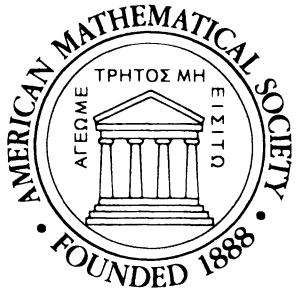


Mathematics of Computation



EDITED BY

James H. Bramble
Bille C. Carlson
Walter Gautschi, *Managing Editor*
Donald Goldfarb
Eugene Isaacson
Heinz-Otto Kreiss
James N. Lyness
Morris Newman
Syvert P. Nørsett
Andrew M. Odlyzko
Frank W. J. Olver
John E. Osborn
Stanley Osher
Beresford Parlett
Philip Rabinowitz
Larry L. Schumaker
Ridgway Scott
Daniel Shanks
Frank Stenger
Hans J. Stetter
G. W. Stewart
Vidar C. Thomée
Lars B. Wahlbin
Hugh C. Williams
John W. Wrench, Jr.

July 1986

Volume 47, Number 175, Pages 1–386

**Published by the American Mathematical Society
Providence, Rhode Island USA**

ISSN 0025-5718

Editorial Committee

WALTER GAUTSCHI, Chairman, Dept. of Computer Sciences, Purdue Univ., West Lafayette, IN 47907
DONALD GOLDFARB, Dept. of Industrial Engineering and Operations Research, Seely W. Mudd Building,
Columbia Univ. in the City of New York, New York, NY 10027
JOHN E. OSBORN, Dept. of Mathematics, Univ. of Maryland, College Park, MD 20742
HUGH C. WILLIAMS, Dept. of Computer Science, Univ. of Manitoba, Winnipeg, Manitoba, Canada R3T 2N2

Technical Editor

MIRIAM E. PORILE, Dept. of Computer Sciences, Purdue Univ., West Lafayette, IN 47907

Board of Associate Editors

JAMES H. BRAMBLE, Dept. of Mathematics, Cornell Univ., Ithaca, NY 14853
BILLE C. CARLSON, Dept. of Mathematics, Iowa State Univ., Ames, IA 50011
EUGENE ISAACSON, Courant Institute of Mathematical Sciences, New York Univ., 251 Mercer Street, New
York, NY 10012
HEINZ-OTTO KREISS, Dept. of Applied Mathematics, California Institute of Technology, Pasadena, CA
91125
JAMES N. LYNNESS, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439
MORRIS NEWMAN, Dept. of Mathematics, Univ. of California, Santa Barbara, CA 93106
SYVERT P. NØRSETT, Div. of Numerical Mathematics, The University of Trondheim and The Norwegian
Institute of Technology, Alfred Getz vei 1, N-7034 Trondheim-NTH, Norway
ANDREW M. ODLYZKO, AT & T Bell Laboratories, 600 Mountain Avenue, Murray Hill, NJ 07974
FRANK W. J. OLVER, Inst. for Physical Science and Technology, Univ. of Maryland, College Park, MD 20742
STANLEY OSHER, Dept. of Mathematics, Univ. of California, Los Angeles, CA 90024
BERESFORD PARLETT, Dept. of Mathematics, Univ. of California, Berkeley, CA 94720
PHILIP RABINOWITZ, Dept. of Applied Mathematics, The Weizmann Institute of Science, Rehovot, Israel
LARRY L. SCHUMAKER, Center for Approximation Theory, Dept. of Mathematics, Texas A & M Univ.,
College Station, TX 77843-3368
RIDGWAY SCOTT, Dept. of Mathematics, Univ. of Michigan, Ann Arbor, MI 48109
DANIEL SHANKS, Dept. of Mathematics, Univ. of Maryland, College Park, MD 20742
FRANK STENGER, Dept. of Mathematics, Univ. of Utah, Salt Lake City, UT 84112
HANS J. STETTER, Institut für Numerische Mathematik, Technische Universität Wien, Wiedner Hauptstrasse
6-10, A-1040, Wien, Austria
G. W. STEWART, Dept. of Computer Science, Univ. of Maryland, College Park, MD 20742
VIDAR C. THOMÉE, Mathematics Dept., Chalmers Univ. of Technology, Göteborg, Sweden
LARS B. WAHLBIN, Dept. of Mathematics, Cornell Univ., Ithaca, NY 14853
JOHN W. WRENCH, JR., 6310 Jefferson Blvd., Frederick, MD 21701

