APPENDIX

A

Text symbol tables

A.1 Some European characters

Name	Type	Typeset	Type	Typeset
a-ring	`\aa`	å	`\AA`	Å
aesc	`\ae`	æ	`\AE`	Æ
ethel	`\oe`	œ	`\OE`	Œ
eszett	`\ss`	ß	`\SS`	SS
inverted question mark	`?‘`	¿		
inverted exclamation mark	`!‘`	¡		
slashed L	`\l`	ł	`\L`	Ł
slashed O	`\o`	ø	`\O`	Ø

G. Grätzer, *Practical LaTeX*, DOI 10.1007/978-3-319-06425-3,

A.2 Text accents

Name	Type	Typeset	Name	Type	Typeset
acute	`\'{o}`	ó	macron	`\={o}`	ō
breve	`\u{o}`	ŏ	overdot	`\.{g}`	ġ
caron/hačeк	`\v{o}`	ǒ	ring	`\r{u}`	ů
cedilla	`\c{c}`	ç	tie	`\t{oo}`	o͡o
circumflex	`\^{o}`	ô	tilde	`\~{n}`	ñ
dieresis/umlaut	`\"{u}`	ü	underdot	`\d{m}`	ṃ
double acute	`\H{o}`	ő	underbar	`\b{o}`	o̲
grave	`\‘{o}`	ò			
dotless i	`\i`	ı	dotless j	`\j`	ȷ
	`\'{\i}`	í		`\v{\j}`	ǰ

A.3 Text font commands

A.3.1 Text font family commands

Command with Argument	Command Declaration	Switches to the font family
`\textnormal{...}`	`{\normalfont ...}`	document
`\emph{...}`	`{\em ...}`	*emphasis*
`\textrm{...}`	`{\rmfamily ...}`	roman
`\textsf{...}`	`{\sffamily ...}`	sans serif
`\texttt{...}`	`{\ttfamily ...}`	`typewriter style`
`\textup{...}`	`{\upshape ...}`	upright shape
`\textit{...}`	`{\itshape ...}`	*italic shape*
`\textsl{...}`	`{\slshape ...}`	*slanted shape*
`\textsc{...}`	`{\scshape ...}`	SMALL CAPITALS
`\textbf{...}`	`{\bfseries ...}`	**bold**
`\textmd{...}`	`{\mdseries ...}`	normal weight and width

A.3.2 Text font size changes

Command	AMS 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

A.3.3 Special characters

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

A.4 Additional text symbols

Name	Type	Typeset
ampersand	`\&`	&
asterisk bullet	`\textasteriskcentered`	*
backslash	`\textbackslash`	\
bar (caesura)	`\textbar`	|
brace left	`\{`	{
brace right	`\}`	}
bullet	`\textbullet`	•
circled a	`\textcircled{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 `!‘`	¡
greater than	`\textgreater`	>
less than	`\textless`	<
lowline	`\_`	_
midpoint	`\textperiodcentered`	·
octothorp	`\#`	#
percent	`\%`	%
pilcrow (paragraph)	`\P`	¶
question down	`\textquestiondown` or `?‘`	¿
registered trademark	`\textregistered`	®
section	`\S`	§
single quote left	`\textquoteleft` or ‘	‘
single quote right	`\textquoteright` or ’	’
sterling	`\pounds`	£
superscript	`\textsuperscript{a}`	a
tilde	`\textasciitilde`	~
trademark	`\texttrademark`	TM
visible space	`\textvisiblespace`	␣

APPENDIX

B

Math symbol tables

B.1 Hebrew and Greek letters

Hebrew letters

Type	Typeset
`\aleph`	ℵ
`\beth`	ℶ
`\daleth`	ℷ
`\gimel`	ℸ

G. Grätzer, *Practical LaTeX*, DOI 10.1007/978-3-319-06425-3,

Greek letters

Lowercase

Type	Typeset	Type	Typeset	Type	Typeset
\alpha	α	\iota	ι	\sigma	σ
\beta	β	\kappa	κ	\tau	τ
\gamma	γ	\lambda	λ	\upsilon	υ
\delta	δ	\mu	μ	\phi	ϕ
\epsilon	ϵ	\nu	ν	\chi	χ
\zeta	ζ	\xi	ξ	\psi	ψ
\eta	η	\pi	π	\omega	ω
\theta	θ	\rho	ρ		
\varepsilon	ε	\varpi	ϖ	\varsigma	ς
\vartheta	ϑ	\varrho	ϱ	\varphi	φ
	\digamma $\digamma$		\varkappa $\varkappa$		

Uppercase

Type	Typeset	Type	Typeset	Type	Typeset
\Gamma	Γ	\Xi	Ξ	\Phi	Φ
\Delta	Δ	\Pi	Π	\Psi	Ψ
\Theta	Θ	\Sigma	Σ	\Omega	Ω
\Lambda	Λ	\Upsilon	Υ		
\varGamma	$\varGamma$	\varXi	$\varXi$	\varPhi	$\varPhi$
\varDelta	$\varDelta$	\varPi	$\varPi$	\varPsi	$\varPsi$
\varTheta	$\varTheta$	\varSigma	$\varSigma$	\varOmega	$\varOmega$
\varLambda	$\varLambda$	\varUpsilon	$\varUpsilon$		

B.2 Binary relations

Type	Typeset	Type	Typeset
`<`	$<$	`>`	$>$
`=`	$=$	`:`	$:$
`\in`	$\in$	`\ni` or `\owns`	$\ni$
`\leq` or `\le`	$\leq$	`\geq` or `\ge`	$\geq$
`\ll`	$\ll$	`\gg`	$\gg$
`\prec`	$\prec$	`\succ`	$\succ$
`\preceq`	$\preceq$	`\succeq`	$\succeq$
`\sim`	$\sim$	`\approx`	$\approx$
`\simeq`	$\simeq$	`\cong`	$\cong$
`\equiv`	$\equiv$	`\doteq`	$\doteq$
`\subset`	$\subset$	`\supset`	$\supset$
`\subseteq`	$\subseteq$	`\supseteq`	$\supseteq$
`\sqsubseteq`	$\sqsubseteq$	`\sqsupseteq`	$\sqsupseteq$
`\smile`	$\smile$	`\frown`	$\frown$
`\perp`	$\perp$	`\models`	$\models$
`\mid`	$\mid$	`\parallel`	$\parallel$
`\vdash`	$\vdash$	`\dashv`	$\dashv$
`\propto`	$\propto$	`\asymp`	$\asymp$
`\bowtie`	$\bowtie$		
`\sqsubset`	$\sqsubset$	`\sqsupset`	$\sqsupset$
`\Join`	$\Join$		

Note the `\colon` command used in $f\colon x \to x^2$, typed as `f \colon x \to x^2`

Some of the symbols on this page and in the rest of this appendix require the `latexsym` and `amssymb` packages.

