centertags, 298
eqnarray, 222	combining, 308
equation, 27, 33, <b>156-157</b> , 201, 231, 328	draft, 13, 96, 249, 300, <b>306</b>
equation*, 157, <b>157</b> , 201, 231, 328	executivepaper, 306
flalign, 208, 210, <b>221</b>	final, 300, 306
font size in, 199	fleqn, <b>298</b> , 307
gather, 208, 210, <b>211-212</b> , 219, 242	for AMSFonts, 300
gather*, 211	for bibliographies, 308, 308
in direct succession, 482	for double-column documents, 299, 307
inline-style binomials in, 160	for double-sided printing, 299, 307, 468
multline, 208, 210, <b>212-214</b>	for font sizes, 297, 306
multline*, 213-214	for page orientation, 307
subequations, 203, 204, 219, 401	for position of equation numbers, 298, 307
displayed text environments, 117, 143–147	for start of chapters, 468
alltt, 159, 311	for title pages, 299, 307, 468
blank lines in, 118	handout, 358
404 500	
multicols, 101, 523	landscape, 307
proof, 39	legalpaper, 85, 298, 306
quotation, 144	leqno, <b>298</b> , 307
quote, 143	letterpaper, 298, 306
tabbing, 141-143, 551, 552	noamsfonts, 300
tabular, 78, <b>133-140</b> , 237, 259, 312,	$\mathtt{nomath}, 300$
313, 523, 551, 552	notitlepage, <b>299</b> , 307, 468
theorem, 37, 46, 52, 125, 128, 343, 384	onecolumn, 299, 307
verbatim, 145-147, 148, 313	oneside, <b>299</b> , 307, 468
verse, 144-145	
xcb, 476	

document class options (continued)	documentation
openany, 468	for AMS document classes and packages,
openbib, <b>308</b> , <i>308</i>	552
openright, 468	for beamer document class, 325, 358
psamsfonts, 300	for LATEX, 311, 552
regno, <b>298</b> , 307	packages, 312
tbtags, 298	for New Font Selection Scheme (NFSS),
titlepage, 249, <b>299</b> , 307, 468	553
trans, 358	\documentclass (preamble com.), 4, 13, 35,
twocolumn, 85, 101, 259, <b>299</b> , 307, 308,	36, 53, <b>70</b> , 85, 180, 249, 294, 326, 355
313	and \NeedsTeXFormat command, 250
twoside, 85, 249, <b>299</b> , 307, 308, 468	documents
document classes, 53, 82, 125, 376, 528, 529	body of, 11, 36, 37, 41, 68, 164, <b>248–268</b>
amsart, 36, 82, 118, 125, 249–251, 254,	cross-referencing among multiple, 313
<b>271–302</b> , 465, 469, 525, 529, 536	design of, 268–270
amsbook, xxxii, 253, 465, 468, 469, 476,	LATEX, 247–270
525, 529	on the Internet, 317–323
amsproc, 273, 529	using AMS document classes in, 271
anatomy of, 35–43	legacy, 319
article, 35–43, 249, 251, 254, 263, 265,	master, 477–479
273, 302, 303, <b>303–308</b> , 525, 529	preamble of, 249–251
beamer, 325–359	printing and viewing, 5, 318, 530
book, xxxii, 253, 465, 469, 474, 524, 525,	readability of, 93, 358
529	splitting into multiple files, 476–479
changing, 536	dollar sign (\$), see also \$ and \\$, 9
	•
cls files, 250, 375, 410 design of, 522	as inline math delimiter, 17, 18, 33, 74,
determine	152, <b>152</b> , 518 as text symbol, <i>77</i> , <i>81</i>
	•
placement of equation numbers, 298, 307	Doob, Michael, 110, 528, 557
	\dot ( $\dot{x}$ math accent), 177, 512
position of equations, 298, 307	\doteq (= binary rel.), 503, 504
spacing, 102	\dotfill (space fill com.), 106
foils, 53	dotless i and j (1 and j), <b>79</b> , 79, 516
for books, 253, 465, <b>466–473</b> , 474, 476,	\dotplus (\dotplus nath op.), 506
524, 525, 529	\dots ( math ellipsis com.), 24, 78,
options of, 468	160–161, 186
for presentations, see under FoilTEX and	dots, filling lines with, 106
beamer	$\dotsb(\cdots \text{ math com.}), 161$
legacy, 54, 118, 249, 254, 263, 273, 302,	\dotsc ( math com.), 161
<i>305</i> , <b>303–313</b> , 529	\dotsi (··· math com.), 161
letter, 308-310, 529	\dotsm (··· math com.), 161
options of, see document class options	\dotso ( math com.), 161
proc, 529	double accents, in math, 177
proc-1,272	double acute (" text accent), 79, 516
report, 253, 303, <b>303-308</b> , 529	double dagger (‡)
sample, 10	math symbol, 506, 508
sample.cls, 11	text symbol, 81, 518
slides, 303, 529	double guillemet, 519
document font families, 8, 14, 90, <b>89–90</b> , <b>93</b> ,	double quote ("), 9, see also quotation marks,
<b>123</b> , 163, 301, 390, 412, <i>516</i> , 544	<b>75</b> , 81, 518
normal, 90	in \index commands, 457
roman, <b>89</b> , 544	in BIBT <sub>E</sub> X database fields, <b>424</b> , 445, <b>446</b>
sans serif, <b>89</b> , 544	key, 9, 63, 75
typewriter style, <b>89</b> , 544	double spacing, 99
document parameters, for page design, 552	

double subscripts and superscripts, font size of,	Eijkhout, Victor, 553, 557
199	electronic mail address, see \email
double vertical lines in CD environments, 241	\ell ( $\ell$ math sym.), 508
double-column	ellipses ()
documents	centered (···), <b>24</b> , <b>160</b>
and footnotes, 313	diagonal, 235
document class options for, 85, 299, 307	in math, <b>24</b> , <b>160–161</b> , 233
figures and tables, 259	in text, <b>78</b>
double-sided printing	vertical, 235
and marginal comments, 112	\em (font shape com. dec.), 90, 91, 92, 123,
document class options for, 85, 299, 307,	367, 382, <i>516</i>
468	em (font shape env.), 123
\doublebarwedge ( $\overline{\wedge}$ math op.), 506	em (rel. unit), 403, 513
\doublebar wedge (\lambda math op.), 506	em dash (—), <b>14</b> , <b>75</b> , <i>81</i> , 83, <i>518</i>
\doublecup (\U math op.), 506	EM fonts, see European Modern fonts
\doublecup (@ main op.), 500 \doublespacing (setspace com.), 99	\email (top matter com.), 278, 281–283, 295,
\Downarrow (\U)	296
math arrow, 507, 509	rules for using, 278
math delimiter, 167	\emph (font shape com.), 8, 14, 68, 90, <b>91</b> , 337,
	516
\downarrow (\downarrow, 507	emphasized (font shape), 8, 14, 28, 68, 90, <b>91</b> ,
math delimiter, 167, 509	92, <b>123</b> , 125, 156, 367, 382, 516
\downdownarrows (↓ math arrow), 507	and italic correction, 92
Downes, Michael, 447, 523, 524	context dependence of, 91
\downharpoonleft (\lambda math arrow), 507	empty (page style), 268
\downharpoonright (  math arrow), 507	empty group ({ }), 39, 55, 70, 159, 179, 188,
draft (doc. class opt.), 13, 96, 249, 300, <b>306</b>	189, 194, 204, 279, 309
drivers	\emptyset (\( \text{m} \) math sym.), 508
printer, 312, 320, 526, <b>530</b> , 539	en dash (-), <b>14</b> , 81, 83, 518
video (DVI viewer), 526, 530	in BIBT <sub>E</sub> X databases, 427
Duchier, Denys, 523	Encapsulated PostScript (EPS), see EPS
Dupré, Lyn, 85, 553, 557	\enclname (redef. name), 376
DVI files, 526, 530, 539	encodings, font, see font encodings
converting to PostScript, 318	\end (end of env.), 67, <b>68</b> , 72
printing, 530	errors with, 72, 146, 478
viewing, 526, 530	end-of-line characters, see line ending
dvipdf (opt. of hyperref pack.), 320	characters
dvipdfm (opt. of hyperref pack.), 320	\endinput (input ending com.), 392, 478
dvipdfmx (opt. of hyperref pack.), 320	eng (Eur. char), 519
dvips (opt. of hyperref pack.), 320	\enlargethispage (spacing com.), 101, 484,
dvipsnam (opt. of xcolor pack.), 349	487
dvipsone (opt. of hyperref pack.), 320	\enlargethispage* (spacing com.), 101
dviwindo (opt. of hyperref pack.), 320	\ensuremath (math mode com.), <b>369</b> , 370, 375
dyet (Eur. char), 519	Enter key, see Return key
	entries
E	bibliographic, see under bib
e-mail, see \email	glossary, see under glossaries
e-mail clients, 65	index, see under indexing
editing cycle, 4–6	enumerate (list text env.), 313, 382
Mac, 498	enumerate (pack.), 123, 313, 382, 387
PC, 491	enumi (counter), 123, 399
edition (BIBT <sub>E</sub> X database field), 425	enumii (counter), 399
editor (BIBTEX database field), 425	enumiii (counter), 399
editors, text, xxvi, 4, 5, 9, 18, 48, 55, 63, 84, 88,	enumiv (counter), 399
365, 490, 526	

environments, 8, 14, 18, 07–74	equation (disp. main env.), 27, 33, 130-137,
*-ed forms, 157, 201, 211, 213, 215, 231,	201, 231, 328
259	blank lines in, 157
act as braces, 72	equation* (disp. math env.), 157, 157, 201,
arguments of, see under arguments or	231, 328
specific environments	\equationname (hyperref redef. name), 32.
\\ in, 124, 145	equations, 27–29
begin with \begin, 68, 72	document class options for placement of
body of, 68	numbers, 298, 307
case-sensitivity of names of, <b>69</b>	grouping, 203–204
end with \end, 68, 72	in multiline math environments, 215
font size, 123	in presentations, 328
for presentations, see under beamer and	labels for, <b>28</b> , 256
FoilT <sub>E</sub> X	marginal comments in, 112
for proclamations, see proclamations	numbering of, <b>27–29</b> , 55, <b>156–157</b> , 201,
for tables, see tables	211, 213, 215
indenting contents of, in source file, 155	groups, 218–219
legacy, 123, 143-145, 407	in chapters of books, 466
list, see list text environments	preventing, 30, 31, 157, 201, 211, 213,
logical design using, 535	215, 218, 231
typesetting environment names, 535	variants, <b>203</b> , 218
math, see under inline and displayed math	within sections, 156, 250
environments, subsidiary math	position of, 298, 307
environments, and displayed text	systems of, 225–226
environments	tagging, 29, <b>201–204</b> , 211, 213, 215, 218,
modifying, 380–383	230, 231
\newline in, 98	\equiv (≡)
operating, see under PC, Mac, and UNIX	binary relation, 503
short, 385	math operator, 24, 174, 182, 371, 379
subsidiary math, see subsidiary math	error messages, 5, see also warning messages,
environments	48–52, 534
text, see displayed text environments, list	Argument of $\xxx$ has an extra $\$
text environments, and text	146
environments	Bad math environment delimiter,
user-defined, see user-defined	132, 153, 475
environments, see user-defined	\begin{document} ended by
environments	\end{xxx}, 87, 146
visual design using	\begin{split} not allowed here,
typesetting environment names, 535	231
EPS (Encapsulated PostScript)	\begin{ $xxx$ } on input line $xx$
. 1	e i
files, 476, 483, 496	ended by \end{yyy}, 49, 50, 72
format, 39, <b>259</b> , 483, 552	Can be used only in preamble, 250
\epsilon ( $\epsilon$ Greek char.), 502	Command \xxx already defined, 367
\eqcirc (= binary rel.), 504	376, 381
eqnarray (math align. env.), 222	Display math should end with \$\$,
\eqref (cross-ref. com.), <b>28</b> , 29, 31, 156, 202,	51
203, 215, 219, 255, 256, 263, 328, 370	Double superscript, 158
\eqslantgtr (≥ binary rel.), 504	Environment xxx undefined, 381
\eqslantless (€ binary rel.), 504	Extra alignment tag has been
equals (=)	changed to \cr, 237
binary relation, 63, 503	Extra $\}$ , or forgotten $\xspace xxx$ , 73,
in BiBT <sub>E</sub> X database fields, 424	223
key, 8	File 'xxx' not found, 534
equation (counter), <b>399</b> , <i>399</i>	I was expecting a ',' or a ')',
54225201 (counter), 577, 577	445, 446
	773, 770

characters, 15, <b>79–80</b> , <i>515–516</i> , <i>519</i>
quotation marks, 519
European Modern (EM) fonts, 524
ex (rel. unit), 403
examples
of bibliographies, <b>40–41</b> , <b>43</b> , 47, <b>261–263</b> <b>421–423</b>
of indexes, 450–452
of nonbreakable spaces (~ spacing com.),
76
of top matter commands, 282-285
\except (table of contents com.), 473
exclamation marks (!), 9, 62
as float control, <b>260</b> , 486
in \index commands, 453, 454, 457
Spanish (;), 81, 515, 518
terminating sentences with, 64–67
executivepaper (doc. class opt.), 306
exercises, 476
in books, 476
within a section, 476
\exists ( $\exists$ math sym.), 508
exiting, from interactive mode, 491, 534
\exp (exp math op.), 172, 510
expanding values of counters, 80, <b>400</b>
exscale (pack.), 301, 311
extensibility of LATEX and TEX, 525
, E E
F
F Fairbairns, Robin, 523
Fairbairns, Robin, 523
_
Fairbairns, Robin, 523 \fallingdotseq (= binary rel.), 504
Fairbairns, Robin, 523 \fallingdotseq (= binary rel.), 504 fancyhdr (pack.), 270, 537, 540
Fairbairns, Robin, 523 \fallingdotseq (= binary rel.), 504 fancyhdr (pack.), 270, 537, 540 FAQ (Frequently Asked Questions), 539, 542
Fairbairns, Robin, 523 \fallingdotseq (= binary rel.), 504 fancyhdr (pack.), 270, 537, 540 FAQ (Frequently Asked Questions), 539, 542 \fboxrule (length com.), 110
Fairbairns, Robin, 523 \fallingdotseq (= binary rel.), 504 fancyhdr (pack.), 270, 537, 540 FAQ (Frequently Asked Questions), 539, 542 \fboxrule (length com.), 110 \fboxsep (length com.), 110
Fairbairns, Robin, 523 \fallingdotseq (= binary rel.), 504 fancyhdr (pack.), 270, 537, 540 FAQ (Frequently Asked Questions), 539, 542 \fboxrule (length com.), 110 \fboxsep (length com.), 110 \fcolorbox (beamer com.), 349
Fairbairns, Robin, 523 \fallingdotseq (\= binary rel.), 504 fancyhdr (pack.), 270, 537, 540 FAQ (Frequently Asked Questions), 539, 542 \fboxrule (length com.), 110 \fboxsep (length com.), 110 \fcolorbox (beamer com.), 349 fd (font def. file), 544, 545, 546
Fairbairns, Robin, 523 \fallingdotseq (\(=\) binary rel.), 504 fancyhdr (pack.), 270, 537, 540  FAQ (Frequently Asked Questions), 539, 542 \fboxrule (length com.), 110 \fboxsep (length com.), 110 \fcolorbox (beamer com.), 349 fd (font def. file), 544, 545, 546 Fear, Simon, 140
Fairbairns, Robin, 523 \fallingdotseq (\(=\) binary rel.), 504 fancyhdr (pack.), 270, 537, 540 FAQ (Frequently Asked Questions), 539, 542 \fboxrule (length com.), 110 \fboxsep (length com.), 110 \fcolorbox (beamer com.), 349 fd (font def. file), 544, 545, 546 Fear, Simon, 140 fields, bibliographic, see under bib figure (counter), 399
Fairbairns, Robin, 523 \fallingdotseq (\(=\) binary rel.), 504 fancyhdr (pack.), 270, 537, 540  FAQ (Frequently Asked Questions), 539, 542 \fboxrule (length com.), 110 \fboxsep (length com.), 110 \fcolorbox (beamer com.), 349 fd (font def. file), 544, 545, 546 Fear, Simon, 140 fields, bibliographic, see under bib
Fairbairns, Robin, 523 \fallingdotseq (\(=\) binary rel.), 504 fancyhdr (pack.), 270, 537, 540  FAQ (Frequently Asked Questions), 539, 542 \fboxrule (length com.), 110 \fboxsep (length com.), 110 \fcolorbox (beamer com.), 349 fd (font def. file), 544, 545, 546 Fear, Simon, 140 fields, bibliographic, see under bib figure (counter), 399 figure (float env.), 39, 259-260, 327
Fairbairns, Robin, 523 \fallingdotseq (\(=\) binary rel.), 504 fancyhdr (pack.), 270, 537, 540  FAQ (Frequently Asked Questions), 539, 542 \fboxrule (length com.), 110 \fboxsep (length com.), 110 \fcolorbox (beamer com.), 349 fd (font def. file), 544, 545, 546 Fear, Simon, 140 fields, bibliographic, see under bib figure (counter), 399 figure (float env.), 39, 259-260, 327 optional arguments of, 260, 486
Fairbairns, Robin, 523 \fallingdotseq (\(=\) binary rel.), 504 fancyhdr (pack.), 270, 537, 540  FAQ (Frequently Asked Questions), 539, 542 \fboxrule (length com.), 110 \fboxsep (length com.), 110 \fcolorbox (beamer com.), 349 fd (font def. file), 544, 545, 546 Fear, Simon, 140 fields, bibliographic, see under bib figure (counter), 399 figure (float env.), 39, 259-260, 327 optional arguments of, 260, 486 placement of, 484, 486
Fairbairns, Robin, 523 \fallingdotseq (\(=\) binary rel.), 504 fancyhdr (pack.), 270, 537, 540  FAQ (Frequently Asked Questions), 539, 542 \fboxrule (length com.), 110 \fboxsep (length com.), 110 \fcolorbox (beamer com.), 349 fd (font def. file), 544, 545, 546 Fear, Simon, 140 fields, bibliographic, see under bib figure (counter), 399 figure (float env.), 39, 259-260, 327 optional arguments of, 260, 486 placement of, 484, 486 figure* (float env.), 259
Fairbairns, Robin, 523 \fallingdotseq (= binary rel.), 504 fancyhdr (pack.), 270, 537, 540  FAQ (Frequently Asked Questions), 539, 542 \fboxrule (length com.), 110 \fboxsep (length com.), 110 \fcolorbox (beamer com.), 349 fd (font def. file), 544, 545, 546 Fear, Simon, 140 fields, bibliographic, see under bib figure (counter), 399 figure (float env.), 39, 259-260, 327 optional arguments of, 260, 486 placement of, 484, 486 figure* (float env.), 259 \figurename (redef. name), 375, 376
Fairbairns, Robin, 523 \fallingdotseq (\(=\) binary rel.), 504 fancyhdr (pack.), 270, 537, 540  FAQ (Frequently Asked Questions), 539, 542 \fboxrule (length com.), 110 \fboxsep (length com.), 110 \fcolorbox (beamer com.), 349 fd (font def. file), 544, 545, 546 Fear, Simon, 140 fields, bibliographic, see under bib figure (counter), 399 figure (float env.), 39, 259-260, 327 optional arguments of, 260, 486 placement of, 484, 486 figure* (float env.), 259 \figurename (redef. name), 375, 376 and hyperref package, 323
Fairbairns, Robin, 523 \fallingdotseq (\(=\) binary rel.), 504 fancyhdr (pack.), 270, 537, 540  FAQ (Frequently Asked Questions), 539, 542 \fboxrule (length com.), 110 \fboxsep (length com.), 110 \fcolorbox (beamer com.), 349 fd (font def. file), 544, 545, 546 Fear, Simon, 140 fields, bibliographic, see under bib figure (counter), 399 figure (float env.), 39, 259-260, 327 optional arguments of, 260, 486 placement of, 484, 486 figure* (float env.), 259 \figurename (redef. name), 375, 376 and hyperref package, 323 figures, 259-260
Fairbairns, Robin, 523 \fallingdotseq (\(=\) binary rel.), 504 fancyhdr (pack.), 270, 537, 540  FAQ (Frequently Asked Questions), 539, 542 \fboxrule (length com.), 110 \fboxsep (length com.), 110 \fcolorbox (beamer com.), 349 fd (font def. file), 544, 545, 546 Fear, Simon, 140 fields, bibliographic, see under bib figure (counter), 399 figure (float env.), 39, 259-260, 327 optional arguments of, 260, 486 placement of, 484, 486 figure* (float env.), 259 \figurename (redef. name), 375, 376 and hyperref package, 323 figures, 259-260 captions in, 476
Fairbairns, Robin, 523 \fallingdotseq (\(=\) binary rel.), 504 fancyhdr (pack.), 270, 537, 540 FAQ (Frequently Asked Questions), 539, 542 \fboxrule (length com.), 110 \fboxsep (length com.), 110 \fcolorbox (beamer com.), 349 fd (font def. file), 544, 545, 546 Fear, Simon, 140 fields, bibliographic, see under bib figure (counter), 399 figure (float env.), 39, 259-260, 327 optional arguments of, 260, 486 placement of, 484, 486 figure* (float env.), 259 \figurename (redef. name), 375, 376 and hyperref package, 323 figures, 259-260 captions in, 476 fragile commands in, 74
Fairbairns, Robin, 523 \fallingdotseq (\(=\) binary rel.), 504 fancyhdr (pack.), 270, 537, 540 FAQ (Frequently Asked Questions), 539, 542 \fboxrule (length com.), 110 \fboxsep (length com.), 110 \fcolorbox (beamer com.), 349 fd (font def. file), 544, 545, 546 Fear, Simon, 140 fields, bibliographic, see under bib figure (counter), 399 figure (float env.), 39, 259-260, 327 optional arguments of, 260, 486 placement of, 484, 486 figure* (float env.), 259 \figurename (redef. name), 375, 376 and hyperref package, 323 figures, 259-260 captions in, 476 fragile commands in, 74 commands for, 259, 476, 479
Fairbairns, Robin, 523 \fallingdotseq (\(=\) binary rel.), 504 fancyhdr (pack.), 270, 537, 540  FAQ (Frequently Asked Questions), 539, 542 \fboxrule (length com.), 110 \fboxsep (length com.), 110 \fcolorbox (beamer com.), 349 fd (font def. file), 544, 545, 546 Fear, Simon, 140 fields, bibliographic, see under bib figure (counter), 399 figure (float env.), 39, 259-260, 327 optional arguments of, 260, 486 placement of, 484, 486 figure* (float env.), 259 \figurename (redef. name), 375, 376 and hyperref package, 323 figures, 259-260 captions in, 476 fragile commands in, 74 commands for, 259, 476, 479 double-column, 259
Fairbairns, Robin, 523  \fallingdotseq (\(=\) binary rel.), 504 fancyhdr (pack.), 270, 537, 540  FAQ (Frequently Asked Questions), 539, 542 \fboxrule (length com.), 110 \fboxsep (length com.), 110 \fcolorbox (beamer com.), 349 fd (font def. file), 544, 545, 546 Fear, Simon, 140 fields, bibliographic, see under bib figure (counter), 399 figure (float env.), 39, 259-260, 327 optional arguments of, 260, 486 placement of, 484, 486 figure* (float env.), 259 \figurename (redef. name), 375, 376 and hyperref package, 323 figures, 259-260 captions in, 476 fragile commands in, 74 commands for, 259, 476, 479 double-column, 259 forcing typesetting of, 101

figures (continued)	final (doc. class opt.), 300, 306
numbering of, 258, 259	final preparation, of books, 482–487
old-style, 62	fine tuning
placement of, <b>260</b> , 484, 486	of mathematical formulas, 190–192
file formats, for graphics	placement of root with \sqrt, 162
EPS, 39, <b>259</b> , 483, 496, 552	placement of text boxes, 115
PDF, 39, <b>259</b> , 326	\Finv ( $\exists$ math sym.), 508
file transfer protocol, see FTP	fixed-size math delimiters, 168
fileerr (pack.), 313	fixltx2e.dtx, 311
files	fixltx2e.ins, 311
MakeIndex log, see ilg	fixltx2e.sty, 311, 312
auxiliary, see aux	flalign (math align. env.), 208, 210, 221
BIBTEX databases, see bib	\flat ( $\flat$ math sym.), 508
BIBTEX log, see blg	fleqn (doc. class opt.), 298, 307
BIBTEX style, see bst	floats, see also tables and figures, 258–261
class (cls), see under document classes	commands, 259, 260
command, see command files	controls, 134, <b>260–261</b>
converting from articles to presentations,	environments, 133, <b>258–260</b>
<b>53</b> , 326	figure, 39, <b>259–260</b> , 260, 327
documents composed of multiple, 476–479	figure*, 259
DVI, see DVI files	locating, 484, 486
Encapsulated PostScript, see EPS	table, 134, <b>258</b> , 260
font definition, see fd	table*, 259
	forcing typesetting of, 101
font metric, see also tfm, see under font	C 11
metrics	specifying placement of, <b>260</b> , 484
glossary, see glo	floor math delimiters, 167, 509
hyperref bookmarks, see out	flush left
hyphenation pattern, see under	alignment of formulas, 209, 210, 212, 214,
hyphenation	221, 307
including in other files, 386, <b>478</b>	column alignment, 231–232, 236
index entry, see idx	columns in tabular environments, 135
list	setting equations, 298, 307
of figures, see lof	flush right
of tables, see lot	alignment of formulas, 209, 210, 212, 214,
listing those used by a document, 387	221
log, see log files	alignment of text, 106
naming of, 44	column alignment, 231-232, 236
with \graphicspath command, 479	columns in tabular environments, 135
organization of, 476–479	setting equations, 298, 307
package source, see under packages	flushleft (text align. env.), 8, 124, 407
portability of, 9	breaking lines in, 124
Portable Document Format, see PDF, see	flushright (text align. env.), 8, 68, 124, 407
PDF	breaking lines in, 124
PostScript (PS), see under PostScript	\fnsymbol (footnote counter style com.), 87
processed bibliography, see bbl	\foilhead (FoilTEX com.), 53, 55
processed index, see ind	optional argument of, 56
sample, see sample files	foils (doc. class), 53
source, see source files	FoilT <sub>E</sub> X, 53
start on new page with \include	commands for, 55
command, 478	folders, 3
style, see sty	samples, see samples
tables of contents, see toc	structure of, 477–479
terminating, 392, <b>478</b>	work, see work
filling horizontal space, <b>106</b> , 113, 126, 186, 233,	font command declarations, see also font
235, 414	commands, 90
233, 414	Commanus, 50

for shape	obsolete, 94
\em, 90, 91, 92, 123, 516	orthogonality of, 94
\itshape, 90, 91, 92, 94, 123, 412, 516	two-letter (obs. LATEX 2.09), and italic
\normalfont, 90, 90, 123, 163, 516,	correction, 95
545	using in math environments, 163
\rmfamily, 90, 123, 516	font encodings, <b>78</b> , 78
\scshape, 90, 91, 123, 516	koi8-u, 548
\sffamily, 90, 94, 123, 516	LY1, 545, 546
\slshape, 90, 91, 92, 94, 95, 123, 516	OT1, 544
\ttfamily, 90, 123, 142, 516	T1, 82, 519, 547
\upshape, 90, 91, 123, 382, 412, 516	font environments
for weight	for series
\bfseries, <b>71</b> , 73, 90, <b>93</b> , 94, 95, 123,	bfseries, 123
516	for shape
\mdseries, 90, <b>93</b> , 516	em, 123
font commands, see also font command	itshape, 123
declarations	rmfamily, 123
and italic correction, 90, 92	scshape, 123
and MakeIndex, 90	sffamily, 123
for selecting fonts using family names, 544	slshape, 123
for series	ttfamily, 123
\textmd, 90, <b>93</b> , 516	upshape, 123
for shape	for weight
\emph, 14, 68, 90, <b>91</b> , 337, 516	bfseries, 123
\textit, 90, 91, 337, 516	font families, document, <i>see</i> document font
\textnormal, 90, 90, 163, 516	families
\textrm, 90, 301, 516	font metrics files, 318, <b>529</b> , 544, 545
\textsc, 90, 91, 516	font series, 89, <b>93</b>
\textsf, 90, 516	command declarations for, see command
\textsl, 90, <b>91</b> , 516	declarations
\texttt, 14, 76, 90, 516	commands for, see under font commands
\textup, 90, <b>91</b> , 516	environments for, see under font
\upn, 156	environments
for size	font shapes
\footnotesize, 93, <b>94</b> , 517	command declarations for, see under font
\Huge, <b>93</b> , <i>93</i> , <i>517</i>	command declarations
\huge, <b>93</b> , 93, 517	commands for, see under font commands
\LARGE, <b>93</b> , 93, 517	environments for, see under font
\Large, 93, 93, 94, 517	environments
\large, <b>93</b> , 93, 517	sans serif, 89
\larger, 94	serif, 89
\normalsize, 93, 93, 517	font substitution, 94, 318, 484
\scriptsize, <b>93</b> , 93, 517	warning messages, 94
\SMALL, <b>93</b> , <i>93</i> , <i>517</i>	font weight, 89
\Small, <b>93</b> , 93, 517	command declarations for, see under font
\small, <b>93</b> , 93, 517	command declarations
\Tiny, <b>93</b> , 93, 517	commands for, see under font commands
\tiny, 93, 93, 517	environments for, see under font
for weight	environments
\textbf, 14, 73, 90, 93, 163, 301, 337,	font width, 89
516	fontenc (pack.), <b>545</b> , 547, 548
low-level, 95	\fontfamily (font selection com.), 544
math, see math font commands	

