# Contents

## Part I


List of Figures xxviii

List of Tables xxxi

Foreword xxxvii

Preface xxxix

Chapter 1 Introduction 1

1.1 A brief history (of nearly half a century) . . . . . 1

1.2 Today's systems . . . . . 8

1.3 Working with this book . . . . . 13

1.3.1 What's where . . . . . 13

1.3.2 Typographic conventions . . . . . 15

1.3.3 Using the examples . . . . . 18

Chapter 2 The Structure of a LaTeX Document 21

2.1 The overall structure of a source file . . . . . 22

2.1.1 Spoiler alert — The \DocumentMetadata command . . . . . 23

2.1.2 Processing of options of the document class and packages . . 24

2.1.3 Front, main, and back matter . . . . . 26

2.1.4 Splitting the source document into several files . . . . . 28

2.1.5 askinclude — Managing your inclusions . . . . . 30

2.1.6 tagging — Providing variants in the document source . . . . . 30

2.2 Sectioning commands . . . . . 32
2.2.1 Numbering headings . . . . . 34
2.2.2 Changing fixed heading texts . . . . . 36
2.2.3 Introduction to heading design . . . . . 37
2.2.4 quotchap, epigraph — Mottos on chapters and sections . . . . 38
2.2.5 indentfirst — Indent the first paragraph after a heading . . . . 39
2.2.6 nonumonpart — No page numbers on parts . . . . . 40
2.2.7 titlesec — A package approach to heading design . . . . . 40
2.2.8 Formatting headings — LaTeX's internal low-level methods. . . . 51
2.3 Table of contents structures . . . . . 54
2.3.1 tocdata — Providing extra data for the TOC. . . . . 56
2.3.2 titletoc — A high-level approach to contents list design. . . . . 59
2.3.3 multitoc — Setting contents lists in multiple columns. . . . . 70
2.3.4 LaTeX's low-level interfaces . . . . . 70
2.4 Managing references . . . . . 75
2.4.1 varioref — More flexible cross-references . . . . . 79
2.4.2 cleveref — Cleverly formatted references . . . . . 86
2.4.3 nameref — Non-numerical references . . . . . 93
2.4.4 showkeys, refcheck — Displaying & checking reference keys . . 93
2.4.5 xr — References to external documents. . . . . 95
2.4.6 hyperref — Active references . . . . . 96
2.5 Document source management. . . . . 108
2.5.1 Combining several files. . . . . 109
2.5.2 Document archival information . . . . . 110
2.5.3 snapshot, bundledoc — Document archival and verification. . . 111
2.5.4 mkjobtexmf — Providing a minimal TeX file tree . . . . . 113
2.5.5 The rollback concept for LaTeX and individual packages . . . . . 114

**Chapter 3 Basic Formatting Tools — Paragraph Level 119**

3.1 Shaping your paragraphs . . . . . 120
3.1.1 ragged2e — Improving unjustified text . . . . . 123
3.1.2 nolbreaks — Preventing line breaks in text fragments. . . . . 125
3.1.3 microtype — Enhancing justified text . . . . . 126
3.1.4 parskip — Adjusting the look and feel of paragraphs . . . . . 137
3.1.5 setspace — Changing interline spacing . . . . . 139
3.1.6 lettrine — Dropping your capital . . . . . 141
3.1.7 Alphabets for initials . . . . . 145
3.1.8 magaz — Special handling of the first line . . . . . 146
3.1.9 fancypar — Fancy layouts for individual paragraphs. . . . . 147
3.2 Dealing with special characters . . . . . 147
3.2.1 ellipsis, lips — Marks of omission . . . . . 148
3.2.2 extdash and amsmath — Dashes in text . . . . . 149
3.2.3 underscore — Making that character more usable. . . . . 151
3.2.4 xspace — Gentle spacing after a macro . . . . . 152

3.3 Generated or specially formatted text . . . . . 154
3.3.1 fmtcount — Ordinals and cardinals . . . . . 154
3.3.2 acro — Managing your abbreviations and acronyms. . . . . 156
3.3.3 xfrac — Customizable $^{\text{text}}/_{\text{fractions}}$ . . . . . 164
3.3.4 siunitx — Scientific notation of units and quantities . . . . . 167
3.4 Various ways of highlighting and quoting text. . . . . 177
3.4.1 Change case of text intelligently (formerly textcase) . . . . . 178
3.4.2 csquotes — Context-sensitive quotation marks . . . . . 179
3.4.3 embrac — Upright brackets and parentheses . . . . . 188
3.4.4 ulem — Emphasize and copy-edit via underline . . . . . 189
3.4.5 dashundergaps — Produce fill-in forms . . . . . 190
3.4.6 microtype & soul — Letterspacing or stealing sheep . . . . . 191
3.4.7 url — Typesetting URLs, path names, and the like. . . . . 198
3.4.8 uri — Typesetting various types of URIs . . . . . 202
3.5 Footnotes, endnotes, and marginals . . . . . 204
3.5.1 Using standard footnotes. . . . . 205
3.5.2 Customizing standard footnotes . . . . . 208
3.5.3 footmisc — Various footnotes styles . . . . . 210
3.5.4 footnoterange — Referencing footnote ranges . . . . . 216
3.5.5 fnpct — Managing footnote markers and punctuation. . . . . 216
3.5.6 perpage — Resetting counters on a “per-page” basis . . . . . 218
3.5.7 manyfoot, bigfoot — Independent footnotes . . . . . 220
3.5.8 parnotes — Present the notes inside the galley . . . . . 226
3.5.9 ftnright — Right footnotes in a two-column environment . . . . 228
3.5.10 enotez — Endnotes, an alternative to footnotes . . . . . 228
3.5.11 Marginal notes . . . . . 232
3.5.12 marginnote — An alternative to `\marginpar` . . . . . 234
3.5.13 snotez — Numbered or otherwise marked side notes . . . . . 235
3.6 Support for document development . . . . . 237
3.6.1 todonotes — Adding todos to your document. . . . . 237
3.6.2 fixme — A slightly different approach to todos . . . . . 242
3.6.3 changes — A set of typical editorial commands . . . . . 245
3.6.4 pdfcomment — Using PDF annotations and tool tips . . . . . 250
3.6.5 vertbars — Adding bars to paragraphs . . . . . 251