More binary relations

Type	Typeset	Type	Typeset
`\leqq`	$\leqq$	`\geqq`	$\geqq$
`\leqslant`	$\leqslant$	`\geqslant`	$\geqslant$
`\eqslantless`	$\eqslantless$	`\eqslantgtr`	$\eqslantgtr$
`\lesssim`	$\lesssim$	`\gtrsim`	$\gtrsim$
`\lessapprox`	$\lessapprox$	`\gtrapprox`	$\gtrapprox$
`\approxeq`	$\approxeq$		
`\lessdot`	$\lessdot$	`\gtrdot`	$\gtrdot$
`\lll`	$\lll$	`\ggg`	$\ggg$
`\lessgtr`	$\lessgtr$	`\gtrless`	$\gtrless$
`\lesseqgtr`	$\lesseqgtr$	`\gtreqless`	$\gtreqless$
`\lesseqqgtr`	$\lesseqqgtr$	`\gtreqqless`	$\gtreqqless$
`\doteqdot`	$\doteqdot$	`\eqcirc`	$\eqcirc$
`\circeq`	$\circeq$	`\triangleq`	$\triangleq$
`\risingdotseq`	$\risingdotseq$	`\fallingdotseq`	$\fallingdotseq$
`\backsim`	$\backsim$	`\thicksim`	$\thicksim$
`\backsimeq`	$\backsimeq$	`\thickapprox`	$\thickapprox$
`\preccurlyeq`	$\preccurlyeq$	`\succcurlyeq`	$\succcurlyeq$
`\curlyeqprec`	$\curlyeqprec$	`\curlyeqsucc`	$\curlyeqsucc$
`\precsim`	$\precsim$	`\succsim`	$\succsim$
`\precapprox`	$\precapprox$	`\succapprox`	$\succapprox$
`\subseteqq`	$\subseteqq$	`\supseteqq`	$\supseteqq$
`\Subset`	$\Subset$	`\Supset`	$\Supset$
`\vartriangleleft`	$\vartriangleleft$	`\vartriangleright`	$\vartriangleright$
`\trianglelefteq`	$\trianglelefteq$	`\trianglerighteq`	$\trianglerighteq$
`\vDash`	$\vDash$	`\Vdash`	$\Vdash$
`\Vvdash`	$\Vvdash$		
`\smallsmile`	$\smallsmile$	`\smallfrown`	$\smallfrown$
`\shortmid`	$\shortmid$	`\shortparallel`	$\shortparallel$
`\bumpeq`	$\bumpeq$	`\Bumpeq`	$\Bumpeq$
`\between`	$\between$	`\pitchfork`	$\pitchfork$
`\varpropto`	$\varpropto$	`\backepsilon`	$\backepsilon$
`\blacktriangleleft`	$\blacktriangleleft$	`\blacktriangleright`	$\blacktriangleright$
`\therefore`	$\therefore$	`\because`	$\because$

Negated binary relations

Type	Typeset	Type	Typeset
`\neq` or `\ne`	$\neq$	`\notin`	$\notin$
`\nless`	$\nless$	`\ngtr`	$\ngtr$
`\nleq`	$\nleq$	`\ngeq`	$\ngeq$
`\nleqslant`	$\nleqslant$	`\ngeqslant`	$\ngeqslant$
`\nleqq`	$\nleqq$	`\ngeqq`	$\ngeqq$
`\lneq`	$\lneq$	`\gneq`	$\gneq$
`\lneqq`	$\lneqq$	`\gneqq`	$\gneqq$
`\lvertneqq`	$\lvertneqq$	`\gvertneqq`	$\gvertneqq$
`\lnsim`	$\lnsim$	`\gnsim`	$\gnsim$
`\lnapprox`	$\lnapprox$	`\gnapprox`	$\gnapprox$
`\nprec`	$\nprec$	`\nsucc`	$\nsucc$
`\npreceq`	$\npreceq$	`\nsucceq`	$\nsucceq$
`\precneqq`	$\precneqq$	`\succneqq`	$\succneqq$
`\precnsim`	$\precnsim$	`\succnsim`	$\succnsim$
`\precnapprox`	$\precnapprox$	`\succnapprox`	$\succnapprox$
`\nsim`	$\nsim$	`\ncong`	$\ncong$
`\nshortmid`	$\nshortmid$	`\nshortparallel`	$\nshortparallel$
`\nmid`	$\nmid$	`\nparallel`	$\nparallel$
`\nvdash`	$\nvdash$	`\nvDash`	$\nvDash$
`\nVdash`	$\nVdash$	`\nVDash`	$\nVDash$
`\ntriangleleft`	$\ntriangleleft$	`\ntriangleright`	$\ntriangleright$
`\ntrianglelefteq`	$\ntrianglelefteq$	`\ntrianglerighteq`	$\ntrianglerighteq$
`\nsubseteq`	$\nsubseteq$	`\nsupseteq`	$\nsupseteq$
`\nsubseteqq`	$\nsubseteqq$	`\nsupseteqq`	$\nsupseteqq$
`\subsetneq`	$\subsetneq$	`\supsetneq`	$\supsetneq$
`\varsubsetneq`	$\varsubsetneq$	`\varsupsetneq`	$\varsupsetneq$
`\subsetneqq`	$\subsetneqq$	`\supsetneqq`	$\supsetneqq$
`\varsubsetneqq`	$\varsubsetneqq$	`\varsupsetneqq`	$\varsupsetneqq$

B.3 Binary operations

Type	Typeset	Type	Typeset
`+`	$+$	`-`	$-$
`\pm`	$\pm$	`\mp`	$\mp$
`\times`	$\times$	`\cdot`	$\cdot$
`\circ`	$\circ$	`\bigcirc`	$\bigcirc$
`\div`	$\div$	`\bmod`	$\bmod$
`\cap`	$\cap$	`\cup`	$\cup$
`\sqcap`	$\sqcap$	`\sqcup`	$\sqcup$
`\wedge` or `\land`	$\wedge$	`\vee` or `\lor`	$\vee$
`\triangleleft`	$\triangleleft$	`\triangleright`	$\triangleright$
`\bigtriangleup`	$\bigtriangleup$	`\bigtriangledown`	$\bigtriangledown$
`\oplus`	$\oplus$	`\ominus`	$\ominus$
`\otimes`	$\otimes$	`\oslash`	$\oslash$
`\odot`	$\odot$	`\bullet`	$\bullet$
`\dagger`	$\dagger$	`\ddagger`	$\ddagger$
`\setminus`	$\setminus$	`\smallsetminus`	$\smallsetminus$
`\wr`	$\wr$	`\amalg`	$\amalg$
`\ast`	$\ast$	`\star`	$\star$
`\diamond`	$\diamond$		
`\lhd`	$\lhd$	`\rhd`	$\rhd$
`\unlhd`	$\unlhd$	`\unrhd`	$\unrhd$
`\dotplus`	$\dotplus$	`\centerdot`	$\centerdot$
`\ltimes`	$\ltimes$	`\rtimes`	$\rtimes$
`\leftthreetimes`	$\leftthreetimes$	`\rightthreetimes`	$\rightthreetimes$
`\circleddash`	$\circleddash$	`\uplus`	$\uplus$
`\barwedge`	$\barwedge$	`\doublebarwedge`	$\doublebarwedge$
`\curlywedge`	$\curlywedge$	`\curlyvee`	$\curlyvee$
`\veebar`	$\veebar$	`\intercal`	$\intercal$
`\doublecap` or `\Cap`	$\Cap$	`\doublecup` or `\Cup`	$\Cup$
`\circledast`	$\circledast$	`\circledcirc`	$\circledcirc$
`\boxminus`	$\boxminus$	`\boxtimes`	$\boxtimes$
`\boxdot`	$\boxdot$	`\boxplus`	$\boxplus$
`\divideontimes`	$\divideontimes$	`\vartriangle`	$\vartriangle$
`\And`	$\And$		