fonts	footpotos 97 99
fonts AMSFonts, 300, <b>301–302</b> , 525, 528	footnotes, 87–88 and double-column documents, 313
document class options for, 300	fragile commands in, 74
obtaining, 540	in minipage environments, 112
PostScript versions of, 300, 301, 524,	indicated by symbols, 87
525, 533	on title pages, 87
technical support for, 542	unmarked, 44, 279
updates to, 533	\footnotesize, 93, <b>94</b> , 517
bitmap, 543	\forall (\forall math sym.), 508
blackboard bold, 181, <b>197</b> , 390	forcing
bold math, 184, <b>196</b> , 196, <b>197</b> , 512	floats to typeset, 101
calligraphic, 185, <b>197</b> , 301, 390, <i>512</i>	indentation, 99
commands, see under font commands and	formats
font command declarations	IATEX, 529
Computer Modern, see Computer Modern	T <sub>E</sub> X
Courier (typewriter shape), 317, 496, 544	creating with initex, 528
encodings, see font encodings	files read by virtex, 528
Euler Fraktur, 180, <b>197</b> , 301, 302, 390, <i>512</i>	Plain T <sub>F</sub> X, 528
Euler Script, <b>301</b> , 302, 390, 512	formats, file, see file formats
European Modern (EM), see European	formatting of documents, determined by
Modern fonts	document classes, 61
for text in math mode, 163	formula.tex (sample file), 164–166
Helvetica, 89, 544	formulas, 18
including in PDF files, 318	adjusted, 210, <b>231–242</b>
including in Post Script files, 317	flush left and right, 214
Lucida Bright, 543, 546	aligning, <b>30–32</b> , 209–210, <b>219–231</b> , 242,
math, 195–197	298. 524
size of, 199	298, 324 multiline, 217–218
	rules for, 217–218, 221
monospaced, 88 names of	text in, 226–227
	annotating, 225
LATEX 2.09, 313 PSNFSS (Berry scheme), 544	boxed, <i>see under</i> boxes
PostScript, see under PostScript	breaking into multiple lines, 30–31,
proportional, 88	217–218
proprietary	displayed, 483
using in PDF files, 318	rules for, 217
using in Post Script files, 317	commas in, 155
samples, 313	components of, 22–27, 157–162
selecting, 88–95	building using, 164–166
with \fontfamily command, 544	displayed, see displayed math
with \selectfont command, 95, 544	environments
shapes, see font shapes	gallery, 180–186
size of, 55, 89, 93, <b>93–94</b> , 123, 517	grouping, 210, <b>211–212</b>
document class options for, 297, 306	inline, see inline math environments
sources for, 546	multiline, 30–32
substitution of, 94, 318, 484	splitting, 212–214
Times, 89, 544–545	numbering, see under equation
typewriter style, 88	specifying fonts for, 163
weight, see font weight	foundries, type, 544, 546
width, see font width	\frac $(\frac{x}{y})$ , 19, 21, 23, 70, <b>158</b> , 186, 200
fontsmpl (pack.), 313	fractions, 19, 21, 23, 70, <b>158</b> , 186
fonttbl.tex (sample file), 78, 134	continued, 200
footers, page, 268–270	displayed, <b>158</b> , 186
\footnote, 87	generalized, 204–205
footnote (counter), 399	inline, 158
200 220 (Counter), 577	

fragile commands, 74	denning, 404, 331
protecting, 74, 252, 253, 466, 475	\glossary (glossary com.), 464, 531
frame (beamer env.), 327, 328, 344	glue, <b>378</b> , 407, <b>530</b> , 530
\framebox, 109	horizontal, 530
frames, see also under presentations, 327, 358	parameters of, 530
environments of, 327	vertical, see also under vertical spacing,
outline (table of contents), 328	530
titles, 327, 358	glyphs, see also characters
\frametitle (beamer com.), 327, 328, 344	measuring, 530
\frenchspacing (spacing com.), 67	\gnapprox (& neg. binary rel.), 505
Frequently Asked Questions (FAQ), 539, 542	$\gray (\ge \text{neg. binary rel.}), 505$
front matter, 467	\gneqq (≩ neg. binary rel.), 505
numbering of chapters in, 467	\gnsim (\geq neg. binary rel.), 505
of AMS documents, 285	go to line productivity tool, see jump to a line
of books, 473–475	Google, 464, 538
\frontmatter (struct. com.), 467	Goossens, Michel, xxxiii, 558, 559
\frown (\sigma binary rel.), 503	graphics
ftnright (pack.), 313	commands for, 54, 259, <b>259</b> , 260, 327,
FTP (File Transfer Protocol), 538	341, 479, 496
111 (The 11alister 110tocol), 330	file extensions in, 496
G	in presentations, 342
\Game (∂ math sym.), 508	formats
\Gamma (Γ Greek char.), 502	EPS, 39, <b>259</b> , 483, 496, 552
\gamma ( $\gamma$ Greek char.), 502	PDF, 39, 259, 326
gather (disp. math env.), 208, 210, <b>211–212</b> ,	including in documents, 259–260
219, 483	scaling, 259
page breaks in, 242	graphics (IATEX distr. directory), 311, 539
rules for, 211	graphics (pack.), 312
gather* (disp. math env.), 211	\graphicspath (graphics com.), 477
gathered (subsid. math env.), 211, 227–230	graphicx (pack.), 37, 39, 250, 259–260, 300
and \allowdisplaybreaks commands,	523, 552
243	grave (`grave text accent), 62, 79, 516
\gcd (gcd math op.), 172, 510	\grave (\hat{x} math accent), 177, 512
\ge ( $\geq$ binary rel.), 503	greater than (>)
generalized	as binary relation, 503
commands, see user-defined commands	text symbol, 81, 518
fractions, 204–205	Greek letters, 181, 389–390, 502
\genfrac (math com.), 204-205	Greenwade, George D., 99
geometry (pack.), 270	grouping
$\gcd$ ( $\geq$ binary rel.), 503	chapters into parts, 466
$\geqq (\ge binary rel.), 504$	equations, 203–204
\geqslant (≥ binary rel.), 504	formulas, 210, <b>211–212</b>
german (opt. of babel pack.), 548	symbols with math delimiters, 169
german.tex (sample file), 548	groups
$\g (\gg \text{binary rel.}), 503$	of equations, 203–204
gg.tex (sample file), 44-48	cross-referencing, 218–219
gg2.tex (sample file), 45–46	labels for, 204
ggamsart.tpl (template file), 297	numbering, 218–219
\ggg (⋙ binary rel.), 504	of tokens, 530
\gimel (☐ Hebrew char.), 501	\gtrapprox (≳ binary rel.), 504
glo (glossary files), 464, 531	\gtrdot (> binary rel.), 504
global commands, see under scope	\gtreqless ( $\geq$ binary rel.), 504
glossaries, 464	\gtreqqless (\geq \text{binary rel.}), 504 \gtrless (\geq \text{binary rel.}), 504
as a custom list environment, 414	\gtrless (> hinary rel ) 504
auxiliary file (glo), 464, 531	(8011699 ( Villary 101.), 304

\gtrsim ( $\gtrsim$ binary rel.), 504	\! (negthinspace), 182, <b>190</b> , 190, 513,
guillemets, 519	520
\guillemotleft (Eur. quot. mark), 519	(thinspace), 25, 67, 75, 188, 190,
\guillemotright (Eur. quot. mark), 519	190, 513, 520
\guilsingleft (Eur. quot. mark), 519	\: (medspace), 190, 513, 520
\guilsingright (Eur. quot. mark), 519	\; (thickspace), 190, 513, 520
Gurari, Eitan, 558	\@. (intersentence space), 520
GUTenberg (French T <sub>E</sub> X user group), 541	\dotfill (fill com.), 106
\gvertneqq ( $\geqq$ neg. binary rel.), 505	\frenchspacing, 67
**	\hdotsfor (fill com.), <b>186</b> , 233, 235
H	\hfill (fill com.), 106, 126, 131, 414
\H double acute text accent (**), 79, 516	\hrulefill (fill com.), 106, 113
Hahn, Harley, 554, 558	\hspace, <b>102</b> , 142
handout (beamer doc. class opt.), 358	\hspace*, 69, 103-104
\hangafter	\medspace, 190, 513, 520
T <sub>E</sub> X command, 377	\mspace, <b>190</b> , 190, 513
length command, 100	\negmedspace, 190, 513, 520
\hangindent (length com.), 99	\negthickspace, 190, 513, 520
hanging indentation, <b>99–100</b> , 145	\negthinspace, 182, <b>190</b> , 190, 513,
Hargreaves, Kathryn A., 553, 557	520
Harrison, Michael A., 449, 463, 557	\nobreakspace, 76
Hart, Horace, 553, 559	\nonfrenchspacing, 67
\hat ( $\hat{x}$ math accent), 25, 177, 512	\phantom, 102-103, 191-192, 223, 406
\hbar (\hbar math sym.), 508	\qquad, 27, 102, 105, 190, 190, 224,
\hdotsfor (space fill com.), <b>186</b> , 233, 235	513, 520
optional argument of, 233	, 24, 27, 102, 105, 154, 190, 190,
headers, page, <i>see</i> running heads	225, 513, 520
headings (page style), 268 \headtoname (redef. name), 376	\thickspace, 190, 513, 520
	\thinspace, 25, 67, 75, 188, 190, 190,
\heartsuit ( $\heartsuit$ math sym.), 508 Hebrew letters, 501	513, 520
\height (length com.), 108, <b>108</b> , 111	to avoid using, 481 \xspace, 368–369
height, of text boxes, 108, 110, 111, 113, 405,	in math, <b>19</b> , <b>154–156</b> , <b>187–192</b> , 233, 236
405	in text, 11, <b>64–67</b> , <b>102–104</b> , 114, 126, 414,
Helvetica (sans serif font), 89, 544	513, 520
\hfill (space fill com.), 106, 126, 131, 414	intersentence, 11, 64–67
\\\Hfootnotename (hyperref redef. name),	interword space (_), 11, 64–67, 70, 76,
323	102, 383, 427
\hfuzz (\hbox warning adjustment), 96	preventing removal of, 103
hhline (pack.), 140, 313	howpublished (BIBTEX database field), 425
hierarchy of structural commands, 252, 466	\href (hyperref com.), 323
history of $\mathcal{A}_{\mathcal{M}}S$ -IATEX, $\mathcal{A}_{\mathcal{M}}S$ -TEX, TEX, and	\hrulefill (space fill com.), 106, 113
ETFX, 521–525	\hslash ( $\hbar$ math sym.), 508
\hline (table com.), 135, 137	\hspace (spacing com.), <b>102</b> , 142
Høgholm, Morten, 206	\hspace* (spacing com.), 69, 103–104
\hom (hom math op.), 172, 510	HTTP (Hypertext Transfer Protocol), 538
\hookleftarrow ( $\leftarrow$ math arrow), 507	\Huge (font size com.), <b>93</b> , 93, 517
\hookrightarrow (← math arrow), 507	\huge (font size com.), <b>93</b> , 93, 517
horizontal lines (rules), in tabular	\hyperlink (beamer com.), 344
environments, 135, 137	hyperlinks, 319
horizontal spacing, 313	in PDF files, <b>319–323</b>
adjusting, 188	increasing size of, 322
commands	suppressing, 322
\_ (interword space), 11, <b>66</b> , 70, 102,	to bibliographic citations, 321
190, 520	to Web sites, 322–323

in presentations, 343–347, 358 putting bookmarks in documents, 321	\iff( \iff ( \iff arrow), 365, 507 \ignorespacesafterend (spacing com.), 383
to bibliographic citations, 321	\iiiint ( $\iiint$ large math op.), <b>161</b> , 175, 511
with hyperref pack., 320, 321, 320-322	\iiint ( $\iiint$ large math op.), <b>161</b> , 175, 511
hyperref (pack.), 320-323	\iint ( $\iint$ large math op.), <b>161</b> , 175, 511
bookmarks file (out), 321	ilg (MakeIndex log files), 461
commands	illustrations, 258, <b>259–260</b>
\autoref, 320, 320, 322, 323	commands for, 479, 496
\pageref, 322	double-column, 259
\ref, 322	Encapsulated PostScript (EPS), 39, 259,
\urladdr, 323	476, 483, 496
\WriteBookmarks, 322	graphicx (pack.), 250, 259
documentation for, 320	placement of, 102, 260
options, 320	portability of, 552
bookmarks=true, 320, 321	Portable Document Format (PDF), 39, 259,
colorlinks, 320, 321, <b>321</b>	476, 496, 552
dvipdf, 320	preparation of, 483
dvipdfm, 320	sample files, 39, 54, 327
dvipdfmx, 320	scaling, 54, 259
dvips, 320	with graphicx (pack.), 37
dvipsone, 320	with the picture environment, 259
dviwindo, 320	\Im (\3 math sym.), 508
hypertex, 320	\imath ( $i$ math sym.), 508
pagebackref, 320, 321, 321	implementations, LATEX, see LATEX
pdftex, 320	implementations
ps2pdf, 320	$in (\in binary rel.), 503$
tex4ht, 320	in (inch abs. unit), 12, 15, 96, 105, 107, 111,
textures, 320	403
vtex, 320	inbibl.tpl (sample file), 263
hypertex (opt. of hyperref pack.), 320	INBOOK (bibl. entry type), 424, <b>436</b>
Hypertext Transfer Protocol, see HTTP	inch (in abs. unit), 12, 15, 96, 105, 107, 111,
hyphen.tex, 82	403
hyphenation, <b>13</b> , <b>82–85</b> , 530	\include (inclusion com.), 392, 477, <b>478</b>
determined by optional hyphen, 82	and auxiliary files, 531
displaying, 84	and counters, 400
LATEX's algorithm, 79, 82	errors with, 478
of German text, 13, 548	files start on new pages, 478
of hyphenated words, 13	\includegraphics (graphics com.), 54,
of words with accents, 82	<b>260</b> , 327, 479, 496
preventing, 83–84, 107 rules for English, 85	file extensions in, 259, 496
specifying, 82	in presentations, 341, 342
tables, 528	\includeonly (preamble inclusion com.), 400,
hyphenation, 82	477, <b>478</b>
* -	including
hyphens, <b>14</b> , 62, <b>75</b> key, 9, 63	files in other files, 386, 392
optional, 13, 82, <b>82</b> , 96, 483	fonts
unbreakable, 83	in PDF files, 318
unoreakuole, 65	in PostScript files, 317
I	graphics in documents, 259–260
\i (1 dotless i), <b>79</b> , 79, 516	INCOLLECTION (bibl. entry type), 424, 431
\idotsint $(\int \cdots \int \text{large math op.})$ , 161, 175,	incrementing counters, 399
511	ind (proc. index files), <b>459</b> , <i>460</i> , 461, 487
idx (index aux. file), 459, 460, 461, 464	\indent (indentation com.), 99

indentation	subentries, 267, 449, <b>453</b>
hanging, <b>99–100</b> , 145	subsubentries, 267, 449, <b>454</b>
in multline and multline*	environment for, 267, 407, 449, 459
environments, 213	page ranges, 454–455
in source files, 166	placement of commands for, 458
of environment bodies, 155	processed files (ind), 487
of first lines of paragraphs, 99, 313, <b>404</b>	processed index files (ind), 459–461
of subformulas, 217	rules for, 462–463
of text, 99–100	typesetting entries in margins, 311
customizing, 103	with AMS document classes, 450
forcing, 99	with Aws document classes, 430 with user-defined commands, 371
preventing, 99	\indexname (redef. name), 376
indentfirst (pack.), 313	\indexname (react: name), 576 \indexspace (indexing com.), 449
\index(indexing com.), 371, 450, <b>450</b> ,	\inf (inf math op.), 172, 299, 510
453–459	information, top matter
at signs (@) in, 455, 456	AMS specific, 279–281
defining cross-references in indexes with,	AMS subject classifications, 279
457	keywords, 280, 297
double quote (") in, 457	author, 275–279, 304
	addresses, 44, 277, 296
encapsulators, 454, 455	
exclamation marks (!) in, 453, 454, 457	current addresses, 277, 281
modifiers, 454, 455 page ranges in, 455	e-mail addresses, 278, 281, 296 Internet addresses, 278, 281, 296
1 6 6 .	
placement of commands, <b>458</b> , 486	research support, 44, 279, 281, 296, 304
spaces in argument of, 462	for articles, 37–38, 273–285
syntax of, 458	author names, 276, 296, 304
vertical line ( ) in, 454, 457	dedications, 275
indexes, 311, 452, <b>449–464</b>	title, 273, 297, 304
appear in back matter, 450	translator, 274
auxiliary files (idx), 459, <b>461</b>	\infty (\infty math sym.), 20, 508
cross-references in, 457	initex (TEX program), 528
defining, see indexing	initials
entries	periods in, 67
sorting, 455–456	typographical rules for, 67
stored in idx files, 459, <b>461</b>	\injlim (inj lim math op.), 172
log files (i1g), 461	inline
main entries, 267, 449, <b>453</b>	fractions, 158
multiple, 463–464	math formulas, see inline math
placement of, <b>450</b> , 461	environments
processed files (ind), <b>459–461</b> , 487	tables, 133
processing, 459–461	inline math environments, 17, <b>152</b>
sample, 452, 450–452	\( (start math mode), 18, 74, 152
simple, 267	\) (end math mode), 18, 74, 152
special characters in, 457	act as special braces, 152, 153
subentries, 267, 449, <b>453</b>	and \$, 17, 18, 33, 74, 152, <b>152</b>
subsubentries, 267, 449, <b>454</b>	display-style binomials in, 158
syntax of, 458	font size of, 199
typesetting, 459–461	math, 152
using showidx, 453	matrices in, 235
vertical space in, 267, 449	size of delimiters in, 170
indexing, see also MakeIndex, 449-464	INPROCEEDINGS (bibl. entry type), 424,
commands for, 267, 371, <b>449–459</b> , 461	430–431
CTAN systems for, 539	\input (inclusion com.), 528
entries	inputenc (pack.), 547
main, 267, 449, <b>453</b>	\institute (beamer com.), 326

institution (BIBTEX database field), 425 instructions to LATEX, <i>see also</i> commands <i>and</i>	proclamations, 37, 46, 52, <b>125</b> , 128, 343, 384
environments, 7, 11, 35, 48, 63, 67,	user-defined commands, 366
248, 252, 534	\iota ( $\iota$ Greek char.), 502
\int ( $\int$ large math op.), <b>25</b> , 175, 511	ISBN (bibl. com.), 425
integrals, 25, 161, 299	\it (obs. LATEX 2.09 font com.), 94
integration of fonts into LATEX, 523, 543	italic correction, 91–93, 520
interactive mode, 113, 376–378, 491, <b>534–535</b>	and commas, 92
\intercal (\tau math op.), 506	and \em, 92
intercolumn spacing, 209, 220, 220	and font commands, 90, 92
in aligned math environments, 224, 228	and \itshape, 92
in tabular environments, 136	and periods, 92
interline spacing, 242	and \slshape, 92
adjusting, 95, 98-99, 104	suppressing, 92
international T <sub>F</sub> X users groups, 537	with two-letter font commands, 95
Internet, 278, 322, 415, 538	italics
addresses, 279, 323	bold math, 197
in top matter (\urladdr com.), 278,	font shape, 14, 28, 68, 88, 90, 91, 94, 123
279, 296, 323	412, 516
and LATEX, 537-542	in math mode, 196, 196, 512
browsers, <b>538</b> , 540	math font, 196
FTP transfers, 538	\item (list item com.), 118-123
viewing PDF files in, 318	and square brackets, 122
documents in PostScript format, 317	in simple indexes, 267, 449
finding LATEX and TEX related material on,	optional arguments of, 120, <b>122</b> , 409, 410
537	\itemindent (length com.), 407, 408
finding IATeX- and TeX-related material on,	itemize (text list env.), 118, <b>119</b>
538	\Itemname (hyperref redef. name), 323
hyperlinks in PDF documents, 319, 323	\itemsep (length com.), <b>407</b> , 413
LATEX and TEX resources on, 538, 542	\itshape (font shape com. dec.), 90, 91, 94,
putting LATEX documents on, 317–323	123, 412, 516
types of sites for downloading files, 538	and italic correction, 92
intersentence spaces (\@.), 11, 64–67, 520	itshape (font shape env.), 123
and \frenchspacing, 67	1 ( ( ) ( ) ( ) ( )
and \nonfrenchspacing, 67	J
\intertext (text in math com.), 226–227	\j (j dotless j), <b>79</b> , <i>79</i> , <i>516</i>
interword space, 11, 64–67, 76, 383, 427	Jackowski, Bogusław, 525
and \frenchspacing, 67	Java, with BIBT <sub>E</sub> X, 447
and \nonfrenchspacing, 67	JavaScript, 318
command (\_), 11, <b>66</b> , 70, 102, <i>190</i> , <i>520</i>	Jeffrey, Alan, 523
intlimits (opt. of amsmath pack.), 299	Jensen, Frank, 403
intrart.tex (sample file), <b>35–43</b> , 53, 55, 326,	\jmath ( $j$ math sym.), 508
331	\Join (⋈ binary rel.), 503
typeset, 41–43	Jones, David M., 447, 524
intrarti.idx (index entry file), 459, 460, 461	journal (BIBTEX database field), 425
intrarti.ilg (index log file), 461	Jr., in bibliographic entries, 426
intrarti.ind (index proc. file), 459–461	jump to a line productivity tool, <b>6</b> , 494, 498
intrarti.tex (sample file), 450-452, 460,	justification of text
459–461	left, 8
intropres.tex (sample file), 53, 55, 57-58	right, 8, 14, 68
invalid characters, 9, 63	115111, 0, 11, 00
inverse search, see synchronization	К
invisible boxes, see struts	\k (ogonek Eur. accent), 519
invoking	\kappa ( $\kappa$ Greek char.), 502
delimited commands, 378	\ker (ker math op.), 172, 510
	, ( op./, 1/2, 510

Kern, Uwe, 325, 348, 349, 559	\lambda ( $\lambda$ Greek char.), 502
kerning, 529, 530	Lamport, Leslie, xxix, 403, 522, 523, 529, 552,
key (BIBTEX database field), 425	559
keyboard, 8–9, 11, <b>62–64</b> , 547	\land ( $\wedge$ math op.), 506
equivalents, 494, 499	landscape (doc. class opt.), 307
keys, 17	\langle (\langle math delimiter), 167, <b>168</b> , 509
alphanumeric, 8–9	language (BIBT <sub>E</sub> X database field), 425
arrow, 53	\LARGE (font size com.), <b>93</b> , <i>93</i> , <i>517</i>
Enter, see Return key	\Large (font size com.), <b>93</b> , 93, 94, 517
Esc (escape), 63, 365	large
letter, 8–9, <b>62</b>	math delimiters
math symbol, 63	in array subsidiary math environment,
math typing, 17	313
modifier, 62, 63	operators, 25, <b>26</b> , 161, <i>175</i> , <b>174–176</b> , <i>511</i>
number, 62	limits of, <b>174</b> , 299
prohibited, 9, 63	sizing of math delimiters with, 169
Return, 9, 11, 63	symbols, 117, 227–230
	\large (font size com.), <b>93</b> , 93, 517
space bar, 9, 11, 53, 63, 325, 334	
special, 9, 17, <b>63</b> , 76	\larger (font size com.), <b>94</b> LATEX, <b>521</b> , 525
Tab, 9, 11, 63	and the Internet, 537–542
keys, sorting (in \index commands), 455-456	
case sensitivity of, 462	counters, 399
\keywords (top matter com.), 297	customizing, 363–417
rules for using, 280	distribution, 78, 86, <b>310–313</b> , 489, 525,
keywords (bibl. com.), 425	528, <b>529</b> , 532, 534, 539, 540
\keywordsname (redef. name), 376	components of, 303–308
\kill (tabbing com.), 141, 142	directories, 257, <b>310–311</b> , 312, 540,
Knuth, Donald E., xxix, 363, 521–523, 525,	547, 553
528, 539, 553, 559	on CTAN, 540
koi8-u (font encoding), 548	document classes, see under document
	classes
L	document structure, 247–270, 467
L, slashed (Ł, ł), 81, 515	documentation for, 311, 552
\label (cross-ref. com.), 28, 29, 31, 50, 156,	packages, 312
215, 231, 252, <b>255</b> , 328	documents, 247–270
and simple indexes, 267	printing and viewing, 530
arguments of, 29, 257	putting on the Internet, 317–323
assigning counters to, 402	files created by, 531–534
in table environments, 259	files, portability of, 9
placement of commands, 486	font substitution, 94, 318, 484
rules for, 257	formats, 529
showing in margin, 257, 313	history of, 521–525
with \ 215 labels	implementations, xxvi, 3, 5, 311, 318, 326, 525, 537
for \bibitem commands, 263	discussion groups, 542
for bibliographic items, 48, 121	for Mac, 3, 326, 489, 495–499
for equations, 255	PC, 3
for groups of equations, 204	for PC, 326, 489–494
in list environments, 121, <b>121</b>	productivity tools, <b>5</b> , 494, 498
of items in a list environment, 408, <b>409</b> ,	technical support for, 541–542
410	UNIX, 3, 442, 461, 489
setting with \label, 255	inner workings of, 528–534
\labelsep (length com.), 407, 408	layers of, 528–529
\labelsep (length com.), 407, 408	localization of, 79, 547–548
\Lambda (Λ Greek char.), 502	numbers stored by, 80
Lambaa (11 Olock Char.), 302	numbers stored by, 60