**Chapter 4 Basic Formatting Tools — Larger Structures 253**

4.1 Lists . . . . . 254
4.1.1 Using and modifying the standard lists . . . . . 254
4.1.2 LaTeX’s generic list environments . . . . . 258
4.1.3 enumitem — Extended list environments . . . . . 261
4.1.4 amsthm — Providing headed lists . . . . . 281
4.1.5 thmtools — Advanced theorem declarations . . . . . 284
4.1.6 tasks — Making horizontally oriented lists . . . . . 289
4.1.7 typed-checklist — Developing and maintaining checklists. . . . 292

4.2 Simulating typed text . . . . . 296
4.2.1 Displaying spaces in verbatim material . . . . . 297
4.2.2 Simple verbatim extensions . . . . . 298
4.2.3 upquote — Computer program style quoting . . . . . 302
4.2.4 fancyvrb, fvextra — Verbatim environments on steroids . . . . 303
4.2.5 listings — Pretty-printing program code. . . . . 322
4.3 Lines and columns . . . . . 333
4.3.1 lineno — Numbering lines of text . . . . . 334
4.3.2 paracol — Several text streams aligned . . . . . 339
4.3.3 multicol — A flexible way to handle multiple columns . . . . . 351
4.3.4 multicolrule — Custom rules for multicolumned pages . . . . . 361
4.4 Generating sample texts . . . . . 361
4.4.1 lipsum and friends — Generating text samples . . . . . 361
4.4.2 blindtext — More elaborate layout testing . . . . . 363

**Chapter 5 The Layout of the Page 365**

5.1 Geometrical dimensions of the layout . . . . . 366
5.2 Changing the layout . . . . . 368
5.2.1 layouts — Displaying your layout . . . . . 371
5.2.2 A collection of page layout packages . . . . . 374
5.2.3 typearea — A traditional approach . . . . . 375
5.2.4 geometry — Layout specification with auto-completion . . . . . 377
5.2.5 lscape — Typesetting individual pages in landscape mode . . . 384
5.2.6 savetrees — Options to reduce the document length . . . . . 384
5.3 Dynamic page data: page numbers and marks . . . . . 385
5.3.1 LaTeX page numbers . . . . . 385
5.3.2 lastpage — A way to reference it . . . . . 386
5.3.3 chappg — Page numbers by chapters . . . . . 387
5.3.4 LaTeX's legacy mark commands . . . . . 388
5.3.5 LaTeX's new mark mechanism . . . . . 390
5.4 Page styles . . . . . 395
5.4.1 The low-level page style interface. . . . . 397
5.4.2 fancyhdr — Customizing page styles . . . . . 398
5.4.3 truncate — Truncate text to a given length . . . . . 405
5.4.4 continue — Help with turning pages . . . . . 407
5.5 Page decorations and watermarks . . . . . 409
5.5.1 draftwatermark — Put a visible stamp on your document . . . . 409
5.5.2 crop — Producing trimming marks . . . . . 411
5.6 Visual formatting . . . . . 414
5.6.1 Standard tools for page explicit page breaking . . . . . 414
5.6.2 Running pages and columns short or long . . . . . 415
5.6.3 addlines — Adjusting whole double spreads . . . . . 416
5.6.4 nextpage — Extensions to `\clearpage` . . . . . 418

5.6.5 needspace — Conditionally start a new page . . . . . 419
5.6.6 Avoiding widows and orphans . . . . . 420
5.6.7 widows-and-orphans — Finding all widows and orphans . . . . 424
5.6.8 \looseness — Shortening or lengthening paragraphs . . . . . 427
5.7 Doing layout with class . . . . . 429
5.7.1 KOMA-Script — A drop-in replacement for article et al. . . . . 429
5.7.2 memoir — Producing complex publications . . . . . 430

**Chapter 6 Tabular Material 431**

6.1 Standard LaTeX environments . . . . . 432
6.1.1 Using the tabbing environment . . . . . 433
6.1.2 tabto — An alternative way to tab stops . . . . . 434
6.1.3 Using the tabular environment . . . . . 436
6.2 array — Extending the tabular environments . . . . . 437
6.2.1 The behavior of the \\ command . . . . . 437
6.2.2 Examples of preamble specifiers . . . . . 438
6.2.3 Defining new column specifiers . . . . . 445
6.3 Calculating column widths . . . . . 446
6.3.1 tabularx — Automatic calculation of column widths . . . . . 448
6.3.2 tabulary — Column widths based on content . . . . . 450
6.3.3 Differences between tabular*, tabularx, and tabulary . . 452
6.3.4 Managing tables with wide entries . . . . . 453
6.3.5 widetable — An alternative to tabular* . . . . . 453
6.4 Multipage tabular material . . . . . 456
6.4.1 supertabular — Making multipage tabulars . . . . . 456
6.4.2 longtable — Alternative multipage tabulars . . . . . 459
6.4.3 xltabular — Marriage of tabularx and longtable . . . . . 463
6.4.4 Problems with multipage tables (all packages) . . . . . 464
6.5 Color in tables . . . . . 466
6.6 Customizing table rules and spacing . . . . . 467
6.6.1 Colored table rules . . . . . 467
6.6.2 boldline — Bolder table rules . . . . . 468
6.6.3 arydshln — Dashed rules . . . . . 469
6.6.4 hhline — Combining horizontal and vertical lines . . . . . 470
6.6.5 booktabs — Formal ruled tables . . . . . 471
6.6.6 bigstrut — Spreading individual table lines apart . . . . . 473
6.6.7 cellspace — Ensure minimal clearance automatically . . . . . 474
6.7 Other extensions . . . . . 476
6.7.1 multirow — Vertical alignment in tables . . . . . 476
6.7.2 diagbox — Making table cells with diagonal lines . . . . . 479
6.7.3 dcolumn — Decimal column alignments . . . . . 481
6.7.4 siunitx — Scientific numbers in tables . . . . . 484
6.7.5 fcolumn — Managing financial tables . . . . . 487