B.4 Arrows

Type	Typeset	Type	Typeset
`\leftarrow`	$\leftarrow$	`\rightarrow` or `\to`	$\rightarrow$
`\longleftarrow`	$\longleftarrow$	`\longrightarrow`	$\longrightarrow$
`\Leftarrow`	$\Leftarrow$	`\Rightarrow`	$\Rightarrow$
`\Longleftarrow`	$\Longleftarrow$	`\Longrightarrow`	$\Longrightarrow$
`\leftrightarrow`	$\leftrightarrow$	`\longleftrightarrow`	$\longleftrightarrow$
`\Leftrightarrow`	$\Leftrightarrow$	`\Longleftrightarrow`	$\Longleftrightarrow$
`\uparrow`	$\uparrow$	`\downarrow`	$\downarrow$
`\Uparrow`	$\Uparrow$	`\Downarrow`	$\Downarrow$
`\updownarrow`	$\updownarrow$	`\Updownarrow`	$\Updownarrow$
`\nearrow`	$\nearrow$	`\searrow`	$\searrow$
`\swarrow`	$\swarrow$	`\nwarrow`	$\nwarrow$
`\iff`	$\iff$	`\mapstochar`	$\mapstochar$
`\mapsto`	$\mapsto$	`\longmapsto`	$\longmapsto$
`\hookleftarrow`	$\hookleftarrow$	`\hookrightarrow`	$\hookrightarrow$
`\leftharpoonup`	$\leftharpoonup$	`\rightharpoonup`	$\rightharpoonup$
`\leftharpoondown`	$\leftharpoondown$	`\rightharpoondown`	$\rightharpoondown$
`\leadsto`	$\leadsto$		
`\leftleftarrows`	$\leftleftarrows$	`\rightrightarrows`	$\rightrightarrows$
`\leftrightarrows`	$\leftrightarrows$	`\rightleftarrows`	$\rightleftarrows$
`\Lleftarrow`	$\Lleftarrow$	`\Rrightarrow`	$\Rrightarrow$
`\twoheadleftarrow`	$\twoheadleftarrow$	`\twoheadrightarrow`	$\twoheadrightarrow$
`\leftarrowtail`	$\leftarrowtail$	`\rightarrowtail`	$\rightarrowtail$
`\looparrowleft`	$\looparrowleft$	`\looparrowright`	$\looparrowright$
`\upuparrows`	$\upuparrows$	`\downdownarrows`	$\downdownarrows$
`\upharpoonleft`	$\upharpoonleft$	`\upharpoonright`	$\upharpoonright$
`\downharpoonleft`	$\downharpoonleft$	`\downharpoonright`	$\downharpoonright$
`\leftrightsquigarrow`	$\leftrightsquigarrow$	`\rightsquigarrow`	$\rightsquigarrow$
`\multimap`	$\multimap$		
`\nleftarrow`	$\nleftarrow$	`\nrightarrow`	$\nrightarrow$
`\nLeftarrow`	$\nLeftarrow$	`\nRightarrow`	$\nRightarrow$
`\nleftrightarrow`	$\nleftrightarrow$	`\nLeftrightarrow`	$\nLeftrightarrow$
`\dashleftarrow`	$\dashleftarrow$	`\dashrightarrow`	$\dashrightarrow$
`\curvearrowleft`	$\curvearrowleft$	`\curvearrowright`	$\curvearrowright$
`\circlearrowleft`	$\circlearrowleft$	`\circlearrowright`	$\circlearrowright$
`\leftrightharpoons`	$\leftrightharpoons$	`\rightleftharpoons`	$\rightleftharpoons$
`\Lsh`	$\Lsh$	`\Rsh`	$\Rsh$

B.5 Miscellaneous symbols

Type	Typeset	Type	Typeset
\hbar	$\hbar$	\ell	ℓ
\imath	$\imath$	\jmath	$\jmath$
\wp	$\wp$	\partial	∂
\Im	$\Im$	\Re	$\Re$
\infty	∞	\prime	$\prime$
\emptyset	$\emptyset$	\varnothing	$\varnothing$
\forall	$\forall$	\exists	$\exists$
\smallint	$\smallint$	\triangle	$\triangle$
\top	$\top$	\bot	$\bot$
\P	¶	\S	§
\dag	†	\ddag	‡
\flat	$\flat$	\natural	$\natural$
\sharp	$\sharp$	\angle	$\angle$
\clubsuit	$\clubsuit$	\diamondsuit	$\diamondsuit$
\heartsuit	$\heartsuit$	\spadesuit	$\spadesuit$
\surd	$\surd$	\nabla	∇
\pounds	£	\neg or \lnot	¬
\Box	$\Box$	\Diamond	$\Diamond$
\mho	$\mho$		
\hslash	$\hslash$	\complement	$\complement$
\backprime	$\backprime$	\nexists	$\nexists$
\Bbbk	$\Bbbk$		
\diagup	$\diagup$	\diagdown	$\diagdown$
\blacktriangle	▲	\blacktriangledown	▼
\triangledown	$\triangledown$	\eth	$\eth$
\square	$\square$	\blacksquare	■
\lozenge	$\lozenge$	\blacklozenge	⧫
\measuredangle	$\measuredangle$	\sphericalangle	$\sphericalangle$
\circledS	Ⓢ	\bigstar	★
\Finv	$\Finv$	\Game	$\Game$

B.6 Delimiters

Name	Type	Typeset
left parenthesis	`(`	(
right parenthesis	`)`	)
left bracket	`[` or `\lbrack`	[
right bracket	`]` or `\rbrack`	]
left brace	`\{` or `\lbrace`	{
right brace	`\}` or `\rbrace`	}
backslash	`\backslash`	\
forward slash	`/`	/
left angle bracket	`\langle`	⟨
right angle bracket	`\rangle`	⟩
vertical line	`|` or `\vert`	|
double vertical line	`\\|` or `\Vert`	‖
left floor	`\lfloor`	⌊
right floor	`\rfloor`	⌋
left ceiling	`\lceil`	⌈
right ceiling	`\rceil`	⌉
upward	`\uparrow`	↑
double upward	`\Uparrow`	⇑
downward	`\downarrow`	↓
double downward	`\Downarrow`	⇓
up-and-down	`\updownarrow`	↕
double up-and-down	`\Updownarrow`	⇕
upper-left corner	`\ulcorner`	⌜
upper-right corner	`\urcorner`	⌝
lower-left corner	`\llcorner`	⌞
lower-right corner	`\lrcorner`	⌟

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

Type	Typeset	Type	Typeset
`\det`	det	`\limsup`	lim sup
`\gcd`	gcd	`\max`	max
`\inf`	inf	`\min`	min
`\lim`	lim	`\Pr`	Pr
`\liminf`	lim inf	`\sup`	sup
`\injlim`	inj lim	`\projlim`	proj lim
`\varliminf`	$\underline{\lim}$	`\varlimsup`	$\overline{\lim}$
`\varinjlim`	$\varinjlim$	`\varprojlim`	$\varprojlim$

B.7.1 Large operators

Type	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}`	$\iiint_a^b$	$\iiint_a^b$
`\iiiint_{a}^{b}`	$\iiiint_a^b$	$\iiiint_a^b$
`\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}`	$\bigcup_{i=1}^{n}$	$\bigcup_{i=1}^{n}$
`\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}`	$\bigsqcup_{i=1}^{n}$	$\bigsqcup_{i=1}^{n}$
`\biguplus_{i=1}^{n}`	$\biguplus_{i=1}^{n}$	$\biguplus_{i=1}^{n}$
`\bigotimes_{i=1}^{n}`	$\bigotimes_{i=1}^{n}$	$\bigotimes_{i=1}^{n}$
`\bigoplus_{i=1}^{n}`	$\bigoplus_{i=1}^{n}$	$\bigoplus_{i=1}^{n}$
`\bigodot_{i=1}^{n}`	$\bigodot_{i=1}^{n}$	$\bigodot_{i=1}^{n}$
`\sum_{i=1}^{n}`	$\sum_{i=1}^{n}$	$\sum_{i=1}^{n}$

B.8 Math accents and fonts

Math accents

		amsxtra	
Type	Typeset	Type	Typeset
`\acute{a}`	$\acute{a}$		
`\bar{a}`	$\bar{a}$		
`\breve{a}`	$\breve{a}$	`\spbreve`	$\breve{}$
`\check{a}`	$\check{a}$	`\spcheck`	$\check{}$
`\dot{a}`	$\dot{a}$	`\spdot`	$\dot{}$
`\ddot{a}`	$\ddot{a}$	`\spddot`	$\ddot{}$
`\dddot{a}`	$\dddot{a}$	`\spdddot`	$\dddot{}$
`\ddddot{a}`	$\ddddot{a}$		
`\grave{a}`	$\grave{a}$		
`\hat{a}`	$\hat{a}$		
`\widehat{a}`	$\widehat{a}$	`\sphat`	$\hat{}$
`\mathring{a}`	$\mathring{a}$		
`\tilde{a}`	$\tilde{a}$		
`\widetilde{a}`	$\widetilde{a}$	`\sptilde`	$\tilde{}$
`\vec{a}`	$\vec{a}$		