SUBSCRIPTION INFORMATION: MATHEMATICS OF COMPUTATION is published quarterly, with issues numbered serially since Volume 1, Number 1. Subscription prices for Volumes 46 and 47 (1986) are \$164.00 list; \$131.00 institutional member; \$107.00 member of CBMS organizations; \$98.00 individual AMS member. A late charge of 10% of the subscription price will be imposed upon orders received from nonmembers after January 1 of the subscription year. Subscribers outside the United States and India must pay a postage surcharge of \$8.00; subscribers in India must pay a postage surcharge of \$18.00. Combination paper and microfiche subscription prices are \$218.00 list; \$174.00 institutional member. Microfiche of each issue will be mailed the fastest way before the issue is mailed by the printer.

BACK NUMBER INFORMATION: Back number prices *per volume* are for Volumes 1–21, \$80.00 list, \$64.00 member; for Volumes 22–33, \$120.00 list, \$96.00 institutional member; for Volumes 34–43, \$80.00 list, \$64.00 institutional member; Volumes 44–45, \$113.00 list, \$90.00 institutional member. Back volumes may be purchased on microfilm or microfiche from University Microfilms International, 300 North Zeeb Road, Ann Arbor, MI 48106.

UNPUBLISHED MATHEMATICAL TABLES: The editorial office of the journal maintains a repository of Unpublished Mathematical Tables (UMT). When a table is deposited in the UMT repository a brief summary of its contents is published in the section *Reviews and Descriptions of Tables and Books*. Upon request, the chairman of the editorial committee will supply copies of any table for a nominal cost per page. All tables and correspondence concerning the UMT should be sent to Walter Gautschi, Chairman, Editorial Committee, Mathematics of Computation, Department of Computer Sciences, Purdue University, West Lafayette, IN 47907.

Orders for subscriptions and publications of the American Mathematical Society should be addressed to the AMS, P.O. Box 1571, Annex Station, Providence, RI 02901-1571. *All orders must be accompanied by payment.* Other correspondence should be addressed to P.O. Box 6248, Providence, RI 02940.

MATHEMATICS OF COMPUTATION is published quarterly by the American Mathematical Society, 201 Charles Street, Providence, RI 02904. Second-class postage is paid at Providence, Rhode Island, and additional mailing offices. Postmaster: Send address changes to Mathematics of Computation, American Mathematical Society, P.O. Box 6248, Providence, RI 02940.

Copyright © 1986, American Mathematical Society All rights reserved.

Printed in the United States of America

The paper used in this journal is acid-free and falls within the guidelines

Editorial Committee

WALTER GAUTSCHI, Chairman, Dept. of Computer Sciences, Purdue Univ., West Lafayette, IN 47907

DONALD GOLDFARB, Dept. of Industrial Engineering and Operations Research, Seely W. Mudd Building,
Columbia Univ. in the City of New York, New York, NY 10027

JOHN E. OSBORN, Dept. of Mathematics, Univ. of Maryland, College Park, MD 20742

HUGH C. WILLIAMS, Dept. of Computer Science, Univ. of Manitoba, Winnipeg, Manitoba, Canada R3T 2N2

Technical Editor

MIRIAM E. PORILE, Dept. of Computer Sciences, Purdue Univ., West Lafayette, IN 47907