6.8 Footnotes in tabular material . . . . . 491
6.8.1 Using minipage footnotes with tables . . . . . 491
6.8.2 threeparttable — Setting table and notes together . . . . . 492
6.9 keyvaltable — Separating table data and formatting . . . . . 494
6.10 tabularray — Late breaking news . . . . . 504

**Chapter 7 Mastering Floats 505**

7.1 An overview of LaTeX's float concepts . . . . . 506
7.1.1 LaTeX float terminology . . . . . 506
7.1.2 Basic behavioral rules of LaTeX's float mechanism . . . . . 508
7.1.3 Consequences of the algorithm . . . . . 512
7.1.4 fltrace — Tracing the float algorithm . . . . . 518
7.2 Float placement control . . . . . 519
7.2.1 fewerfloatpages — Improving LaTeX's float algorithm . . . . . 519
7.2.2 placeins — Preventing floats from crossing a barrier . . . . . 524
7.2.3 afterpage — Taking control at the page boundary . . . . . 525
7.2.4 endfloat — Placing figures and tables at the end . . . . . 525
7.3 Extensions to LaTeX's float concept . . . . . 528
7.3.1 float — Creating new float types . . . . . 529
7.3.2 Captions for nonfloating figures and tables . . . . . 532
7.3.3 rotating, rotfloat — Rotating floats . . . . . 533
7.3.4 wrapfig — Inline floats, wrapping text around a figure . . . . . 535
7.4 Controlling the float caption . . . . . 538
7.4.1 caption — Customizing your captions . . . . . 540
7.4.2 subcaption — Substructuring floats . . . . . 551
7.5 Key/value approaches for floats and subfloats . . . . . 560
7.5.1 hvfloat — Sophisticated caption placement control and more . . 560
7.5.2 keyfloat — Bringing most packages under one roof . . . . . 567

**Chapter 8 Graphics Generation and Manipulation 575**

8.1 LaTeX's image loading support . . . . . 576
8.1.1 Options for graphics and graphicx . . . . . 577
8.1.2 The \includegraphics syntax in the graphics package . . . 578
8.1.3 The \includegraphics syntax in the graphicx package . . . 580
8.1.4 Setting default key values for the graphicx package . . . . . 585
8.1.5 Declarations guiding the inclusion of images . . . . . 586
8.2 Manipulating graphical objects in LaTeX . . . . . 587
8.2.1 Image and box manipulations with graphics and graphicx . . . 587
8.2.2 overpic — Graphic annotation made easy . . . . . 593
8.2.3 adjustbox — Box manipulation with a key/value interface . . . 595
8.3 Producing (fairly) portable line graphics . . . . . 602
8.3.1 A kernel picture environment enhancement . . . . . 602
8.3.2 pict2e — An extension of LaTeX's picture environment . . . . . 602

8.3.3 bxeepic — A differently enhanced picture environment . . . 608
8.3.4 Special-purpose languages . . . 612
8.3.5 qrcode — Generating Quick Response codes . . . 612
8.4 Flexible boxes for multiple purposes . . . 614
8.4.1 tcolorbox — The basic usage . . . 614
8.4.2 Extending tcolorbox through libraries . . . 619
8.4.3 Defining new tcolorbox environments and commands . . . 626
8.4.4 Special tcolorbox applications . . . 628
8.5 tikz — A general-purpose graphics system . . . 631
8.5.1 Basic objects . . . 633
8.5.2 Transformations and other operations . . . 642
8.5.3 Going further . . . 646

**Chapter 9 Font Selection and Encodings 647**

9.1 Introduction . . . 648
9.1.1 The history of LaTeX's font selection scheme (NFSS) . . . 648
9.1.2 Input and output handling in TeX systems over the years . . . 649
9.2 Understanding font characteristics . . . 652
9.2.1 Monospaced and proportional fonts . . . 652
9.2.2 Serifed and sans serif fonts . . . 653
9.2.3 Font families and their attributes . . . 653
9.2.4 Font encodings . . . 657
9.3 Using fonts in text . . . 658
9.3.1 Standard LaTeX font commands . . . 659
9.3.2 Font commands versus declarations . . . 666
9.3.3 Combining standard font commands . . . 668
9.3.4 Accessing all characters of a font . . . 669
9.3.5 LaTeX 2.09 font support — Compatibility for really ancient documents . . . 670
9.3.6 Changing the default text fonts . . . 670
9.3.7 relsize, scalefnt — Relative changes to the font size . . . 675
9.4 Using fonts in math . . . 676
9.4.1 Special math alphabet identifiers . . . 677
9.4.2 Text font commands in math . . . 682
9.4.3 Mathematical formula versions . . . 682
9.5 Standard LaTeX font support . . . 683
9.5.1 Computer Modern, Latin Modern — The LaTeX standard fonts . . . 684
9.5.2 PSNFSS and TeX Gyre — Core PostScript fonts for LaTeX . . . 688
9.5.3 A note on baselines and leading . . . 691
9.5.4 inputenc — Explicitly selecting the input encoding . . . 692
9.5.5 fontenc — Selecting font encodings . . . 693
9.5.6 Additional text symbols not part of OT1 or T1 encodings . . . 694
9.5.7 exscale — Scaling large Computer Modern math operators . . . 704