	\T_G;
omissions in discussion of, 551–552	\Leftarrow ( $\Leftarrow$ math arrow), 507
overview of, 521–536	\leftarrow (← math arrow), 364, 374, 507
packages, see under packages	\leftarrowtail (← math arrow), 507
release dates of, 86, 251, 532	\leftharpoondown (\leftharpoondown), 507
resources on the Internet, 542	\leftharpoonup (\( -\ \text{math arrow} \), 507
source files, see under source files	\leftleftarrows (\pm math arrow), 507
spacing in text, 11	\leftmargin (length com.), <b>407</b> , 408, 411
structure of, 525, 526	\Leftrightarrow (\Leftrightarrow), 507
updates to, 532	\leftrightarrow (↔ math arrow), 507
using, <b>525</b> , 527	\leftrightarrows (\(\leftarrow\) math arrow), 507
versions of, 532–534	\leftrightharpoons (≒ math arrow), 507
specifying, in documents, 86, 250, 386,	\leftrightsquigarrow (<> math arrow),
532	507
writing books with, 465–487	\leftroot (root-adjustment com.), 162
latex (LATEX distr. directory), 499	\leftthreetimes (\times math op.), 506
\LaTeX (LaTeX logo com.), 8, 80	\left  (  math delimiter), 24, 26, 168, 180,
LATEX 2.09, 386, 522–524	189, 191
font names, 313	legacy
two-letter font commands, 94, <b>94</b>	document classes, 54, 118, 249, 254, 263,
$AT_{EX} 2\varepsilon$ , see $AT_{EX}$	273, 302, <i>305</i> , <b>303–313</b> , 529
latex.ltx, 311	documents, 319
LATEX3, <b>523</b> , 524, 541	environments, 123, 143–145, 407
\LaTeXe (IATeX $2_{\varepsilon}$ logo com.), 80, 524	quotation, 144
latexsym (pack.), 37, 180, 249, 294, 300, 311	quote, 143
layers, of LATEX and TEX, 528–529	verse, 144
layout	legacy-article.tex (sample file), 304, 305
of a list, 408	legalpaper (doc. class opt.), 85, 298, 306
of Computer Modern typewriter font, 78,	Lehman, Philipp, 447
78	lemmas, see proclamations
of pages, <b>268–270</b> , 313, 525	length commands, 108, 270, 398, <b>403–406</b>
\layout (page-layout diagram com.), 268	and boxes, 405
layout (pack.), 268, 313	arithmetic with, 312, 405
\lbrace ({ math delimiter), 167, 509	\baselineskip, 95, 101
\lbrack ([ math delimiter), 167, 509	\baselinestretch, 99
\lceil ( math delimiter), 167, 509	defining new, 404
\ldots()	\depth, 108, <b>108</b> , 111
in math, 160, 186	\fboxrule, 110
in text, <b>24</b>	\fboxsep, 110
\le (≤ binary rel.), $503$	\hangafter, 100
\leadsto (→ math arrow), 507	\hangindent, 99
\left (math delim.), <b>167–168</b> , 170, 184, 235	\height, 108, <b>108</b> , 111
blank, 168, 182	in list environments, 407
must be balanced, 168, 217	$\time 1407,408$
left double quote (")	\itemsep, 407, 413
text symbol, 75, 81, 518	\labelsep, 407, 408
typing, 11	$\labelwidth, 407, 408$
left justification of text, 8	\leftmargin, <b>407</b> , 408, 411
left single quote (')	\listparindent, 407, 408, <b>414</b>
key, 9, 11, 62, <b>75</b>	\marginparpush, 404
text symbol, <b>75</b> , <i>519</i>	\marginparwidth, 113
\left((( math delimiter), 24, 26, 166, 168,	\medskipamount, 377, 406
184, 217, 235	\multlinegap, 213
\left. (blank math delim.), 168, 182	\oddsidemargin, 270
\left< ( \ math delimiter), 168	\overfullrule, 96
\left[([math delimiter), 24, 166, 182	\parindent, <b>404</b> , 414
	•

length commands (continued)	line boxes, see under boxes
\parsep, <b>407</b> , 408, 413, 414	line ending characters, 63-65, 68, 84, 102
\parskip, <b>404</b> , 407, 408, 414, 481	commenting out, 84, 85, 458
\partopsep, 407	on Mac, PCs, and UNIX systems, 9
\rightmargin, 407, 408, 411	translation of, 63
setting, 99, 100, 113, <b>404–406</b>	line numbers, in error messages, 6, 9, 153, 154
\textwidth, 270, 398, <b>404</b>	\linebreak (line breaking com.), 484, 486
\topsep, <b>407</b> , 408	\linebreak (line-breaking com.), 97, 97
\totalheight, 108, <b>108</b> , 110, 111	optional arguments of, 98
\width, 108, <b>108</b> , 111	lines
lengths, rubber, see rubber lengths	adding to
$\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ $	lists of figures and tables, 476
legno (doc. class opt.), <b>298</b> , 307	tables of contents, 473–474
$\ensuremath{leqq}\xspace (\le \text{binary rel.}), 504$	blank
\leqslant (≤ binary rel.), 504	in displayed math environments, 51,
less than (<)	153, 157, 215
as binary relation, 503	in inline math environments, 153
text symbol, 81, 518	in text environments, 118
\lessapprox ( $\lesssim$ binary rel.), 504	in top matter commands, 273
\lessdot (< binary rel.), 504	in verbatim environments, 146
\lesseqgtr (\lesseq binary rel.), 504	terminating paragraphs with, 11, <b>64</b> , 99,
\lesseqqgtr ( $\stackrel{\leq}{>}$ binary rel.), 504	118, 144
$\lceil \leq \text{binary rel.} \rceil$ , 504	breaking, 15
\lesssim ( $\lesssim$ binary rel.), 504	preventing, 99
letter (doc. class), 308–310, 529	with \ 25, 30, 31, 33, 44, 46, 98, 124,
letter (letter env.), 308-310	135, 141, 142, 145, 176, 211, 213,
argument of, 309	215, 216, 227, 231, 242, 273–278,
breaking lines in, 309	297, 304, 309, 358
errors with, 309	distance between, 104
letter keys, 8–9, <b>62</b>	adjusting, 114
letter.tex (sample file), 308-310	filling with space or dots, <b>106</b> , 113, 126,
letterpaper (doc. class opt.), 298, 306	186, 233, 235, 414
letters	separating
counter style, 401	with \ 25, 30, 31, 33, 44, 46, 98, 124,
Greek, 181, 389–390, 502	135, 141, 142, 145, 176, 211, 213,
Hebrew, 501	215, 216, 227, 231, 242, 273–278,
Levy, Silvio, 553, 560	297, 304, 309, 358
\lfloor (  math delimiter), 167, 509	with \linebreak, 97, <b>97</b> , 484, 486
\lg (lg math op.), 172, 510	stretchable, 179
\1hd (<  math op.), 506	too wide warnings, 12–13
ligatures, 79	wrapping, 84
suppressing, <b>79</b> , 181, 365	lines (rules)
\lim (lim math op.), 172, 510	horizontal
\liminf (lim inf math op.), 172, 510	filling lines with, 106, 113
limits	in tabular environments, 135, 137
as subscripts, <b>25</b> , <b>161</b> , 171–174, 182, 299	intersecting in tables, 140, 313
as superscripts, <b>25</b> , <b>161</b> , 174, 182, 299	vertical
large operators with, 25, 27, 161, 174, <b>174</b> ,	in CD environments, 241
175, 299, 511	in tabular environments, 135
multiline, 176	links, hyper, see hyperlinks
operators with, 171, 172, 299, 510	Linux, 3, see also UNIX, 554
operators with, 171, 172, 299, 310 placement of, 299	list (list text env.), 118, 406, 408, 409-414
	arguments of, 410
\limits (limit-control com.), <b>161</b> , 174	length commands in, 407
\limsup (lim sup math op.), 172, 510	using counters with, 411

list text environments, see also specific	for indexes, see ilg
environments, 118–123	for LATEX, see log
description, 120	log-like functions, see operators
enumerate, <b>119</b> , 123	logical
in proclamations, 126	design, 52–53
itemize, 119	of books, 479–481
list, 118	units, 11, 35-41, 46, 48, 49, 51, 52, 66, 68,
mixing, 121	164, 248, <b>252–255</b> , 261, 267, 285,
nesting, 121	304, 308–310, 406, 437, 442, 449,
rules for, 120	459, <b>466–467</b> , 522, 536
trivlist, 414	hierarchy of, 252
\listfigurename (redef. name), 375, 376	numbering of, <b>403</b> , <b>466</b>
\listfiles (file list com.), 387, 532, <b>533</b>	numbering of proclamations within, 128
listing files used by a document, 387, 533	logos, 80
\listoffigures (front matter com.), 475, 532	long commands, 73
\listoftables (front matter com.), 475, 532	\Longleftarrow ( $\iff$ math arrow), 507
\listparindent (length com.), 407, 408, <b>414</b>	\longleftarrow ( $\leftarrow$ math arrow), 507
lists	$\Longleftrightarrow\ (\Longleftrightarrow math\ arrow),$
cross-referencing items in, 119, 123	507
custom	$\label{longleftrightarrow} \ (\longleftrightarrow \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ $
and counters, 410	507
defining, 406–415	\longmapsto ( $\longmapsto$ math arrow), 507
environments for, see list text environments	$\Longrightarrow (\Longrightarrow math arrow), 507$
in presentations, 339–341	$\label{longright} \label{longright} \label{longright} $$100$ ($\longrightarrow$ math arrow), 507$
of figures, 475–476	longtable (pack.), 313
adding a line to, 476	\looparrowleft ( $\leftarrow$ math arrow), 507
auxiliary file (lof), 475, 487, 532	\looparrowright ( $\hookrightarrow$ math arrow), 507
fragile commands in, 74	\lor ( $\vee$ math op.), 506
of tables, 134, <b>475–476</b>	lot (list of tables files), <b>475</b> , 487, <b>532</b>
adding a line to, 476	low-level font commands, 95
auxiliary file (lot), <b>475</b> , 487, <b>532</b>	for NFSS, 552
fragile commands in, 74	lowercase counter styles
\listtablename (redef. name), 376	letters (\alph), 401
$11 (\ll binary rel.), 503$	roman numerals (\roman), 123, 401
\llcorner (\( \text{math delimiter} \), 167, 509	lowline (_ text symbol), 77, 81, 518
\Lleftarrow ( $\Leftarrow$ math arrow), 507	\lozenge ( $\Diamond$ math sym.), 508
\111 (⋘ binary rel.), 504	\lrcorner (¬ math delimiter), 167, 509
\ln (ln math op.), 172, 510	\Lsh (\frac{1}{2} math arrow), 507
\lambda lnapprox (≨ neg. binary rel.), 505	\ltimes (⋉ math op.), 506
$\label{lneq} (\c neg.\ binary\ rel.), 505$	LuaT <sub>E</sub> X, 554
lem:lem:lem:lem:lem:lem:lem:lem:lem:lem:	Lucida Bright, 543, 546
\lnot (¬ math sym.), 508	lucidabr (pack.), 546
$\n$ insim ( $\lesssim$ neg. binary rel.), 505	lucidabr.dtx (PSNFSS distr. file), 546
local commands, see under scope	lucidabr.fdd (PSNFSS distr. file), 546
localization, of LAT <sub>E</sub> X, 547–548	lucidabr.ins (PSNFSS distr. file), 546
locating errors, 87	lucidabr.sty (PSNFSS distr. file), 546
location of BIBT <sub>E</sub> X database and style files, 439	lucidabr.yy (PSNFSS distr. file), 546
lof (list of figures file), <b>475</b> , 476, 487, <b>532</b>	\lVert (    math delimiter), 168
\log (log math op.), 172, 510	\lvert (   math delimiter), 168
log (LATEX log file), 5, 5, 9, 12, 29, 84, 96, 378,	\lvertneqq (\sqrt{neg. binary rel.}), 505
386, 441, 475, 493, 499, <b>526</b> , <b>531</b> , 533	LY1 (pack. opt.), 545, 546
error and warning messages recorded in,	M
12, 96	M Marana Marintark
log files	Mac, see Macintosh
for BIBT <sub>E</sub> X, see blg	line ending characters, 9

Macintosh, xxvi, 3, 4, 9, 319, 479, 489, 522	math, 7
editing cycle with, 498	accents, 25, 176-178, 183, 185, 301, 377,
FTP clients, 538	483
LATEX implementations, 3, 326, 489,	alphabets, 180-182, 185, 196, 195-197,
495–499	301, 390, 512
OS X, 554	arrows, 179, 187, 240, 507
spelling checkers, 495	as delimiters, 166, 167, <b>168</b>
TeXShop LATeX front end, xxvi, 9, 11, 53,	stretchable, 179, 240–242
326, 442, 461, 496, 498	vertical, 241
macron ( text accent), 79, 516	binary operations, see binary operations
macros, see commands and user-defined	binary relations, see binary relations
commands	characters, 17, 63
main entries, in indexes, 267, 449, <b>450</b> , <b>453</b> ,	commands, see math commands
456, 457	environments, 152–154
main matter, 249, <b>251–261</b> , 467	aligned, see under aligned
\mainmatter (struct. com.), 467	and \verb commands, 148
\makebox (box com.), <b>107</b> , 108, 109, 111, 113	blank lines in, 153, 157
makeglos (pack.), 464	displayed, see displayed math
\makeglossary (preamble glossary com.),	environments
464, 531	inline, see inline math environments
makeidx (pack.), 311, <b>450</b> , 478	multiline, <b>215–219</b> , 333
MakeIndex, 77, 268, <b>449–464</b> , 532	page breaks in, 242
and font commands, 90	spaces in, 153
\maketitle (title-page com.), 37, 44, 46, 54,	fonts, 195–197
248, 249, 469	blackboard bold, 181, <b>197</b> , 390, <i>512</i> bold, 184, <b>196</b> , <i>196</i> , <b>197</b> , 390, <i>512</i>
and abstracts, 251, 285, 306	bold, 184, <b>196</b> , <i>197</i> , 390, <i>312</i> bold italic, 196
and page styles, 270 MANUAL (bibl. entry type), 424, <b>436</b>	calligraphic, 185, <b>197</b> , 301, 390, <i>512</i>
manuals, in BIBTFX database files, 436	Euler Fraktur, 180, <b>197</b> , 301, 390, 312
manuscripts	512
in BibT <sub>F</sub> X database files, 435–436	Euler Script, <b>301</b> , 390, 512, <i>512</i>
preparing for publication, 465	italic, <b>196</b> , <i>196</i> , <i>512</i>
\mapsto ( $\mapsto$ math arrow), 507	roman, <b>196</b> , <i>196</i> , <i>512</i>
\mapstochar (math arrow), 507	sans serif, <b>196</b> , <i>196</i> , <i>512</i>
marginal comments, 112–113, 484	size of, 199
in double-sided documents, 112	typewriter, <b>196</b> , 196, 512
in equations, 112	mode, see math mode
in multiline math environments, 112	multiline, 207–243
space between, 404	Visual Guide to, 207, 208
width of paragraph box for, 113	operators, 22, 24, 26, 157, 172, <b>170–176</b> ,
\marginpar (marginal comment com.), 112	371, 506, 510
in double-sided documents, 112	declaring, 173
\marginparpush (length com.), 404	large, 25, <b>26</b> , 161, 169, 175, <b>174–176</b> ,
\marginparwidth (length com.), 113	299, 511
margins, 404, 407	with limits, 25, 27, 161, 171, 172, 174,
of nested lists, 407	175, 299, 510, 511
showing symbolic references in, 257, 313	subscripts and superscripts, 199
\markboth (left and right page header com.),	symbol alphabets, 197
268	blackboard bold, 197
arguments of, 268	calligraphic, 197
\markleft (left page header com.), 270, 281	Euler Fraktur, 197
\markright (right page header com.), 268	Greek, 197
master document, 477–479	symbols, see math symbols
MASTERSTHESIS (bibl. entry type), 425,	text in, 19, <b>27</b> , 83, 99, 107, 154, <b>162–163</b> ,
433–434	181, 196, 226–227, 241, 301

specifying fonts for, 163	math mode, 7, <b>62</b> , 76, 147, 154, 163, 170, 171,
typing, 17–33, 151–206	173, 199, 369, 375, 392
math (inline math env.), 152	math symbols, 19, 20, 63, 131, 177, 182, 240,
math arrows, 179, 187, 240	249, 294, 311, <i>501–513</i>
as delimiters, 166, 167, 168, 509	alphabets, 197
stretchable, <b>179</b> , 240–242	and delimiters, 24, 166, 168
vertical, 241	bold, <b>197–199</b> , 301, 312
math commands, 23, 27, 160, 161, 176, 191,	building new, 183, <b>192–195</b> , 372
194, 200, 204	classification of, <b>188–189</b> , 195
for alignment of formulas, 214	declaring types of, 195
math delimiters, <b>24</b> , 26, <i>167</i> , <b>166–170</b> , 180–184,	end of proof, 113, 374
186, 188, 189, 191, 217, 235, <i>509</i>	in text, 365
and large operators, 169	large, 227–229
arrows, 166	negated, 194-195
balancing, 168, 182, 217	shorthand commands for, 364
blank, 168, 182	side-setting, 194–195
fixed-size, 168	sizes of, 199
for grouping, 169	spacing of, 187–192
in inline math environments, 170	stacking, 192–193
in smallmatrix subsidiary math	stretchable, 178–180
environments, 235	suppressing, 131
large, in array subsidiary math	math units, see mu
environment, 313	math.tex (sample file), 17-19
left bracket ([), 24, 166, 182	mathb.tex (sample file), 19-22
right bracket (]), 24, 166, 182	\mathbb ( $\mathbb{X}$ ), 181, <b>197</b> , 512
specifying size of, <b>168</b> , 184	\mathbf (math font weight com.), 184, 196,
stretchable, 167–168	196, <b>197</b> , 512
with matrix variants, 234–235	\mathbin (binary-op. com.), 195
math font commands, see also font command	\mathcal ( $X$ ), 185, <b>197</b> , 512
declarations and font commands	and Euler Script, 301
for bold	Mathematical Reviews, 159
\boldsymbol, 184, 197, <b>198</b> , 301, <i>512</i>	$Mathfrak(\mathfrak{X}), 180, 197, 301, 302, 512$
\mathbb, 181, <b>197</b> , 512	\mathit (math font shape com.), <b>196</b> , <i>196</i> , <i>512</i>
\mathbf, 184, <b>196</b> , 196, <b>197</b> , 512	\mathnormal (math font shape com.), 196,
\pmb, <b>198–199</b> , 301	196, 512
for italics	\mathrel (binary-rel. def. com.), 195
\mathit, <b>196</b> , 196, 512	\mathring ( $\mathring{x}$ math accent), 177, 512
for series	\mathrm (math font shape com.), 196, 512
\mathnormal, <b>196</b> , 196, 512	mathscr (opt. of eucal pack.), <b>301</b> , 386, 390,
for shape	512
\mathcal, 185, <b>197</b> , 512	\mathscr ( $\mathcal{X}$ math font shape com.), <b>301</b> , 512,
\mathfrak, 180, <b>197</b> , 301, 302, 512	512
\mathrm, 196, 512	\mathsf (math font shape com.), <b>196</b> , <i>196</i> , <i>512</i>
\mathscr, <b>301</b> , 512, 512	\mathstrut (spacing com.), 114, 200
\mathsf, <b>196</b> , 196, 512	MathTime, 545
\mathtt, <b>196</b> , 196, 512	installing, 545
for size	mathtime (pack.), 545
\displaystyle, <b>199</b> , 204	mathtime.dtx (PSNFSS distr. file), 545
\scriptscriptstyle, 199, 204	mathtime.ins (PSNFSS distr. file), 545
\scriptstyle, <b>199</b> , 204	mathtime.sty (PSNFSS distr. file), 545
\textstyle, <b>199</b> , 204	mathtools (pack.), 206
for weight	\mathtt (math font shape com.), <b>196</b> , <i>196</i> , <i>512</i>
\boldsymbol, 184, 197, <b>198</b> , 301, 512	\mathversion, 198
\mathbf, 184, <b>196</b> , 196, <b>197</b> , 512	matrices, 25–26, 232–238
\pmb, <b>198-199</b> , 301	in inline math environments, 235

	modifications 62, 62
matrix (subsid. math env.), 25–26, 208, 210,	modifier keys, 62, 63
231, <b>232–238</b>	modifiers, in \index commands, 454
variants, 234–235	combining, 455
\max (max math op.), 172, 510	modifying environments, 380–383
MaxMatrixCols (counter), 233	monospaced fonts, 88
\mbox (box com.), xxvi, 107	\month (time com.), 80
McLean, Ruari, 553, 559	month (BIBTEX database field), 425, 436
McPherson, Kent, 268	Moore, Ross, xxvii, 242, 558
\mdseries (font weight com. dec.), 90, 93, 516	movable arguments of commands, 74, 475
\measuredangle ( $\measuredangle$ math sym.), 508	\mp ( $\mp$ math op.), 506
measurements, of text boxes, 405, 405	mpfootnote (counter), 399
commands for, 406	mrabbrev.bib (BIBTEX database file), 436
medium (font weight), 89, 90, 93, 516	mrnumber (bibl. com.), 425
\medskip (spacing com.), 104	\mspace (spacing com.), <b>190</b> , <i>190</i> , <i>513</i>
\medskipamount (length com.), 377, 406	mtbold (opt. of mathtime pack.), 545
\medspace (spacing com.), 190, 513, 520	mtfonts.fdd (PSNFSS distr. file), 545
messages	\mu ( $\mu$ Greek char.), 502
error, see error messages	mu (math unit, rel.), 190, 190, 513
warning, see warning messages	multicol (pack.), 101, 307, 313
Metafont, 539	multicols (disp. text env.), 101, 523
metrics, font, see font metrics	\multicolumn (table com.), 137, 138, 137-139
\mho (\text{\$\cup\$ math sym.}), 508	multicolumn text
Microsoft	in documents, <b>101</b> , 313, 523
typography web page, 546	in tables, 137–139
Vista, 555	multiline
Windows, see also PCs, 446, 554	boxes, 107
\mid (  binary rel.), <b>170</b> , 181, <b>189</b> , <b>190</b> , <i>503</i>	formulas, <b>30–32</b> , <b>207–243</b>
midpoint (· text sym.), 81, 518	Visual Guide to, <b>207</b> , 208
MiKTeX (Windows LATEX front end), xxvi, 326,	aligning, 217–218
490–491, 494	splitting, 212–214
	limits, 176
discussion groups, 542 millimeter (mm abs. unit), 403	math environments, 333
	adjusting columns in, 209, 210, <b>231–239</b>
\min (min math op.), 172, 299, 510	v v
minipage (text box env.), 107, 109, 112, 383,	aligning, 209, 210
384	marginal comments in, 112
displaying footnotes in, 112	page breaks in, 242–243
minus (-), 9, 22, 63, 76, 157, 188, 191, 192,	subscripts and superscripts, 176
196, 216–218	table entries, 137, 138
as binary operation, 506	\multimap (→ math arrow), 507
mirrors, of CTAN, 540	multipage tables, 313
MISC (bibl. entry type), 425, <b>436</b>	multiple
Mittelbach, Frank, xxxiii, 101, 523, 524, 558,	arguments
559	in user-defined commands, 370, 371
mixing list text environments, 121	authors
mm (millimeter abs. unit), 403	in bibliographies, 426
\mod (mod math op.), <b>173</b> , <i>174</i>	in documents, 46, 281, 304
$\mbox{models}$ ( $\models$ binary rel.), 503	bibliographies in a document, 267
modes	captions, 259
interactive, 113, 376–378, 491, <b>534–535</b>	citations, 264
quiet, 534	documents, cross-referencing among, 313
typographic	files, documents composed of, 476–479
math, see also inline and displayed math	indexes, 463–464
environments, 7, <b>62</b> , 76, 147, 154,	spaces, 19, 64, 71
163, 170, 171, 173, 199, 369, 375, 392	tables of contents, 474
text, 7, <b>62</b> , 63, 154, 181, 369, 375, 392	multiplication, 23, 158, 161
	<u>.</u>

multline (disp. math env.), 208, 210, <b>212–214</b>	\newcommand* (user-defined com.), 373
indentation of lines in, 213	\newcounter (user-defined counter com.), 400,
rules for, 213	404
multline* (disp. math env.), 213-214	optional argument of, 400
indentation of lines in, 213	\newenvironment (user-defined env.),
\multlinegap (length com.), 213	380–383
myams.tpl, 294–297	\newenvironment* (user-defined env.), 385
myheadings (page style), 268	\newlabel (aux. file com.), 531
myneadings (page style), 200	
N	newlattice (pack.), 250, 386, 387
N	newlattice.sty (sample file), 311, 379, 383,
<i>n</i> -th root, 27, <b>162</b>	386–392
\nabla ( $\nabla$ math sym.), 508	\newlength (length-command def. com.), 404
namelimits (opt. of amsmath pack.), 299	\newline (line breaking com.), see also \ 15
names	\newline (line-breaking com.), 97, 98
base (of files), 531	\newpage (page breaking com.), 15, <b>100</b> , <b>101</b> ,
for abstracts, 251	261
for proclamations, 125, 128	\newtheorem (procl. com.), 37, 125, 127, 129,
of authors	131, 294, 326, 402
in articles, 276, 296, 304	optional arguments of, 127, 128
in bibliographies, 426	syntax of, 128
in running heads, 276	\newtheorem* (procl. com.), 129, 382
of commands, 68, 69, 386	\newtheoremstyle (procl. com.), 131
of counters, 128	\nexists (∄ math sym.), 508
of files, 44	NFSS (New Font Selection Scheme), <b>523</b> , 524
with \graphicspath command, 479	documentation for, 553
of fonts	low-level font commands, 552
IATEX 2.09, 313	nfssfont (pack.), 311
PSNFSS (Berry scheme), 544	nfssfont.tex (IAT <sub>E</sub> X distr. file), 78, 311
redefinable, 267, 322, 323, 363, <b>375</b> , 548	\NG (Eng Eur. char.), 519
tagging equations with, 29, <b>201–204</b> , 211,	\ng (eng Eur. char.), 519
213, 215, 218, 230, 231	\ngeq (≱ neg. binary rel.), 505
naming rule, see source files, naming of	\ngeqq ( $\ngeq$ neg. binary rel.), 505
\natural (\pi math sym.), 508	\ngeqslant (≱ neg. binary rel.), 505
\ncong ( $\ncong$ neg. binary rel.), 505	\ngtr (≯ neg. binary rel.), 505
\ne ( $\neq$ neg. binary rel.), 194, 505	\ni (∋ binary rel.), 503
\nearrow ( / math arrow), 507	\nLeftarrow (≠ math arrow), 507
\NeedsTeXFormat (preamble com.), 86, 250,	\nleftarrow (← math arrow), 507
386, 532	\nLeftrightarrow (\$\to\$ math arrow), 507
$\ng(\neg \text{ math sym.}), 508$	\nleftrightarrow (\(\dots\) math arrow), 507
negated math symbols, <b>194–195</b> , <i>505</i>	\nleq (≰ neg. binary rel.), 505
\negmedspace (spacing com.), 190, 513, 520	· ,
\negthickspace (spacing com.), 190, 513,	\nleqq (≰ neg. binary rel.), 505
520	\nleqslant (≰ neg. binary rel.), 505
\negthinspace (spacing com.), 182, <b>190</b> , 190,	\nless ( $\nleq$ neg. binary rel.), 505
513, 520	\nmid (∤ neg. binary rel.), 194, 505
\neq ( $\neq$ neg. binary rel.), 505	noamsfonts (doc. class opt.), 300
nesting	\nobreakdash (hyph. prev. com.), 83
of comment environments, 86	\nobreakspace (spacing com.), 76
	\nocite (bibl. com.), <b>439</b> , 441
of list text environments, 121	\nocite* (bibl. com.), 439
New Font Selection Scheme, see NFSS and	\nofiles (preamble com.), 486
PSNFSS	and auxiliary files, 486, 531
\newcommand (user-defined com.), 74, 364-380	\noindent (indentation-suppression com.), 99,
defining arguments with, 370	484
name already in use, 376	nointlimits (opt. of amsmath pack.), 299
optional arguments, 374	normerrances (opt. of amsmath pack.), 299

\nolimits (limit-control com.), 161, 172, 174,	NTG (Dutch T <sub>E</sub> X user group, 541
182	\ntriangleleft (≮ neg. binary rel.), 505
\nolinebreak (linebreak-suppression com.),	\ntrianglelefteq (≰ neg. binary rel.), 505
99	\ntriangleright (p neg. binary rel.), 505
nomath (doc. class opt.), 300	\ntrianglerighteq (≱ neg. binary rel.), 505
nonamelimits (opt. of amsmath pack.), 299	\nu ( $\nu$ Greek char.), 502
nonbreakable spaces (~ tie), 11, 28, 63, 66, 75,	number (BIBTEX database field), 424, 425
<b>76</b> , 99, 520	numbered lists, see enumerate
absorb spaces, 76	numbering
in BIBTeX databases, 427	automatic, 28, 30, 37, 46, 119, 125, 231,
with cross-references, 257	252
\nonfrenchspacing (spacing com.), 67	of appendices, 255, 467
\nopagebreak (page break suppression com.),	of equations, <b>27–29</b> , 55, <b>156–157</b> , 201,
100	211, 213, 215
normal	groups, 218–219
document font family, 89	in chapters of books, 467
font shape	in multiline math environments, 215
command declarations for, <b>90</b> , 90, 123,	is relative, 201, 203
516, 545	of subsidiary math environments, 230,
commands for, <b>90</b> , <i>90</i> , <i>516</i> , 545	231
math commands for, <b>163</b> , <b>196</b> , <i>196</i> , <i>512</i>	suppressing, 30, 31, 157, 201, 211, 213
\normalfont (font shape com. dec.), <b>90</b> , 90,	215, 218, 231
123, 163, 516, 545	variations, <b>203</b> , 218
\normalsize (font size com.), <b>93</b> , 93, 517	within sections, 156, 250
nosumlimits (opt. of amsmath pack.), 299	within split subsid. math align. env.,
\not (math com.), 194	230–231
\notag, 30, 31, 211, 213, <b>215</b> , 218, 231	of figures, 258
notation (text env.), 327	of pages, style of, 401
notations, see proclamations	of proclamations, 125, <b>127–128</b>
notcite (opt. of showkeys pack.), 257	consecutively, 127–128
note (beamer doc. class opt.), 355	suppressing, 129, 130, 382
\note (beamer com.), 355	within sections, 127
note (BIBT <sub>E</sub> X database field), 425	of structural units, 400, 466, 536
note1.tex (sample file), 9–11	controlling, 403
note1b.tex (sample file), 12–13	in books, 466
note2.tex (sample file), 13–15	sections, 252
notes, in presentations, 355, 356	suppressing, 46, 253, 467
noteslug.tex (sample file), 13	of tables, 258
\notin ( $\notin$ neg. binary rel.), <b>194</b> , 505	renumbering, 28, 536
notitlepage (doc. class opt.), <b>299</b> , 307, 468	with counters, 398–406
Nowacki, Janusz M., 525	resetting, 399, 402
\nparallel (\mathref{m} neg. binary rel.), 505	\numberline (toc file com.), 475
- "	numbers
\nprec (⊀ neg. binary rel.), 505 \npreceq (⊀ neg. binary rel.), 505	counter styles for, 123, 401, <b>400–401</b> , 411
\nRightarrow (\(\Rightarrow\) math arrow), 507	
•	for proclamations, position of 131
\nrightarrow (→ math arrow), 507 \nshortmid (r neg. binary rel.), 505	for proclamations, position of, 131
, ,	in bibliographic fields, 424
\nshortparallel (# neg. binary rel.), 505	in lists, 119
\nsim ( ≈ neg. binary rel.), 505	keys, 62
\nsubseteq (\preceq \text{neg. binary rel.}), 181, 505	line
\nsubseteqq (\(\preceq\) neg. binary rel.), 505	in error messages, 6, <b>9</b> , 153, 154
\\nsucc (\forall \neg. \text{binary rel.}), 505	in warning messages, 12
\\nsucceq (\frac{1}{2}\text{ neg. binary rel.}), 505	page
\nsupseteq (⊉ neg. binary rel.), 505	referencing, 258
\nsupseteqq (\noting neg. binary rel.), 505	style of, 401

ranges, <b>14</b> , <b>75</b> , 81	large, 25, <b>26</b> , 161, 169, 175, <b>174–176</b> , 299
in BIBT <sub>E</sub> X databases, 424, 427	511
in index entries, 454	sizing of math delimiters with, 169
real, in length commands, 403	with limits, 25, 27, 161, 171, 172, 174,
stored by LATEX, 80	175, 299, 510, 511
stored in	defining, 173, 195, 196
counters, 399	without limits
registers, 377	defining, 173, 195, 196, 198, 250, 301
version, 532	\oplus (⊕ math op.), 506
\numberwithin, <b>156</b> , 250, 466	optional
numeric counter style (\arabic), 401, 401, 411	arguments, 15, 71, 98, 100, 112, 113, 115,
\nVDash (⊭ neg. binary rel.), 505	125, 162, 179, 233, 242, 250
\nVdash (⊮ neg. binary rel.), 505	multiple, 70
\nvDash (⊭ neg. binary rel.), 505	of \ <b>15</b> , <b>98</b> , 242
\nvdash (⊬ neg. binary rel.), 505	of commands, 56, 120, 122, 123, 127,
\nwarrow (\sqrtan) arrow), 507	200, 201, 264, 266, 276–279, 351, 400, 402, 407, 409, 410, 414, 475
0	
	of environments, 125, 128, 132, 135,
O'Sean, Arlene Ann, 217, 553, 560	229, 243, 260, 384, 486
O, slashed $(\emptyset, \emptyset)$ , $81$ , $515$	of sectioning commands, 253, 473
Oberdiek, Heiko, 319	of structural commands, 255, 466
obtaining	of top matter commands, 273–281, 331
files from the Internet, 537–541	of user-defined commands, 374
PostScript fonts, 546	of user-defined environments, 380, 382,
sample files for this book, 4, 541	384
the AMS packages and AMSFonts, 540	use square brackets ([]), 15, 27, <b>69–70</b> ,
octothorp (#), 77, 81, 518	123, 132, 135, 285
\oddsidemargin (length com.), 270	bibliographic fields, 425, 428–436
$\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ $	hyphens, 13, 82, <b>82</b> , 96
\OE ethel ( $\times$ ), 81, 515	options
\oe ethel ( $\alpha$ ), $81$ , $515$	of document classes, see document class
ogonek (Eur. accent), 519	options
\oint (∮ large math op.), <b>161</b> , <i>175</i> , <i>511</i>	of packages, see package options
old-style digits, 62	organization (BIBTEX database field), 425,
\oldstylenums (old-style digits com.), 62	431
$\Omega \subseteq (\Omega Greek char.), 502$	organization of files, 476–479
$\omega$ Greek char.), 502	orientation of pages, document class options for
\ominus ( $\ominus$ math op.), 506	307
onecolumn (doc. class opt.), 299, 307	orthogonality of font commands, 94
\onecolumn (single-column com.), 101	\oslash (⊘ math op.), 506
oneside (doc. class opt.), <b>299</b> , 307, 468	OT1 font encoding, 544
\only (beamer com.), 333-335, <b>337-339</b> , 343	\otimes ( $\otimes$ math op.), 506
\onslide (beamer com.), 333, 335, <b>337-339</b> ,	out (hyperref bookmarks file), 321
342, 343	\overbrace (horizontal brace com.), 178, 183
openany (doc. class opt.), 468	with a superscript, 178
openbib (doc. class opt.), 308, 308	overdot ( 'text accent), 79, 516
openright (doc. class opt.), 468	\overfullrule (length com.), 96
operating systems, see Mac, PC, or UNIX	overlapping braces, 72
operations	overlays, see also under presentations
arithmetical, 22–23, 157–159	commands for, 337
binary, see binary operations	layering, 334
operators, math, 22, 24, 26, 157, 172, 175,	\overleftarrow ( $\overleftarrow{x}$ math arrow), 179
<b>170–176</b> , 371, <i>506</i> , <i>510</i>	\overleftrightarrow ( $\overrightarrow{x}$ math arrow), 179
declaring, 173	\overline ( $\overline{x}$ math line sym.), 177, 179, 185
	overprint (beamer env.), 359