Board of Associate Editors

JAMES H. BRAMBLE, Dept. of Mathematics, Cornell Univ., Ithaca, NY 14853

BILLE C. CARLSON, Dept. of Mathematics, Iowa State Univ., Ames, IA 50011

EUGENE ISAACSON, Courant Institute of Mathematical Sciences, New York Univ., 251 Mercer Street, New
York, NY 10012

HEINZ-OTTO KREISS, Dept. of Applied Mathematics, California Institute of Technology, Pasadena, CA
91125

JAMES N. LYNES, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439

MORRIS NEWMAN, Dept. of Mathematics, Univ. of California, Santa Barbara, CA 93106

SYVERT P. NØRSETT, Div. of Numerical Mathematics, The University of Trondheim and The Norwegian
Institute of Technology, Alfred Getz vei 1, N-7034 Trondheim-NTH, Norway

ANDREW M. ODLYZKO, AT & T Bell Laboratories, 600 Mountain Avenue, Murray Hill, NJ 07974

FRANK W. J. OLVER, Inst. for Physical Science and Technology, Univ. of Maryland, College Park, MD 20742

STANLEY OSHER, Dept. of Mathematics, Univ. of California, Los Angeles, CA 90024

BERESFORD PARLETT, Dept. of Mathematics, Univ. of California, Berkeley, CA 94720

PHILIP RABINOWITZ, Dept. of Applied Mathematics, The Weizmann Institute of Science, Rehovot, Israel

LARRY L. SCHUMAKER, Center for Approximation Theory, Dept. of Mathematics, Texas A & M Univ.,
College Station, TX 77843-3368

RIDGWAY SCOTT, Dept. of Mathematics, Univ. of Michigan, Ann Arbor, MI 48109

DANIEL SHANKS, Dept. of Mathematics, Univ. of Maryland, College Park, MD 20742

FRANK STENGER, Dept. of Mathematics, Univ. of Utah, Salt Lake City, UT 84112

HANS J. STETTER, Institut für Numerische Mathematik, Technische Universität Wien, Wiedner Hauptstrasse
6-10, A-1040, Wien, Austria

G. W. STEWART, Dept. of Computer Science, Univ. of Maryland, College Park, MD 20742

VIDAR C. THOMÉE, Mathematics Dept., Chalmers Univ. of Technology, Göteborg, Sweden

LARS B. WAHLBIN, Dept. of Mathematics, Cornell Univ., Ithaca, NY 14853

JOHN W. WRENCH, JR., 6310 Jefferson Blvd., Frederick, MD 21701

SUBSCRIPTION INFORMATION: MATHEMATICS OF COMPUTATION is published quarterly, with issues numbered serially since Volume 1, Number 1. Subscription prices for Volumes 46 and 47 (1986) are \$164.00 list; \$131.00 institutional member; \$107.00 member of CBMS organizations; \$98.00 individual AMS member. A late charge of 10% of the subscription price will be imposed upon orders received from nonmembers after January 1 of the subscription year. Subscribers outside the United States and India must pay a postage surcharge of \$8.00; subscribers in India must pay a postage surcharge of \$18.00. Combination paper and microfiche subscription prices are \$218.00 list; \$174.00 institutional member. Microfiche of each issue will be mailed the fastest way before the issue is mailed by the printer.

BACK NUMBER INFORMATION: Back number prices *per volume* are for Volumes 1–21, \$80.00 list, \$64.00 member; for Volumes 22–33, \$120.00 list, \$96.00 institutional member; for Volumes 34–43, \$80.00 list, \$64.00 institutional member; Volumes 44–45, \$113.00 list, \$90.00 institutional member. Back volumes may be purchased on microfilm or microfiche from University Microfilms International, 300 North Zeeb Road, Ann Arbor, MI 48106.

UNPUBLISHED MATHEMATICAL TABLES: The editorial office of the journal maintains a repository of Unpublished Mathematical Tables (UMT). When a table is deposited in the UMT repository a brief summary of its contents is published in the section *Reviews and Descriptions of Tables and Books*. Upon request, the chairman of the editorial committee will supply copies of any table for a nominal cost per page. All tables and correspondence concerning the UMT should be sent to Walter Gautschi, Chairman, Editorial Committee, Mathematics of Computation, Department of Computer Sciences, Purdue University, West Lafayette, IN 47907.

