Writing the first LaTeX-Book

Walter Gander

2^5 Anniversary of TeX

San Francisco, June 29, 2010

Before TEX

$$(18e)\quad \int_{\alpha_{Min}}^{\alpha} \frac{d\alpha}{\sqrt{\bar{a}_2 - \frac{\bar{\alpha}_3^2}{\sin^2\alpha} - \frac{\bar{\alpha}_4^2}{\cos^2\alpha}}\,\sin^2\alpha} = -\frac{1}{2\bar{a}_3}\left[\arcsin \frac{\bar{a}_3^2 - \frac{1}{2}\cdot(\bar{a}_2+\bar{a}_3^2-\bar{a}_4^2)\sin^2\alpha}{\sin^2\alpha\sqrt{\frac{1}{4}(\bar{a}_2+\bar{a}_3^2-\bar{a}_4^2)^2 - \bar{a}_2\bar{a}_3^2}} - \frac{\pi}{2}\right]$$

$$(18f)\quad \int_{\alpha_{Min}}^{\alpha} \frac{d\alpha}{\sqrt{\bar{a}_2 - \frac{\bar{\alpha}_3^2}{\sin^2\alpha} - \frac{\bar{\alpha}_4^2}{\cos^2\alpha}}\,\cos^2\alpha} = \frac{1}{2\bar{a}_4}\left[\arcsin \frac{\bar{a}_4^2 - \frac{1}{2}(\bar{a}_2-\bar{a}_3^2+\bar{a}_4^2)\cos^2\alpha}{\cos^2\alpha\sqrt{\frac{1}{4}(\bar{a}_2-\bar{a}_3^2+\bar{a}_4^2)^2 - \bar{a}_2\bar{a}_4^2}} + \frac{\pi}{2}\right]$$

We state, once and for all, that the function arcsin is to be taken in the interval $[-\frac{\pi}{2}, \frac{\pi}{2}]$, while the function arccos is to be taken in $[0, \pi]$.

By making use of Eqs.(18) it is easy to establish the transformation formulae (13),(14),(13'),(14').

PhD Thesis ETH of Urs Kirchgraber 1972: The mathematics is hand-written, text with a typewriter, text not stored electronically.

Peter Henrici (IBM golf-ball typewriter 1970)

Then

$$\underset{\sim}{x} = \frac{1}{n} \sum_{k=0}^{n-1} x_k \, E^{-k} \underset{\sim}{\delta} ,$$

and by (i) and (ii) we have

$$P \underset{\sim}{x} = \frac{1}{n} \sum_{k=0}^{n-1} x_k \, P \, E^{-k} \underset{\sim}{\delta} = \frac{1}{n} \sum_{k=0}^{n-1} x_k \, E^{-k} \, P \underset{\sim}{\delta} .$$

If $p := P \underset{\sim}{\delta} \in \Pi$, there follows

$$b_m = \frac{1}{n} \sum_{k=0}^{n-1} x_k \int_0^1 (E^{-k} p)(\tau) \, e^{-2\pi i m \tau} \, d\tau$$

$$= \frac{1}{n} \sum_{k=0}^{n-1} x_k \int_0^1 p(\tau - \frac{k}{n}) \, e^{-2\pi i m \tau} \, d\tau .$$

By changing the ball, a golf-ball typewriter could also print Greek characters and special fonts. No storage of text.

Peter Henrici, typeset page

Then

$$\mathbf{x} = \frac{1}{n} \sum_{k=0}^{n-1} x_k E^{-k} \boldsymbol{\delta},$$

and by (i) and (ii) we have

$$P\mathbf{x} = \frac{1}{n} \sum_{k=0}^{n-1} x_k P E^{-k} \boldsymbol{\delta} = \frac{1}{n} \sum_{k=0}^{n-1} x_k E^{-k} P \boldsymbol{\delta}.$$

If $p := P\boldsymbol{\delta} \in \Pi$, it follows that

$$\begin{aligned} b_m &= \frac{1}{n} \sum_{k=0}^{n-1} x_k \int_0^1 (E^{-k} p)(\tau)\, e^{-2\pi i m \tau}\, d\tau \\ &= \frac{1}{n} \sum_{k=0}^{n-1} x_k \int_0^1 p\left(\tau - \frac{k}{n}\right) e^{-2\pi i m \tau}\, d\tau. \end{aligned}$$

His book "Applied Computational Complex Analysis" had still to be typeset by a typesetter.