9.5.8 tracefnt — Tracing the font selection . . . . . 704
9.5.9 nfssfont.tex — Displaying 8-bit font tables and samples . . . . 705
9.6 fontspec — Font selection for Unicode engines . . . . . 705
9.6.1 Setting up the main document font families . . . . . 706
9.6.2 Setting up additional font families . . . . . 711
9.6.3 Setting up a single font face . . . . . 711
9.6.4 Interfacing with core NFSS commands . . . . . 712
9.6.5 Altering the look and feel of fonts . . . . . 713
9.6.6 General configuration options . . . . . 727
9.6.7 unicodefonttable — Displaying font tables for larger fonts . . . 728
9.7 The low-level NFSS interface . . . . . 730
9.7.1 Setting individual font attributes . . . . . 731
9.7.2 Setting several font attributes . . . . . 738
9.7.3 Automatic substitution of fonts. . . . . 738
9.7.4 Substituting the font family if unavailable in an encoding . . . 739
9.7.5 Using low-level commands in the document . . . . . 740
9.8 Setting up new fonts for NFSS . . . . . 740
9.8.1 Declaring new font families and font shape groups. . . . . 741
9.8.2 Modifying font families and font shape groups . . . . . 746
9.8.3 Declaring new font encoding schemes . . . . . 747
9.8.4 Internal file organization . . . . . 748
9.8.5 Declaring new fonts and symbols for use in math . . . . . 749
9.9 LaTeX's encoding models . . . . . 754
9.9.1 Character data within the LaTeX system . . . . . 754
9.9.2 LaTeX's internal character representation (LICR) . . . . . 757
9.9.3 Input encodings . . . . . 758
9.9.4 Output encodings . . . . . 760

## Part II

Foreword, Part II II v

Preface, Part II II vii

Chapter 10 Text and Symbol Fonts II 1
10.1 Overview . . . . . II 2
10.1.1 Notes on the font samples . . . . . II 4
10.1.2 Notes on the font family tables . . . . . II 5
10.1.3 Font support packages . . . . . II 7
10.1.4 Direct use of the fonts (without a package) . . . . . II 10
10.2 Samples of larger font families. . . . . II 11
10.2.1 Alegreya . . . . . II 11
10.2.2 CM Bright — A design based on Computer Modern Sans . . . II 12

10.2.3 DejaVu — A fork of Bitstream Vera . . . II 12
10.2.4 Fira fonts . . . II 14
10.2.5 Gandhi fonts . . . II 15
10.2.6 Go fonts . . . II 15
10.2.7 Inria fonts . . . II 16
10.2.8 Kp (Johannes Kepler) fonts . . . II 17
10.2.9 Libertinus — A fork of Linux Libertine and Biolinum . . . II 19
10.2.10 Lucida fonts . . . II 21
10.2.11 Merriweather fonts . . . II 25
10.2.12 Google's Noto and Droid fonts . . . II 26
10.2.13 IBM Plex . . . II 30
10.2.14 PT fonts . . . II 31
10.2.15 Quattrocento . . . II 33
10.2.16 Google Roboto families . . . II 34
10.2.17 Adobe Source Pro . . . II 35
10.3 Humanist (Oldstyle) serif fonts . . . II 36
10.3.1 Alegreya . . . II 37
10.3.2 Coelacanth . . . II 37
10.3.3 fbb — A version of Cardo . . . II 37
10.4 Garalde (Oldstyle) serif fonts . . . II 38
10.4.1 Accanthis . . . II 39
10.4.2 GFS Artemisia . . . II 39
10.4.3 Crimson, Crimson Pro, and Cochineal . . . II 40
10.4.4 Cormorant Garamond . . . II 41
10.4.5 EB Garamond . . . II 41
10.4.6 Garamond Libre . . . II 42
10.4.7 URW Garamond No. 8 . . . II 43
10.4.8 Gentium Plus . . . II 45
10.4.9 Kp (Johannes Kepler) Roman . . . II 45
10.4.10 Palatino (TEX Gyre Pagella) . . . II 46
10.5 Transitional/Neoclassical serif fonts . . . II 46
10.5.1 Antykwa Poltawskiego . . . II 46
10.5.2 BaskervilleF and Libre Baskerville . . . II 47
10.5.3 Baskervald (Baskervaldx) . . . II 48
10.5.4 ITC Bookman (TEX Gyre Bonum) . . . II 48
10.5.5 Cambria . . . II 49
10.5.6 Bitstream Charter . . . II 50
10.5.7 Charis SIL — A design based on Bitstream Charter . . . II 51
10.5.8 Caslon — Reinterpreted as Libre Caslon . . . II 51
10.5.9 Gandhi Serif . . . II 52
10.5.10 Inria Serif . . . II 52
10.5.11 Libertinus Serif . . . II 52
10.5.12 Literaturnaya — A favorite in the days of the USSR . . . II 53
10.5.13 Lucida Bright . . . II 53

10.5.14 Lucida Fax . . . II 54
10.5.15 Merriweather . . . II 54
10.5.16 New Century Schoolbook (TEX Gyre Schola) . . . II 54
10.5.17 Plex Serif . . . II 55
10.5.18 PT Serif . . . II 55
10.5.19 Quattrocento . . . II 55
10.5.20 Times Roman (TEX Gyre Termes and Tempora) . . . II 55
10.5.21 Tinos . . . II 57
10.5.22 STIX 2 . . . II 57
10.5.23 Utopia (Heuristica, Erewhon, and Linguistics Pro) . . . II 58
10.6 Didone (Modern) serif fonts . . . II 60
10.6.1 Computer Modern Roman / Latin Modern Roman . . . II 60
10.6.2 GFS Bodoni . . . II 61
10.6.3 Libre Bodoni . . . II 61
10.6.4 GFS Didot . . . II 62
10.6.5 Theano Didot . . . II 62
10.6.6 Noto Serif . . . II 63
10.6.7 Old Standard . . . II 63
10.6.8 Playfair Display . . . II 64
10.7 Slab serif (Egyptian) fonts . . . II 64
10.7.1 Bitter . . . II 65
10.7.2 Concrete Roman . . . II 65
10.7.3 DejaVu Serif . . . II 67
10.7.4 Roboto Slab Serif . . . II 67
10.7.5 Source Serif Pro . . . II 67
10.8 Sans serif fonts . . . II 67
10.8.1 Alegreya Sans . . . II 68
10.8.2 Arimo . . . II 68
10.8.3 ITC Avant Garde Gothic (TEX Gyre Adventor) . . . II 69
10.8.4 Cabin . . . II 70
10.8.5 Chivo . . . II 70
10.8.6 Classico — A design based on Optima . . . II 71
10.8.7 Clear Sans . . . II 72
10.8.8 CM Bright . . . II 72
10.8.9 Cuprum . . . II 73
10.8.10 Cyklop . . . II 73
10.8.11 DejaVu Sans . . . II 74
10.8.12 Fira Sans . . . II 74
10.8.13 Gandhi Sans . . . II 74
10.8.14 GFS Neo-Hellenic . . . II 75
10.8.15 Gillius . . . II 75
10.8.16 Helvetica (TEX Gyre Heros) . . . II 76
10.8.17 Inria Sans . . . II 77
10.8.18 Iwona . . . II 77