\overrightarrow ( $\overrightarrow{x}$ math arrow), 179	outral 202
\overset (symbol-building com.), 183, <b>192</b> ,	eufrak, 302 exscale, 301, 311
372	fancyhdr, 270, 537, 540
	•
creating binary operations and relations	fileerr, 313
with, 193	fontenc, <b>545</b> , 547, 548
$\langle owns (\exists binary rel.), 503$	fontsmpl, 313 ftnright, 313
P	6 1
\P (¶ pilcrow or paragraph)	geometry, 270
math symbol, 508	graphics, 312
•	graphicx, 37, 39, 250, 259-260, 300,
text symbol, 81, 518 package options, see also specific packages,	523, 552 hhline, 140, 313
249, 257, 298–299, 301, 320–322,	hyperref, 320–323
	in required directory, 312
386, 512, 545, 546, 548 are passed down from document classes,	in tools directory, 312—313
250	in unpacked directory, 311
handled electively, 313	indentfirst, 313
preventing loading of, 300	
	inputenc, 547
packages, 36, 249, 311, 522, 524–526	interdependencies of, 271
accents, 178	latexsym, 37, 180, 249, 294, 300, 311
afterpage, 312	layout, 268, 313
alltt, 147, 311, 534	loading with \usepackage, 70, 249
amsbsy, 301, 302, 528	multiple, 250
amscd, 301	longtable, 313
amsfonts, <b>301–302</b> , 528	lucidabr, 546
amsgen, 301, 302	makeglos, 464
amsmidx, 302	makeidx, 311, <b>450</b> , 478
amsmath, xxvi, 53, 231, 299, <b>300</b> , 301,	mathtime, 545
302, 403, 524, 525, 528, 533	mathtools, 206
amsopn, 301, 302	multicol, 101, 307, 313
amssymb, 37, 180, 294, 300, 301, 374, 528	newlattice, 250, 386, 387
amstext, 301, 302 amsthm, 302, 525	nfssfont, 311
amsxtra, 176, 177, 300, 301	obtaining the AMS packages and AMSFonts, 540
apalike, 437	options, see package options
array, 312	paralist, 123
automatic loading of, 53, 349, 528, 529	psnfss, 312
babel, 312, 547–548	rawfonts, 313
backref, 320	setspace, 99
biblatex, 447	showidx, 311, 453
bm, 312	showkeys, 257, 313
booktabs, 140	somedefs, 313
calc, 312, 403, 406	source files, 250, <b>310</b> , 437, 540
commands in, 386	tabularx, 313
cyrillic, 312	theorem, 313
dates of, 533	times, 544
dcolumn, 136, 313	tools, 312
delarray, 313	trace, 313
distribution, AMS, 271, <b>300–302</b> , 325,	updates to AMSFonts and amsmath, 533
380, 417, 436, 437, 521, 528, 553	upref, 300, 301
documentation for, 113, 261, 312, 313,	varioref, 258, 313
359, 380, 545, 546, 553	verbatim, 86, 87, 147, 313, 387
enumerate, 123, 313, 382, 387	versions of, 524, 525, 532–534
eucal, 301, 302, 386, 512	xcolor, 325, 348
options, <b>301</b> , 390, 512	xr, 258, 313
opuono, e v 2, e > 0, e 1 2	,,

xspace, 313, 368-369	paragraph text symbol, see \P
xy-pic, 242	\paragraph* (struct. com.), 253
page (counter), 399, 399	\paragraphname (hyperref redef. name),
pagebackref (opt. of hyperref pack.), 320,	323
321	paragraphs, 64, <b>99–100</b>
\pagebreak (page breaking com.), 100, 484,	breaking into lines, 12, 96, 97, 530
486	breaking lines in, 82
optional arguments of, 100	hanging indents, 99
\pagename (redef. name), 376	horizontal alignment of, 124
\pagenumbering (page-number style com.),	indentation of first lines, 99, 103, 313, <b>404</b>
401	interline spacing of, 23
\pageref (cross-ref. com.), 28, 29, 31, 202,	terminating
255, <b>258</b> , 267, 322, 484	with blank lines, 11, <b>64</b> , 99, 118, 144
\pageref* (hyperref cross-ref. com.), 322	with \par command, 64, 65, 73, 90, 95,
pages	99, 124
breaking, 15, <b>100–101</b> , 261	vertical spacing between, 124, 404, 407,
in align environment, 242	413, 481
in cases subsidiary environment, 242	paralist (pack.), 123
in displayed math environments,	\parallel(   binary rel.), 503
242–243	\parbox (box com.), 107, 109, <b>110, 111</b> , 138,
in gather environment, 242	405
in multiline math environments, 243	in tabular environments, 111
preventing, 242	parentequation, 401
components of, 268	parentheses (()), 8, 62
headers, <i>see</i> running heads	as math delimiters, <b>24</b> , 26, 166, <i>167</i> , 184,
layout of, <b>268–270</b> , 313	217, 509
for amsart document class, 269	in index entries, 455
numbering, style of, 401	suppressing the use of in tags, 202
odd, starting chapters on, 468	\parindent (length com.), <b>404</b> , 414
orientation of, document class options for,	\parsep (length com.), 407, 408, 413, 414
307	\parskip (length com.), <b>404</b> , 407, 408, 414,
referencing, 202, 258	481
with varioref package, 313	\part (struct. com.), 253, 304, 350, <b>466</b>
size changing with \enlargethispage,	part (counter), 399
101, 484, 487	\partial ( $\partial$ math sym.), 508
styles of, 268–270	\partname (redef. name), 376
title, 535	and hyperref package, 323
document class options for, 249, 299,	\partopsep (length com.), 407
300, 307	parts
of articles, 37, 249, 251	in books, 466
of books, 467, 469	in presentations, 354
of presentations, 55	Patashnik, Oren, 421, 446, 559
pages (BIBTFX database field), 425	pathnames, on Mac, PC, and UNIX systems, 479
page ranges in, 427	\pause (beamer com.), 333, <b>333</b> , 334, 337
\pagestyle (set page style), 268	pc (point abs. unit), 403
pagination, 484–486	per (PSNFSS font name), 544
paper size, document class options for, 298, 306	PCs, xxvi, 3, 4, 9, 479, 522
\par (paragraph breaking com.), <b>64</b> , 65, 73, 90,	FTP clients, 538
273	LATEX front end, 3, 326, 489
\par (paragraph-breaking com.), 95, 118, 124	LATEX implementations, 490–494
in error messages, 99	line ending characters, 9
\paragraph (struct. com.), 252, 466	WinEdt LATEX front end, xxvi, 9, 11, 53,
paragraph (sounter), 399	442, 461, 490, 491, <i>492</i>
paragraph boxes, 110–112	, , . , . , . , . , . , . ,
ror 00o, 110 112	

PDF (Portable Document Format), 518–519, 480	of commas in formulas, 155
files	of equation numbers, 298, 307
bibliographic citations in, 321	of equations, 298, 307
bookmarks in, 321	of figures, <b>260</b> , 484, 486
creating, 319	of \index commands, 458, 486
external hyperlinks in, 322–323	of index in document, 450, 461
for graphics, 39, <b>259</b> , 326	of \label commands, 486
for legacy documents, 319	of limits, 299
for presentations, 53–58, 325–359	of roots, 162
hyperlinks in, 319–323	of tables, 484, 486
JavaScript in, 318	of text boxes, 115
putting on the Internet, 319	
	plain
size of, 318	BIBTEX style, 421
suppressing hyperlinks in, 322	page style, 268
typeset, 5, 318, 326	theorem style, <b>129</b> , 129–131
viewing in Web browsers, 318	Plain T <sub>E</sub> X, 552
fonts	plain text, 9
partial downloading of, 318	plain.bst (BIBTEX style file), 421
proprietary, 318	plain.tex (Plain TEX source file), 528
pdftex (opt. of hyperref pack.), 320	platform independence
percent (%)	of graphics, 325
as comment character, 6, 10, 19, 21, 61,	of source files, 3, 9
<b>85–86</b> , 141, 294, 458	platforms, see under Mac, PC, and UNIX
in BIBTEX databases, 86, 443	plus (+), 22, 188, 191, 192, 216–218
as text symbol, 9, 77, 81, 518	as binary operation, 506
in e-mail addresses, 278	plus and minus rule, <b>188</b> , 191, 192
periods (.), 9, 62, <b>66–67</b>	and subformulas, 216
and initials, 67	in multline environments, 213
and italic correction, 92	\pm (± math op.), 506
and spacing rules, 66–67	pmatrix (subsid. math env.), 25–26, <b>235</b>
end of sentences, 66	\pmb (poor man's bold font com.), 198–199,
following capital letters, 67	301
in abbreviations, 66	\pmod ( (mod ) math op.), 24, <b>173</b> , 174
in bibliographies, 66	\pod ( () math op.), 24, 173, 174
in BibT <sub>E</sub> X databases, 426	poetry, typing, 144–145
terminating sentences with, <b>64–67</b>	point (pt abs. unit), 12, 15, 54, 89, 93, 95, 96.
\perp ( $\perp$ binary rel.), 503	* *
· ·	105, 107, 110, 111, 308, 403
personal computer, see computer, Mac, or PC	poor man's bold, <b>198–199</b> , 301
Personal T <sub>E</sub> X, Inc., 545	portability 126, 429
personalized templates	of bibliographic databases, 426, 428
for AMS document classes, 294–297	of illustrations, 552
\phantom (spacing com.), 102-103, 191-192,	of LATEX files, 9
223, 406	of prohibited characters, 64
PHDTHESIS (bibl. entry type), 425, <b>433–434</b>	of T <sub>E</sub> X files, 9
\Phi ( $\Phi$ Greek char.), 502	Portable Document Format, see under PDF
\phi ( $\phi$ Greek char.), 502	Portable Graphics Format, 325
phv (PSNFSS font name), 544	position, of proclamation numbers, 131
\Pi ( $\Pi$ Greek char.), 502	PostScript (PS), 317
\pi ( $\pi$ Greek char.), 502	documents on the Internet, 317
pica (pc abs. unit), 403	files
picture (drawing env.), 259, 551	converting to PDF, 319
portability of, 552	including fonts in, 317
pilcrow (¶ text sym.), 81, 518	putting on the Internet, 319
\pitchfork (\pi binary rel.), 504	size of, <b>317</b> , 319
placement	fonts, 317, 523, <b>543–546</b>
<b>1</b>	, , ,

AMSFonts, 300, 301, 524, 525, 533	frames in, 358
Computer Modern, 523, 525, <b>543</b>	hyperlinks in, 343–347, 358
European Modern, 524	in color, 348–350
•	lists in, 339–341
obtaining, 546	
using with LATEX, 312, 545	navigation symbols, 354
PostScript New Font Selection Scheme, see	notes in, 355, 356
PSNFSS	overlays in, <b>333</b> , 333–343
\pounds	commands for, 333, 335, 337
math symbol $(\pounds)$ , 508	examples of, 335–337
pound sign or sterling $(\pounds)$ , 519	layering, 334, 335
\Pr (\text{Pr math op.}), 172, 510	specifications, 337, 341
preamble, 35–37, 248–251	syntax of, 337–339
commands in, 13, 35, 53–55, 70, 85, 86,	parts in, 354
99, 125, 127, 129, 131, 156, 173, 196,	planning, 358
249, 250, 294, 300, 320, 326–327,	preamble of, 53–55, 326–327
366, 382, 386, 402, 463, 478, 486,	quickbeamer1, 328, 329, 330, 333
531, 532	quickbeamer2, 331, 332, 333
customizing, in template files, 44, 294	sectioning of, 55, 328, 331
defining counters in, 400	sidebars, 331
proclamations defined in, 250	sidebars in, 343, 350
user-defined commands in, 250, 366	slides, 333
\prec ( $\prec$ binary rel.), 503	structure of, 350
\precapprox (≲ binary rel.), 504	tables of contents in, 351, 358
\preccurlyeq (≼ binary rel.), 504	themes for, 328, 331, 356, <b>356</b> , 357
\preceq (≤ binary rel.), 503	color options, 357
\precnapprox (≈ neg. binary rel.), 505	font options, 357
\precneqq (≨ neg. binary rel.), 505	theorems in, 358
\precnsim ( $\gtrsim$ neg. binary rel.), 505	top matter of, 53–55, 326–327, 331
\precsim (≾ binary rel.), 504	with beamer document class, 325–359
preparation	with FoilT <sub>E</sub> X, 53
final, of books, 482–487	preventing
of illustrations, 483	case changes in bibliographic entries, 427
presentations, 53, 325	hyphenation, 83–84, 107
abstracts in, 53–55	indentation of paragraphs, 99
babybeamer1, 334, 333-335	line breaks, 99, 107
babybeamer2, 333	page breaks, <b>98</b> , 100, 242
babybeamer3, $338$	removal
babybeamer4, 340	of horizontal space, 103
babybeamer5, 341	of vertical space, 105
babybeamer6, 341	spaces following environments, 383
babybeamer7, 346, 345-347	\prime (' math sym.), 508
babybeamer8, 348	prime ('), 23, 159, 194, 508
babybeamer9, 351	primitive commands, 377, 528
babybeamer10, 359, 360	printers
beamerstructure1, 352	drivers for, 526, <b>530</b>
beamerstructure2, 354, 354	specifying for hyperref package, 320
body of, 327	DVI drivers for, 312, 539
columns in, 347–348	\Printindex (index com. for multiple
commands for, 53, 55, 349, 351, 357	indexes), 464
optional arguments of, 351	\printindex (index com.), 450, 461
cross-referencing within, 328	printing
equations in, 328	typeset (DVI) files, 530
file formats	typeset (PDF) files, 530
PDF, 326	proc (doc. class), 529
flexibility in, 358	proc-1 (doc. class), 272, 376
•	

PROCEEDINGS (bibl. entry type), 425, 432–433,	?, 20, 48, 491, 534
436	file name, 534
proceedings, conference, in BIBTEX database	responding to, 20, 48, <b>534–535</b>
files, 424	proof (text env.), 39, 117, <b>131–133</b> , 302, 327
processed	changing q.e.d. symbol, 374
bibliography files, see bbl	lines following, 118
index files, see ind	lists in, 131
processing	optional arguments of, 132
bibliographies, 437–446	placement of q.e.d. symbol, 132
indexes, 459–461	\proofname (redef. name), 376
proclamations, 37, 46, 117, <b>124–131</b> , 407	proofs, 131–133
commands for	proportional fonts, 88
\newtheorem (procl. com.), 37, 125,	propositions, see proclamations
127, 129, 131, 294, 402	\propto (\pi binary rel.), 503
\newtheorem* (procl. com.), 129, 382	\protect (protect fragile commands), <b>74</b> , 252,
\newtheoremstyle, 131	253, 466, 475
\theoremstyle (procl. com.), 129-131	protecting
\theoremstyle* (procl. com.),	capitalization in bibliographic entries, 427
129–131	
	fragile commands, <b>74</b> , 252, 253, 466, 475
counters for, 399	protocols
defining, 37, 46, <b>125</b> , 127, 128, 131, 294,	File Transfer, see FTP
382, 402	Hypertext Transfer, see HTTP
in preamble, 250	\providecommand (user-defined com.), 373,
with theorem package, 313	<b>375</b> , 378
environments for	\providecommand* (user-defined com.), 373
theorem, 37, 46, 52, 54, 125, 128, 343,	\ProvidesPackage (pack. com.), 534
384	providing commands, 375
invoking, 37, 46, 52, <b>125</b> , 128, 343, 384	PS, see PostScript
lines following, 118	ps2pdf (opt. of hyperref pack.), 320
lists in, 126	psamsfonts
logical design using, 535	amsfonts package option, 301
names of, 55, 128	document class option, 300
numbering of	psfonts.ins (PSNFSS distr. file), 544
consecutively, 127–128	\Psi (Ψ Greek char.), 502
within sections, 127	\psi ( $\psi$ Greek char.), 502
position of numbers, 131	PSNFSS (PostScript New Font Selection
styles of, <b>129–131</b> , 524	Scheme), 544, 545
definition, <b>129</b> , 129-130	distribution, 540, 544–545
plain, <b>129</b> , 129–130	font names (Berry scheme), 544
remark, 129, 129-130	psnfss (LATEX distr. directory), 311
unnumbered, 129, 130, 382	psnfss (pack.), 312
\prod (\Bigcap large math op.), 175, 511	pt (point abs. unit), 12, 15, 54, 89, 93, 95, 96,
productivity tools, 5, 494, 498, see also	105, 107, 110, 111, 308, 403
synchronization, block comment,	ptm (PSNFSS font name), 544
jump to a line	publisher (BIBT <sub>E</sub> X database field), 424, 425
products, 26, 27, 174	publishers, preparing manuscripts for, 465
products.eps (sample illus. file), 39	punctuation
products.pdf (sample illus. file), 39, 54, 327	in BIBT <sub>E</sub> X databases, 423–428, 445–446
programming, in T <sub>E</sub> X, 553	marks, 9, 14, <b>62</b> , <b>75–76</b> , 81, 156, 368, 515,
programs, typing, 141–143, 145–147	518
prohibited keys, 9, 63	
\projlim (proj lim math op.), 172, 510	Q
prompts, 534–535	q.e.d. symbol, 132, 374
* (interactive), 113, 376–378, 534	\qedhere (proof com.), 133
**, 534	\qedsymbol (□ math sym.), 131, 374

suppressing, 132	redefining commands, 374–375
\qquad (spacing com.), 27, 102, 105, 190, 190,	\ref (cross-ref. com.), 28, 29, 31, 123, 156,
224, 513, 520	202, 215, 255, <b>255</b> , 258, 301, 313,
(spacing com.), 24, 27, 102, 105, 154,	322, 384
190, 190, 225, 513, 520	\ref* (hyperref cross-ref. com.), 322
question marks (?), 9, 62	references
Spanish (¿), 81, 515, 518	bibliographic, 29, 40–41, 48, 66, <b>261–267</b> ,
terminating sentences with, 64–67	328, 375, 407, 437, 442
quickbeamer.pdf (sample file), 326	citing, 29, 47, <b>264</b> , 441
quickbeamer.tex (sample file), 326-328	citing with BIBT <sub>E</sub> X, 439
quickbeamer1.pdf (sample file), 328	including without citing, 439, 441
quickbeamer1.tex (sample file), 328	defining, 28, 29, 31, 50, 156, 215, 231,
quickbeamer2.pdf (sample file), 331	252, <b>255</b> , 328
quickbeamer2.tex (sample file), 331	symbolic, showing in margins, 257, 313
quiet mode, 534	to equations, <b>28</b> , 29, 31, 156, 202, 203,
quotation (disp. text env.), 144, 407	215, 219, 255, 256, 263, 328
quotation marks, 9, 63, <b>75</b> , 81	to pages, 28, 29, 31, 202, 255, <b>258</b> , 322,
double quote key, 9, 62, 63, <b>75</b>	484
in BIBT <sub>E</sub> X database fields, <b>424</b> , 445, 446	and varioref package, 313
in BIBTEX entries, 436	to sections, 28, 29, 31, 123, 156, 202, 215,
in \index commands, 457	<b>255</b> , 258, 301, 313, 322, 384
European, 519	referencing, <i>see</i> cross-referencing <i>or</i> symbolic
•	referencing
single quote key, 9, 23, 62, <b>75</b>	\refname (redef. name), 376
typing, 11	\refstepcounter (cross-ref. counter incr.
quotations, typing, 143–144	
quote (disp. text env.), <b>143</b> , 407	com.), 402
\quotedblbase (Eur. quot. mark), 519	registered trademark (® text sym.), 81, 518
quoting, special characters in \index	registers, 377
commands, 457	relations, binary, see binary relations
n.	relative
R	numbering of equations, 29, 201, 203
\r (° ring text accent), 79, 516	spaces, 105
\raggedleft (align. command dec.), 124	units, 105, 107, 111, <b>403</b>
\raggedright (align. command dec.), 124	\relax (do nothing com.), 385
Rahtz, Sebastian, 259, 319, 523, 542, 558	release dates, of LATEX, 86, 251, 532
\raisebox (box com.), 115	remark (procl. style), 129, 129-131
ranges, numeric, <b>14</b> , <b>75</b> , <i>81</i> , <i>518</i>	\renewcommand (user-defined com.), 87,
in BIBT <sub>E</sub> X databases, 424, 427	88, 99, 123, 132, 139, 267, 322,
in index entries, 454	370, 373, <b>374–375</b> , 378, 382, 383,
\rangle ( \rangle math delimiter), 167, 168, 509	400–402
rawfonts (pack.), 313	\renewcommand* (user-defined com.), 373
\rbrace() math delimiter), 167, 509	\renewenvironment (user-defined com.),
\rbrack(] math delimiter), 167, 509	383, <b>385</b>
\rceil ( ] math delimiter), 167, 509	\renewenvironment* (user-defined com.),
\Re ( $\Re$ math sym.), 508	385
read-only, making templates, 297	renumbering, automatic, 28, 536
readability	report (doc. class), 253, 303, 303-308,
of documents, 93, 358	376, 529
of source files, 19, 22, 65, 135, 154, 166,	reports, technical, in BibTeX database
363–367, 379, 415	files, 434–435
Reader, Adobe Acrobat, see under Adobe	reqno
Reader	amsmath package option, 302
real numbers, in length commands, 403	document class option, 249, <b>298</b> , 307
redefinable names, 322, 323, 363, <b>375</b> , 376, 548	• , , , , , , , , , , , , , , , , , , ,

required	\rightthreetimes ( $\angle$ math op.), 506
arguments, 111, 112, 179, 194, 272,	\right  (  math delimiter), 24, 26, 168,
273, 535	180, 189, 191
multiple, 19, 70, 137, 192, 194,	ring (° text accent), 79, 516
268, 311, 379, 404–406	ring A (Å), 81, 515
of commands, 19, <b>69</b> , 137, 192, 194,	ring a (å), 81, 515
257, 268, 280, 404, 473, 478, 516	\risingdotseq (= binary rel.), 504
of environments, <b>69</b> , 135, 136, 224,	Ritter, R. M., 553
226, 236, 237, 263-264, 266, 309,	\rm (obs. LATEX 2.09 font com.), 94
<b>383–385</b> , 476	$\mbox{rmfamily (font shape com. dec.)}, 90,$
use braces ({}), 8, 14, 19, <b>69</b> , 70,	123, 516
530	rmfamily (font shape env.), 123
bibliographic fields, 425, 426,	\Roman (uppercase roman-numeral
428-436	counter-style com.), 401
required (LATEX distr. directory), 311,	roman
540	document font family, 89, <b>89</b> , 544
packages in, 312	font shape, 28, 88, 90, <b>123</b> , 301, 516
\RequirePackage (pack. com.), 386, 387	math, 173, <b>196</b> , 196
research support (\thanks top matter	\roman (lowercase roman-numeral
com.), 44, 87, 279, 281, 296, 304	counter-style com.), 123, 401
resetting counters, 400, 402	roots, 27, 161–162
resolution, of Type 1 fonts, 543	<i>n</i> -th, 27, <b>162</b>
Return key, 9, 11, 21, 48–51, 63, 153, 491,	placement of, 162
534	square, 27, <b>161</b>
\rfloor (   math delimiter), 167, 509	using struts with, 200
\rhd (> math op.), 506	Rose, Kristoffer H., 242
\rho (ρ Greek char.), 502	row separator (\\), 25, 30, 31, 33, 44, 46
\right (math delim.), 167–168, 170, 184,	98, 124, 135, 141, 142, 145, 176,
235	211, 213, 215, 216, 227, 231, 242
blank, 168, 182	273-278, 297, 304, 309
must be balanced, 168, 217	Rowley, Chris, xxxiii, 523, 524, 559
right double quote (")	\Rrightarrow ( $\Rightarrow$ math arrow), 507
text symbol, 75, 81, 518	\Rsh (r math arrow), 507
typing, 11	\rtimes ( $\times$ math op.), 506
right justification of text, 8, 14, 68	rubber lengths, <b>378</b> , <b>406</b> , 407, 530
right single quote (')	\rule (box com.), 113, 114, 140
key, 9, 11, 62, <b>75</b>	rules (lines), filling lines with, see also
	· , , , , , , , , , , , , , , , , , , ,
text symbol, <b>75</b> , 519	lines (rules), 106, 113
\right) () math delimiter), 24, 26, 166,	running
168, 184, 217, 235	BibTeX, 437–446
\right. (blank math delim.), 168	MakeIndex, 459-461
\right> () math delimiter), 168	running heads, 56, 252, <b>268–270</b>
\right] (] math delimiter), 24, 166, 182	author's name in, 276
\Rightarrow ( $\Rightarrow$ math arrow), 507	fragile commands in, 74
\rightarrow ( $\rightarrow$ math arrow), 507	title in, 274, 297
\rightarrowtail (→ math arrow), 507	\rVert (    math delimiter), 168
\rightharpoondown (\rightharpoondown), 507	\rvert (  math delimiter), 168
\rightharpoonup (\sim \text{math arrow}), 507	( (
\rightleftarrows (\Rightarrow), 507	${f S}$
· , , , , , , , , , , , , , , , , , , ,	
\rightleftharpoons (\Rightleftharpoons),	\S (§)
507	math symbol, 508
\rightmargin (length com.), 407, 408,	section text symbol, 81, 518
411	sampart-ref.tex (sample file), 320, 323
\rightrightarrows ( $\Rightarrow$ math arrow), 507	sampart.tex (sample file), 125, 129, 131
\rightsquigarrow ( $\rightsquigarrow$ math arrow), 507	230, 266, 272, 273, <b>285–293</b> , 371
	392, 437, 536