Orders for subscriptions and publications of the American Mathematical Society should be addressed to the AMS, P.O. Box 1571, Annex Station, Providence, RI 02901-1571. *All orders must be accompanied by payment.* Other correspondence should be addressed to P.O. Box 6248, Providence, RI 02940.

MATHEMATICS OF COMPUTATION is published quarterly by the American Mathematical Society, 201 Charles Street, Providence, RI 02904. Second-class postage is paid at Providence, Rhode Island, and additional mailing offices. Postmaster: Send address changes to Mathematics of Computation, American Mathematical Society, P.O. Box 6248, Providence, RI 02940.

Copyright © 1986, American Mathematical Society. All rights reserved.

Printed in the United States of America

The paper used in this journal is acid-free and falls within the guidelines established to ensure permanence and durability

MATHEMATICS OF COMPUTATION

TABLE OF CONTENTS

July 1986

Claes Johnson and Jukka Saranen , Streamline Diffusion Methods for the Incompressible Euler and Navier-Stokes Equations.....	1
Bradley J. Lucier , On Nonlocal Monotone Difference Schemes for Scalar Conservation Laws	19
Randall J. LeVeque , Intermediate Boundary Conditions for Time-Split Methods Applied to Hyperbolic Partial Differential Equations	37
I. Lasiecka , Galerkin Approximations of Abstract Parabolic Boundary Value Problems With Rough Boundary Data— L_p Theory	55
Ohannes A. Karakashian , On Runge-Kutta Methods for Parabolic Problems with Time-Dependent Coefficients	77
J. H. Bramble, J. E. Pasciak and A. H. Schatz , The Construction of Preconditioners for Elliptic Problems by Substructuring. I.....	103
R. S. Falk and P. B. Monk , Logarithmic Convexity for Discrete Harmonic Functions and the Approximation of the Cauchy Problem for Poisson's Equation.....	135
F. Brezzi and M. Fortin , Numerical Approximation of Mindlin-Reissner Plates	151
Ezio Venturino , On Solving Singular Integral Equations via a Hyperbolic Tangent Quadrature Rule	159
M. C. Delfour and F. Dubeau , Discontinuous Polynomial Approximations in the Theory of One-Step, Hybrid and Multistep Methods for Nonlinear Ordinary Differential Equations	169
Howard C. Elman , A Stability Analysis of Incomplete LU Factorizations.....	191
A. J. Hughes Hallett , The Convergence of Accelerated Overrelaxation Iterations	219
Frank Stenger , Explicit Nearly Optimal Linear Rational Approximation with Preassigned Poles	225
C. Underhill , Some Asymptotic Properties of Padé Approximants to e^{-x}	253
Ronald G. Mosier , Root Neighborhoods of a Polynomial	265
Coert Olmsted , Two Formulas for the General Multivariate Polynomial Which Interpolates a Regular Grid on a Simplex.....	275
Claus Schneider and Wilhelm Werner , Some New Aspects of Rational Interpolation	285
Giovanni Monegato , Quadrature Formulas for Functions with Poles Near the Interval of Integration	301
J. N. Lyness and G. Giunta , A Modification of the Weeks Method for Numerical Inversion of the Laplace Transform.....	313
Paul N. Swarztrauber , Symmetric FFTs	323
E. Elizalde , An Asymptotic Expansion for the First Derivative of the Generalized Riemann Zeta Function.....	347
P. Shiu , Counting Sums of Two Squares: The Meissel-Lehmer Method	351
H. J. J. te Riele , Computation of All the Amicable Pairs Below 10^{10}	361
Reviews and Descriptions of Tables and Books	369
Kaucher and Miranker 19 , Jerri 20 , Wimp 21 , Moore 22 , Böhmer and Stetter, Editors 23 , Golub and Van Loan 24 , Bellman 25 , Thompson 26 , Miller 27 , Baxter, Scheuer, Blischke and McConalogue 28 , Verwer,	