10.8.19 Kp (Johannes Kepler) Sans . . . II 79
10.8.20 Kurier . . . II 79
10.8.21 Latin Modern Sans . . . II 80
10.8.22 Lato . . . II 80
10.8.23 Libertinus Sans . . . II 81
10.8.24 Libre Franklin . . . II 81
10.8.25 Lucida Sans . . . II 82
10.8.26 Merriweather Sans . . . II 82
10.8.27 Mint Spirit . . . II 82
10.8.28 Montserrat . . . II 83
10.8.29 Noto Sans . . . II 84
10.8.30 Overlock . . . II 84
10.8.31 Plex Sans . . . II 85
10.8.32 PT Sans . . . II 85
10.8.33 Quattrocento Sans . . . II 85
10.8.34 Raleway . . . II 86
10.8.35 Roboto Sans . . . II 86
10.8.36 Rosario . . . II 86
10.8.37 Source Sans Pro . . . II 87
10.8.38 Universalis . . . II 87
10.9 Monospaced (typewriter) fonts . . . II 88
10.9.1 Algol . . . II 89
10.9.2 Anonymous Pro . . . II 90
10.9.3 CM Bright Typewriter Light . . . II 90
10.9.4 Courier . . . II 91
10.9.5 DejaVu Sans Mono . . . II 91
10.9.6 Fira Mono . . . II 92
10.9.7 Go Mono . . . II 92
10.9.8 Inconsolata . . . II 92
10.9.9 Kp (Johannes Kepler) Typewriter . . . II 93
10.9.10 Latin Modern Typewriter . . . II 93
10.9.11 Libertinus Mono . . . II 94
10.9.12 Lucida's monospaced families . . . II 94
10.9.13 Luximono . . . II 95
10.9.14 Noto Sans Mono . . . II 96
10.9.15 Plex Mono . . . II 96
10.9.16 PT Mono . . . II 96
10.9.17 Roboto Mono . . . II 97
10.9.18 Source Code Pro . . . II 97
10.10 Historical and other fonts . . . II 97
10.10.1 Cinzel . . . II 98
10.10.2 Marcellus . . . II 99
10.10.3 The Fell Types . . . II 99
10.10.4 Almendra . . . II 100

10.10.5 Antykwa Toruńska . . . . . II 100
10.10.6 Lucida Casual, Calligraphy, and Handwriting . . . . . II 102
10.10.7 Zapf Chancery (TEX Gyre Chorus) . . . . . II 102
10.10.8 Miama Nueva . . . . . II 103
10.10.9 Lucida Blackletter . . . . . II 104
10.10.10 Blackletter — Yannis Gothic, Schwabacher, and Fraktur. . . . II 104
10.11 Fonts supporting Latin and polytonic Greek . . . . . II 106
10.11.1 Serif designs . . . . . II 107
10.11.2 Sans Serif designs. . . . . II 109
10.11.3 Monospaced fonts . . . . . II 109
10.11.4 Handwriting fonts. . . . . II 110
10.12 Fonts supporting Latin and Cyrillic. . . . . II 110
10.12.1 Serif designs . . . . . II 110
10.12.2 Sans Serif designs. . . . . II 111
10.12.3 Monospaced fonts . . . . . II 112
10.12.4 Handwriting fonts. . . . . II 113
10.13 The LATEX world of symbols. . . . . II 113
10.13.1 pifont — Accessing Pi and Symbol fonts . . . . . II 113
10.13.2 wasysym — Waldi's symbol font . . . . . II 116
10.13.3 marvosym — Interface to the MarVoSym font . . . . . II 117
10.13.4 adforn — Adding ornaments to your document . . . . . II 118
10.13.5 fourier-orns — GUT*enberg*-Fourier's ornaments . . . . . II 119
10.13.6 Web-O-Mints — Another collection of ornaments and borders . II 119
10.13.7 fontawesome5 — Accessing Font Awesome icons . . . . . II 120
10.13.8 tipa — International Phonetic Alphabet symbols . . . . . II 125

**Chapter 11 Higher Mathematics** II 127

11.1 Introduction to amsmath and mathtools . . . . . II 128
11.2 Display and alignment structures for equations. . . . . II 131
11.2.1 Comparison of amsmath/mathtools with standard LATEX. . . . II 132
11.2.2 A single equation on one line . . . . . II 133
11.2.3 A single equation on several lines: no alignment . . . . . II 134
11.2.4 A single equation on several lines: with alignment . . . . . II 135
11.2.5 Equation groups without alignment . . . . . II 137
11.2.6 Equation groups with simple alignment . . . . . II 138
11.2.7 Multiple alignments: `align` and `flalign` . . . . . II 138
11.2.8 Display environments as mini-pages . . . . . II 140
11.2.9 Interrupting displays with short text . . . . . II 143
11.2.10 Vertical space in and around displays . . . . . II 143
11.2.11 Page breaks in and around displays. . . . . II 145
11.2.12 breqn — Automatic line breaking in math displays . . . . . II 146
11.2.13 Equation numbering and tags. . . . . II 149
11.2.14 Fine-tuning tag placement . . . . . II 150
11.2.15 Subordinate numbering sequences . . . . . II 152
11.2.16 Resetting the equation counter . . . . . II 153