sampartb.bbl (sample bibl. file), 441-443 sampartb.bib (sample bibl. file), 437, 437-443 quickbeamer1.tex, 328 quickbeamer2.pdf, 331 quickbeamer2.pdf, 331 quickbeamer2.tex, 331 sampartb.blg (sample BibTeX log file), 441, 442 sampartb.tex (sample file), 421, 437, 439-441, 443 sampartt.tex, 125, 129, 131, 230, 266, 439-441, 443 sampartu.tex (sample file), 376, 383, 392-398, 535 source file, 290-293	source file, 290–293	products.pdf (illus. file), 39, 54, 327
sampartb.bbl (sample bibl. file), 441-443 sampartb.bly (sample bibl. file), 437, 437-443 sampartb.bg (sample BibTEX log file), 441, 442 sampartb.tex (sample file), 421, 437, 439-441, 443 sampartt.tex (sample file), 376, 383, 392-398, 535 sample files amsart.tp1, 294 amsproc.template, 297 babybeamer1.pdf, 333-335 babybeamer2.tex, 334 babybeamer3.tex, 338 babybeamer4.tex, 343 babybeamer6.tex, 343 babybeamer6.tex, 341 babybeamer6.tex, 343 babybeamer7.tex, 343, 345-347 babybeamer9.tex, 349 babybeamer9.tex, 349 babybeamer9.tex, 359 beamerstructure.tex, 352, 354 bibl.tp1, 47 cleardoublepage.sty, 101 fonttbl.tex, 78, 134 formula.tex, 164-166 gg.tex, 44-48 ggamsart.tp1, 297 inbibl.tp1, 263 intrart.tex, 35-43, 53, 55, 57-58 legacy-article.tex, 304, 305 letter.tex, 308-302 notel.tex, 9-11 notelb.tex, 12-13 note2.tex, 13-15 noteslug, tex, 13 obtaining, 4 of presentations, 54, 326-331 products.eps (filts, file), 39  quickbeamer1.tex, 328 quickbeamer1.tex, 328 quickbeamer1.tex, 328 quickbeamer2.tex, 331 quickbeamer2.tex, 331 quickbeamer2.tex, 332 quickbeamer2.tex, 320, 323 sampart.tex, 125, 129, 131, 230, 266, 272, 273, 285-293, 371, 392, 437, 437, 437, 443 sampartb.tex, 421, 437, 439-441, 443 sampartb.tex, 421, 437, 437-443 sampartb.tex, 421, 4	typeset, 286–288	quickbeamer.pdf, 326
sampartb.bib (sample bibl. file), 437, 437-443 sampartb.big (sample BirTpX log file), 441, 442 sampartb.tex (sample file), 421, 437, 439-441, 443 sampartu.tex (sample file), 376, 383, 392-398, 535 sample files amsart.tpl, 294 amsproc.template, 297 babybeamer2.tex, 338 babybeamer3.tex, 338 babybeamer3.tex, 338 babybeamer6.tex, 341 babybeamer6.tex, 343 babybeamer6.tex, 341 babybeamer6.tex, 343 babybeamer7.tex, 343, 345-347 babybeamer9.tex, 349 babybeamer10.tex, 359 beamerstructure.tex, 352, 354 bibl.tpl, 263 intrart.tex, 35-43, 53, 55, 326, 331 typeset, 41-43 intrarti.tex, 450-452, 460, 459-461 intropres.tex, 35, 55, 57-68 legacy-article.tex, 304, 305 letter.tex, 308-310 math.tex, 17-19 mathb.tex, 19-22 myams.tpl, 294-297 newlattice.sty, 311, 379, 383, 386-392 notel.tex, 9-11 notelb.tex, 12-13 note2.tex, 13-15 note3.tex nuclekeamer2.tex, 332 nampart.tex, 23-20, 323 sampart.tex, 23-20, 33, 33 sampart.tex, 23-20, 33, 33 sampart.tex, 23-20, 33, 34 sampart.tex, 25-28 sample.clx (x1-24, 37, 43-44 sampart.tex, 14-24 sampartb.tex, 14-24, 143 sampartb.tex, 14-24, 143 sam	sampartb.aux (sample aux. file), 441, 442	quickbeamer.tex, $326-328$
437-443 sampartb.blg (sample BisTjEX log file), 441, 442 sampartb.tex (sample file), 421, 437, 439-441, 443 sampartt.tex (sample file), 376, 383, sampartt.tex (sample file), 376, 383, sampartt.tex (sample file), 376, 383, sampartt.tex, 125, 129, 131, 230, 266, 272, 273, 285-293, 371, 392, 437, 536 source file, 290-293 typeset, 286-288 sampartb.tex, 421, 437, 439-441, 443 sampartt.tex, 333-345 babybeamer1, pdf, 333-335 babybeamer2.tex, 334 babybeamer3.tex, 334 babybeamer6.tex, 343 babybeamer6.tex, 341 babybeamer6.tex, 343 babybeamer6.tex, 343 babybeamer9.tex, 349 babybeamer9.tex, 349 babybeamer9.tex, 359 beamerstructure.tex, 352, 354 bibl.tpl, 47 cleardoublepage.sty, 101 fonttbl.tpx, 78, 134 formula.tex, 164-166 gg, tex, 44-48 gg2.tex, 45-46 ggamsart.tpl, 297 inbibl.tpl, 263 intrart.tex, 35-43, 53, 55, 57-58 legacy-article.tex, 304, 305 letter.tex, 308-310 math.tex, 17-19 mathb.tex, 19-12 noteslue, tex, 13 obtaining, 4 of presentations, 54, 326-331 products.eps (filts, file), 39  quickbeamer2.tex, 331 sampart.tex, 125, 129, 131, 230, 266, 272, 273, 285-293, 371, 392, 437, 352-288-383, 392-498, 535 sample.cls, 11 SymbolTables.pdf, 4, 9, 15, 19 template bib, 423, 437, 446 topmat.tpl, 282 sample.cls (doc. class), 10 samples.les, 11 SymbolTables.pdf, 4, 9, 15, 19 template bib, 423, 437, 446 topmat.tpl, 282 sample.cls (doc. class), 10 sample.cls (doc. class), 10 samples.les, 11 SymbolTables.pdf, 4, 9, 15, 19 template bib, 423, 437, 446 topmat.tpl, 282 sample.cls (doc. class), 10 sample.se, 10, 10, 12, 12, 12 sample.cls (doc. class), 10, 11 SymbolTables.pdf, 4, 9, 15, 19 template bib, 423, 437, 446 topmat.tpl, 282 sample.cls (doc. class), 10, 11 SymbolTables.pdf, 4, 9, 15, 19 template bib, 423, 437, 446 topmat.tpl, 282 sample.cls, 11 SymbolTables.pdf, 4, 9, 15, 19 template bib, 423, 437, 446 topmat.tpl, 282 sample.cls, 11 SymbolTables.pdf, 4, 9, 15, 19 template bib, 423, 437, 446 topmat.tpl, 282 sample.cls, 11 SymbolTables.pdf, 4, 9, 15, 19 template bib, 423, 437, 446 topmat.tpl, 282 sample.cls, 11 SymbolTables.pdf, 4	sampartb.bbl (sample bibl. file), 441-443	quickbeamer1.pdf, 328
sampartb.blg (sample BibTEX log file), 441, 442 sampartb.tex (sample file), 421, 437, 439-441, 443 sampartu.tex (sample file), 376, 383, 392-398, 535 sample files amsart.tpl, 294 amsproc.template, 297 babybeamer1.pdf, 333-335 babybeamer3.tex, 338 babybeamer6.tex, 338 babybeamer6.tex, 343 babybeamer6.tex, 343 babybeamer6.tex, 343 babybeamer6.tex, 347 babybeamer9.tex, 347 babybeamer9.tex, 347 babybeamer9.tex, 347 babybeamer9.tex, 347 babybeamer10.tex, 359 beamerstructure.tex, 352, 354 bibl.tpl, 47 cleardoublepage.sty, 101 fonttbl.tex, 78, 134 formula.tex, 164-166 gg.tex, 44-48 gg2.tex, 45-46 ggamsart.tpl, 297 inbibl.tpl, 297 inbibl.tpl, 297 inbibl.tpl, 263 intrart.tex, 35-43, 53, 55, 326, 331 typeset, 41-43 intrart.tex, 450-452, 460, 459-461 intropres.tex, 53, 55, 57-58 legacy-article.tex, 304, 305 letter.tex, 308-310 math.tex, 17-19 matb.tex, 19-22 myms.tpl, 294-297 nevlattice.sty, 311, 379, 383, 386-392 notel.tex, 9-11 notelb.tex, 12-13 noteslug.tex, 13 obtaining, 4 of presentations, 54, 326-331 products.eps (illus. file), 39 sampart.tex, 125, 129, 131, 230, 266, 272, 273, 285-293, 371, 392, 437, 392, 437, 437-443 sampartb.tex, 421, 437, 439-441, 443 sampartb.tex, 421, 437, 439-441, 443 sampartb.tex, 362-838 sample.cls (doc. class), 10, 11 SymbolTables.pdf, 4, 9, 15, 19 template.bib, 423, 437, 446 topmattb.tex, 128 sample.cls (doc. class), 10 sample.cls, 11 sample.cls (doc. class), 10 sample.cls (doc. class), 10 samples font, 31 sampartb.tex, 421, 437, 439-441, 443 sampartb.tex, 421, 437, 446 topmattb.tex, 142, 143 sampartb.tex, 421, 437, 446 topmattb.tex, 142, 1437, 439-441 sample.cls (loc. class), 10, 11 sam	sampartb.bib (sample bibl. file), 437,	quickbeamer1.tex, 328
**sampartb.tex* (sample file), 421, 437, 439-441, 443 **sampartu.tex* (sample file), 376, 383, 392-398, 535 **sample files  ansart.tpl, 294  ansproc.template, 297  babybeamer1.pdf, 333-335  babybeamer2.tex, 334  babybeamer3.tex, 343  babybeamer6.tex, 343  babybeamer6.tex, 343  babybeamer6.tex, 343  babybeamer7.tex, 343, 345-347  babybeamer9.tex, 349  babybeamer9.tex, 349  babybeamer1.tex, 359, 354  bibl.tpl, 47  cleardoublepage.sty, 101  fonttbl.tex, 78, 134  formula.tex, 164-166  gg.tex, 44-48  gg2.tex, 45-46  gg.msart.tpl, 297  inbibl.tpl, 263  intrart.tex, 35-43, 53, 55, 326, 331  typeset, 41-43  intrarti.tex, 450-452, 460, 459-461  intropres.tex, 53, 55, 57-58  legacy-article.tex, 304, 305  letter.tex, 308-302  newlattice.sty, 311, 379, 383, 386-392  newlattice.sty, 311, 379, 383, 386-392  notel.tex, 9-11  notelb.tex, 12-13  note2.tex, 13-15  noteslug.tex, 13  obtaining, 4  of presentations, 54, 326-331  products.eps (illus, file), 39  sampart.tex, 22, 32, 285-293, 371, 392, 437, 536  source file, 290-293  typeset, 286-288  sampartb.tbt, 437, 443-443  sampartb.tex, 421, 437, 439-441, 443  sampartb.tex, 421, 437, 439-441, 445  sampartb.tex, 421, 437, 439-441, 443  sampartb.tex, 421, 437, 439-441, 445  sampartb.tex, 421, 437,	437–443	quickbeamer2.pdf, 331
sampartb.tex (sample file), 421, 437, 439-441, 443 sampartu.tex (sample file), 376, 383, 392-398, 535 sample files ansart.tpl, 294 amsproc.template, 297 babybeamer1.pdf, 333-335 babybeamer2.tex, 334 babybeamer3.tex, 338 babybeamer4.tex, 343 babybeamer6.tex, 341 babybeamer6.tex, 341 babybeamer6.tex, 343 babybeamer7.tex, 343 babybeamer7.tex, 343 babybeamer8.tex, 347 babybeamer9.tex, 349 babybeamer9.tex, 349 babybeamer9.tex, 359 beamerstructure.tex, 352, 354 bibl.tpl, 47 cleardoublepage.sty, 101 fonttbl.tex, 78, 134 formula.tex, 164-166 gg.tex, 44-48 gg2.tex, 45-46 ggamsart.tpl, 297 inbibl.tpl, 263 intrart.tex, 35-43, 53, 55, 57-58 legacy-article.tex, 304, 305 letter.tex, 304	sampartb.blg (sample BibTEX log file),	quickbeamer2.tex, 331
272, 273, 285-293, 371, 392, 437, 536 sampartu.tex (sample file), 376, 383, 332-398, 535 sample files amsart.tpl, 294 amsproc.template, 297 babybeamer1.pdf, 333-335 babybeamer2.tex, 334 babybeamer3.tex, 343 babybeamer6.tex, 341 babybeamer6.tex, 343 babybeamer6.tex, 343 babybeamer6.tex, 344 babybeamer9.tex, 349 babybeamer9.tex, 352, 354 bibl.tpl, 47 cleardoublepage.sty, 101 fonttbl.tex, 78, 134 formula.tex, 164-166 gg.tex, 44-48 gg2.tex, 45-46 gggansart.tpl, 297 inbibl.tpl, 263 intrart.tex, 35-43, 53, 55, 326, 331 typeset, 286-288 sampartb.tbi, 437, 437-443 sampartb.tex, 321, 437, 439-441, 443 sampartb.tex, 321, 437, 439-441, 443 sampartb.tex, 376, 383, 392-398, 535 sample.cls (doc.class), 10, 11 sample.cls (doc.class), 10, 11 sample.cls (doc.class), 10 samples font, 313 of bibliographies, 47, 261-263, 423, 437, 437, 438, 446 of command (style) files, 311, 379, 383, 386-398 of indexes, 452, 450-452 samples (folder), 4, 9, 10, 12-15, 18-20, 35, 39, 44, 45, 47, 48, 78, 101, 134, 230, 263, 282, 285, 294, 297, 386, 392, 423, 437, 438, 450, 468, 496, 535, 548 creating, 4 sans serif document font family, 89, 94, 544 font shape, 55, 89, 90, 123, 196, 196, 512, 516 Helvetica, 89, 544 sans serif document font family, 89, 94, 544 font shape, 55, 89, 90, 123, 196, 196, 512, 516 Helvetica, 89, 544 sompartb.tbx, 421, 437, 439-441, 443 sampartb.tex, 376, 383, 392-398, 535 sample.cls (doc.class), 10, 11 sample.cls (doc. class), 10 samples sompartb.tex, 421, 437, 439-441, 443 sampartb.tex, 376, 383, 392-398, 535 sample.cls (doc. class), 10 samples sompartb.tex, 421, 437, 439-441, 443 sampartb.tex, 376, 383, 392-398, 535 sample.cls (doc. class), 10 samples sompartb.tex, 421, 437, 439-441, 443 sampartb.tex, 421, 437, 439-441, 443 sampartb.tex, 376, 383, 392-398, 535 sample.cls (doc. class), 10 samples sompartb.tex, 421, 437, 446 topmat.tpl, 247 topmal.tex, 376, 383, 392-398, 535 sample.cls (doc.class), 10 samples sompartb.tex, 421, 437, 446 topmat.tpl, 249 sampartb.tex, 421, 437, 446 topmat.tpl, 249 sample.cls (doc.class), 10 sam	441, 442	$\mathtt{sampart-ref.tex},\ 320,\ 323$
sampartu.tex (sample file), 376, 383,       392-398, 535       source file, 290-293         sample files       typeset, 286-288       sampartb.bib, 437, 437-443         amsproc.template, 297       sampartb.tex, 421, 437, 439-441, 443         babybeamer1.pdf, 333-335       sampartb.tex, 421, 437, 439-441, 443         babybeamer2.tex, 334       sampartb.tex, 376, 383, 392-398, 535         babybeamer3.tex, 343       sampartb.tex, 421, 437, 439-441, 443         babybeamer6.tex, 341       topmat.tpl, 282         babybeamer6.tex, 4343       sample.cls (doc. class), 10, 11         babybeamer7.tex, 343, 345-347       sample.cls (doc. class), 10         babybeamer9.tex, 349       sample.cls (doc. class), 10         babybeamer10.tex, 359       sample.cls (doc. class), 10         babybeamer1.pdf, 4, 9, 10, 12-15, 18-20       sample.cls (doc. class), 10         samples (folder), 4, 9, 10, 12-15, 18-20       samples (folder), 4, 9, 10, 12-15, 18-20         formula.tex, 164-166       35, 39, 44, 45, 47, 48, 78, 101, 134, 230, 263, 282, 285, 294, 297, 304, 308, 320, 326-328, 331, 333, 333, 331, 333, 331, 333, 334, 335, 359, 376, 386, 392, 423, 437, 438, 450, 468, 496, 535, 548         typeset, 286-288       sample (folder), 4, 9, 10, 12-15, 18-20         formula.tex, 164-166       sampartb.tex, 264-6         gaz, tex, 45-46       sampartb.tex, 343         gaz-tex, 45-36       sampartb.	sampartb.tex (sample file), 421, 437,	$\mathtt{sampart.tex},\ 125,\ 129,\ 131,\ 230,\ 266,$
sample files amsart.tpl, 294 amsproc.template, 297 babybeamer1.pdf, 333-335 babybeamer2.tex, 334 babybeamer3.tex, 338 babybeamer6.tex, 343 babybeamer6.tex, 341 babybeamer6.tex, 343 babybeamer6.tex, 344 babybeamer7.tex, 343 babybeamer7.tex, 344 babybeamer9.tex, 349 babybeamer9.tex, 349 babybeamer10.tex, 359 beamerstructure.tex, 352, 354 bibl.tpl, 47 cleardoublepage.sty, 101 fontbl.tex, 78, 134 formula.tex, 164-166 gg.tex, 44-48 gg2.tex, 45-46 gg.stex, 44-48 gg2.tex, 45-46 ggamsart.tpl, 297 inbibl.tpl, 263 intrart.tex, 35-43, 53, 55, 326, 331 typeset, 41-43 intrarti.tex, 35-43, 53, 55, 57-58 legacy-article.tex, 304, 305 letter.tex, 308-310 math.tex, 19-92 myams.tpl, 294-297 newlattice.sty, 311, 379, 383, 386-392 note1.tex, 9-11 note1b.tex, 12-13 note2.tex, 13-15 noteslug.tex, 13 obtaining, 4 of presentations, 54, 326-331 products.eps (illus. file), 39  sampartb.tbx, 421, 437, 439-441, 443 sampartb.tex, 216, 41, 43 sampartb.tex, 21, 437, 439-441, 443 sampartb.tex, 21, 437, 446 topmat.tex, 36, 437, 446 topmat.tex, 36, 426, 425, 437, 437, 446 of contmand (style) files, 311, 379, 383, 386-398 of indexes, 452, 450-452 sample.cls (doc. class), 10 sample.cls (d	439–441, 443	272, 273, <b>285–293</b> , 371, 392, 437,
sample files     amspart.tpl, 294     amsproc.template, 297     babybeamer1.pdf, 333-335     babybeamer2.tex, 334     babybeamer3.tex, 338     babybeamer4.tex, 343     babybeamer6.tex, 341     babybeamer6.tex, 341     babybeamer6.tex, 343     babybeamer7.tex, 343, 345-347     babybeamer9.tex, 349     babybeamer9.tex, 349     babybeamer9.tex, 349     babybeamer10.tex, 359     beamerstructure.tex, 352, 354     bibl.tpl, 47     cleardoublepage.sty, 101     fontbl.tex, 78, 134     formula.tex, 164-166     gg.tex, 44-48     gg2.tex, 45-46     ggamsart.tpl, 297     inbibl.tpl, 263     intrart.tex, 35-43, 53, 55, 57-58     legacy-article.tex, 304, 305     letter.tex, 308-310     math.tex, 17-19     mathb.tex, 19-22     myams.tpl, 294-297     nevlattice.sty, 311, 379, 383, 386-392     notel.tex, 9-11     noteblb.tex, 13     obtaining, 4     of presentations, 54, 326-331     products.eps (fillus. file), 39     typeset, 286-288     sampartb.bib, 427, 437-443     sampartb.tex, 221, 437, 439-441, 443     sampartb.tex, 376, 383, 392-398, 535     sample.cls (doc.class), 10, 11     symbolTables.pdf, 4, 9, 15, 19     template.bib, 423, 437, 446     topmat.tpl, 282     sample.cls (doc.class), 10     sample.	sampartu.tex (sample file), 376, 383,	
amsart.tpl, 294 amsproc.template, 297 babybeamer1.pdf, 333-335 babybeamer2.tex, 334 babybeamer3.tex, 338 babybeamer3.tex, 343 babybeamer6.tex, 341 babybeamer6.tex, 341 babybeamer6.tex, 343 babybeamer6.tex, 343 babybeamer7.tex, 343, 345-347 babybeamer10.tex, 349 babybeamer10.tex, 359 beamerstructure.tex, 352, 354 bibl.tpl, 47 cleardoublepage.sty, 101 fontbl.tex, 78, 134 formula.tex, 164-166 gg.tex, 44-48 gg2.tex, 45-46 gg.tex, 44-48 gg2.tex, 45-46 gg.tex, 44-48 intrarti.tex, 450-452, 460, 459-461 intropres.tex, 53, 55, 57-58 legacy-article.tex, 304, 305 letter.tex, 308-310 math.tex, 17-19 mathb.tex, 19-12 myams.tpl, 294-297 nevlattice.sty, 311, 379, 383, 386-392 notel.tex, 9-11 notelb.tex, 12-13 note2.tex, 13 obtaining, 4 of presentations, 54, 326-331 products.eps (illus. file), 39  sampartb.tex, 42, 143, 43, 439-441, 443 sampartb.tex, 43, 437, 437, 438, 392-398, 535 sample.cls (doc. class), 10, 11 SymbolTables.pdf, 4, 9, 15, 19 template.bib, 423, 437, 446 topmat.tpl, 282 sample.cls (doc. class), 10 samples font, 313 of bibliographies, 47, 261-263, 423, 437, 437-4438, 446 of command (style) files, 311, 379, 383, 386-398 of indexes, 452, 450-452 samples (folder), 4, 9, 10, 12-15, 18-20, 35, 39, 44, 45, 47, 48, 78, 101, 134, 230, 263, 282, 285, 294, 297, 304, 308, 320, 326-328, 331, 333, 339, 341, 343, 354, 358, 359, 376, 366, 392, 423, 437, 437, 437, 437, 438, 450 of command (style) files, 311, 379, 383, 368-398 of indexes, 452, 450-452 samples (folder), 4, 9, 10, 12-15, 18-20, 35, 39, 44, 45, 47, 48, 78, 101, 134, 230, 263, 282, 285, 294, 297, 364, 393, 341, 343, 354, 358, 359, 376, 366, 392, 423, 437, 437, 437, 437, 438, 446 of command (style) files, 311, 379, 383, 366-398 of indexes, 452, 450-452 samples (folder), 4, 9, 10, 12-15, 18-20, 35, 39, 44, 45, 47, 48, 78, 101, 134, 230, 263, 282, 285, 294, 297, 363, 365, 394, 41, 34, 354, 358, 359, 376, 365, 392,	<b>392–398</b> , 535	source file, 290–293
amsproc.template, 297 babybeamer1.pdf, 333-335 babybeamer2.tex, 334 babybeamer3.tex, 338 babybeamer3.tex, 338 babybeamer4.tex, 343 babybeamer5.tex, 341 babybeamer6.tex, 343 babybeamer6.tex, 343 babybeamer6.tex, 343 babybeamer7.tex, 343, 345-347 babybeamer9.tex, 349 babybeamer9.tex, 349 babybeamer9.tex, 349 babybeamer9.tex, 352 beamerstructure.tex, 352, 354 bibl.tpl, 47 cleardoublepage.sty, 101 fonttbl.tex, 78, 134 formula.tex, 164-166 gg.tex, 44-48 gg2.tex, 45-46 gg.tex, 45-46 gg.tex, 45-46 gg.tex, 45-46 intrarti.tex, 35-43, 53, 55, 326, 331 typeset, 41-43 intrarti.tex, 35-43, 53, 55, 57-58 legacy-article.tex, 304, 305 letter.tex, 308-310 math.tex, 17-19 mathb.tex, 19-22 myams.tpl, 294-297 newlattice.sty, 311, 379, 383, 386-392 notel.tex, 9-11 notelb.tex, 12-13 note2.tex, 13-15 noteslug.tex, 13 obtaining, 4 of presentations, 54, 326-331 products.eps (illus. file), 39 sampartb.tex, 321, 63, 389, 3998, 335 sample.cls (doc. class), 10 sample.cls (doc. class), 10 sample.cls (doc. class), 10 sample.cls (doc. class), 10 sample.cls, 11 sample.cls (doc. class), 10 sample.cls, 11 sample.cls, 12 sample.cls, 11 sample.cls, 12 sample.cls, 13 of bibliographies, 47, 261-263, 423, 437, 437-438, 446 of command (style) files, 311, 379, 383, 386-398 of indexes, 452, 450-452 samples (folder), 4, 9, 10, 12-15, 18-20, 35, 39, 44, 45, 47, 48, 78, 101, 313, 230, 263, 282, 285, 294, 297, 304, 308, 320, 326-328, 331, 333, 39, 341, 343, 354, 358, 359, 376, 386, 392, 423, 437, 438, 450, 468, creating, 4 sans serif document font family, 89, 94, 544 font shape, 55, 89, 90, 123, 196, 196, 512, 516 belevetica, 89, 544 sb (math subscript com.), 94 scaling grap	sample files	typeset, $286-288$
babybeamer1.pdf, 333-335 babybeamer2.tex, 334 babybeamer3.tex, 338 babybeamer3.tex, 343 babybeamer6.tex, 341 babybeamer6.tex, 343 babybeamer6.tex, 343 babybeamer6.tex, 343 babybeamer7.tex, 343, 345-347 babybeamer9.tex, 349 babybeamer9.tex, 349 babybeamer10.tex, 359 beamerstructure.tex, 352, 354 bibl.tpl, 47 cleardoublepage.sty, 101 fonttbl.tex, 78, 134 formula.tex, 164-166 gg.tex, 44-48 gg2.tex, 45-46 gg.tex, 44-48 gg2.tex, 45-46 jintrart.tex, 35-43, 53, 55, 326, 331 typeset, 41-43 intrarti.tex, 450-452, 460, 459-461 intropres.tex, 304, 305 letter.tex, 308-310 math.tex, 17-19 mathb.tex, 19-22 myams.tpl, 294-297 nevlattice.sty, 311, 379, 383, 386-392 notel.tex, 9-11 notelb.tex, 12-13 note2.tex, 13-15 noteslug.tex, 13 obtaining, 4 of presentations, 54, 326-331 products.eps (illus. file), 39  sample.cls (doc. class), 10 template.bitb, 423, 437, 446 topmat.tpl, 282 sample.cls (doc. class), 10 symbolTables.pdf, 4, 9, 15, 19 template.bitb, 423, 437, 446 topmat.tpl, 282 sample.cls (doc. class), 10 sample.cls (doc. class), 10 sample.cls (doc. class), 10 sample.cls (doc. class), 10 samples otemplate.bitb, 423, 437, 446 topmat.tpl, 282 sample.cls (doc. class), 10 samples of objective, 42, 446 topmat.tpl, 282 sample.cls (doc. class), 10 samples of ont, 313 of bibliographies, 47, 261-263, 423, 437, 437-438, 446 of command (style) files, 311, 379, 383, 386-398 of indexes, 45-2, 450-452 samples (folder), 4, 9, 10, 12-15, 18-20, 35, 39, 44, 45, 47, 48, 78, 101, 134, 230, 263, 282, 285, 294, 297, 386, 392, 423, 437, 437, 436 of command (style) files, 311, 379, 383, 386-398 of indexes, 45-2, 450-452 samples (folder), 4, 9, 10, 12-15, 18-20, 35, 39, 44, 45, 47, 48, 78, 101, 134, 230, 263, 282, 285, 294, 297, 386, 392, 423, 437, 438, 450, 468, 496, 535, 548 creating, 4 of command (style) files, 311, 379, 383, 386-398 of indexes, 45-2, 450-452 samples.cls (doc. class), 10 sample cls (doc. class), 10 sample cls (doc. class), 10 sample cls (doc. class), 10 sample.cls (doc. class), 10 sample.cls (doc. class), 10 sample.cls (doc. clas	$\mathtt{amsart.tpl},294$	$\mathtt{sampartb.bib},437,437 – 443$
babybeamer2.tex, 334 babybeamer3.tex, 338 babybeamer4.tex, 343 babybeamer5.tex, 341 babybeamer6.tex, 343 babybeamer6.tex, 343 babybeamer6.tex, 343 babybeamer7.tex, 343 babybeamer7.tex, 343 babybeamer7.tex, 343 babybeamer7.tex, 349 babybeamer9.tex, 349 babybeamer9.tex, 349 babybeamer9.tex, 349 babybeamer9.tex, 359 beamerstructure.tex, 352, 354 bibl.tpl, 47 cleardoublepage.sty, 101 fonttbl.tex, 78, 134 formula.tex, 164-166 gg.tex, 44-48 gggamsart.tpl, 297 inbibl.tpl, 263 intrart.tex, 35-43, 53, 55, 57-58 legacy-article.tex, 304, 305 letter.tex, 308-310 math.tex, 17-19 mathb.tex, 19-22 myams.tpl, 294-297 nevlattice.sty, 311, 379, 383, 386-392 notel.tex, 9-11 notelb.tex, 12-13 noteslug.tex, 13 obtaining, 4 of presentations, 54, 326-331 products.eps (illus. file), 39  sample.cls (doc. class), 10 symbolTables.pdf, 4, 9, 15, 19 template.bib, 423, 437, 446 topmat.tpl, 282 sample.cls (doc. class), 10 symbolTables.pdf, 4, 9, 15, 19 template.bib, 423, 437, 446 topmat.tpl, 282 sample.cls (doc. class), 10 samples font, 313 of bibliographies, 47, 261-263, 423, 437, 437-438, 446 of command (style) files, 311, 379, 383, 386-398 of indexes, 452, 450-452 samples (folder), 4, 9, 10, 12-15, 18-20, 35, 39, 44, 45, 47, 48, 78, 101, 134, 230, 263, 282, 285, 294, 297, 386, 392, 423, 437, 438, 450, 468, 496, 535, 548 creating, 4 sans serif document font family, 89, 94, 544 font shape, 55, 89, 90, 123, 196, 196, 512, 516 Helvetica, 89, 544 font shape, 55, 89, 90, 123, 196, 196, 512, 516 Helvetica, 89, 544 scaling graphics, 54 in figures, 259 in FoiffgX, 54 schöpf, Rainer, 523, 559, 560 School (BibTeX database field), 425	${\tt amsproc.template},297$	$\mathtt{sampartb.tex},421,437,439441,443$
babybeamer3.tex, 338 babybeamer4.tex, 343 babybeamer5.tex, 341 babybeamer6.tex, 343 babybeamer6block.tex, 343 babybeamer7.tex, 343 babybeamer7.tex, 343 babybeamer7.tex, 344 babybeamer9.tex, 347 babybeamer9.tex, 349 babybeamer10.tex, 359 beamerstructure.tex, 352, 354 bibl.tpl, 47 cleardoublepage.sty, 101 fonttbl.tex, 78, 134 formula.tex, 164-166 gg.tex, 44-48 gg2.tex, 45-46 gg.tex, 45-46 intrart.tex, 35-43, 53, 55, 57-58 legacy-article.tex, 304, 305 letter.tex, 308-310 math.tex, 17-19 mathb.tex, 19-22 myams.tpl, 294-297 nevlattice.sty, 311, 379, 383, 386-392 note1.tex, 9-11 note1b.tex, 12-13 noteslug.tex, 13 obtaining, 4 of presentations, 54, 326-331 products.eps (illus. file), 39  SymbolTables.pdf, 4, 9, 15, 19 template.bib, 423, 437, 446 topmat.tpl, 282 sample.cls (doc. class), 10 samples font, 313 of bibliographies, 47, 261-263, 423, 437, 437-438, 446 of command (style) files, 311, 379, 383, 386-398 of indexes, 452, 450-452 samples (folder), 4, 9, 10, 12-15, 18-20, 35, 39, 44, 45, 47, 48, 78, 101, 134, 230, 263, 282, 285, 294, 297, 304, 308, 320, 326-328, 331, 333, 339, 341, 343, 354, 358, 359, 376, 386, 392, 423, 437, 438, 450, 468, 496, 535, 548 creating, 4 sans serif document font family, 89, 94, 544 font shape, 55, 89, 90, 123, 196, 196, 512, 516 Helvetica, 89, 544  \text{\shother} \	$\verb babybeamer1.pdf , 333-335 $	sampartu.tex, 376, 383, <b>392-398</b> , 535
babybeamer4.tex, 343 babybeamer6.tex, 341 babybeamer6block.tex, 343 babybeamer7.tex, 343, 345-347 babybeamer9.tex, 347 babybeamer9.tex, 349 babybeamer10.tex, 359 beamerstructure.tex, 352, 354 bibl.tpl, 47 cleardoublepage.sty, 101 fontbl.tex, 78, 134 formula.tex, 164-166 gg.tex, 44-48 gg2.tex, 45-46 gg.ztex, 45-46 intrart.tex, 35-43, 53, 55, 326, 331 typeset, 41-43 intrarti.tex, 450-452, 460, 459-461 intropres.tex, 330, 330 gamsar.tpl, 294-297 nevlattice.sty, 311, 379, 383, 386-392 note1.tex, 9-11 note1b.tex, 12-13 note2.tex, 13-5 noteslug.tex, 13 obtaining, 4 of presentations, 54, 326-331 products.eps (illus. file), 39  template.bib, 423, 437, 446 topmat.tpl, 282 sample.cls, (doc. class), 10 samples font, 313 of bibliographies, 47, 261-263, 423, 437, 437-438, 446 of command (style) files, 311, 379, 383, 386-398 of indexes, 452, 450-452 sample.cls, 11 sample.cls, (doc. class), 10 samples font, 313 of bibliographies, 47, 261-263, 423, 437, 437-438, 446 of command (style) files, 311, 379, 383, 386-398 of indexes, 452, 450-452 sample.cls, 11 sample.cls, (doc. class), 10 samples font, 313 of bibliographies, 47, 261-263, 423, 437, 437-438, 446 of command (style) files, 311, 379, 383, 386-398 of indexes, 452, 450-452 sample.cls (doc. class), 10 samples font, 313 of bibliographies, 47, 261-263, 423, 437, 437-438, 446 of command (style) files, 311, 379, 383, 386-398 sinters, 452, 450-452 sample.cls (doc. class), 10 sample.cls font, 313 of bibliographies, 47, 261-263, 423, 437, 437-438, 446 of command (style) files, 311, 379, 383, 386-398 sinters, 452, 450-452 sample.cls font, 313 of bibliographies, 47, 261-263, 423, 437, 437-438, 446 of command (style) files, 311, 379, 383, 386-398 sinters, 42, 450-452 sample.cls font, 313 of bibliographies, 47, 261-263, 423, 437, 437-438, 446 of command (style) files, 311, 379, 383, 386-398 sof indexes, 452, 450-452 sample.cls font, 313 of bibliographies, 47, 261-263, 423, 437, 437-438, 446 of command (style) files, 311, 379, 383, 38-398 sof indexes, 452, 450-452 sample.cls font, 313 o	${\tt babybeamer2.tex},\ 334$	sample.cls (doc. class), 10, 11
babybeamer6.tex, 341 babybeamer6.tex, 343 babybeamer6.tex, 343 babybeamer7.tex, 343, 345-347 babybeamer8.tex, 347 babybeamer9.tex, 349 babybeamer9.tex, 359 beamerstructure.tex, 352, 354 bibl.tpl, 47 cleardoublepage.sty, 101 fonttbl.tex, 78, 134 formula.tex, 164-166 gg.tex, 44-48 gg.tex, 45-46 gg.tex, 45-46 gg.tex, 45-36 intrart.tex, 35-43, 53, 55, 326, 331 typeset, 41-43 intrarti.tex, 450-452, 460, 459-461 intropres.tex, 53, 55, 57-58 legacy-article.tex, 304, 305 letter.tex, 308-310 math.tex, 17-19 mathb.tex, 19-22 myams.tpl, 294-297 newlattice.sty, 311, 379, 383, 386-392 note1.tex, 9-11 note1b.tex, 12-13 note2.tex, 13-15 noteslug.tex, 13 obtaining, 4 of presentations, 54, 326-331 products.eps (illus. file), 39  topmat.tpl, 282 sample.cls, 11 sample.cls (doc. class), 10 samples font, 313 od bibliographies, 47, 261-263, 423, 437, 437-438, 446 of command (style) files, 311, 379, 383, 386-398 of indexes, 452, 450-452 sample.cls, 11 sample.cls (doc. class), 10 samples font, 313 od bibliographies, 47, 261-263, 423, 437, 438, 446 of command (style) files, 311, 379, 383, 386-398 of indexes, 452, 450-452 sample.cls, 11 sample.cls (doc. class), 10 samples font, 313 of bibliographies, 47, 261-263, 423, 437, 438, 446 of command (style) files, 311, 379, 383, 386-398 of indexes, 452, 450-452 sample.cls, 11 sample.cls (doc. class), 10 samples font, 313 of bibliographies, 47, 261-263, 423, 437, 438, 446 of command (style) files, 311, 379, 383, 386-398 of indexes, 452, 450-452 sample.cls, 11 sample.cls (doc. class), 10 samples font, 313 of bibliographies, 47, 261-263, 423, 437, 438, 446 of command (style) files, 311, 379, 383, 384, 434, 45, 47, 48, 78, 101, 134, 230, 263, 282, 285, 294, 297, 366, 392, 423, 437, 438, 450, 468, 496, 535, 548 creating, 4 sans serif document font family, 89, 94, 544 font shape, 55, 89, 90, 123, 196, 196, 512, 516 Helvetica, 89, 544 sans serif solventure.tex, 352, 354 sample.cls (alignment) and policies, 47, 261-263, 423, 437, 438, 446 of command (style) files, 311, 379, 383, 384, 434, 45, 47, 48,	${\tt babybeamer3.tex},338$	${\tt SymbolTables.pdf},4,9,15,19$
babybeamer6.tex, 343 babybeamer7.tex, 343, 345-347 babybeamer8.tex, 347 babybeamer9.tex, 349 babybeamer10.tex, 359 beamerstructure.tex, 352, 354 bibl.tpl, 47 cleardoublepage.sty, 101 fortbl.tex, 78, 134 formula.tex, 164-166 gg.tex, 44-48 gg.tex, 45-46 intrart.tex, 35-43, 53, 55, 326, 331 typeset, 41-43 intrarti.tex, 450-452, 460, 459-461 intropres.tex, 308-310 math.tex, 17-19 mathb.tex, 19-22 myams.tpl, 294-297 newlattice.sty, 311, 379, 383, 386-392 note1.tex, 9-11 notebl.tex, 12-13 note2.tex, 13-15 noteslug.tex, 13 obtaining, 4 of presentations, 54, 326-331 products.eps (illus. file), 39  sample.cls, 11 sample.cls (doc. class), 10 samples font, 313 of bibliographies, 47, 261-263, 423, 437, 437-438, 446 of command (style) files, 311, 379, 383, 386-398 of indexes, 452, 450-452 samples (folder), 4, 9, 10, 12-15, 18-20, 35, 39, 44, 45, 47, 48, 78, 101, 134, 230, 263, 282, 285, 294, 297, 304, 308, 320, 326-328, 331, 333, 339, 341, 343, 354, 358, 359, 376, 386, 392, 423, 437, 438, 450, 468, 496, 535, 548 creating, 4 sans serif document font family, 89, 94, 544 font shape, 55, 89, 90, 123, 196, 196, 512, 516 Helvetica, 89, 544 schopf, Rainer, 523, 559, 560 Schandl, Bernd, 123 scharfes (8, SS), 81, 515 Schleyer, Antoinette Tingley, 217, 553, 560 school (BieTeX database field), 425	babybeamer4.tex, 343	template.bib, 423, 437, 446
babybeamer 6block.tex, 343 babybeamer 7.tex, 343, 345-347 babybeamer 8.tex, 349 babybeamer 10.tex, 359 beamerstructure.tex, 352, 354 bibl.tpl, 47 cleardoublepage.sty, 101 fonttbl.tex, 78, 134 formula.tex, 164-166 gg.tex, 44-48 gg2.tex, 45-46 ggarsart.tpl, 297 inbibl.tpl, 263 intrart.tex, 35-43, 53, 55, 326, 331 typeset, 41-43 intrartitex, 450-452, 460, 459-461 intropres.tex, 304, 305 letter.tex, 308-310 math.tex, 17-19 mathb.tex, 19-22 myams.tpl, 294-297 newlattice.sty, 311, 379, 383, 386-392 note1.tex, 9-11 note1b.tex, 12-13 note2.tex, 13-15 noteslug.tex, 13 obtaining, 4 of presentations, 54, 326-331 products.eps (illus. file), 39  sample.cls (doc. class), 10 samples font, 313 of bibliographies, 47, 261-263, 423, 437, 437-438, 446 of command (style) files, 311, 379, 383, 383, 386-398 of indexes, 452, 450-452 samples (folder), 4, 9, 10, 12-15, 18-20, 35, 39, 44, 45, 47, 48, 78, 101, 134, 230, 263, 282, 285, 294, 297, 304, 308, 320, 326-328, 331, 333, 334, 354, 358, 359, 376, 386, 392, 423, 437, 438, 450, 468, 496, 535, 548 creating, 4 sans serif document font family, 89, 94, 544 font shape, 55, 89, 90, 123, 196, 196, 512, 516 Helvetica, 89, 544 in figures, 259 in FoilTEX, 54 Schleyer, Antoinette Tingley, 217, 553, 560 school (BieTEX database field), 425	babybeamer5.tex, 341	topmat.tp1, 282
babybeamer7.tex, 343, 345-347 babybeamer8.tex, 347 babybeamer9.tex, 349 babybeamer10.tex, 359 beamerstructure.tex, 359 beamerstructure.tex, 352, 354 bibl.tpl, 47 cleardoublepage.sty, 101 fortbl.tex, 78, 134 formula.tex, 164-166 gg.tex, 44-48 gg.tex, 45-46 gg.tex, 45-46 ggmsart.tpl, 297 inbibl.tpl, 263 intrart.tex, 35-43, 53, 55, 326, 331 typeset, 41-43 intrarti.tex, 450-452, 460, 459-461 intropres.tex, 53, 55, 57-58 legacy-article.tex, 304, 305 letter.tex, 308-310 math.tex, 17-19 mathb.tex, 19-22 myams.tpl, 294-297 newlattice.sty, 311, 379, 383,	babybeamer6.tex, 343	sample.cls, 11
babybeamer 8. tex, 347 babybeamer 9. tex, 349 babybeamer 10. tex, 359 beamer structure. tex, 352, 354 bibl. tpl, 47 clear double page. sty, 101 font bl. tex, 78, 134 formula. tex, 164–166 gg. tex, 44–48 gg. tex, 45–46 gg. smart. tpl, 297 inbibl. tpl, 263 intrart. tex, 35–33, 55, 57–58 legacy-article. tex, 304, 305 letter. tex, 308–310 math. tex, 17–19 mathb. tex, 17–19 mathb. tex, 19–22 myams. tpl, 294–297 nevlattice. sty, 311, 379, 383, 386–392 note1. tex, 9–11 note1b. tex, 13–15 notes lug. tex, 13 obtaining, 4 of presentations, 54, 326–331 products. eps (illus. file), 39  font, 313 of bibliographies, 47, 261–263, 423, 437, 437–438, 446 of command (style) files, 311, 379, 383, 386–398 of indexes, 452, 450–452 samples (folder), 4, 9, 10, 12–15, 18–20, 35, 39, 44, 45, 47, 48, 78, 101, 134, 230, 263, 282, 285, 294, 297, 304, 308, 320, 326–328, 331, 333, 339, 341, 343, 354, 358, 359, 376, 386, 392, 423, 437, 438, 450, 468, 134, 230, 263, 282, 285, 294, 297, 304, 308, 320, 326–328, 331, 333, 341, 343, 354, 358, 359, 376, 386, 392, 423, 437, 438, 450, 468, creating, 4 sans serif document font family, 89, 94, 544 font shape, 55, 89, 90, 123, 196, 196, 512, 516 Helvetica, 89, 544  'sb (math subscript com.), 159 \text{ sc (obs. IMTEX 2.09 font com.), 94} \text{ sc (obs. IMTEX 2.09 font com.), 159} \text{ in FoilTEX, 54} \text{ Schöpf, Rainer, 523, 559, 560} \text{ Scharfes s (B, SS), 81, 515} \text{ Scheyer, Antoinette Tingley, 217, 553, 560} \text{ school (BieTEX database field), 425}	${\tt babybeamer6block.tex},343$	sample.cls (doc. class), 10
babybeamer9.tex, 349 babybeamer10.tex, 359 beamerstructure.tex, 352, 354 bibl.tpl, 47 cleardoublepage.sty, 101 fonttbl.tex, 78, 134 formula.tex, 164-166 gg.tex, 44-48 gg2.tex, 45-46 ggmsart.tpl, 297 inbibl.tpl, 263 intrart.tex, 35-43, 53, 55, 326, 331 typeset, 41-43 intrarti.tex, 450-452, 460, 459-461 intropres.tex, 53, 55, 57-58 legacy-article.tex, 304, 305 letter.tex, 308-310 math.tex, 17-19 mathb.tex, 19-22 myams.tpl, 294-297 newlattice.sty, 311, 379, 383, 386-392 note1.tex, 9-11 note1b.tex, 12-13 note2.tex, 13-15 noteslug.tex, 13 obtaining, 4 of presentations, 54, 326-331 products.eps (illus. file), 39  of bibliographies, 47, 261-263, 423, 423, 446 of command (style) files, 311, 379, 424 of presentations, 54, 326-331 products.eps (illus. file), 39  of bibliographies, 47, 261-263, 423, 437, 438, 446 of command (style) files, 311, 379, 383, 438, 386-398 of indexes, 452, 450-452 samples (folder), 4, 9, 10, 12-15, 18-20, 35, 39, 44, 45, 47, 48, 78, 101, 134, 230, 263, 282, 285, 294, 297, 304, 308, 320, 326-328, 331, 333, 341, 343, 354, 358, 359, 376, 386, 392, 423, 437, 438, 450, 468, intrarti.tex, 450-452, 460, 459-461 intropres.tex, 53, 55, 57-58 legacy-article.tex, 304, 305 letter.tex, 308-310 math.tex, 17-19 mathb.tex, 19-22 myams.tpl, 294-297 hotel.tex, 9-11 note1b.tex, 12-13 hoteslug.tex, 13 obtaining, 4 of presentations, 54, 326-331 products.eps (illus. file), 39	$\verb"babybeamer7.tex", 343, 345-347"$	samples
baybeamer10.tex, 359 beamerstructure.tex, 352, 354 bibl.tpl, 47 cleardoublepage.sty, 101 fontbl.tex, 78, 134 formula.tex, 164-166 gg.tex, 44-48 gg.tex, 45-46 gg.tex, 45-46 intrart.tex, 35-43, 53, 55, 326, 331 typeset, 41-43 intrarti.tex, 450-452, 460, 459-461 intropres.tex, 308-310 math.tex, 17-19 mathb.tex, 19-22 myams.tpl, 294-297 nevlattice.sty, 311, 379, 383,	babybeamer8.tex, 347	font, 313
beamerstructure.tex, 352, 354 bibl.tpl, 47 cleardoublepage.sty, 101 fonttbl.tex, 78, 134 formula.tex, 164-166 gg.tex, 44-48 gg2.tex, 45-46 ggamsart.tpl, 297 inbibl.tpl, 263 intrart.tex, 35-43, 53, 55, 326, 331 typeset, 41-43 intrartilex, 450-452, 460, 459-461 intropres.tex, 53, 55, 57-58 legacy-article.tex, 304, 305 letter.tex, 308-310 math.tex, 17-19 mathb.tex, 19-22 myams.tpl, 294-297 newlattice.sty, 311, 379, 383, 386-392 notel.tex, 9-11 notelb.tex, 12-13 noteslug.tex, 13 obtaining, 4 of command (style) files, 311, 379, 384, 388, 386-398 of indexes, 459, 450-452 samples (folder), 4, 9, 10, 12-15, 18-20, 35, 39, 44, 45, 47, 48, 78, 101, 134, 230, 263, 282, 285, 294, 297, 304, 308, 320, 326-328, 331, 333, 496, 535, 548, 359, 376, 386, 392, 423, 437, 438, 450, 468, 468, 496, 535, 548 creating, 4 sans serif document font family, 89, 94, 544 font shape, 55, 89, 90, 123, 196, 196, 512, 516 Helvetica, 89, 544  **sb (math subscript com.), 159  **sc (obs. LATEX 2.09 font com.), 94 scaling graphics, 54 in figures, 259 in FoilTeX, 54 Schöpf, Rainer, 523, 559, 560 Schandl, Bernd, 123 scharfes s (ß, SS), 81, 515 Schleyer, Antoinette Tingley, 217, 553, 560 school (BieTeX database field), 425	babybeamer9.tex, 349	of bibliographies, 47, <b>261–263</b> , 423,
bibl.tpl, 47 cleardoublepage.sty, 101 fonttbl.tex, 78, 134 formula.tex, 164-166 gg.tex, 44-48 gg2.tex, 45-46 ggmsart.tpl, 297 inbibl.tpl, 263 intrart.tex, 35-43, 53, 55, 326, 331 typeset, 41-43 intrarti.tex, 450-452, 460, 459-461 intropres.tex, 53, 55, 57-58 letter.tex, 308-310 math.tex, 17-19 mathb.tex, 19-22 myams.tpl, 294-297 newlattice.sty, 311, 379, 383,	babybeamer10.tex, 359	437, <b>437–438</b> , 446
bibl.tpl, 47 cleardoublepage.sty, 101 fonttbl.tex, 78, 134 formula.tex, 164-166 gg.tex, 44-48 gg2.tex, 45-46 ggmsart.tpl, 297 inbibl.tpl, 263 intrart.tex, 35-43, 53, 55, 326, 331 typeset, 41-43 intrarti.tex, 450-452, 460, 459-461 intropres.tex, 53, 55, 57-58 letter.tex, 308-310 math.tex, 17-19 mathb.tex, 19-22 myams.tpl, 294-297 newlattice.sty, 311, 379, 383,	beamerstructure.tex, 352, 354	of command (style) files, 311, 379,
cleardoublepage.sty, 101 fonttbl.tex, 78, 134 formula.tex, 164-166 gg.tex, 44-48 gg.tex, 45-46 ggsmsart.tpl, 297 inbibl.tpl, 263 intrart.tex, 35-43, 53, 55, 326, 331 typeset, 41-43 intrarti.tex, 450-452, 460, 459-461 intropres.tex, 53, 55, 57-58 legacy-article.tex, 304, 305 letter.tex, 308-310 math.tex, 17-19 mathb.tex, 19-22 myams.tpl, 294-297 newlattice.sty, 311, 379, 383, 386-392 note1.tex, 9-11 note1b.tex, 12-13 noteslug.tex, 13 obtaining, 4 of presentations, 54, 326-331 products.eps (illus. file), 39  of indexes, 452, 450-452 samples (folder), 4, 9, 10, 12-15, 18-20, 35, 39, 44, 45, 47, 48, 78, 101, 36, 39, 445, 27, 48, 78, 101, 36, 39, 304, 308, 320, 326-328, 331, 333, 304, 308, 320, 326-328, 331, 333, 339, 341, 343, 354, 358, 359, 376, 386, 392, 423, 437, 438, 450, 468, and, 536, 548 creating, 4 sans serif document font family, 89, 94, 544 font shape, 55, 89, 90, 123, 196, 196, 512, 516 document font family, 89, 94, 544 sealing graphics, 54, 89, 544 scaling graphics, 54 in figures, 259 in FoilTEX, 54 schorf, Rainer, 523, 559, 560 school (BibTeX database field), 425		• • • • • • • • • • • • • • • • • • • •
$\begin{array}{llllllllllllllllllllllllllllllllllll$	<del>-</del> '	of indexes, 452, 450–452
$\begin{array}{llllllllllllllllllllllllllllllllllll$		samples (folder), 4, 9, 10, 12-15, 18-20,
$\begin{array}{c} {\rm gg.tex,} \ 44-48 \\ {\rm gg2.tex,} \ 45-46 \\ {\rm gg2.tex,} \ 45-46 \\ {\rm ggamsart.tpl,} \ 297 \\ {\rm inbibl.tpl,} \ 263 \\ {\rm intrart.tex,} \ 35-43, \ 53, \ 55, \ 326, \ 331 \\ {\rm typeset,} \ 41-43 \\ {\rm intrarti.tex,} \ 450-452, \ 460, \ 459-461 \\ {\rm intropres.tex,} \ 53, \ 55, \ 57-58 \\ {\rm legacy-article.tex,} \ 304, \ 305 \\ {\rm letter.tex,} \ 308-310 \\ {\rm math.tex,} \ 17-19 \\ {\rm mathb.tex,} \ 19-22 \\ {\rm myams.tpl,} \ 294-297 \\ {\rm newlattice.sty,} \ 311, \ 379, \ 383, \\ {\rm 386-392} \\ {\rm note1.tex,} \ 9-11 \\ {\rm note1b.tex,} \ 12-13 \\ {\rm note2.tex,} \ 13-15 \\ {\rm noteslug.tex,} \ 13 \\ {\rm obtaining,} \ 4 \\ {\rm of presentations,} \ 54, \ 326-331 \\ {\rm products.eps} \ (illus. file), \ 39 \\ \end{array} \begin{array}{c} 134, \ 230, \ 263, \ 282, \ 285, \ 294, \ 297, \\ 304, \ 308, \ 320, \ 326-328, \ 331, \ 333, \\ 304, \ 308, \ 320, \ 326-328, \ 331, \ 333, \\ 304, \ 308, \ 320, \ 326-328, \ 331, \ 333, \\ 309, \ 341, \ 343, \ 354, \ 358, \ 359, \ 376, \\ 386, \ 392, \ 423, \ 437, \ 438, \ 450, \ 468, \\ 496, \ 535, \ 548 \\ {\rm creating,} \ 4 \\ {\rm fort \ shape,} \ 55, \ 89, \ 90, \ 123, \ 196, \ 196, \\ {\rm font \ shape,} \ 55, \ 89, \ 90, \ 123, \ 196, \ 196, \\ {\rm font \ shape,} \ 55, \ 89, \ 90, \ 123, \ 196, \ 196, \\ {\rm font \ shape,} \ 55, \ 89, \ 90, \ 123, \ 196, \ 196, \\ {\rm font \ shape,} \ 55, \ 89, \ 90, \ 123, \ 196, \ 196, \\ {\rm font \ shape,} \ 55, \ 89, \ 90, \ 123, \ 196, \ 196, \\ {\rm font \ shape,} \ 55, \ 89, \ 90, \ 123, \ 196, \ 196, \\ {\rm font \ shape,} \ 55, \ 89, \ 90, \ 123, \ 196, \ 196, \\ {\rm font \ shape,} \ 55, \ 89, \ 90, \ 123, \ 196, \ 196, \\ {\rm font \ shape,} \ 55, \ 89, \ 90, \ 123, \ 196, \ 196, \\ {\rm font \ shape,} \ 55, \ 89, \ 90, \ 123, \ 196, \ 196, \\ {\rm font \ shape,} \ 55, \ 89, \ 90, \ 123, \ 196, \ 196, \\ {\rm scobs. \ InTex} \ 2.09 \ {\rm font \ com.}), \ 94, \\ {\rm scobs. \ InTex} \ 2.09 \ {\rm font \ com.}), \ 94, \\ {\rm scobs. \ InTex} \ 2.09 \ {\rm font \ com.}), \ 94, \\ {\rm scobs. \ InTex} \ 2.09 \ {\rm font \ com.}), \ 94, \\ {\rm scobs. \ InTex} \ 3.00, \ 196, \\ {\rm scobs. \ InTex} \ 3.00, \ 196, \\ {\rm scobs. \ InTex} \ 3.00,$	formula.tex, 164-166	35, 39, 44, 45, 47, 48, 78, 101,
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	gg.tex, 44-48	134, 230, 263, 282, 285, 294, 297,
inbibl.tpl, 263 intrart.tex, 35–43, 53, 55, 326, 331 typeset, 41–43 intrarti.tex, 450–452, 460, 459–461 intropres.tex, 53, 55, 57–58 legacy-article.tex, 304, 305 letter.tex, 308–310 math.tex, 17–19 mathb.tex, 19–22 myams.tpl, 294–297 newlattice.sty, 311, 379, 383, 386–392 note1.tex, 9–11 note1b.tex, 12–13 noteslug.tex, 13 obtaining, 4 of presentations, 54, 326–331 products.eps (illus. file), 39  386, 392, 423, 437, 438, 450, 468, 496, 535, 548 creating, 4 sans serif document font family, 89, 94, 544 font shape, 55, 89, 90, 123, 196, 196, 512, 516 Helvetica, 89, 544 scaling graphics, 54 in figures, 259 in Foil∏EX, 54 Schöpf, Rainer, 523, 559, 560 Schandl, Bernd, 123 scharfes s (β, SS), 81, 515 Schleyer, Antoinette Tingley, 217, 553, 560 school (BibTeX database field), 425	gg2.tex, 45-46	304, 308, 320, 326–328, 331, 333,
$\begin{array}{llllllllllllllllllllllllllllllllllll$	ggamsart.tpl, 297	339, 341, 343, 354, 358, 359, 376,
$\begin{array}{llllllllllllllllllllllllllllllllllll$	inbibl.tpl, 263	386, 392, 423, 437, 438, 450, 468,
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		
$\begin{array}{llllllllllllllllllllllllllllllllllll$		creating, 4
$\begin{array}{llllllllllllllllllllllllllllllllllll$	intrarti.tex, 450-452, 460, 459-461	sans serif
legacy-article.tex, 304, 305 letter.tex, 308-310 math.tex, 17-19 mathb.tex, 19-22 myams.tpl, 294-297 newlattice.sty, 311, 379, 383, 386-392 note1.tex, 9-11 note1b.tex, 12-13 noteslug.tex, 13 obtaining, 4 of presentations, 54, 326-331 products.eps (illus. file), 39  font shape, 55, 89, 90, 123, 196, 196, 196, 123, 516 Helvetica, 89, 544 Helvetica, 89, 544 Melvetica, 89, 5		document font family, 89, 94, 544
letter.tex, 308-310       512, 516         math.tex, 17-19       Helvetica, 89, 544         mathb.tex, 19-22       \sb (math subscript com.), 159         myams.tpl, 294-297       \sc (obs. LATEX 2.09 font com.), 94         newlattice.sty, 311, 379, 383,       scaling graphics, 54         386-392       in figures, 259         note1.tex, 9-11       in FoilTEX, 54         note1b.tex, 12-13       Schöpf, Rainer, 523, 559, 560         note2.tex, 13-15       Schandl, Bernd, 123         noteslug.tex, 13       scharfes s (β, SS), 81, 515         obtaining, 4       Schleyer, Antoinette Tingley, 217, 553,         of presentations, 54, 326-331       560         products.eps (illus. file), 39       school (BiBTEX database field), 425	legacy-article.tex, 304, 305	font shape, 55, 89, 90, <b>123</b> , <b>196</b> , 196,
mathb.tex, 19-22       \sb (math subscript com.), 159         myams.tpl, 294-297       \sc (obs. IΔTEX 2.09 font com.), 94         newlattice.sty, 311, 379, 383,       scaling graphics, 54         386-392       in figures, 259         note1.tex, 9-11       in FoilTeX, 54         note2.tex, 13-15       Schöpf, Rainer, 523, 559, 560         noteslug.tex, 13       scharfes s (β, SS), 81, 515         obtaining, 4       Schleyer, Antoinette Tingley, 217, 553, of presentations, 54, 326-331         products.eps (illus. file), 39       school (ΒΙΒΤΕΧ database field), 425	letter.tex, 308-310	
myams.tpl, 294–297 newlattice.sty, 311, 379, 383, 386–392 note1.tex, 9–11 note1b.tex, 12–13 note2.tex, 13–15 noteslug.tex, 13 obtaining, 4 of presentations, 54, 326–331 products.eps (illus. file), 39  \sc (obs. LATEX 2.09 font com.), 94 scaling graphics, 54 in figures, 259 in FoilTEX, 54 Schöpf, Rainer, 523, 559, 560 Schandl, Bernd, 123 scharfes s (β, SS), 81, 515 Schleyer, Antoinette Tingley, 217, 553, 60 school (BiBTEX database field), 425	math.tex, 17-19	Helvetica, 89, 544
myams.tpl, 294–297 newlattice.sty, 311, 379, 383, 386–392 note1.tex, 9–11 note1b.tex, 12–13 note2.tex, 13–15 noteslug.tex, 13 obtaining, 4 of presentations, 54, 326–331 products.eps (illus. file), 39  \sc (obs. LATEX 2.09 font com.), 94 scaling graphics, 54 in figures, 259 in FoilTEX, 54 Schöpf, Rainer, 523, 559, 560 Schandl, Bernd, 123 scharfes s (β, SS), 81, 515 Schleyer, Antoinette Tingley, 217, 553, 60 school (BiBTEX database field), 425	mathb.tex, 19-22	\sb (math subscript com.), 159
newlattice.sty, 311, 379, 383,  386-392  note1.tex, 9-11  note1b.tex, 12-13  note2.tex, 13-15  noteslug.tex, 13  obtaining, 4  of presentations, 54, 326-331  products.eps (illus. file), 39  scaling graphics, 54  in figures, 259  in FoilTeX, 54  Schöpf, Rainer, 523, 559, 560  Schandl, Bernd, 123  scharfes s (ß, SS), 81, 515  Schleyer, Antoinette Tingley, 217, 553,  560  school (BibTeX database field), 425		=
386-392       in figures, 259         note1.tex, 9-11       in FoilTeX, 54         note1b.tex, 12-13       Schöpf, Rainer, 523, 559, 560         note2.tex, 13-15       Schandl, Bernd, 123         noteslug.tex, 13       scharfes s (ß, SS), 81, 515         obtaining, 4       Schleyer, Antoinette Tingley, 217, 553, of presentations, 54, 326-331         products.eps (illus. file), 39       school (BiBTeX database field), 425		
note1.tex, 9-11 in FoilT <sub>E</sub> X, 54 note1b.tex, 12-13 Schöpf, Rainer, 523, 559, 560 note2.tex, 13-15 Schandl, Bernd, 123 noteslug.tex, 13 scharfes s (\(\mathbe{B}\), SS), 81, 515 obtaining, 4 Schleyer, Antoinette Tingley, 217, 553, of presentations, 54, 326-331 products.eps (illus. file), 39 school (BibTeX database field), 425	** * * * * * * * * * * * * * * * * * * *	
note1b.tex, 12–13       Schöpf, Rainer, 523, 559, 560         note2.tex, 13–15       Schandl, Bernd, 123         noteslug.tex, 13       scharfes s (β, SS), 81, 515         obtaining, 4       Schleyer, Antoinette Tingley, 217, 553, of presentations, 54, 326–331       560         products.eps (illus. file), 39       school (BibTeX database field), 425		
$\begin{array}{llllllllllllllllllllllllllllllllllll$		<b>2</b> ·
noteslug.tex, 13 scharfes s $(\beta, SS)$ , $81, 515$ obtaining, 4 Schleyer, Antoinette Tingley, 217, 553, of presentations, 54, 326–331 560 school (BiBTEX database field), 425		
obtaining, 4 Schleyer, Antoinette Tingley, 217, 553, of presentations, 54, 326–331 560 school (BiBTeX database field), 425		
of presentations, 54, 326–331 560 products.eps (illus. file), 39 school (BibTeX database field), 425	<u> </u>	
products.eps (illus. file), 39 school (BibTeX database field), 425	9.	<b>v</b> ,
	- · · · · ·	
	- ' '	