Editor 29, Brebbia, Editor 30, Whiteman, Editor 31, Griffiths, Editor 32, Hackbusch, Editor 33, Evans, Editor 34, Glowinski and Lions, Editors 35

Corrigendum	385
Hasegawa, Torii and Ninomiya	
Supplement to “Discontinuous Polynomial Approximations in the Theory of One-Step, Hybrid and Multistep Methods for Nonlinear Ordinary Differential Equations” by M. C. Delfour and F. Dubeau	S1
Supplement to “Computation of All the Amicable Pairs Below 10^{10} ” by H. J. J. te Riele	S9

Information for Contributors

Authors are encouraged to prepare articles electronically with the AMS-TeX software package in the AMS pre-print style and to provide the article in this electronic form for typesetting. While this procedure may not reduce the interval between submission and publication of an article, generally much more accurate copy will be returned for proofreading. Production time for manuscripts prepared with other systems, even TeX itself without AMS-TeX, currently prevents cost-effective use of the existing electronic form. Before sending an AMS-TeX manuscript for typesetting, contact the AMS Composition Department for details.

Manuscripts prepared by some means other than AMS-TeX should be double-spaced and produced in the format used by the journal. For journal abbreviations, see the latest *Mathematical Reviews* volume index. An author should submit the original and two copies of the manuscript and retain one copy. The author may suggest an appropriate editor for his paper. It is recommended that the author acquaint himself with the pertinent material contained in “A Manual for Authors of Mathematical Papers,” which is available from the American Mathematical Society. All contributions intended for publication and all books for review should be addressed to Walter Gautschi, Chairman, Editorial Committee, Mathematics of Computation, Department of Computer Sciences, Purdue University, West Lafayette, Indiana 47907. The date received, which is published with the final version of an accepted paper, is the date received in the office of the Chairman of the Editorial Committee, and it is the responsibility of the author to submit manuscripts directly to this office. Institutions sponsoring research reported in the journal are assessed page and microfiche charges.

Each article submitted for publication must be accompanied by a brief and reasonably self-contained abstract, and by 1980 *Mathematics Subject Classification* (1985 Revision) numbers. If a list of key words and phrases is included, it will be printed as a footnote on the first page. A list of the classification numbers may be found in the 1984 Subject Index to Mathematical Reviews.

The research journals of the American Mathematical Society carry a page charge of \$50.00 per page to help defray the cost of publication. This amount is charged to the institution or to a contract supporting the research reported in the published paper. The publication charge policy of the United States Federal Council for Science and Technology (FCST) is reported on page 112 of the February, 1975 issue of the NOTICES of the American Mathematical Society. In no case is the author personally responsible for paying the page charge, nor is acceptance of the author’s paper for publication dependent upon payment of the page charge.

Copying and Reprinting

Individual readers of this publication, and nonprofit libraries acting for them, are permitted to make fair use of the material, such as to copy an article for use in teaching or research. Permission is granted to quote brief passages from this publication in reviews provided the customary acknowledgement of the source is given.

Republication, systematic copying, or multiple reproduction of any material in this publication (including abstracts) is permitted only under license from the American Mathematical Society. Requests for such permission should be addressed to the Executive Director, American Mathematical Society, P. O. Box 6248, Providence, Rhode Island 02940.

The appearance of the code on the first page of an article in this journal indicates the copyright owner’s consent for copying beyond that permitted by Sections 107 or 108 of the U. S. Copyright Law, provided that the fee of \$1.00 plus \$.25 per page for each copy be paid directly to Copyright Clearance Center, Inc., 21 Congress Street, Salem, Massachusetts 01970. This consent does not extend to other kinds of copying, such as copying for general distribution, for advertising or promotion purposes, for creating new collective works, or for resale.