Flexowriter – Solution of Heinz Rutishauser

Handbook for Automatic Computation, Description of Algol 60

Heinz Rutishauser wrote the whole book on paper-tape!

Flexowriter

Each page was stored on a paper-tape. A page had to be typed line by line sequentially. When modified a new tape was punched.

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Schreibt man die letzte Gleichung auf mit $i := i+1$ so ist

$$T_{ki} = T_{k-1,i} - \frac{h_k - h_{k-i-1}}{h_k - x} \Delta T_{ki}$$

Die Differenz der beiden letzten Gleichungen ergibt

$$\Delta T_{k,i-1} = \Delta T_{k-1,i-1} - \frac{h_k - h_{k-i-1}}{h_k - x} \Delta T_{ki} + \frac{h_k - h_{k-i}}{h_k - x} \Delta T_{k,i-1}$$

$$\Leftrightarrow \frac{h_k - h_{k-i-1}}{h_k - x} \Delta T_{ki} = \Delta T_{k-1,i-1} + \frac{x - h_{k-i}}{h_k - x} \Delta T_{k,i-1}$$

$$\Leftrightarrow \Delta T_{ki} = \frac{(h_k - x)\, \Delta T_{k-1,i-1} + (x - h_{k-i})\, \Delta T_{k,i-1}}{h_k - h_{k-i-1}}$$

q.e.d.

PhD Thesis ETH of Walter Gander 1973

1977/78 Postdoc Year in Stanford

Phyllis Winkler (technical typist of Don Knuth) typed my Habilitation

Finally (P2E) and (P3E) will be the corresponding problems with equality sign in the constraint.

The solution of (P1) is a stationary point of the Lagrange function (with the Lagrange multiplier λ)

$$L(\underline{x},\lambda) = \|\underline{A}\underline{x} - \underline{b}\|^2 + \lambda\{\|\underline{C}\underline{x} - \underline{d}\|^2 - \alpha^2\}$$

and therefore a solution of $\frac{\partial L}{\partial \underline{x}} = \underline{0}$ and $\frac{\partial L}{\partial \lambda} = 0$, which are the "normal equations":

$$(\underline{A}^T\underline{A} + \lambda\,\underline{C}^T\underline{C})\underline{x} = \underline{A}^T\underline{b} + \lambda\,\underline{C}^T\underline{d} \qquad (1.3)$$

$$\|\underline{C}\underline{x} - \underline{d}\|^2 = \alpha^2 \quad . \qquad (1.4)$$

If the matrix $\underline{A}^T\underline{A} + \lambda\,\underline{C}^T\underline{C}$ is nonsingular, then we can define

$$f(\lambda) := \|\underline{C}\,\underline{x}(\lambda) - \underline{d}\|^2 \qquad (1.5)$$

where $\underline{x}(\lambda)$ is the solution of (1.3). We will call f the "length

The Magic

- 1978 I saw for the first time a printed page full of mathematics coming out of a printer
- it was produced by TeX
- it became my crucial experience!
- I decided to learn to write using TeX

1979: First Beautiful Document sent to me from Stanford

This amounts to two real equations to be satisfied.

Denote by $\Gamma_1, \ldots, \Gamma_m$ the distinct connected components of P, numbered in counterclockwise order. For each $\ell \geq 2$, impose one more complex condition: if z_{k_ℓ} is the last vertex of Γ_ℓ in the counterclockwise direction, then (real equations 3,4,...,$2m$)

$$w_{k_\ell} - w_c = C \int_0^{z_{k_\ell}} \prod_{j=1}^{N} \left(1 - \frac{z'}{z_j}\right)^{-\beta_j} dz' . \qquad (2.4b)$$

Finally, $N - 2m - 1$ conditions of side length are imposed. For each pair (z_k, z_{k+1}) beginning at $k = 1$ and moving counterclockwise, where both vertices are finite, we require (real equations $2m+1, \ldots, N-1$)

$$|w_{k+1} - w_k| = \left| C \int_{z_k}^{z_{k+1}} \prod_{j=1}^{N} \left(1 - \frac{z'}{z_j}\right)^{-\beta_j} dz' \right| \qquad (2.4c)$$

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PhD Thesis of Nick Trefethen

Sabbatical 1984

Goal of Sabbatical:
Write a Textbook in TeX

Mark Kent pointed out
new LaTeX-version

The LaTeX Document
Preparation System

Leslie Lamport

Second Preliminary Edition
February 28, 1984

For LaTeX version 2.0., TeX version 1.0

1984: Nick Higham, Chris Fraley, Mark Kent, Walter Gander
Pat Worley, Veronica Kent, Visitor, Heidi and Beatrice Gander
Marie-Louise Gander

Writing the book “Computermathematik”

- German textbook teaching algorithms written in Pascal
  mostly focussed on topics in numerical analysis
- computer: UNIX VAX with TEX/ LATEX installation
- editor: emacs
- Starting with Chapter 4 “Polynome”
  quite a challenge for LATEX-beginner!