scope	files to include, 260, 400, 477, 478,
delimited by braces, 71–73	479, 496
of \allowdisplaybreaks commands,	fonts, 88–95
242	semicolon (;), 9, 62
of command declarations, 124,	sentences
<b>367–368</b> , 382	terminating, 11, <b>64–67</b>
of commands, 71–73, 90, 139	with periods, 279
global and local, 74	series (BibTrX database field), 425
setting, with environments, 96, 213	series commands, for fonts, see under
\scriptscriptstyle (math font size	font commands and font
com.), <b>199</b> , 204	command declarations
\scriptsize (font size com.), 93, 93, 517	serif (font shape), see also under roman,
\scriptstyle (math font size com.), 199,	89, 89
204	Seroul, Raymond, 553, 560
\scshape (font shape com. dec.), 90, 91,	\setbeamercolor (beamer com.), 350
123, 516	\setbeamertemplate (beamer com.), 355
scshape (font shape env.), 123	\setcounter (counter-setting com.), 74,
\searrow (\square math arrow), 507	233, 399, 402
\sec (sec math op.), 172, 510	\setlength (length setting com.), 99,
secnumdepth (counter), 403	100, 113, <b>404</b>
\section (struct. com.), 46, 55, <b>252–255</b> ,	setlength environment, 96, 213
331, 350, 467	\setminus (\ math op.), 506
optional argument of, 253	setspace (pack.), 99
section (counter), 398, 399	\settodepth (measurement com.), 406
section (§ text sym.), 81, 518	\settoheight (measurement com.), 406
, , , , , , , , , , , , , , , , , , ,	9 (
\section* (struct. com.), 46, 253, 467	\settowidth (measurement com.), 406
sectioning	\sffamily (font shape com. dec.), 90, 94,
commands, see also structural	123, <i>516</i>
commands	sffamily (font shape env.), 123
optional arguments of, 253	SGML (Standard Generalized Markup
provided by amsart doc. class, 254	Language), 523
provided by article doc. class,	shape commands, for fonts, see under
254	font commands and font
provided by book doc. classes,	command declarations
466–467	\sharp (\pm math sym.), 508
syntax of, 253	short
of articles, 46, <b>252–255</b>	arguments, of user-defined
of books, <b>466–467</b> , 479	commands, 373–374
of documents, 11, 35–41, 46, 48, 49,	arguments, of user-defined
51, 52, 66, 68, 164, 248, 251,	environments, 385
<b>252–255</b> , 261, 267, 285, 304,	commands, <b>73</b> , 90, 273, 284
308–310, 406, 437, 442, 449, 459,	pages, warnings about, 530
<b>466–467</b> , 522, 536	shorthand, see under user-defined
of presentations, 55, 328, 331	commands
\sectionname (redef. name)	\shortmid (  binary rel.), 504
and hyperref package, 323	\shortparallel ( $\parallel$ binary rel.), $504$
sections, numbering of, 252	\shoveleft (align. com.), 214
in books, 466	\shoveright (align. com.), 214
of equations within, 156, 250	\show (command-examination com.),
of proclamations within, 127	377, <b>377</b> , 378, 534
\see (indexing cross-ref. com.), 457	\showhyphens (hyphdisp. com.), 84
\seename (redef. name), 376	showidx (pack.), 311, 453
\selectfont (font selection com.), 95	showkeys (pack.), 257, 313
selecting	options, 257