Math fonts

Type	Typeset
LaTeX	
`\mathbf{A}`	$\mathbf{A}$
`\mathcal{A}`	$\mathcal{A}$
`\mathit{A}`	A
`\mathnormal{A}`	$\mathnormal{A}$
`\mathrm{A}`	A
`\mathsf{A}`	A
`\mathtt{A}`	$\mathtt{A}$
`\boldsymbol{\alpha}`	$\boldsymbol{\alpha}$
`\mathbb{A}`	$\mathbb{A}$
`\mathfrak{A}`	$\mathfrak{A}$
`\mathscr{a}`	$\mathscr{A}$

`\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	ıı	`\,`	`\thinspace`
medspace	ıı	`\:`	`\medspace`
thickspace	ıı	`\;`	`\thickspace`
interword space	ıı	`\␣`	
1 em	ı ı		`\quad`
2 em	ı ı		`\qquad`
Negative space			
1 mu	ı		`\mspace{-1mu}`
thinspace	ıı	`\!`	`\negthinspace`
medspace	ıı		`\negmedspace`
thickspace	ıı		`\negthickspace`

APPENDIX

C

LaTeX on the iPad

A few years back, personal computing was desktop-centric. To update the operating system, for back up, and for many other tasks, you had to connect your smartphone and tablet with a computer. Tim Cook (Apple's CEO as I am writing this book) coined the term "Post PC revolution" to describe the trend that a tablet is no longer a younger brother of a PC, but an equal partner; in fact, for many users, it can be the only computer they will ever need.

But can you use it for your LaTeX documents? Isn't the iPad designed only for e-mail, to read news, and enjoy entertainment? Certainly. While it has a dual-core CPU, it has a quad-core graphics chip so viewing videos and complex Web pages is quick. The operating system is designed to make performing these basic tasks very easy and intuitive. iOS masks the complexities of the underlying computer.

Nevertheless, underneath this easy-to-use interface there is a Mac. Get a little familiar with the iPad as a computer, and you can work with your LaTeX documents pretty well.

There are good reasons why the iPad is the only tablet I'll discuss. Today, the iPad is clearly the dominant tablet of more than a hundred on the market and the iPad is the only tablet with a decent market share that is in an *ecosystem*: the iPad is just one device under iCloud along with the iPhone, the Mac desktops, and the Mac notebooks.

G. Grätzer, *Practical LaTeX*, DOI 10.1007/978-3-319-06425-3,

I work on a LaTeX document on my iMac, and when I am away from home, I continue my work on my MacBook Air or iPad; there is no interruption, all the devices are fully synchronized.

In Section C.1, we discuss the iPad file system, sandboxing, file transfers, printing, and text editing. In Section C.2, we briefly review why is it difficult to implement LaTeX on an iPad. We discuss where are the files to be LaTeXed and where the LaTeX process takes place in Section C.3. Finally, in Section C.4, we introduce two LaTeX implementations for the iPad: Texpad and TeX Writer.

This appendix is based on my articles in the Notices of the Amer. Math. Soc. **60** (2013), 332–334 and 434–439.

C.1 The iPad as a computer

To work on a document, Roth sits in front of his computer, in the complex folder hierarchy he finds `document.tex`, double clicks it to start the LaTeX implementation, edits it, typesets it. Then he prints `document.pdf`, proofreads it, and then he goes back to editing...

How do you work with these on an iPad? On the iPad, there is only a rectangular array of apps. No documents are visible. There may be folders containing more apps, but no folder in a folder. There are no Library folders, no Download folder. And no File menu containing the Print command!

I have `document.tex` on my desktop, but how do I transfer it to the iPad? I would plug in my thumb drive to facilitate the transfer, but there is no USB port.

In the Mac operating system, OS 10, there are always features missing. And we always hope that a future version will incorporate a solution. But this is different. These features are missing on purpose. Here is what Steve Jobs said about the file system: "You don't keep your music in the file system, that would be crazy. You keep it in this app that knows about music and knows how to find things in lots of different ways. Same with photos... And eventually, the file system management is just gonna be an app for pros, and consumers aren't gonna need to use it."

I will cover now the file system and sandboxing, file transfers, and printing for the iPad. Finally, I briefly introduce text editing.

C.1.1 File system, sandboxing, and file transfers

The iPad starts up displaying a rectangular array of icons and folders for apps; see Figure C.1. There are no icons for documents.

There is no familiar Desktop for documents and folders. No Applications folder. No multiple users. The screen is always occupied by a single window—creating difficulties with help screens that crowd out the screens they are supposed to help with. The file system, as we know it from desktop computers, is gone.

Figure C.1: A rectangular array of apps

In its place is an app-centric starting point. Touch the icon of an app and you are in business. When the app opens, you get access to the documents and settings of the app.

For security reasons, the apps are sandboxed, limiting an app's access to files, preferences, network resources, hardware, and so on. Ars Technica's John Siracusa described the goal of sandboxing as follows: "Running an application inside a sandbox is meant to minimize the damage that could be caused if that application is compromised by a piece of malware. A sandboxed application voluntarily surrenders the ability to do many things that a normal process run by the same user could do. For example, a normal application run by a user has the ability to delete every single file owned by that user. Obviously, a well-behaved application will not do this. But if an application becomes compromised, it can be coerced into doing something destructive."

Of course, the iPad is a computer, and it has a File System, we just do not see it. But it is important to visualize it. To help us along, we will use an app.

C.1.2 FileApp Pro

If you search the iPad's App Store for "file" apps, there are more than 1,000 of them. Many of them could be used to help us understand the iPad file system. I choose FileApp Pro (by DigiDNA).

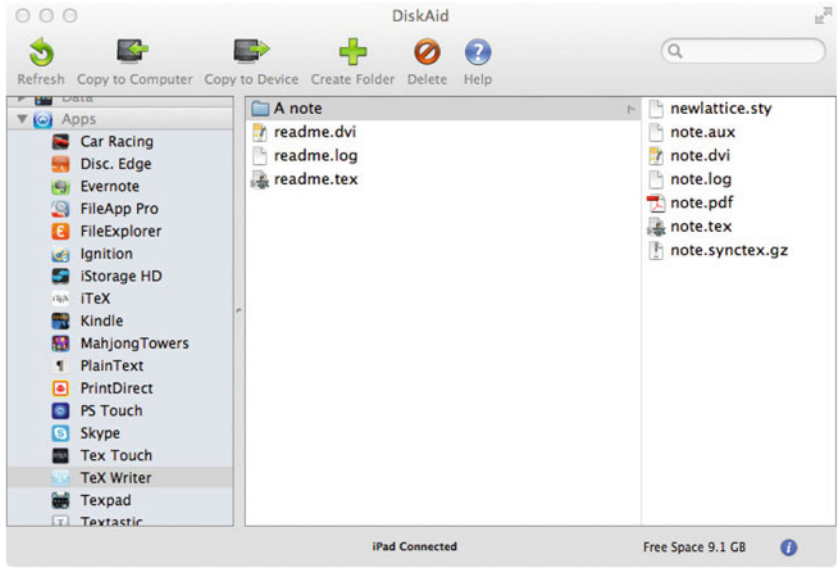

Figure C.2: DiskAid

To get started, plug the iPad into a desktop computer, download and start DiskAid on the computer; download and start FileApp (Pro) on the iPad. On the left panel of DiskAid, click on Apps, then on FileApp. The second pane now shows Imported Files, the right pane shows the files imported to the iPad; see Figure C.2. In FileApp, navigate to Imported Files. Anything you drag into the right pane of DiskAid is copied to FileApp's Imported Files. So much for file transfer. To see the file structure of the various iPad apps, click on their names. I choose TeX Writer.

File App Pro is a Swiss Army Knife of utilities. It can ZIP files, open ZIP files, create and edit text documents, record sound, and sing lullabies. Of course, for file transfers I should also mention the ubiquitous Dropbox. Download it for the iPad, sign in (as you did for your computer Dropbox); that's it.