Kapitel 4
Polynome

Eine häufig verwendete Klasse von Funktionen bilden die *Polynome*.

Definition 4.1 *Seien $a_0, a_1, \ldots, a_n$ mit $a_n \neq 0$ gegebene Zahlen. Es ist dann*

$$P_n(x) = a_0 + a_1 x + \cdots + a_n x^n$$

ein Polynom vom Grade n. Die Zahlen a_i heissen die Koeffizienten von P_n.

4.1 Division durch einen Linearfaktor

Oft stellt sich die Aufgabe, ein Polynom $P_n(x)$ durch den Linearfaktor $(x - z)$ zu dividieren. Man erhält dabei ein Polynom vom Grade $n - 1$ und, falls die Division nicht aufgeht, eine Zahl r als Rest:

$$\frac{P_n(x)}{x - z} = P_{n-1}(x) + \frac{r}{x - z} \tag{4.1}$$

Beispiel 4.1 $P_3(x) = 3x^3 + x^2 - 5x + 1,\ z = 2$

$$\begin{array}{rcrcrcrlc}
(3x^3 & + & x^2 & - & 5x & + & 1) & :(x-2) & = \underbrace{3x^2+7x+9} \\
-3x^3 & + & 6x^2 & & & & & & P_2(x) \\
\hline
& & 7x^2 & - & 5x & & & & \\
& - & 7x^2 & + & 14x & & & & \\
\hline
& & & & 9x & + & 1 & & \\
& & & - & 9x & + & 18 & & \\
\hline
& & & & & & 19 & =r &
\end{array} \tag{4.2}$$

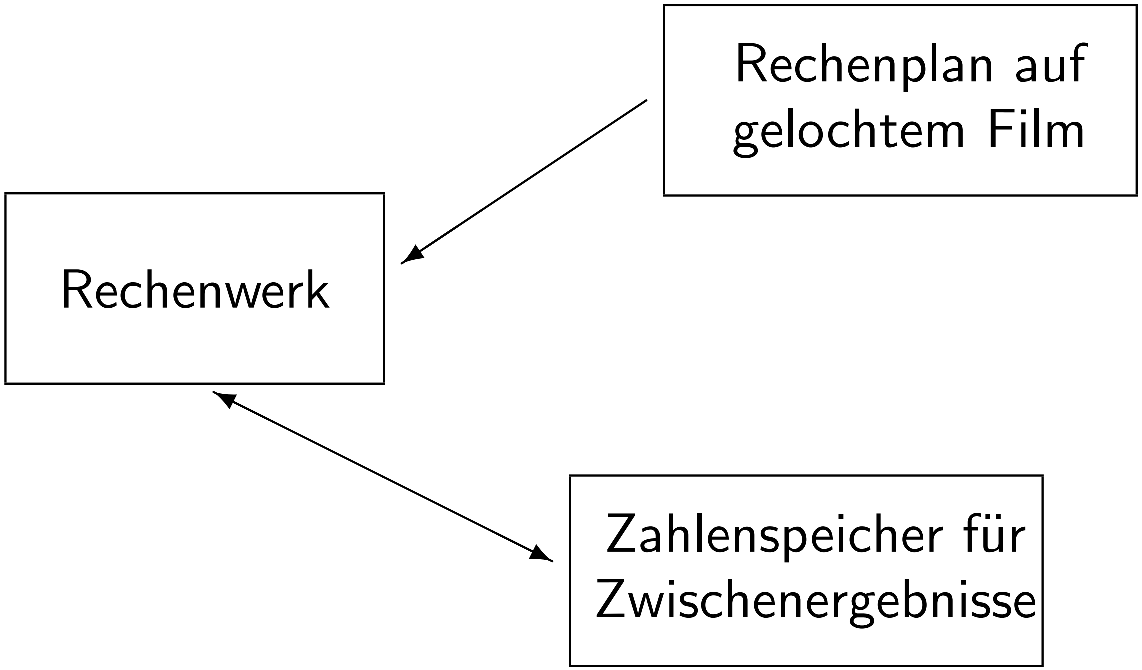
Somit lautet für dieses Beispiel die Gleichung (4.1)