value-examination com.), 115,	for appreviations and acronyms, 91,
377, 378, 534	480
shrinkable lengths, 56, 101, 102, <b>377</b> , <b>406</b> ,	\smaller (font size com.), 94
407, 413, <b>530</b>	\smallfrown (\sigma \text{binary rel.}), 504
side-setting, math symbols, 194–195	\smallint (∫ math sym.), 508
sidebars, in beamer presentations, 328,	smallmatrix (subsid. math env.), 235
331, 343	\smallsetminus (\sim math op.), 506
\sideset (math com.), 194-195	\smallskip (spacing com.), 104
\Sigma (Σ Greek char.), 502	\smallsmile (\sim \text{binary rel.}), 504
\sigma ( $\sigma$ Greek char.), 502	\smash (spacing com.), 115, <b>201</b>
\signature (letter com.), 309	optional argument of, 201
\sim (~ binary rel.), 503	\smile (\scriptimes binary rel.), 503
\simeq ( $\simeq$ binary rel.), 503	Snow, Wynter, 553, 560
simple alignment, of formulas, 31, 30–31	Solaris, see unix
\sin (sin math op.), 26, 170, 172, 196,	solid boxes, 113–114, see also struts
510	solution (beamer distr. directory), 358
single	somedefs (pack.), 313
guillemet, 519	sort keys, $455-456$
quote, 11	case sensitivity of, 462
keys, 9, 23, 62, <b>75</b>	sorting, of index entries, 455–456
text symbols, 519	source files, 4–5, 5, <b>7–8</b> , 9, 18, 35, 51, 52
single quotation, 519	64, 82, 87, 145, 271, 415, 447,
single-lined boxes, see under boxes	461, 473, 496, 525
\sinh (sinh math op.), 172, 510	errors in, 19–22, 491, 498, 534
size	naming of, 4, 44
of files	platform independence of, 3, 9
PDF, 318	putting on the Internet, 317–323
PostScript, <b>317</b> , 319	disadvantages of, 317
of fonts, 55, 89, 93, <b>93–94</b> , 123, 517	readability of, 19, 65, 154, 166,
commands for, see under font	363–367, 379, 415
commands	structure of, see also document
document class options for, 297,	style parameters, see styles,
306	document parameters for
in math, 199	typesetting, 4, 9, 12, 20, 28, 63, 74,
of hyperlinks in PDF files, 322	529, 534
of math delimiters, <b>168–170</b> , 184	white space in, 19
of paper, document class options for,	sources, for fonts, 546
298, 306	\sp (math superscript com.), 159, 183
\sl (obs. IAT <sub>F</sub> X 2.09 font com.), 94, 95	space bar, 9, 11, 53, 63, 325, 334
slanted (font shape), 88, 90, <b>91</b> , 94, 95,	spaces
<b>123</b> , 156, <i>516</i>	at the beginning of a line, 64, 103
and italic correction, 92	at the end of a line, 64, 65, 84
context dependence of, 91	blue, see also tie, unbreakable
slashed L's and O's $(1, L, \emptyset, \emptyset)$ , 81, 515	spaces, nonbreakable spaces, 76
slides, see under presentations	consist of glue, 530
slides (obs. doc. class), 303, 529	expanding, 106
\slshape (font shape com. dec.), 90, 91,	filling lines with, 106
92, 94, 95, 123, <i>516</i>	in arguments of commands, 85
slshape (font shape env.), 123	
- //	\bibtem, 266
slugs, 13, 96, 249, 300, 307	\cite, 264
\SMALL (font size com.), 93, 93, 517	\index, 462
\Small (font size com.), 93, 93, 517	in command definitions, 367
\small (font size com.), <b>93</b> , 93, 517	in command names, 69
small caps (font shape), 88, 90, <b>91</b> , <b>123</b> ,	in delimited commands, 379–380
516	in math environments, 153

spaces (continued)	vertical
in tabular environments, 135	adding to table of contents, 474
in user-defined commands, 313	adjusting, 56, 139, 481
in \verb commands, 148	adjusting with the setspace
in verbatim environments, 146	package, 99
interword (\_), 11, 66, 70, 102, 190,	in boxes, 115
520	in indexes, 267, 449
multiple, act as one, 19, 64, 71	in math, $200-201$
separating words with, 11, 64, 383,	in text, 15, <b>104–105</b> , 201, 377, 474,
427	482, 486
suppressing, 383, 458	preventing removal of, 105
terminating commands with, 19, 69,	using the setspace package, 99
154	spacing commands
typed for readability, 22, 65, 135, 367	avoiding direct use of, 481
unbreakable (* tie), 11, 28, 63, 66,	horizontal, see horizontal spacing
75, <b>76</b> , 99, <i>520</i>	vertical, see vertical spacing
absorb spaces, 76	\spadesuit ( math sym.), 508
in BibTeX databases, 427	\spbreve (~ math accent), 177, 177, 512
with cross-references, 257	\spcheck (\forall \math accent), 177, 183, 512
visible (_), 11, 63	\spdddot (" math accent), 177, 512
and \verb* command, 148	\spddot (" math accent), 177, 177, 512
spacing	\spdot ( math accent), 177, 512
between characters, 530	special
between dots with \hdotsfor	braces, 18, 49, 72, 73, 152, 153, 157
commands, 233	balancing, 72
between math symbols, 187–192	characters, 15, 63, <b>76</b> , <b>77</b> , <b>77</b> , <b>78</b> ,
commands, see spacing commands	515-519
determined by document classes, 102	in \index commands, 457
horizontal	keys, 9, 17, <b>63</b> , 76
adjusting, 188	spelling checkers, 48, 495
in math, <b>19</b> , <b>154–156</b> , <b>187–192</b> , 233,	\sphat (^ math accent), 177, 512
236	\sphericalangle (< math sym.), 508
in text, 11, <b>102–104</b> , 114, 126, 414,	Spivak, Michael D., 522, 545
513, 520	split (subsid. math align. env.), 208,
interword, 11, 64–67, 70, 76, 102,	211, <b>230–231</b> , 298
383, 427, 520	and \allowdisplaybreaks
preventing removal of, 103	commands, 243
in text, 102–106	numbering of equations within,
intercolumn, 209, 220, 220	230–231
in aligned math environments, 224,	rules for, 231
228	splitting
in tabular environments, 136	documents into multiple files,
interline, 242, 370, 482	476–479
adjusting, 95, 98–99, 104, 114	formulas across lines, 212–214
double, 99	\sptilde ( $^{\sim}$ math accent), 177, 512
rules	\sqcap ( $\sqcap$ math op.), $506$
and delimited commands, 379–380	\sqcup (⊔ math op.), 506
for commands, 69, 154	\sqrt $(\sqrt{x} \text{ math com.}), 19, 27, 161$
in arguments of \index commands,	optional argument of, 70
462	\sqsubset (□ binary rel.), 503
in math, 19, 154–156, 187–192,	\sqsubseteq ( $\sqsubseteq$ binary rel.), 503
200–201	\sqsupset (□ binary rel.), 503
in text, 11, 19, <b>64–67</b> , <b>102–106</b>	\sqsupseteq (⊒ binary rel.), 503
in \text commands, 154	\square ( $\square$ math sym.), 508
	square roots, 27, 161

\SS (SS), 81, 515	style files, BibTrX, see bst
\ss (B), 81, 515	styles
stacking math symbols, 192–193	bibliographical, see also bst, 266
Standard Generalized Markup Language	document parameters for, 552
(SGML), 523	for counters, 87, 123, 382, 401,
\star (* math op.), 506	<b>400–401</b> , 411
starred commands and environments, see	of pages, 268–270
under *-form and specific	of proclamations, <b>129–131</b> , 524
commands and environments	of tables, 140
start of chapters, document class options	text environments, 123
for, 468	subarray (subsid. math env.), 161, 176
\stepcounter (counter-incr. com.), 402	subentries, in indexes, 267, 449, <b>453</b> , 454,
sterling (£ text sym.), $519$	456
\stop (interactive control com.), 535	subequations (disp. math env.), 203, 204,
stretchable	219, 401
horizontal braces, 178–179	subformulas
lengths, 102, <b>378</b> , <b>406</b> , 407, 530	indentation of, 217
lines, 179	rules for, <b>215–217</b> , 223–224
math arrows, 179, 240–242	shorthand commands for, 364–366,
math delimiters, 167–168	372–373
math symbols, 178–180	\subitem (index com.), 267, 449
vertical spacing, in displayed text	\subjclass (top matter com.)
environments, 406	optional arguments of, 279
STRING (bibl. entry type), 436	rules for using, 279
structural commands	\subjclassname (redef. name), 376
$\appendix$ , $255$ , $467$	subject classifications, AMS, 279
$\begin{tabular}{ll} \begin{tabular}{ll} \beg$	\subparagraph (struct. com.), 252, 466
\chapter, 253, 255, 304, 466, 466, 467	subparagraph (counter), 399
\frontmatter, $467$	subscripts, math, 23, 25, 158–159, 161,
hierarchy of, 252, 466	182
in presentations, 350	as limits, <b>25</b> , <b>161</b> , 171–176, 182, 299
$\mbox{\mbox{\it mainmatter}},467$	as multiline limits, 176
optional arguments of, 253	double, 199
\paragraph, <b>252</b> , 466	font size of, 199
\paragraph*, 253	with horizontal braces, 178
\part, 253, 304, 466	\subsection (struct. com.), 46, <b>252</b> , 350,
provided by amsart doc. class, 254	466, 467
provided by article doc. class, 254	subsection (counter), 399
provided by book doc. classes,	\subsection* (struct. com.), 46, 467
466–467	\subsectionname (hyperref redef.
\section, 46, <b>252–255</b> , 467	name), 323
\section*, 46, 253, 467	\Subset (€ binary rel.), 504
\subparagraph, 252, 466	\subset (C binary rel.), 503
\subsection, 46, <b>252</b> , 466, 467	\subseteq (\subseteq binary rel.), 503
\subsection*, 46, 467	\subseteqq (\leftarrow \text{binary rel.}), 504
\subsubsection, $46$ , $252$ , $466$ \subsubsection*, $46$	\subsetneq (\subsetneq neg. binary rel.), 505
syntax of, 253	\subsetneqq ( $\subsetneq$ neg. binary rel.), 505 subsidiary math environments
structures, theorem-like, see	aligned, 211, <b>227–230</b> , 243
proclamations	aligned, 211, 227-230, 243 alignedat, 227-230, 243
struts, 114, 139, 200	and \allowdisplaybreaks
style (sty) files, see also packages, 250,	commands, 243
366, 386–392	array, 208, 210, 229, 232, <b>236–238</b> ,
commands in, 386	312, 313, 523, 551, 552
terminating, 392	Bmatrix, 235
O)	bmatrix, 235
	· · · / · · · ·

subsidiary math environments	indents (\noindent com.), 99, 484
(continued)	italic correction, 92
cases, $33$ , $208$ , $210$ , $239$	ligatures, <b>79</b> , 181, 365
CD, 240-242	line breaks (\nolinebreak com.), 99
for aligning formulas, 208, 209,	loading of the amsmath package, 300
<b>227–231</b> , 243, 298	numbering, 211, 215
${\tt gathered},\ 211,\ 227-230,\ 243$	of equations, 30, 31, 157, 201, 211
$\mathtt{matrix},\ 25-26,\ 208,\ 210,\ 231,\ \textbf{232-238}$	213, 215, 218, 231, 270
numbering of, 230, 231	of first page of documents, 270
page breaks in, 242	of proclamations, 129, 130, 382
pmatrix, 25-26, 235	of structural units, 46, 253, 467
smallmatrix, 235	Overfull \hbox warnings, 96
split, 208, 211, <b>230-231</b> , 243, 298	page breaks (\nopagebreak com.),
subarray, 161, 176	100
Vmatrix, 183, 235	placement of floats, 260
vmatrix, 25, 26, <b>235</b>	q.e.d. symbol, 132
\substack (math com.), 161, 176, 176	spaces, 383, 458
substitution, of fonts, 94, 318, 484	\Supset (∋ binary rel.), 504
subsubentries, in indexes, 267, 449, <b>454</b> ,	\supset (⊃ binary rel.), 503
456	\supseteq (⊇ binary rel.), 503
\subsubitem (index com.), 267, 449	\supseteqq ( $\supseteq$ binary rel.), 504
\subsubsection (struct. com.), 46, 252,	\supsetneq ( $\supseteq$ binary rel.), 505
466	\supsetneqq ( $\supseteq$ binary rel.), 505
subsubsection (counter), 399	\surd $(\sqrt{\text{math sym.}})$ , 508
\subsubsection* (struct. com.), 46	Sutor, Robert, 558
\subsubsectionname (redef. name), 322	Swanson, Ellen, 217, 553, 560
subtraction, 22, 63, 157	\swapnumbers (theorem-style com.), 131
\succ (> binary rel.), 503	\swarrow (\squarrow), 507
	\symbol (symbol com.), 77, 311
\succapprox (\subseteq binary rel.), 504	7
\succcurlyeq (\sim \binary rel.), 504	symbol alphabets, math, 197
\succeq (\subseteq binary rel.), 503	blackboard bold, 197
\succnapprox (\subseteq \text{binary rel.}), 505	calligraphic, 197
\succneqq (\(\neg \) binary rel.), 505	Euler Fraktur, 197
\successin (\subseteq binary rel.), 505	Greek, 197
\succsim (\subseteq \text{binary rel.}), $504$	symbolic references, showing in margins
\sum ( $\sum_{i=1}^{n}$ large math op.), 26, 175, 198,	<b>257</b> , 313
511	symbolic referencing, 28, see also
with primes, 194	cross-referencing, 29, <b>255–258</b> ,
sumlimits (opt. of amsmath pack.), 299	531
sums, 26, 27, 174	symbols
\sup (sup math op.), 172, 510	as footnote indicators, 87
superscripts, <b>23</b> , 25, <b>158–159</b> , 161, 177,	math, 19, 20, 63, 131, 177, 182, 240
182	249, 294, 311, 501-513
as limits, <b>25</b> , <b>161</b> , 171, 174–176, 182	alphabets, 197
as multiline limits, 176	and delimiters, 24, 166, 168
in math	bold, <b>197–199</b> , 301, 312
as limits, 299	building new, 183, <b>192–195</b> , 372
font size of, 199	classification of, <b>188–189</b> , 195
with horizontal braces, 178	declaring types of, 195
in text, 311, 519	end of proof, 113, 374
support, technical, see technical support	in text, 365
\suppressfloats (float com.), 260	large, 227–229
suppressing	negated, 194–195
creation of auxiliary files, 486, 531	shorthand commands for, 364
hyperlinks in PDF files, 322	side-setting, 194–195

sizes of, 199	auxiliary file (toc), 473, 487, 532
spacing of, 187–192	commands, 473, 474
stacking, 192–193	depth of, 403
stretchable, 178–180	fragile commands in, 74, 475
suppressing, 131	in frames, 328
text, 76, 77, 80, 278, 516, 518, 519	in presentations, 358
SymbolTables.pdf (sample file), 4, 9, 15,	typesetting, 473–475
19	tabs, setting, 141
synchronization (inverse search), 5, 494,	tabular (table env.), 78, 133-140, 237,
498	259, 312, 313, 523, 551, 552
systems of equations, 225–226	arguments of, 135
systems, operating, see Mac, PC, or UNIX	optional, 135
	breaking lines in, 135
T	column-formatting in, 136
\t (^ tie text accent), 79, 516	horizontal lines in, 135, 137
T1 font encoding, 82, 519, 547	intercolumn space in, 136
tab	\parbox in, 111
character, 63, 64, 68, 102	rules for, 135
Tab key, 9, 11, 63	vertical lines in, 135
Tab key, 9, 11, 63	width of columns in, 136
tabbing (display text env.), 141-143, 551,	tabularx (pack.), 313
552	\tag, 29, 201, 202, 211, 213, 215, 218,
table (counter), 399	230, 231
table (float env.), 258-259	\tag*, 202
optional arguments of, 260, 486	tags (names for equations), 29, 201–204,
placement of, 484, 486	211, 213, 215, 218, 230, 231
table* (float env.), 259	top-or-bottom placement of, 298
\tablename (redef. name), 376	\tan (tan math op.), 172, 510
and hyperref package, 323	\tanh (tanh math op.), 172, 510
\tableofcontents (front-matter com.),	Tantau, Till, 325, 359, 552, 560
328, <b>473</b> , 532	\tau ( $\tau$ Greek char.), 502
tables, <b>133–140</b> , 141, 237, <b>259</b> , 260, 313,	\tbinom (inline-style binomial com.), 160
523, 551, 552	tbtags (doc. class opt.), 298
captions in, 134, <b>259</b> , 476	technical reports, in BibTeX database
fragile commands in, 74	files, 434–435
commands for, 135, 137–140, 259,	technical support
476	on the Internet, 542
cross-referencing of, 134	provided by TEX users groups, 541
designing, 140	provided by the AMS, 542
double-column, 259 float controls, 134	TECHREPORT (bibl. entry type), 425, 434-435
forcing typesetting of, 101	template.bib (sample bibl. file), 423,
hyphenation, 528	437, 446
intersection of lines in, 140, 313	templates, 271, 306
lists of, see under lists	bibliographical, 47, 261, 423, 437, 446
multiline entries in, 138	customizing
multipage, 313	for AMS document classes,
numbering of, 258	294–297
placement of, 484, 486	for articles, 44–45
style of, 140	ggamsart.tpl, 297
typeset inline, 133	myams.tpl, 294-297
tables of contents, 252, 321, <b>473–475</b>	personalized
adding a line to, 473–474	making read-only, 297
adding vertical spacing to, 474	

terminating	framing, 109
captions, 476	in math mode, 19, <b>27</b> , 83, 99, 107,
• ,	
commands, 14, 19, <b>69</b> , 70, 80, 147,	154, <b>162–163</b> , 181, 196, 226–227,
154	241, 301
environments, 68	specifying fonts for, 163
fields in BibTeX database entries, 445	in tables
files, 392, 478	multicolumn, 137–140
lines, 85, 159, 367	multiline, 138
paragraphs, <b>64</b> , 99	mode, 7
sentences, 11, <b>64–67</b> , 279	plain, 9
$T_{E}X$ , 521, 525	spacing in, $102-106$
commands, 378, 380	style commands, see text style
to avoid using, 481	commands
commands in $\LaTeX$ , 482	symbols, see text symbols
distribution, 528	typing, 7–15, 61–115
extensibility of, 525	user-defined commands for, 366
files, portability of, 9	using math symbols in, 365
history of, 521–525	white space in, 102–106
implementations, 489	\text (box com.), xxvi, 27, 33, 83, 99,
inner workings of, 528	<b>107</b> , 162–163, 181, 206, 241, 301
inputs folders, 540, 544–545	spacing rules in, 154
layers of, 528–529	text boxes, 107–115
omissions in discussion of, 552	alignment of contents in, 107, 111
Plain, 528	behave as single characters, 107
programming in, 525, 553	commands for
resources on the Internet, 542	\framebox, 109
source files, see under source files	\makebox, 107, 108, 109, 111, 113
structure of, 528	\mbox, xxvi, 107
users groups, see TFX users groups	\parbox, 107, 109, 110, 111, 138,
and TUG	405
tex (LATEX distr. directory), 499	$\rackled{raisebox}$ , 115
$\text{TeX }(T_{\text{EX}} \text{ com.}), 80$	\rule, 113, 114, 140
T <sub>F</sub> X users groups, see also Tug, 537-542,	\text, xxvi, 27, 33, 83, 99, 107,
547	154, 162–163, 181, 206, 241, 301
international, 541	environments for minipage, 107, 109,
tex4ht (opt. of hyperref pack.), 320	112, 383, 384
T <sub>E</sub> X Live (TUG DVD/CD), xxvi, 489, 490,	framed, <b>109–110</b>
495, 541	measurements of, 405
texmf (IATEX distr. directory), 499	measuring, see measurements
TeXShop (IATEX front end for Mac), xxvi,	single line, 107–109, 163
9, 11, 53, 326, 496	vertical alignment of, 111, 115
customizing, 496	text environments, 117–149
productivity tools in, 498	and stretchable vertical space, 406
with BibTeX, 442	blank lines in, 118
with MakeIndex, 461	displayed, see displayed text
text, 7	environments
accents, 69, 79, 516	for abstracts, see abstract
\\ in, 98	for alignment, 8, 68, 106, 124, 134,
blocks, width of, 270	227, 407, 414
boxes, see text boxes	for bibliographies, see
centering, see centering text, center	thebibliography
(text align. env.), and	for boxes, see under text boxes
\centering	for comments, see comment
editors, xxvi, 4, 5, 9, 18, 48, 55, 63,	for documents, see document
84, 88, 365, 490, 526	for figures, see figures