C.1.3 Printing

When I first wanted to print from my iPhone, I realized that there is no print command. However, lots of apps would do the job. In fact, searching for "print" in the App Store, I discovered over 600 apps; many of them print, utilizing my desktop computer.

Typical of these apps is PrintDirect (EuroSmartz) and Printer Pro (Readdle Productivity). They can use any printer connected with your desktop computer. They wirelessly connect to your computer and print with its help.

If so many apps can help me out with printing, how come iOS does not? Read the comments about iOS printing; I was not the only one confused.

However, if the iPad is the poster child of the Post PC Revolution, its native printing solution cannot involve desktop computers. Apple introduced the appropriate technology; they named it AirPrint. The idea is simple: the iPad collaborates with the printer. Of course, for this you need a wireless printer that is AirPrint aware. Apple lists all the AirPrint aware printers:
http://support.apple.com/kb/ht4356+
as of this writing, about $1,000$. If you are lucky and have one of these printers, test it. Open an e-mail and touch the Action icon (here it is the Reply icon); this offers you the options: Reply, Forward, and Print. Touch Print. Printer Options appears, and you can choose how many copies and on which printer. (Lots of apps provide more choices, such as page range.) Choose the printer and print.

For a second test, open a Web page in Safari. There is only one difference: the action icon is a curved arrow in a rectangle.

As a third test, open the Drudge Report. It has the familiar Action icon; we are in business. Finally, open the Politico app, read the news and look for an action icon. There is none. So to use AirPrint, you need an AirPrint aware printer and an AirPrint aware app! For the time being, these are limiting restrictions.

C.1.4 Text editors

Many of us edit LaTeX documents in text editors more sophisticated than the text editor that comes with the LaTeX implementation. Some thoughts on iPad text editors.

First, writing about apps is like shooting at a moving target. While I was writing about an app, it went through four versions. Adding features, removing bugs.

Second, there are so many text editors, well over 200... Take a look at the table at
http://brettterpstra.com/ios-text-editors/
This table is a 103×31 matrix (as I'm writing this), each row representing a text editor, each column representing a feature (such as Search and Replace). The entries are Yes or No. Hovering over the name of a text editor, you get a listing of additional features and the App Store information.

Third, keeping the iPad horizontal, the keyboard gobbles up too much real estate. Keeping it vertical, the keyboard is less intrusive, but the keys are smaller. If you want to do serious work on the iPad, buy a keyboard.

Fourth, the iOS's touch text editing is nice, but it lacks a feature crucial for text editing: moving the cursor a character ahead or back. (Of course, keyboards have cursor keys!) Text editors offer a variety of solutions, for instance, finger swiping.

I will discuss briefly a very sophisticated text editor: Textastics. If you want Syntax Highlighting, Search and Replace, and Text Expander, this a good choice. In Figure C.3, you see me editing a document.

You can see the extra keyboard row and the cursor navigation wheel (which appears with a two finger tap—finger swipe also moves the cursor). It comes with an excellent user manual. (Textastics can also perform a number of non-editing tasks, such as zipping and unzipping files.) Textastics has a Mac version. And if you spend time shaping it to your liking, then you would like the same tamed editor for all your work.

C.2 Sandboxing and GPL

To implement LaTeX on an iPad, two major—man-made—obstacles have to be overcome: Sandboxing and the GPL license.

We discussed sandboxing in Section C.1.1. Does it impact LaTeX implementations? You bet. For instance: The LaTeX implementation Texpad on the Mac is given a single LaTeX root file; it then reads through the LaTeX source, gets all the included files, and presents you with an outline of your project. Sandboxing would not allow this. The handling of the auxiliary files also poses a problem. Of course, these problems can be overcome by ingenious programmers.

Richard Stallman, of Emacs fame, started the GNU operating system in 1983. Soon after, he started a nonprofit corporation called the Free Software Foundation. Stallman wrote, with the assistance of some law professors, the General Public License (GPL)—the most widely used free software license—released in 1989. Version 3 is dated June 29, 2007, the day the iPhone was released. Many software developers use GPL to ensure the free distribution of their software (source code and executable) under reasonable terms. Some software developers seem not to be aware of the fact that GPL licensed software cannot be used in an app created for the iPad. Two well known developers told to me that they use GPL because their peers do. Both would like to get out of it but do not know how. How ironic: the license that was supposed to allow you to spread your free software to wherever it is needed, now stops you from having it used on the fastest growing platform of all time.

C.3 Files and typesetting

C.3.1 Getting the files

The LaTeX files, of course, can always be composed in the app. But typically you already have them. You can obtain your existing files in two ways:

1. Using iTunes. To transfer files—one at a time—to your app from your computer using iTunes, connect your iPad to your computer and start iTunes by double clicking on its icon. Under Devices, we selected the iPad from the left side of the iTunes window; see Figure C.4. At the top of the iTunes window, next to Summary