$$\frac{3x^3 + x^2 - 5x + 1}{x - 2} = 3x^2 + 7x + 9 + \frac{19}{x - 2}.$$


```
\chapter{Polynome}
Eine h\"aufig verwendete Klasse von Funktionen bilden die {\em
  ^{Polynome}}.

{\defi \it Seien $a_0, a_1, \ldots, a_n$ mit $a_n\ne 0$ gegebene
Zahlen. Es ist dann
\[
P_n(x) = a_0 + a_1 x +\cdots +a_nx^n
\]
ein Polynom vom Grade $n$. Die Zahlen $a_i$ heissen die Koeffizienten
von $P_n$.}
\section{Division durch einen Linearfaktor}
Oft stellt sich die Aufgabe, ein Polynom $P_n(x)$ durch den {\em
  ^{Linearfaktor} } $(x-z)$ zu dividieren. Man erh\"alt dabei ein
Polynom vom Grade $n-1$ und, falls die Division nicht aufgeht, eine
Zahl $r$ als Rest:
\begin{equation}
    \label{44.2}
    \frac{P_n(x)} {x-z} = P_{n-1}(x) + \frac{r}{x-z}
\end{equation}

\begin{bsp}\label{41}
$P_3(x)=3x^3+x^2-5x+1$,   $z=2$
\end{bsp}
\medskip

\begin{equation} \label{44.*}
\arraycolsep 2pt
   \begin{array}{rcrcrcrlc}
    (3x^3 &+& x^2  &-& 5x  &+& 1) & :(x-2) & = \underbrace{3x^2+7x+9}\\
    -3x^3 &+& 6x^2  & &     & &    &        & P_2(x)
\\[-2\smallskipamount]
\multicolumn{3}{c}{\hrulefill&&&&&&\\
          & & 7x^2  &-& 5x  & &    &        &                      \\
          &-& 7x^2  &+&14x  & &    &        &
\\[-2\smallskipamount]
&\multicolumn{4}{c}{\hrulefill&&&&\\
          & &       & & 9x  &+& 1  &        &                      \\
          & &       &-& 9x  &+& 18 &        &
\\[-2\smallskipamount]
&&&\multicolumn{4}{c}{\hrulefill&&\\
          & &       & &     & & 19 &  =r    &
   \end{array}
\end{equation}
Somit lautet f\"ur dieses Beispiel die Gleichung (\ref{44.2})
\[ \frac{3x^3+x^2-5x+1}{x-2}=3x^2+7x+9+\frac{19}{x-2}.\]
```

Graphics: Using Basic LaTeX commands

```
\begin{figure}[htb]
  \begin{center}
  {\setlength{\unitlength}{8mm}
  \begin{picture}(13,7)(0,0)
       \put(0,3){\framebox(4,2){Rechenwerk}}
       \put(4,2){\vector(2,-1){1.8}}
       \put(4,2){\vector(-2,1){1.8}}
       \put(6,0){\framebox(5,2){
          \shortstack{Zahlenspeicher f\"ur\\
                      Zwischenergebnisse}}}
       \put(7,5){\framebox(5,2){
          \shortstack{Rechenplan auf\\
                      gelochtem Film}}}
       \put(6.8,6){\vector(-3,-2){2.6}}
  \end{picture}
  }
  \end{center}
\caption{Erste Computer}  \label{1F1}
\end{figure}
```



today: `\usepackage{graphicx}` and `\includegraphics`

Typesetting Pascal Programs

- today: we use `\verbatim` or `\verbatiminput`
- my programs looked like

```
FUNCTION quadratwurzel(a:real):real;
VAR xneu,xalt:real;
BEGIN
  xneu:=(1+a)/2;
  REPEAT
    xalt:=xneu; xneu:=(xalt+a/xalt)/2
  UNTIL xneu>=xalt;
  quadratwurzel:=xneu
END;
```

- want reserved words boldface: **begin**, **end**, **for**, etc
- indenting: Leslie Lamport recommended tabbing environment
- do not want to retype programs → use emacs to add necessary changes

```
\newcommand{\SETTABS}
{123\=456\=789\=123\=456\=789\=123\=456\=789\=123\=\kill
 \>\>\>\+\+\+}
```