for indexes, see theindex	\textit (font shape com.), $90$ , $91$ , $337$ ,
for letters, see letter	516
for lists, see list text environments	\textless ( $<$ less than), 81, 518
for proofs, see proof	\textmd (font weight com.), 90, 93, 516
for styles, see under text style	$\texttt{\text{textnormal}}$ (font shape com.), $90$ , $90$ ,
for tables, see tables	163, 516
rules for, 118	\TextOrMath (text and math mode com.)
text mode, 62	311
text style commands	\textperiodcentered ( $\cdot$ midpoint), 81,
avoiding direct use of, 480	518
\emph, 8, 14, 68, 90, <b>91</b> , 337, 516	\textquestiondown (; question mark),
\textbf, 14, 73, 90, 93, 163, 301,	81, 518
337, <i>516</i>	\textquotedbl (Eur. quot. mark), 519
\textit, 90, 91, 337, 516	\textquotedblleft (" left double quote)
\textmd, $90$ , $93$ , $516$	81, 518
\textnormal, 90, 90, 163, 516	\textquotedblright (" right double
\textrm, 90, 301, 516	quote), 81, 518
\textsc, 90, <b>91</b> , 516	\textquoteleft (' left single quote), 519
\textsf, 90, 516	<pre>\textquoteright(')</pre>
\textsl, 90, 91, 516	Eur. quot. mark, 519
\texttt, 14, 76, 90, 516	right single quote, 519
\textup, 90, <b>91</b> , 516	\textregistered (® registered
text style environments	trademark), 81, 518
bfseries, $123$	\textrm (font shape com.), 90, 301, 516
em, 123	\textsc (font shape com.), 90, 91, 516
itshape, 123	\textsf (font shape com.), 90, 516
rmfamily, 123	\textsl (font shape com.), 90, 91, 516
scshape, 123	\textstyle (math font size com.), 199,
sffamily, 123	204
slshape, 123	\textsubscript, 251, 311
ttfamily, 123	\textsuperscript (a), 311, 519
upshape, 123	\texttrademark (TM trademark), 519
text symbols, 77, 81	\texttt (font shape com.), 14, 76, 90,
commands, 76, 77, 80, 278, 516, 518,	516
519	\textup (font shape com.), 90, 91, 516
typing, 74–80	textures (opt. of hyperref pack.), 320
\textasciicircum (^ circumflex), 81, 518	\textvisiblespace, 11, 63, <b>64</b> , 519
\textasciitilde ( tilde), 519	\textwidth (length com.), 270, 398, 404
\textasteriskcentered (* asterisk), 77,	tfm (IATEX font metric file), 529
81, 518	\tfrac $(\frac{x}{y})$ , 158, 200
\textbackslash (\backslash), 76-77, 81,	\TH (Thorn Eur. char.), 519
518	\th (thorn Eur. char.), 519
\textbar (   vertical bar), 77, 81, 518	\thanks (top matter com.), 44, 87, 279,
\textbf (font weight com.), 14, 73, 90,	281, 296, 304
<b>93</b> , 163, 301, 337, <i>516</i>	\the (value expansion com.), 80, 87, 113,
\textbullet (• bullet), 81, 518	400
\textcircled ((a), 80, 81, 518	thebibliography (bibliography env.), 40
\textcolor (beamer com.), 349	47–48, 66, <b>261–267</b> , 407, 437, 446
\textcompwordmark (ligsuppr. com.), 79,	argument of, 263, 266
365, 415	in <b>bb1</b> files, 442
\textemdash (— em dash), 81, 518	\thechapter (the value of counter
\textendash (- em dash), 81, 518	chapter), 401
\textexclamdown (; exclamation mark),	\thefootnote (the value of counter
62	footnote), 87, 88
\textgreater (> greater than), 81, 518	25532557, 51, 55

theindex (index env.), 267, 407, 449, 459	time commands
commands in, 267, 449	\date, 44
themes (beamer distr. directory), 356	\day, 80
themes, for beamer presentations, 328,	\month, 80
356-357	\time, 80
Berkeley, 328, 331, 332, 356	\today, 14, 44, 70-71, 80, 148, 275,
color options, 357	304, 380, 548
Warsaw, 331, 332, 356	\year, 80
theorem (proclamation env.), 37, 52, 54,	Times, in IATEX documents, 544–545
125, 128, 343, 384	\times (× math op.), 23, 158, 506
body of, 46	times (pack.), 544
logical design of, 52	times.sty (PSNFSS distr. file), 544
visual design of, 52	\Tiny (font size com.), 93, 93, 517
theorem (pack.), 313	\tiny (font size com.), 93, 93, 517
theorem-like structures, see	\title (top matter com.), 37, 44, 106,
proclamations	249, 297, 304, 331, 469
\theoremname (hyperref redef. name),	optional arguments of, 273, 274, 282,
323	297
\theoremstyle* (procl. com.), 37,	title (BibTeX database field), 424-426,
129–131	433
\theoremstyle (procl. com.), 129-131	title pages, 273, 535
\theparentequation (the value of	commands for, 54
counter parentequation), 401	document class options for, 249, 299,
\therefore (: binary rel.), 504	300, 307
\thesection (the value of counter	environments for, 469
section), 401	footnotes on, 87
theses, in BibTeX database files, 433–434	of articles, 37, 249, 251
\thesubsection (the value of counter	of books, 467, 469
subsection), 401	of presentations, 55
\Theta ( $\Theta$ Greek char.), 502	titlepage (doc. class opt.), 249, <b>299</b> , 307,
\theta ( $\theta$ Greek char.), 502	468
\thickapprox (≈ binary rel.), 504	\titlepage (beamer com.), 328
\thicksim (~ binary rel.), 504	titlepage (front matter env.), 469
\thickspace (spacing com.), 190, 513,	titles
520	in bibliographies
\thinspace (spacing com.), 25, 67, 75,	rules for typing, 426–427
188, 190, 190, 513, 520	in running heads, 274, 297
third-party packages, see specific	of articles, 44, 273, 297
packages	of structural commands, 252
\thispagestyle (set page style), 270	fragile commands in, 74
thorn (Eur. char), 519	\to ( $\rightarrow$ math arrow), 507
Thorup, Kresten K., 403	toc (table of contents files), 473–475,
tie (* spacing com.), 11, 28, 63, 66, 75,	487, 532
<b>76</b> , 99, <i>520</i>	commands in, 475
absorbs spaces, 76	tocdepth (counter), 403, 473
in BibT <sub>E</sub> X databases, 427	\today (time com.), 14, 44, 70-71, 80,
with cross-references, 28, 257	148, 275, 304, 380, 548
tie ( ^ text accent), 79, 516	tokens, 529
TikZ, 552	tools (LATEX distr. directory), 311-313
tilde (~)	packages in, 312–313
text accent, 79, 516	tools (pack.), 312
text symbol, 519	\top ( $\top$ math sym.), 508
\tilde ( $\tilde{x}$ math accent), 25, 177, 512	top matter, 36, <b>37–38</b> , 249, <b>251</b> , 272
\time (time com.), 80	article information, 37–38, 44–46
. (,),	of AMS documents 273–275

commands, 37, 44, 46, 80, 87, 106,	type (BibTeX database field), 425
270, 273, <b>273–281</b> , 282, 284, 285,	type foundries, 544, 546
296, 297, 331, 469	types
blank lines in, 273	of commands, 73–74
examples of, 282–285	of math symbols, <b>188</b> , 198
with multiple authors, 281	declaring, 195
customizing templates, 44, 294	typeset
editing, 44–46	example articles
is document-class specific, 251	intrart.tex, 41-43
of AMS documents, 273–285	sampart.tex, 285-288
AMS information, 279–281	files, 5, 5, 271, 443
author information, 275–279	DVI format, 318, 530
errors with, 284–285	PDF format, 5, 259, 318, 326, 530
examples, $282-285$	typesetting
with multiple authors, 281	indexes, $459-461$
of books, 251	source files, 4, 9, 12, 20, 28, 63, 74,
of presentations, 53–55, 326–327, 331	534
with multiple authors, 46	tables of contents, 473–475
top-or-bottom, placement of tags, 298	with LAT <sub>E</sub> X, <b>522</b> , 526, 527, 529–534
topmat.tpl (sample file), 282	typewriter style
\topsep (length com.), 407, 408	document font family, 89
\totalheight (length com.), 108, 108,	font shape, 14, 76, 78, 90, <b>123</b> , 142,
110, 111	365, <i>516</i> , 544
trace (pack.), 313	fonts, 88
trademark text symbols ( $^{\text{TM}}$ $\mathbb{R}$ ), 81,	in math, <b>196</b> , 196, 512
518, 519	typing
trans (beamer doc. class opt.), 358	bibliographic entries, 426–437
translation, of line ending characters, 63	accents in, 427
\translator (top matter com.), 274	names in, 426
\triangle ( $\triangle$ math sym.), 508	rules for, 443–446
\triangledown ( $\nabla$ math sym.), 508	titles in, 426–427
\triangleleft (< math op.), 506	books, 465–487
\trianglelefteq (≤ binary rel.), 504	exercises, 476
\triangleq ( $\triangleq$ binary rel.), 504	footnotes, 87–88
\triangleright (▷ math op.), 506	math, 17–33, 151–206
\trianglerighteq ( $\trianglerighteq$ binary rel.), 504	poetry, 144–145
trivlist (list text env.), 414	programs, 141–143, 145–147
\tt (obs. IATEX 2.09 font com.), 94	quotations, 143–144
\ttfamily (font shape com. dec.), 90,	text, 7-15, 61-115
123, 142, 516	symbols, 74–80
ttfamily (font shape env.), 123	typographical
TUG (TEX Users Group), 489, 490, 495,	errors, 48
537, 541-542	rules for
TUGboat, 541, 553	abbreviations and acronyms, 91
two-letter font commands, see under font	initials, 67
commands	
twocolumn (doc. class opt.), 85, 101, 259,	$\mathbf{U}$
<b>299</b> , 307, 308	\u breve text accent ( `), 79, 516
and footnotes, 313	UK TUG (United Kingdom TEX Users
\twocolumn (double-column com.), 101	Group), 541
\twoheadleftarrow ( $\leftarrow$ math arrow), 507	Frequently Asked Questions (FAQ),
$\verb \twoheadrightarrow  (\twoheadrightarrow \mathrm{math}\ \mathrm{arrow}),$	542
507	\ulcorner (\( \text{math delimiter} \), 167, 509
twoside (doc. class opt.), 85, 249, <b>299</b> , 307, 308, 468	Umeki, Hideo, 270

umlaut (" text accent), 9, 15, 79, 516,	math arrow, 507
548	math delimiter, 167, 509
unbreakable	updates
hyphens, 83	to AMSFonts and packages, 533
spaces (* tie), 11, 28, 63, 66, 75, <b>76</b> ,	to $\LaTeX$ , 532
99, 520	\Updownarrow $(\updownarrow)$
absorb spaces, 76	math arrow, 507
in BibTeX databases, 427	math delimiter, 167, 509
with cross-references, 257	\updownarrow (↑)
\underbrace (math sym.), 178	math arrow, 507
with a subscript, 178	math delimiter, 167, 509
underdot text accent (), 79, 516	\upharpoonleft (1 math arrow), 507
\underleftarrow ( x math arrow), 179	\upharpoonright (  math arrow), 507
←	\uplus (\text{\text{\text{wath op.}}}, 506
\underleftrightarrow ( $x \to x$ math arrow),	\upn (font shape com.), 156
179	uppercase counter styles
\underline ( $\underline{x}$ math line sym.), 179	letters (\alph), 401
\underrightarrow ( $x$ math arrow), 179	
underscore $(_{-})$ , 77	roman numerals (\roman), 401
	upref (pack.), 300, 301
text symbol, 81, 518	upright (font shape), 28, 88, 89, 90, 91,
in e-mail addresses, 278	<b>123</b> , 156, 382, 412, <i>516</i>
underscore text accent (_), 79, 516	context dependence of, 91
\underset (symbol-building com.), 183,	\uproot (root-adjustment com.), 162
192	\upshape (font shape com. dec.), $90$ , $91$ ,
Unicode, 554	123, 382, 412, 516
units	upshape (font shape env.), 123
absolute, see under absolute	\Upsilon ( $\Upsilon$ Greek char.), 502
dimensional, see under dimensional	\upsilon ( $v$ Greek char.), $502$
units	\upuparrows (↑↑ math arrow), 507
logical, see under logical	\urcorner ( math delimiter), 167, 509
math, see mu	\URL (bibl. com.), 425
relative, see under relative	URL (Uniform Resource Locator), 278, see
UNIX, 3, 9, 522, 554	also hyperlinks
FTP clients, 538	\urladdr (top matter com.), <b>278</b> , 279,
IATEX implementations, 3, 442, 461,	296, 323
489	\usecolortheme (beamer com.), 357
line ending characters, 9	
\unlhd (≤ math op.), 506	\usecounter (list counter com.), 411
unmarked footnotes, 44, 279	\usefonttheme (beamer com.), 357
unnumbered	\usepackage (preamble com.), 35, 53, 70,
environments, 215	249, 294, 320, 326, 366, 386, 450,
	534
equations, 30, 31, 157, 201, 202, 210,	can load multiple packages, 250
211, 213, 215, 218, 231, 328	user-defined commands, $36$ , $364-380$ , $480$
items, 119	arguments of, 370–374
math environments, 211	as shorthand, 364–374
proclamations, 129, 130, 382	as tokens, 529
structural units, 46, 253, 467	command declarations in, 90
unpacked ( $\LaTeX$ distr. directory), 311,	scope of, <b>367–368</b> , 382
540	defining, 87, 99, 132, 139, 266, 267,
UNPUBLISHED (bibl. entry type), 435	364, 366, 373–375, 400
\unrhd ( $\trianglerighteq$ math op.), 506	in preamble, 250
\Uparrow (↑)	delimited, 378–380
math arrow, 507	for environments, 365
math delimiter, 167, 509	for indexing, 371, 454
\uparrow (↑)	for subformulas, 371–373
•••	, 0.1

for text, 366	\varUpsilon ( $\Upsilon$ Greek char.), 502
invoking, 366	\varXi ( $\Xi$ Greek char.), 502
multiple arguments of, 70	\Vdash (⊩ binary rel.), 504
optional arguments of, 374	$\volume{VDash} (\vDash binary rel.), 504$
rules, 366, 367	\vdash (⊢ binary rel.), 503
short arguments, 373–374	\vdots (vertical ellipsis), 161, 235
with \def, 378	\vec ( $\vec{x}$ math accent), 25, 177, 377, 512
user-defined environments, 380–385, 479,	\vee (\vee in math op.), 506
482, 529	\veebar (\(\sigma\) math op.), 506
defining, 381	\verb (inline verbatim com.), 147–149
for custom lists, 406–415	in aligned math environments, 148
optional arguments of, 384	in argument of other commands, 148
short arguments, 385	spaces in, 148
users groups, 537, 539, <b>541–542</b> , 547	\verb* (inline verbatim com.), 148
international, 541	delimiters with, 147–149
\usetheme (beamer com.), 328, 356	verbatim (disp. text env.), 145-147, 313,
UNIX, 479	359, 523
	blank lines in, 146
V	characters following, 146
\v caron text accent ( `), 79, 516	simulating with \verb, 148
\value (value of counter), 402	verbatim (pack.), 86, 87, 147, 313, 387
values, of counters, 87, 402	verse (disp. text env.), 144, 407
printing, 80, 113, 400	breaking lines in, 145
van Oostrum, Piet, 270, 537	versions
\varDelta ( $\Delta$ Greek char.), 502	of AMS packages and AMSFonts,
\varepsilon ( $\varepsilon$ Greek char.), 502	300, 301, 524, 525, 533
\varGamma ( $\Gamma$ Greek char.), 502	of LATEX packages, 532–534
\varinjlim (lim math op.), 172, 510	\Vert (   math delimiter), 167, 509
varioref (pack.), 258, 313	\vert (  math delimiter), 167, 509
\varkappa (\(\nu\) Greek char.), 502	vertical
\varLambda ( $\Lambda$ Greek char.), 502	alignment, of boxes, 111, 115
\varliminf (lim math op.), 172, 510	bar (  text symbol), 81, 518
\varlimsup (lim math op.), 172	ellipses, 161, 235
\varnothing (\varnothing that sym.), 508	glue, 530
$\forall$ varOmega ( $\Omega$ Greek char.), 502	lines
\varPhi ( $\Phi$ Greek char.), 502	in CD environments, 241
\varphi ( $\varphi$ Greek char.), 502	in tabular environments, 135
\varPi ( $\Pi$ Greek char.), 502	math arrows, 241
\varpi ( $\varpi$ Greek char.), 502	vertical spacing
\varprojlim (lim math op.), 172, 510	adding after \ 15
<del></del>	adding to table of contents, 474
\varpropto (\alpha binary rel.), 504	adjusting, 56
VarPsi (Ψ Greek char.), 502	with \arraystretch, 139
\varrho ( $\varrho$ Greek char.), 502	with struts, 139
\varSigma ( $\Sigma$ Greek char.), 502	adjusting with the setspace
\varsigma (ς Greek char.), 502	package, 99
\varsubsetneq (\( \subseteq \text{ neg. binary rel.} \), 505	between marginal notes, 404
\varsubsetneqq ( $\subsetneq$ neg. binary rel.), 505	between paragraphs, 404
\varsupsetneq (\( \rightarrow \text{binary rel.} \), 505	commands
\varsupsetneqq (\varsupsetneqq binary rel.), 505	\bigskip, 104
\varTheta ( $\Theta$ Greek char.), 502	\enlargethispage, 101, 484, 487
\vartheta ( $\vartheta$ Greek char.), 502	\medskip, 104
\vartriangle ( $\triangle$ math op.), 506	\smallskip, 104
\vartriangleleft (< math op.), 506	\smash, 115, 201, <b>201</b>
\vartriangleright ( $\triangleright$ math op.), 506	to avoid using, 481
	00 0.010 001118, 101

vertical spacing	generated by overlapping braces, 72
commands (continued)	Label(s) may have changed, $256$
\vfill (fill com.), 106	line numbers in, 12
\vphantom, 105	lines are too wide, 12–13, 96–97
\vspace, 104	No auxiliary output files, $531$
\vspace*, 105	Overfull \hbox, $12-13$ , $96-97$ , $530$
in boxes, 115	suppressing, 96
in indexes, 267, 449	recorded in log file, 96, 526
in math mode, 200–201	regarding font substitution, 94
in text, 15, <b>104–105</b> , 377, 474, 482,	Rerun to get cross-references
486	right, 256
preventing removal of, 105	Underfull \vbox has occurred
stretchable, 406	while \output is active, 530
using the setspace package, 99	Warning-missing field in label,
\vfill (space fill com.), 106	444–446
viewers	when using \NeedsTeXFormat, 250,
	386, 532
DVI, 526, 530, 539	with BibT <sub>F</sub> X, 443–446
PDF, see under PDF	
viewing typeset files, 494, 530	in log (blg) files, 442
DVI format, 318, 530	Warsaw (beamer theme), 331, 332, 356
PDF format, 5, 259, 318, 530	Web, see Internet
virtex (TEX program), 528	\wedge (∧ math op.), 506
visible spaces ( _), 11, 63	weight, of fonts, see under font
and \verb* command, 148	environments, font commands
Visual	and font declarations
Guide, to multiline math formulas,	white space
207	adjusting, 482
visual	and binary operations and relations,
design, 52-53, 247, 268-270, 358	155
markup, 535	between marginal notes, 404
guide, to multiline math formulas,	between paragraphs, 404
208	commands, avoiding direct use of,
Vmatrix (subsid. math env.), 183, 235	481
vmatrix (subsid. math env.), 25, 26, 235	determined by document classes, 102
volume (BibTeX database field), 424, 425	horizontal, 68, 102, 105, 142, 154,
von, in bibliographic entries, 426	189–191, 224, 225, 313, 368–369,
\vphantom (spacing com.), 105	513, 520
\vspace (spacing com.), 104	in math mode, 186, 233, 236
\vspace* (spacing com.), 105	in text mode, 11, 19, <b>64–67</b> ,
vtex (opt. of hyperref pack.), 320	<b>102–104</b> , <b>106</b> , 114, 126, 414
\Vvdash (⊪ binary rel.), 504	in arguments of commands, 85
, , , ,	in command definitions, 367
W	in command names, 68
warning messages, see also error	in delimited commands, 379–380
messages	in math, 19, 51, 104–105, 154–156,
about hyphenation, 96	187–192, 200–201
Abstract should precede	adjusting, 104
\maketitle in AMS document	in source files, 154
classes, 251	in tabular environments, 135
Characters dropped after	in text, 11, <b>102–106</b> , 383, 427, <i>513</i> ,
\end{verbatim}, 146	520
\end\{verbatims, 140}\end\ occurred\ inside\ a\ group\ at	
	in \verb commands 148
9 -	in verb commands, 148
level $x, 72$	in verbatim environments, 146
9 -	

vertical, 102	year (BibTeX database field), 424, 425
adding to table of contents, 474	
adjusting, 481	X
in math mode, $104-105$ , $200-201$	zero, specifying in arguments, 114
in text mode, 15, 101, <b>104–106</b> ,	\zeta ( $\zeta$ Greek char.), 502
201, 377, 482, 486	
\widehat ( $\hat{x}$ math accent), 177, 177, 184,	
512	
\widetilde ( $x$ math accent), 177, 177,	\ (backslash), 167, 518
512	key, 9, 76
width	starts commands, 8, 14, 68
of columns in tabular environments,	text symbol, 76–77, 81, 509
136	_ (space), 11, 63, <b>64</b>
of fonts, see font width	and \verb* command, 148
of text blocks, 270, 398, 404	in arguments of commands, 85
of text boxes, 107–109, 405	in \bibitem labels, 266
Windows are also PCs are under	in \cite commands, 264
Windows, see also PCs, see under	in command names, 68
Microsoft WinEdt (IATEX front end for PC), xxvi, 9,	in tabular environments, 135
11, 53, 490, 491, 492	text symbol, 519
installation, 490–491	! (exclamation mark), 9, 62
productivity tools in, 494	float control, <b>260</b> , 486
with BibTeX, 442	in \index commands, 453, 454, 457
with MakeIndex, 461	(exclamation mark, Spanish), 81, 515,
word processors, 11	518
words, are separated by spaces, 82	\! (negthinspace), 182, <b>190</b> , 190, 513,
work (folder), 4, 10, 12, 14, 18, 20, 35, 39,	520
53, 164, 294, 320, 326-328, 331,	" (" dieresis/umlaut text accent), 9, 15,
343, 438, 491	79, 516, 548
creating, 4	" (double quote), 9, <b>75</b>
World Wide Web, see Internet	in BibTeX database fields, <b>424</b> , 445,
\wp (\phi \math \sym.), 508	446
\wr (≀ math op.), 506 wrapping, of lines	in <b>\index</b> commands, 457 key, 9, 63, 75
by e-mail clients, 65	"ck (European character), 548
wrapping, of lines by text editors, 84	"s (eszett), 548
wrapping, or mice by tene editors, or	#
X	in user-defined commands, 371, 378
xcb (exercise env.), 476	key, 9, 63
xcolor (pack.), 325, 348	<b>\#</b> (# octothorp), 77, 81, 518
options, 349	\$
\Xi ( $\Xi$ Greek char.), 502	as inline math delimiter, 17, 18, 33,
\xi ( $\xi$ Greek char.), 502	72, 74, <b>152</b>
\xleftarrow (stretchable math arrow),	act as braces, 152
179	must be balanced, 153
xr (pack.), 258, 313	in error messages, 20, 51, 147, 153,
\xrightarrow (stretchable math arrow),	154, 157, 233
179 xspace (pack.), 313, 368–369	key, 9, 63 \\$ (\$ dollar sign), 9, 77, 81, 518
xy-pic (pack.), 242	\$\$
-J F (Passis), 212	in error messages, 51
Y	T <sub>E</sub> X displayed math delimiter, 152
Y&Y, 525, 543	
\year (time com.), 80	

%	in BibTeX databases, $424$ , $425$ , $445$
as comment character, 6, 10, 19, 21,	use in formulas, 155
61, <b>85–86</b> , 141, 294, 458	- (dash, hyphen, minus), 9, 22, 63, 75, 76
in BibTeX databases, 86, 443	157, 188, 191, 192, 196, 216, 217
key, 9, 63	as binary operation, 506
\% (% percent), 9, 61, 77, 81, 86, 518	in \hyphenation commands, 82
in e-mail addresses, 278	\- (opt. hyphen), 13, 82, <b>82</b> , 96
&	(- number ranges, en dash), <b>14</b> , <b>75</b> , <i>81</i>
as alignment point, 30, 31, 216, 218,	518
220, 221	in BibTeX databases, 427
as column separator, 25, 135, 220,	(— em dash), <b>14</b> , <b>75</b> , <i>81</i> , <i>518</i>
221, 231, 236	( period), 9, 62
	and italic correction, 92
key, 9, 63	•
\& (& ampersand), 77, 81, 518	in BibTeX databases, 426
&&, alignment point for annotations, 32	\. overdot text accent ('), 79, 516
' (right single quote), 9, 11, 62, <b>75</b> , 519	\/ (italic correction), <b>91–93</b> , <i>520</i>
for primes ('), 23, 159, 194	and font commands, 92
\' ( ' acute text accent), 79, 516	/ (slash)
\( (start inline math mode), 18, 74	as divisor, 22, 63, 157
acts as special brace, 152, 153	as math delimiter $(/)$ , 167, 509
must be balanced, 153	key, 8
(	\: (medspace spacing com.), 190, 513,
as math delimiter ((), 167, 509	520
in index entries, 455	: (colon), 9, 62
key, 8, 62	as binary relation, 63, 191, 503
(end inline math mode), 18, 74	\; (thickspace), 190, 513, 520
acts as special brace, 152, 153	; (semicolon), 9, 62
must be balanced, 153	< (less than)
)	as binary relation ( $<$ ), $503$
as math delimiter ()), 167, 509	key, 17, 63
in index entries, 455	text symbol, 81, 518
key, 8, 62	\=
* (* asterisk), 77	macron text accent (-), 79, 516
interactive prompt, <b>113</b> , 376–378, <b>534</b>	tab set command, 141
key, 8, 63	= (equal sign)
** prompt, 534	as binary relation $(=)$ , $503$
*-form	in BibTeX database fields, 424
of commands, 46, <b>69</b> , 98, 101, 103,	key, 8, 63
105, 129, 130, 148, 173, 195, 196,	<b>\&gt;</b> (tabbing com.), 141, 142
242, 253, 322, 373, 382, 385, 439,	> (greater than)
467, 473	as binary relation $(>)$ , $503$
of environments, 157, 201, 211, 213,	key, 17, 63
215, 231, 259	text symbol, 81, 518
+ key, 8, 63	?
+ (plus), 22, 63, 157, 188, 191, 192, 213,	prompt, 20, 48, 491, 534
216–218	question mark, 9, 62
as binary operation, 506	¿ (Spanish question mark), 81, 515, 518
+ and - rule, <b>188</b> , 191, 192, 217, 218	<b>c</b> (@ at sign), 9, 63, <b>77</b>
and subformulas, 216	in $BibT_EX$ database (bib) files, 424
in multline environments, 213	in \index commands, 455, 456
(thinspace), 25, 67, 75, 188, 190, 190,	@-expression, 136
513, 520	@. (blank math symbol for comm.
, (comma), 9, 62	diagrams), 240, 241
and italic correction, 92	<b>\0</b> . (intersentence space), 67, 520
in \bibitem commands, 266	

0<>< (stretchable left arrow math sym.), 240	text brace (}), 77, 81, 518 ^ (caret)
©= (stretchable equals sign math sym.),	for superscripts, <b>23</b> , 25, <b>158–159</b> , 161
240	182
@>>> (stretchable right arrow math	key, 9, 63, 77
sym.), 240	\^ circumflex text accent (^), 79, 81, 516
CAAA (stretchable up arrow math sym.),	518
241	\_ (_underscore), 9, 77, 81, 518
QVVV (stretchable down arrow math	in e-mail addresses, 278
sym.), 241	_ (underscore)
Overt (stretchable double vertical line), 241	for subscripts, <b>23</b> , 25, <b>158–159</b> , 161, 178, 182
\[ (start displayed math mode), 18, 152,	key, 9, 63
155	' (left single quote), 9, 11, 62, <b>75</b> , 519
acts as special brace, 152, 157	\'(` grave text accent), 62, 79, 516
[	\  (    math delimiter), 166, 167, 168,
and optional arguments, 15, 27, 69,	185, 509
<b>70</b> , 128, 132, 135	(  vertical line), 9, 17, 63, 77, 168, 189
key, 8, 62	as binary relation, 188, 189
math delimiter ([), 167, 509	as math delimiter, 167, 170, 189,
with \item commands, 122	191, <i>509</i>
with \newcommand, 370	in \index commands, 454, 457
\] (end displayed math mode), 18, 152,	in tabular environments, 135
155	~ (tilde)
acts as special brace, 152, 157	key, 9, 11, 63
]	tie/unbreakable space, 11, 28, 63, 66
and optional arguments, 15, 27, 69,	75, <b>76</b> , 99, <i>520</i>
<b>70</b> , 128, 132, 135	absorbs spaces, 76
key, 8, 62	in BibTeX databases, 427
math delimiter (]), 167, 509	with cross-references, 28, 257
with \item commands, 122	\~ (~ tilde text accent), 77, 79, 516, 518
with \newcommand, 370	
{	9pt (doc. class option), 297
for required arguments, 8, 14, 19, 69,	10pt (doc. class option), 104, 297, 306
70, 159, 366, 530	11pt (doc. class option), 297, 306
for scoping, 71–73	12pt (doc. class option), 93, 297, 306
in BibTeX entries, 424, 427	
key, 9, 63	\\ (new line), 15, 97, 98
must be balanced, 21, 72, 77	and \kill commands, 142
in \index commands, 462	breaking lines with, 25, 30, 31, 33,
with \def, 378	44, 46, 98, 124, 135, 141, 142,
<b>\</b> {	145, 176, 211, 213, 215, 216, 227
as math delimiter ({), 167, 509	231, 242, 273–278, 297, 304, 309
text brace ({ ), 77, 81, 518	358
}	in arguments of commands, 98
for required arguments, 8, 14, 19, <b>69</b> ,	in environments, <b>98</b> , 124, 145
70, 159, 366, 530	in text, 98
for scoping, 71–73	optional argument of, <b>15</b> , 98, <b>98</b> , 242
in BibTeX entries, 424, 427	\\* (new line), 98, 242
key, 9, 63	(( (new mic), 90, 242
must be balanced, 21, 72, 77	
in \index commands, 462	
with \def, 378	
\} as math delimiter ( \) 167 509	
as main denumber (3) ID/ 509	