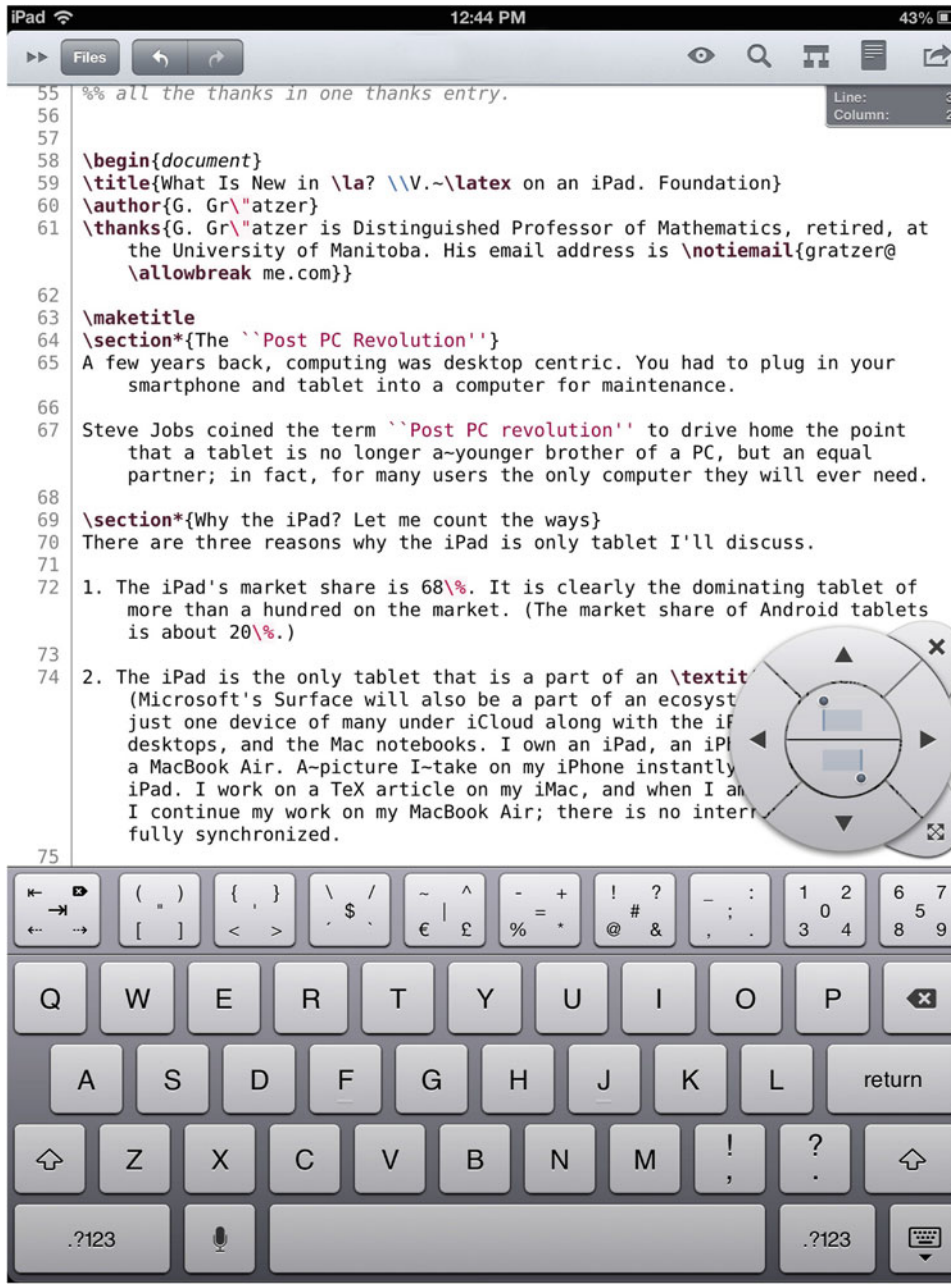

Figure C.3: Editing with Textastics

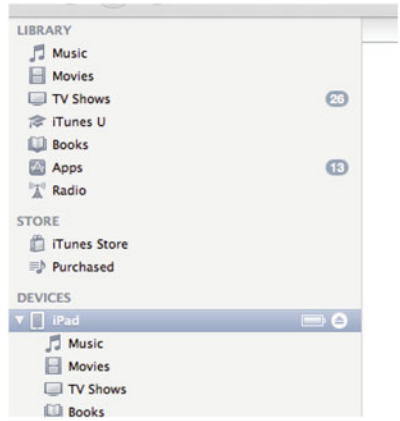

Figure C.4: Under Devices, we selected the iPad

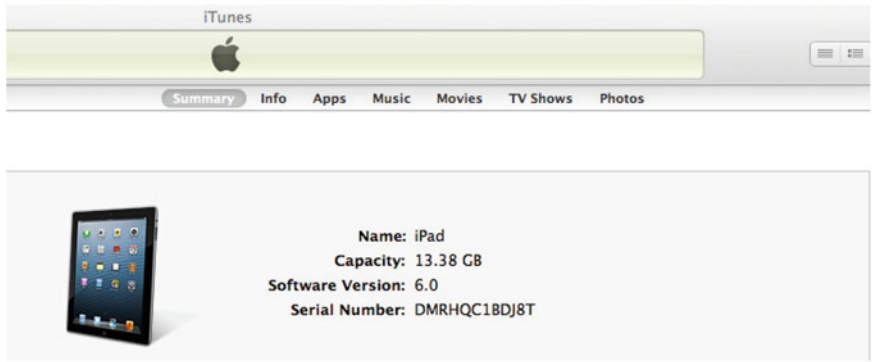

Figure C.5: Choose Apps

and Info, select Apps; see Figure C.5. The lower part of the window now has File Sharing; see Figure C.6. On the left, you see a listing of the apps available for file transfer. Select the app; the files already in the app are then listed in the right pane. Click on the add button and a file browser appears. Choose the file you want to transfer.

2. Via Dropbox. I assume that you have the ubiquitous Dropbox (the application that keeps your files safe and up-to-date across multiple devices and platforms). For an introduction, go to `dropbox.com`. In the app, you sign in to Dropbox. Now the app can see the contents of your Dropbox, or some part of it (at the Dropbox server) as long as you have an Internet connection.

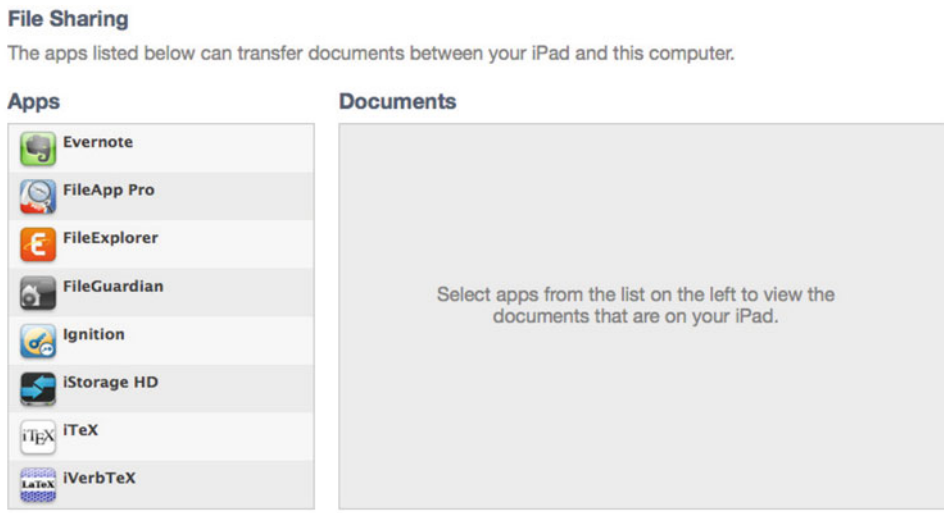

Figure C.6: Select app

C.3.2 Typesetting

The app can typeset the LaTeX file in the following ways:

A. On your iPad. This is the "Post PC revolution" option: the app places a LaTeX distribution on the iPad and you typeset with it. No computer or Internet connection is required. However, a complete LaTeX distribution is about 4 GB! No app can be this big. So you only get a minimal LaTeX distribution.

B. On your computer via Dropbox. This is the most powerful option. You have all the packages and fonts on your computer available to you. An app (such as AutomaTeX by Jonathan Weisberg) monitors if there is any change in the LaTeX file in Dropbox. If there is, the file is retypeset and the pdf is made available to you via the Dropbox.

C. In the cloud. This option provides you with a remote server, the Cloud; you connect to it with Wi-Fi. The server has a full LaTeX implementation, so you miss only the special fonts. And, of course, you must have Wi-Fi to use it. So you cannot polish up your lecture on the airplane on the way to a meeting.

Originally, the LaTeX output was a dvi file. These days, utilizing pdftex (under GPL license) by Hàn Thế Thành, the output is pdf. Since developers could not use GPL-d code, the output was dvi. These days, even on the iPad, pdf rules. In a more perfect world, these talented developers would not have to spend so much time reinventing GPL-d wheels.