- replace `BEGIN` by `\BEGIN`
- with `\newcommand{\BEGIN}{{\bf begin }\+}`
- characters "`\+`" cause the next line to be indented

```
 \begin{alg} \label{3wurzel} \it
\begin{tabbing} \SETTABS \\
\FUNCTION quadratwurzel(a:real):real;\\
\VAR xneu, xalt : real ; \\
\BEGIN \\
   $ xneu := (1+a)/2;$ \\
   \REPEAT \\
    $xalt:=xneu; xneu:=(xalt+a/xalt)/2$ \\
\< \- \UNTIL $xneu \ge xalt;$\\
   quadratwurzel := xneu \\
\END
\end{tabbing}
\end{alg}
```

function *quadratwurzel(a:real):real;*
var *xneu, xalt : real ;*
begin
    $xneu := (1 + a)/2;$
    repeat
        $xalt := xneu; xneu := (xalt + a/xalt)/2$
    until $xneu \geq xalt;$
    quadratwurzel := xneu
end

Printing Room Stanford 1984

Dover Laser Printer

Remark on the Dover

August 1 (Swiss National Day) - Party 1984

Fall 1984

- manuscript finished
- party at Wiederhold's home
- Don Knuth:"Now it is proved that LaTeX is useful"
- submit book to publishers, all accepted, decide for "Birkhäuser"
- proofreading
  no corrections possible in Switzerland, no Internet