11.3 Matrix-like environments ..... II 153
11.3.1 amsmath, mathtools — The matrix environments ..... II 154
11.3.2 amsmath, mathtools, cases — Some case environments ..... II 156
11.3.3 delarray — Delimiters surrounding an array ..... II 157
11.3.4 bigdelim — Delimiters around and inside arrays ..... II 158
11.3.5 Commutative diagrams with standard LaTeX ..... II 159
11.3.6 amscd — Commutative diagrams a là AMS ..... II 160
11.3.7 tikz-cd — Commutative diagrams based on tikz ..... II 161
11.4 Compound structures and decorations ..... II 163
11.4.1 amsmath, mathtools, extarrows — Decorated arrows ..... II 163
11.4.2 Fractions and their generalizations ..... II 164
11.4.3 Continued fractions ..... II 166
11.4.4 Limiting positions ..... II 166
11.4.5 Stacking in subscripts and superscripts ..... II 167
11.4.6 amsmath, esint, wasysym — Multiple integral signs ..... II 168
11.4.7 diffcoeff — Handling derivatives of arbitrary order ..... II 170
11.4.8 Modular relations ..... II 171
11.4.9 mathtools, interval — Properly spaced intervals ..... II 171
11.4.10 braket — Dirac bra–ket and set notation ..... II 173
11.4.11 amsmath, mathtools, empheq — Boxed formulas ..... II 174
11.4.12 amsmath, accents, mathdots — Various accents ..... II 176
11.4.13 mattens — Commands to typeset tensors ..... II 178
11.4.14 Extra decorations for symbols ..... II 179
11.5 Variable symbol commands ..... II 180
11.5.1 Ellipsis and other kinds of ..... II 180
11.5.2 Horizontal extensions in standard LaTeX ..... II 182
11.5.3 Further horizontal extensions ..... II 183
11.5.4 abraces — Customizable over and under braces ..... II 185
11.5.5 underoverlap — Partly overlapping horizontal braces ..... II 189
11.5.6 Vertical extensions ..... II 191
11.6 Words in mathematics ..... II 191
11.6.1 The `\text` command ..... II 192
11.6.2 Operator and function names ..... II 192
11.7 Fine-tuning the mathematical layout ..... II 194
11.7.1 Controlling the automatic sizing and spacing ..... II 195
11.7.2 Subformulas ..... II 197
11.7.3 Line breaking in inline formulas ..... II 197
11.7.4 Big-g delimiters ..... II 199
11.7.5 Radical movements ..... II 199
11.7.6 Ghostbusters™ ..... II 200
11.7.7 Horizontal spaces ..... II 204
11.7.8 resizegather — Downscaling an equation ..... II 206
11.7.9 subdepth — Normalizing subscript positions ..... II 206
11.7.10 Color in formulas ..... II 207

11.8 Symbols in formulas ..... II 208
11.8.1 Mathematical symbol classes ..... II 209
11.8.2 Letters, numerals, and other Ordinary symbols ..... II 211
11.8.3 Mathematical accents ..... II 214
11.8.4 Binary operator symbols ..... II 214
11.8.5 Relation symbols ..... II 216
11.8.6 Operator symbols ..... II 222
11.8.7 Punctuation ..... II 222
11.8.8 Opening and Closing symbols ..... II 223

**Chapter 12 Fonts in formulas** II 225

12.1 The world of (Latin) math alphabets ..... II 226
12.1.1 mathalpha — Simplified setup for math alphabets ..... II 230
12.2 Making it bold ..... II 235
12.2.1 bm — Making bold ..... II 235
12.3 Traditional math font setup through packages ..... II 238
12.3.1 ccfonts — The Concrete fonts for text and math ..... II 238
12.3.2 cmbright — The Computer Modern Bright fonts ..... II 239
12.3.3 euler, eulervm — Accessing Zapf's Euler fonts ..... II 240
12.3.4 newtxmath — A Swiss knife for math font support ..... II 243
12.3.5 newpxmath — Using the PX fonts for math ..... II 248
12.3.6 mathpazo — Another Palatino-based approach for math ..... II 251
12.3.7 notomath — Setting up Noto fonts for math and text ..... II 252
12.4 unicode-math — Using Unicode math fonts ..... II 253
12.4.1 Math alphabets revisited ..... II 254
12.4.2 Adjusting the formula style ..... II 257
12.4.3 Setting up Unicode math fonts ..... II 259
12.5 A visual comparison of different math setups ..... II 261
12.5.1 Garalde (Oldstyle) serif fonts with math support ..... II 263
12.5.2 Transitional serif fonts with math support ..... II 271
12.5.3 Didone serif fonts with math support ..... II 284
12.5.4 Slab serif fonts with math support ..... II 288
12.5.5 Sans serif fonts with math support ..... II 290
12.5.6 Historical fonts with math support ..... II 295

**Chapter 13 Localizing documents** II 297

13.1 TEX and non-English languages ..... II 297
13.1.1 Language-related aspects of typesetting ..... II 299
13.1.2 Culture-related aspects of typesetting ..... II 300
13.1.3 babel — LATEX speaks multiple languages ..... II 300
13.2 The babel user interface ..... II 301
13.2.1 Setting or getting the current language ..... II 302
13.2.2 Handling shorthands ..... II 304
13.2.3 Language attributes ..... II 307