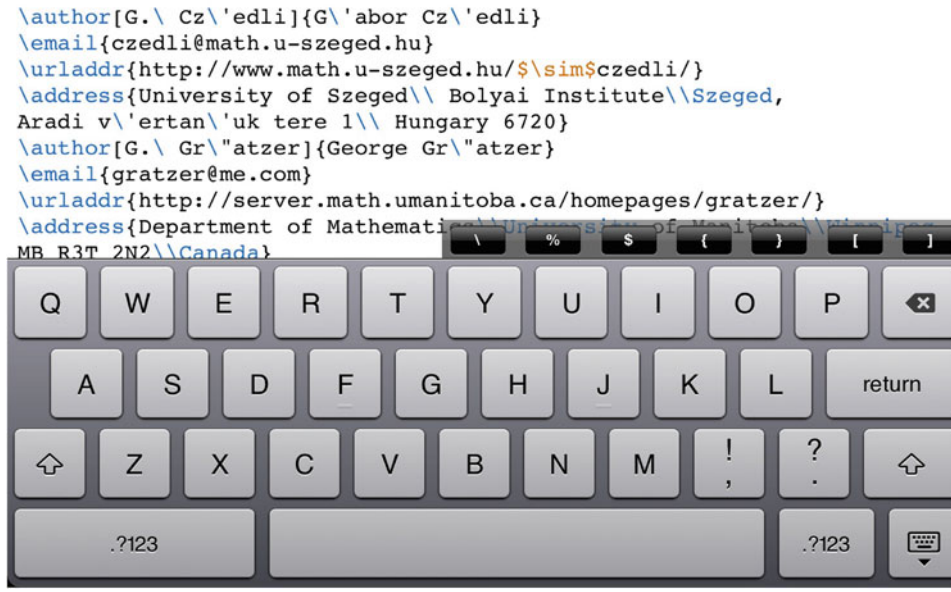

Figure C.7: Editing with soft keyboard

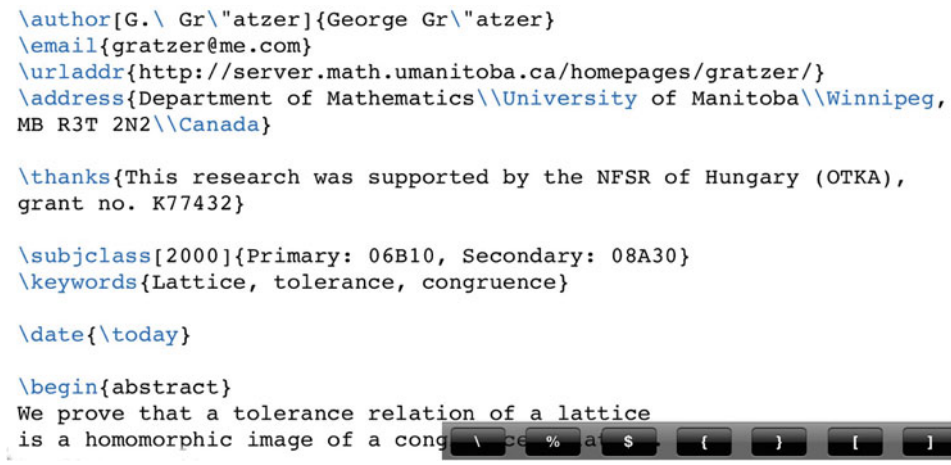

Figure C.8: Editing with Bluetooth keyboard

C.3.3 Keyboard or not to keyboard...

In Figure C.7, you see editing with the iPad's soft keyboard (notice the extra row of LaTeX keys added by the LaTeX implementation, Texpad) and in Figure C.8, editing with a Bluetooth keyboard (notice that the extra row of LaTeX keys of Texpad is still present).

C.4 Two LaTeX implementations for the iPad

We now discuss two LaTeX implementations that typeset on the iPad.

C.4.1 Texpad

Files: Via Dropbox. **Typesetting:** On your iPad, on your computer via Dropbox, in the cloud.
Documentation: Excellent and detailed on the iPad interface. It is available as a help file and also at

http://texpadapp.com/app-help-files/ios/help.html

A. On your iPad. This is the "Post PC revolution" option: the app places a LaTeX distribution on the iPad and you typeset with it. No computer or Internet connection is required. However, a complete LaTeX distribution is about 4 GB! No app can be this big. So you only get a small LaTeX distribution.

B. On your computer via Dropbox. This is the most powerful option. You have all the packages and fonts on your computer available to you. An app (such as AutomaTeX by Jonathan Weisberg) monitors if there is any change in the LaTeX file in Dropbox. If there is, the file is retypeset and the pdf is made available to you via the Dropbox.

C. In the cloud. This option provides you with a remote server, the Cloud; you connect to it with Wi-Fi. The server has a full LaTeX implementation, so you miss only the special fonts. And, of course, you must have Wi-Fi to use it. So you cannot polish up your lecture on the airplane on the way to a meeting.

Texpad is a LaTeX implementation for the Mac and for the iPad. It has some interesting features, including:

- Autocompletion of all common commands and autofilling `\cite`-s and `\ref`-s.
- Replacement of the LaTeX console with a list of errors and warnings linked to the source.
- Global search, outline view, and syntax highlight.

Step 1. To get started with Texpad, go to the iPad App Store and install Texpad.

Sign up for Dropbox with the same e-mail address and password as for your computer's Dropbox.

Step 2. Now open Texpad. Figure C.9 shows Texpad at the first startup.

The Help button gets the help file.

Step 3. Touch Off to turn Dropbox On. (If you have Dropbox installed and connected, it's even simpler, you just have to Allow the connection.) Your File Storage now gives two options: iPad and Dropbox; see Figure C.10. It is important to understand that your LaTeX files will live in the Dropbox (in the Cloud, at the Dropbox server) or locally on your iPad.

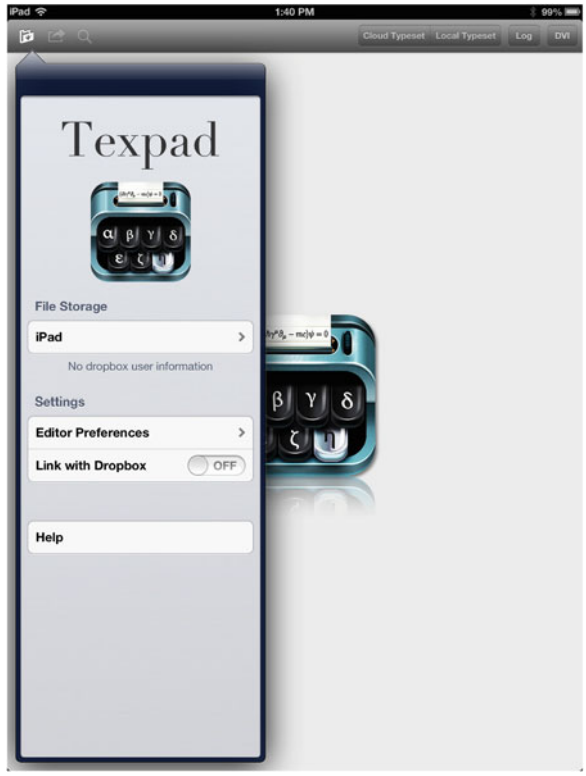

Figure C.9: Texpad first start up

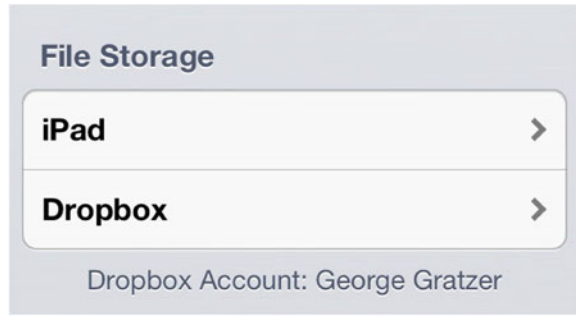

Figure C.10: Expanded File Storage

Step 4. The Dropbox files are now available to you by touching Dropbox under File Storage, see Figure C.10.

- First, create a folder for the LaTeX files to be transferred. Navigate to iPad file storage. Touch the + in the bottom right, and choose Folder. Name the folder.

- Second, navigate to the Dropbox file system view and to the folder containing the file you want to copy. Touch Edit. Select the file to transfer. At the bottom center, touch Copy. Navigate to the folder into which you want to copy the file and touch Copy.

Step 5. Typesetting will take place either on the iPad or in the Cloud. Go to the folder of a LaTeX file, touch the file (on the iPad or in the Dropbox), and typeset it on the iPad (touch Local Typeset) or in the Cloud, that is, at Valletta's server (touch Cloud Typeset).

Step 6. Try to visualize what is happening.

- If you typeset on the iPad and the file is on the iPad, it just typesets locally; that is it.
- If you typeset on the iPad and the file is in Dropbox, the file is transferred to the iPad, typeset, and the resulting pdf is sent back to the Dropbox; nothing is kept at the iPad.
- If you typeset in the Cloud and the file is in Dropbox, the file is transferred to the Cloud, typeset, and the resulting pdf is sent back to the Dropbox; nothing is kept in the Cloud.
- If you typeset in the Cloud and the file is on the iPad, the file is transferred to the Cloud, typeset, and the resulting pdf is sent back to the iPad.

Step 7. Once you touch a LaTeX file, you are ready to edit it. Cursor control is very important. You do it with a two finger swipe. Of course, this is not so important if you use a Bluetooth keyboard; it has cursor keys. But two finger swipe is faster!

Step 8. You edited and typeset your LaTeX file. You want to get to another file. Touch the organize button (the folder icon on the upper left). You get the Organizer window; see Figure C.11. Touch the button in the upper left of the window, you get back to Dropbox, eventually, to the expanded File Storage of Figure 7.

These eight steps should be enough to get you started. Read the Help file for some more information.