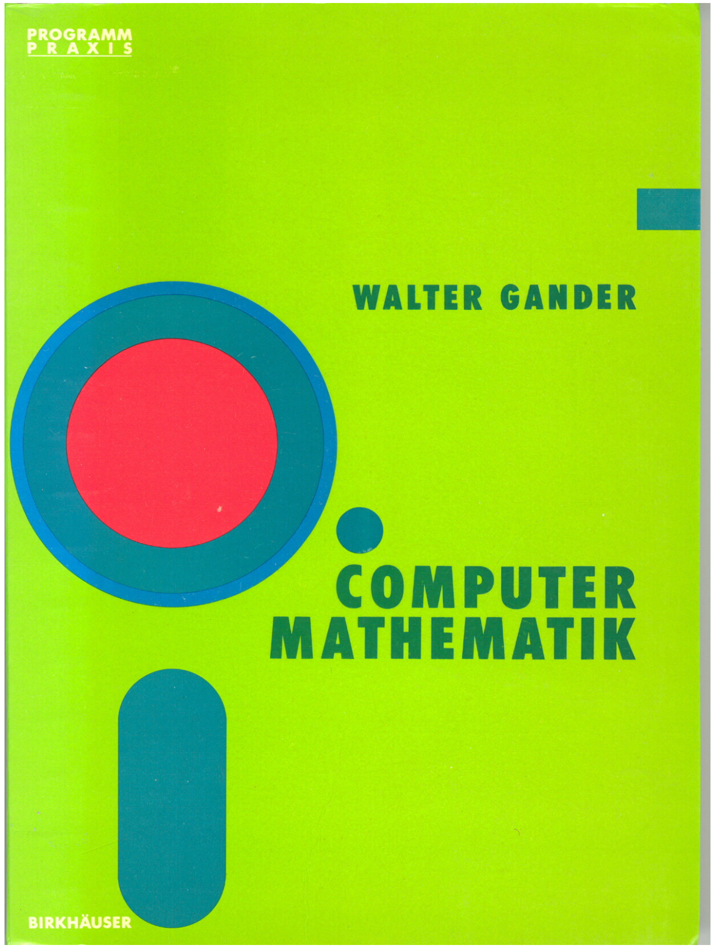
Gio and Voy Wiederhold

January 1985: Back in Stanford for Corrections

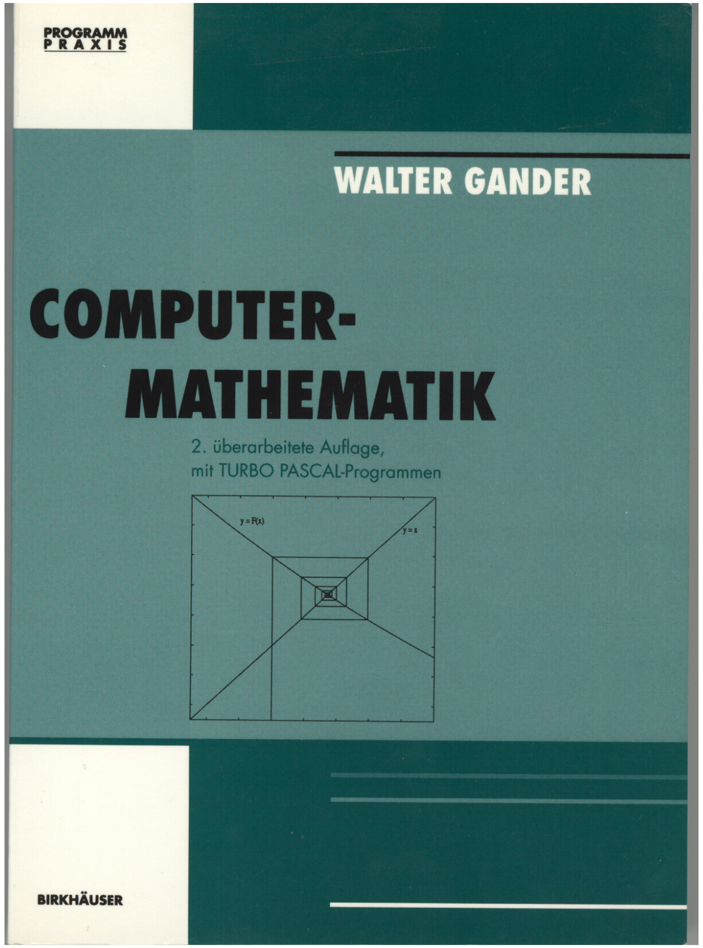
Producing the Book

- final version of the book was to be printed on the AlphaType photo laser printer
- the printer was down in January 1985
- ask Mark Kent to print the book and send the output by air-mail
- a few weeks later I got the book
- looking through: oh terrible – the page break was different!!
  reason: Leslie Lamport had installed a new version of LaTeX
- fix with real "copy/paste"

Printed Book



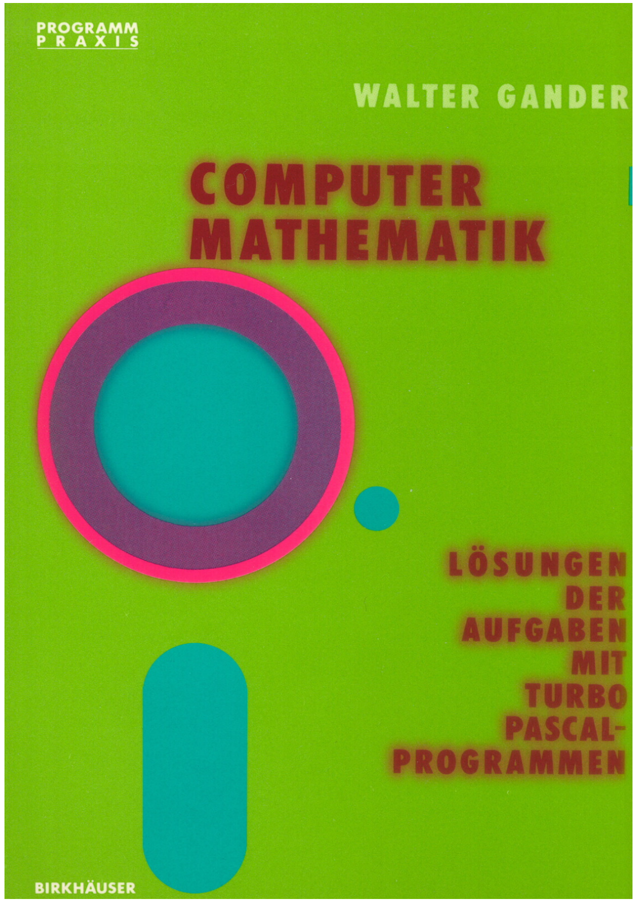
First Edition 1985



Second Edition 1992

Second Volume: Solution of all Exercises

- PC Olivetti M24, $ 6'000.–
  10 MB hard-disk
- TEX from MicroTeX, 5 MB
  no space for LATEX
- Solution book with Plain TEX
- Printing on dot matrix printer:
  very slow, not so nice as Dover
- Jan Olof Stenflo, ETH
  Astronomy, 1986 TEX/LATEX
  installation, laser printer



Epilogue

- book no longer in print, copyrights returned to author
- book now in public domain, offered to Google – very long procedure
- download as pdf-file from:
  `http://www.educ.ethz.ch/unt/um/inf/ad/cm`
- book compiled with `pdflatex` without major changes !!!
- no other type setting system so stable for over 25 years

Thank you very much Don and Leslie !!!!!