13.2.4 BCP 47 tags . . . II 308
13.3 User commands provided by language options . . . II 308
13.3.1 Translations of fixed texts . . . II 309
13.3.2 Available shorthands . . . II 310
13.3.3 Language-specific commands . . . II 315
13.3.4 Layout considerations . . . II 320
13.3.5 Languages and font encoding . . . II 322
13.4 Support for Cyrillic and Greek . . . II 324
13.4.1 The Cyrillic alphabet . . . II 324
13.4.2 The Greek alphabet . . . II 328
13.5 Complex scripts . . . II 330
13.6 Tailoring babel . . . II 332
13.6.1 User level . . . II 333
13.6.2 Package level . . . II 336
13.6.3 The package file . . . II 339
13.7 Other approaches . . . II 341
13.7.1 Complex languages with 8-bit engines . . . II 341
13.7.2 Polyglossia . . . II 342

**Chapter 14 Index Generation** II 343
14.1 Syntax of the index entries . . . II 345
14.1.1 Simple index entries . . . II 346
14.1.2 Generating subentries . . . II 347
14.1.3 Page ranges and cross-references . . . II 347
14.1.4 Controlling the presentation form . . . II 347
14.1.5 Printing special characters . . . II 348
14.1.6 Creating a glossary . . . II 349
14.1.7 Defining your own index commands . . . II 349
14.1.8 Special considerations . . . II 350
14.2 *MakeIndex* — A program to sort and format indexes . . . II 350
14.2.1 Generating the formatted index . . . II 351
14.2.2 Detailed options of the *MakeIndex* program . . . II 351
14.2.3 Error and warning messages . . . II 355
14.2.4 Customizing the index . . . II 356
14.2.5 Pitfalls to watch out for . . . II 362
14.3 upmendex — A Unicode-aware indexing program . . . II 364
14.3.1 Options, warnings, and errors of the program . . . II 364
14.3.2 Customizing the index with upmendex . . . II 366
14.4 xindy, xindex — Two other indexing programs . . . II 370
14.5 Enhancing the index with LaTeX features . . . II 371
14.5.1 Modifying the layout . . . II 371
14.5.2 showidx, repeatindex, tocbibind, indxcite — Little helpers . . . II 372
14.5.3 index — Producing multiple indexes . . . II 372

**Chapter 15 Bibliography Generation** II 375

15.1 The standard LaTeX bibliography environment ..... II 376

15.2 The biber and BibTeX programs ..... II 378

15.2.1 bibtex8 — An 8-bit reimplementation of BibTeX ..... II 379

15.2.2 biber — A Unicode-aware bibliography processor ..... II 379

15.3 The BibTeX database format ..... II 380

15.3.1 Entry types and fields ..... II 384

15.3.2 Additional fields ..... II 390

15.3.3 The text part of a field explained ..... II 393

15.3.4 Abbreviations in BibTeX ..... II 401

15.3.5 Extended data references with biber: the `xdata` entry type ..... II 403

15.3.6 The BibTeXdatabase preamble command ..... II 405

15.3.7 Cross-referencing entries ..... II 406

15.3.8 Managing the BibTeX and biber differences ..... II 408

15.4 Using BibTeX or biber to produce the bibliography ..... II 409

15.5 On-line bibliographies ..... II 413

15.6 Bibliography database management tools ..... II 414

15.6.1 checkcites — Which citations are used, unused, or missing? ..... II 414

15.6.2 biblist — Printing BibTeX database files ..... II 415

15.6.3 bibclean, etc. — A set of command-line tools ..... II 415

15.6.4 Using biber as a tool ..... II 417

15.7 Formatting the bibliography with styles ..... II 418

15.7.1 A collection of BibTeX style files ..... II 419

15.7.2 custom-bib — Generate BibTeX styles with ease ..... II 426

15.7.3 An overview of biblatex styles ..... II 432

15.7.4 Generic styles ..... II 435

15.7.5 Implementations of style guides ..... II 439

15.7.6 Implementations of university and institution styles ..... II 445

15.7.7 Implementations of journal styles ..... II 455

15.7.8 Styles that extend the data model ..... II 461

15.7.9 Styles not fitting in the other categories ..... II 464

**Chapter 16 Managing Citations** II 469

16.1 Introduction ..... II 469

16.1.1 Bibliographical reference schemes ..... II 470

16.2 The number-only system ..... II 473

16.2.1 Standard LaTeX — Reference by number ..... II 475

16.2.2 cite — Enhanced references by number ..... II 478

16.2.3 notoccite — Solving a problem with unsorted citations ..... II 483

16.2.4 natbib's approach to number-only references ..... II 484

16.2.5 biblatex's approach to number-only references ..... II 484

16.3 The author-date system ..... II 487

16.3.1 Early attempts ..... II 489

16.3.2 natbib — Customizable author-date references ..... II 490

16.3.3 biblatex's approach to author-date references . . . . . II 500
16.4 The author-number system . . . . . II 502
16.4.1 natbib — Revisited . . . . . II 503
16.4.2 biblatex's approach to author-number references . . . . . II 506
16.5 The author-title system . . . . . II 507
16.5.1 jurabib — Customizable short-title references . . . . . II 507
16.5.2 biblatex's approach to author-title references . . . . . II 534
16.6 The verbose system . . . . . II 537
16.6.1 bibentry — Full bibliographic entries in running text . . . . . II 537
16.6.2 biblatex's approach to verbose citations . . . . . II 538
16.7 biblatex — One ring to rule them all . . . . . II 541
16.7.1 Basic biblatex setup . . . . . II 543
16.7.2 Package options . . . . . II 543
16.7.3 Citing with biblatex . . . . . II 544
16.7.4 Indexing citations automatically . . . . . II 546
16.7.5 Back references and links . . . . . II 547
16.7.6 Bibliography entries with multiple authors . . . . . II 547
16.7.7 Unambiguous citations . . . . . II 548
16.7.8 Printing the bibliography . . . . . II 550
16.7.9 The sorting of the bibliography . . . . . II 554
16.7.10 Document divisions . . . . . II 556
16.7.11 Annotated bibliographies . . . . . II 557
16.7.12 Bibliography lists . . . . . II 558
16.7.13 Language support . . . . . II 559
16.7.14 Distinguishing the author's gender . . . . . II 560
16.7.15 Sentence casing . . . . . II 561
16.7.16 Customizing . . . . . II 562
16.8 Multiple bibliographies in one document . . . . . II 569
16.8.1 chapterbib — Bibliographies per included file . . . . . II 571
16.8.2 bibunits — Bibliographies for arbitrary units . . . . . II 574
16.8.3 bibtopic — Combining references by topic . . . . . II 578
16.8.4 multibib — Separate global bibliographies . . . . . II 580