C.4.2 TeX Writer

Files: Via Dropbox. **Typesetting:** On your iPad.
Documentation: The file `readme.pdf` is no quick start, but it is useful for understanding how TeX Writer works and how to customize it. TeX Writer was the first to typeset on the iPad. It could only typeset TeX files. Now it has LaTeX and the AMS packages on board.

Step 1. When you start up TeX Writer, first link to Dropbox. In TeX Writer, you get a display showing the source file `readme.tex`; see Figure C.12. Pressing the More icon (right pointing arrow), you get more icons, to read the pdf version or Air Printing `readme.pdf`. On the left is the Organize icon; touching it, you get a file listing: `readme.tex` and `readme.pdf`. At the bottom is New File; touch it to compose one.

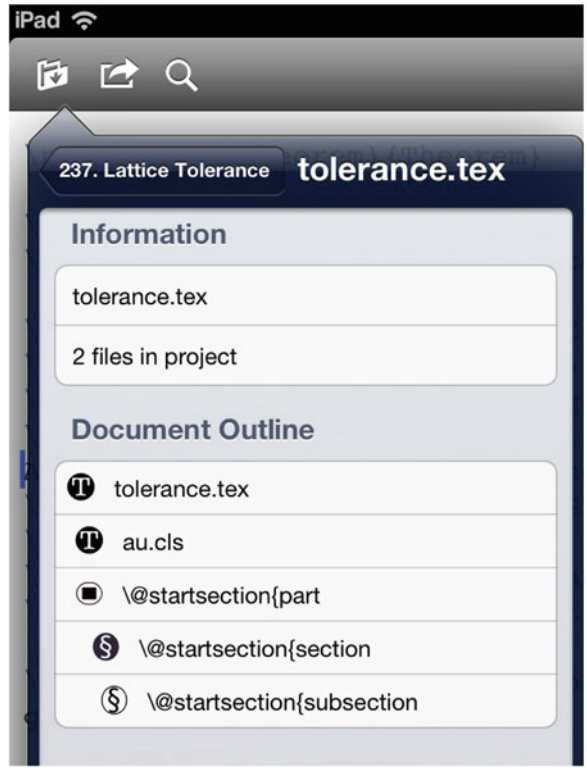

Figure C.11: Organizer window

Step 2. So you are perplexed about what to do next, you ran out of icons. You have to know that TeX Writer accesses the Dropbox in a special way. When you connect to Dropbox from TeX Writer, it creates a new folder `App` in Dropbox. In the folder `App` it creates the subfolder `TeX Writer`. In this subfolder you find `readme.tex`. Anything you put in the `TeX Writer` subfolder is visible in the file listing window on the iPad; anything not in this subfolder is not visible to TeX Writer.

Step 3. TeX Writer gets your files from this subfolder in Dropbox. Place a folder in there with the files of your current project. These will be available to you on your iPad. Moreover, these files are fully synchronized, so the editing changes you make on your iPad show up in Dropbox.

Step 4. LaTeXing, you spend most of your time editing. TeX Writer's editor has some interesting features. Excellent cursor control. Touch `begin{}` type in the name of the environment, and the environment is placed in your document; undo, redo, search, and so on.

When typing, you retain the editing functions you get at the start, and in addition, you get an extra row of LaTeX specific keys. You do not get them with a Bluetooth keyboard; however, the keyboard can have many of these keys you need for typing LaTeX. Nice feature: the Log viewer links to error lines.

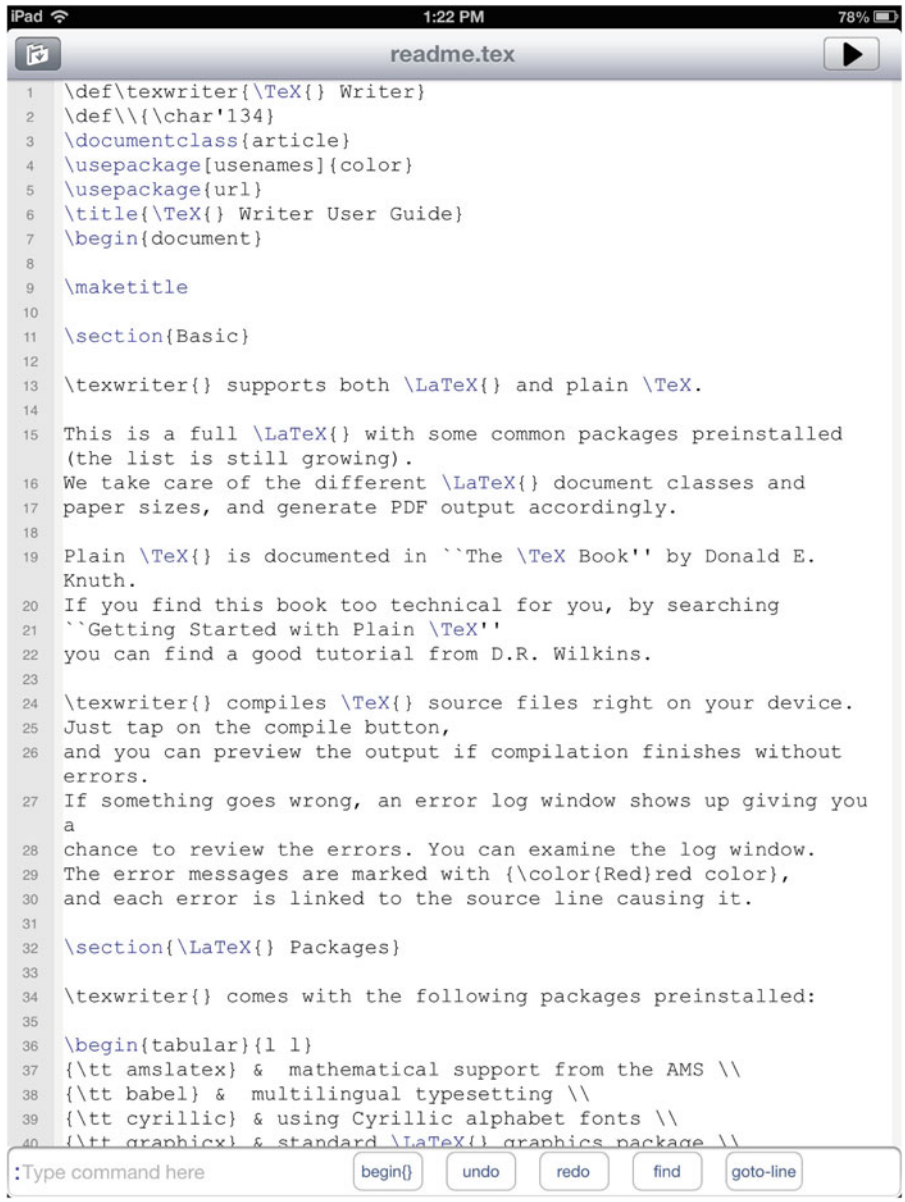

Figure C.12: TeX Writer startup

C.5 Conclusion

Jason Snell was interviewing Craig Federighi, Apple senior vice president of software engineering (and two more executives of Apple), for MacWorld. Snell writes:

"When I walked into Apple's offices for my conversation with the three executives, they noticed that I had brought a phone, a tablet, and a laptop, and had ultimately selected my MacBook Air as my tool of choice for the interview.

'You had a bunch of tools,' Federighi said, pointing at my bag. 'And you pulled out the one that felt right for the job that you were doing. It wasn't because it had more computing power. You pulled it out because it was the most natural device to accomplish a task.' "

I'm not suggesting that you write all your document on an iPad. I do suggest, however, that you can LaTeX with ease, say on a trip, correcting a document or adding a slide to your presentation. Use your iPad to LaTeX when appropriate.

LaTeXing on an iPad requires some compromises, for instance, you cannot use nonstandard fonts. Nevertheless, when not at your desk, the iPad will be nearly as functional as your MacBook Air, and it is so much easier to carry around...

Practical Finder

G. Grätzer, *Practical LaTeX*, DOI 10.1007/978-3-319-06425-3,