**Chapter 17 LaTeX Package Documentation Tools** II 583

17.1 doc — Documenting LaTeX and other code . . . . . II 584
17.1.1 General conventions for the source file . . . . . II 585
17.1.2 Describing new macros and environments . . . . . II 585
17.1.3 Cross-referencing all macros used . . . . . II 588
17.1.4 The documentation driver . . . . . II 589
17.1.5 Conditional code in the source . . . . . II 590
17.1.6 Providing additional documentation elements . . . . . II 592
17.1.7 Producing the actual index entries . . . . . II 593
17.1.8 Overview about all doc commands . . . . . II 594
17.1.9 ltxdoc — A simple LaTeX documentation class . . . . . II 597

17.2 docstrip.tex — Producing ready-to-run code . . . II 599
17.2.1 Invocation of the docstrip utility . . . II 600
17.2.2 docstrip script commands . . . II 601
17.2.3 Using docstrip with L3 programming layer code . . . II 605
17.2.4 Using docstrip with other languages . . . II 605
17.3 l3build — A versatile development environment . . . II 606
17.3.1 The basic interface . . . II 607
17.3.2 Creating tests . . . II 608
17.3.3 Releasing to CTAN . . . II 611
17.3.4 Common configurations . . . II 613
17.4 Making use of version control tools . . . II 615
17.4.1 gitinfo2 — Accessing metadata from Git . . . II 616
17.4.2 svn-multi — Accessing Subversion keywords . . . II 617
17.4.3 filemod — Printing or checking file modification dates . . . II 619

**Appendix A LaTeX Overview for Preamble, Package, and Class Writers II 621**

A.1 Linking markup and formatting . . . II 622
A.1.1 Command and environment names . . . II 622
A.1.2 Defining simple commands . . . II 624
A.1.3 Defining simple environments . . . II 629
A.1.4 Defining more complex commands and environments . . . II 632
A.1.5 Changing arguments to command names . . . II 644
A.2 Counters and length expressions . . . II 646
A.2.1 Defining and changing counters . . . II 646
A.2.2 fmtcount — Specially formatted counters and numbers . . . II 650
A.2.3 sillypage — Page and other counting à la Monty Python . . . II 651
A.2.4 Defining and changing space parameters . . . II 651
A.2.5 The L3 programming layer — Computation support . . . II 657
A.3 Page markup — Boxes and rules . . . II 660
A.3.1 LR boxes . . . II 661
A.3.2 Paragraph boxes . . . II 663
A.3.3 Rule boxes . . . II 667
A.3.4 Manipulating boxed material . . . II 669
A.3.5 Box commands and color . . . II 670
A.4 LaTeX's hook management . . . II 671
A.4.1 Working with existing hooks . . . II 671
A.4.2 Declaring hooks and using them in code . . . II 681
A.5 Control structure extensions . . . II 685
A.5.1 iftex — On which TeX engine are we running on? . . . II 685
A.5.2 calc — Arithmetic calculations . . . II 687
A.5.3 ifthen — Advanced control structures . . . II 689
A.6 Package and class file structure . . . II 693
A.6.1 The rollback part . . . II 693
A.6.2 The identification part . . . II 696

A.6.3 The initial code part . . . II 697
A.6.4 The declaration of options . . . II 697
A.6.5 The execution of options . . . II 699
A.6.6 Declaring and using options with a key/value syntax . . . II 700
A.6.7 The package loading part . . . II 703
A.6.8 The main code part . . . II 704
A.6.9 Special commands for package and class files . . . II 704
A.6.10 Special commands for class files . . . II 708
A.6.11 A minimal class file . . . II 710

**Appendix B Tracing and Resolving Problems** II 711

B.1 Error messages . . . II 712
B.2 Dying with memory exceeded . . . II 744
B.3 Warnings and informational messages . . . II 749
B.4 TEX and LATEX commands for tracing . . . II 765
B.4.1 Displaying command definitions and register values . . . II 766
B.4.2 Diagnosing page-breaking problems . . . II 769
B.4.3 Diagnosing and solving paragraph-breaking problems . . . II 773
B.4.4 Other low-level tracing tools . . . II 779
B.4.5 trace — Selectively tracing command execution . . . II 781

**Appendix C Going beyond** II 783

C.1 Learn LATEX — A LATEX online course for beginners . . . II 784
C.2 Finding information available on your computer . . . II 785
C.2.1 kpsewhich — Find files the way TEX does . . . II 785
C.2.2 texdoc — A command-line interface to local TEX information . . . II 786
C.3 Accessing online information and getting help . . . II 787
C.3.1 `texdoc.org` — searchable documentation on the Web . . . II 787
C.3.2 Frequently Asked Questions (FAQ) resources . . . II 787
C.3.3 Using news groups and forums . . . II 788
C.3.4 The LATEX Project's web presence . . . II 789
C.4 Getting all those TEX files . . . II 789
C.4.1 CTAN — The Comprehensive TEX Archive Network . . . II 789
C.4.2 TEX distributions — past and present . . . II 790
C.5 Giving back to the community . . . II 792

**Bibliography** II 795

**Index of Commands and Concepts** II 817

**People** II 967

**Biographies** II 973

**Production Notes** II 977