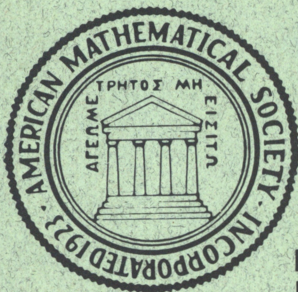


Mathematics of Computation



EDITED BY
James H. Bramble, *Managing Editor*
Carl de Boor
Todd Dupont
Walter Gautschi
Donald Goldfarb
Eugene Isaacson
Heinz-Otto Kreiss
Yudell L. Luke
James N. Lyness
Morris Newman
Beresford Parlett
Lawrence E. Payne
Philip Rabinowitz
John R. Rice
Daniel Shanks
Hans J. Stetter
Vidar C. Thomée
Hugh C. Williams
John W. Wrench, Jr.

October 1979

Volume 33, Number 148, Pages 1125–1390

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

ISSN 0025-5718

Editorial Committee

JAMES H. BRAMBLE, Chairman. Center for Applied Mathematics, 275 Olin Hall, Cornell Univ., Ithaca, NY 14853

CARL DE BOOR, Mathematics Research Center, Univ. of Wisconsin, Madison, WI 53706

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

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

Technical Editor

CAROL A. HOLLAND, Center for Applied Mathematics, 275 Olin Hall, Cornell Univ., Ithaca, NY 14853

Board of Associate Editors

TODD DUPONT, Dept of Mathematics, Univ. of Chicago, Chicago, IL 69637

DONALD GOLDFARB, Dept. of Computer Sciences, School of Engineering, The City College of the City Univ. of New York, 139th Street & Convent Avenue, New York, NY 10031

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

HEINZ-OTTO KREISS, Computer Science Dept., Univ. of Uppsala, Uppsala, Sturegaten 4, Sweden

YUDELL L. LUKE, Dept. of Mathematics, Univ. of Missouri at Kansas City, Kansas City, MO 64110

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

BERESFORD PARLETT, Dept. of Computer Science, Univ. of California, Berkeley, CA 94720

LAWRENCE E. PAYNE, Dept. of Mathematics, Cornell Univ., Ithaca, NY 14853

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

JOHN R. RICE, Division of Mathematical Sciences, Purdue Univ., Lafayette, IN 47907

HANS J. STETTER, Institut für Numerische Mathematik, Technische Universität Wien, Karlsplatz 13, A-1040, Wien, Austria

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

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

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

SUBSCRIPTION INFORMATION: MATHEMATICS OF COMPUTATION is published quarterly in one volume per year, with issues numbered serially since Volume 1, Number 1. Subscription prices for Volume 33 (1979) are \$55.00 list; \$39.00 institutional member; \$20.00 individual member; \$29.00 member of CBMS organizations. Combination paper and microform (microfiche or microfilm) subscription prices are \$74.00 list; \$52.00 institutional member. Microfiche of each issue will be mailed the fastest way before the camera copy is sent to the printer.

BACK NUMBER INFORMATION: Back number prices *per volume* are for Volumes 1–27, \$36.00 list, \$27.00 member; for Volumes 28–29, \$54.00 list, \$40.50 member; for Volume 30, \$72.00 list, \$54.00 member; for Volumes 31–32, \$84.00 list, \$63.00 member. Back volumes are also available on 16mm positive or negative microfilm. The microfilm may be mounted on spools or in Kodak or 3M cartridges. Only current subscribers are eligible to purchase back volumes on microfilm. Write to the AMS for a detailed price list.

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.

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

Second class postage paid at Providence, Rhode Island, and additional mailing offices.

U. S. Postal Service Publication No. 333980

Copyright © 1979, American Mathematical Society

Printed in the United States of America

MATHEMATICS OF COMPUTATION

TABLE OF CONTENTS

October 1979

Richard E. Ewing and Richard S. Falk , Numerical Approximation of a Cauchy Problem for a Parabolic Partial Differential Equation.....	1125
Saul Abarbanel and David Gottlieb , Stability of Two-Dimensional Initial Boundary Value Problems Using Leap-Frog Type Schemes.....	1145
Tsutomu Ikeda and Tomoyasu Nakagawa , On the SHASTA FCT Algorithm for the Equation $\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x} (v(\rho)\rho) = 0$	1157
David Hoff , A Finite Difference Scheme for a System of Two Conservation Laws with Artificial Viscosity.....	1171
Peter Alfeld , A Special Class of Explicit Linear Multistep Methods as Basic Methods for the Correction in the Dominant Space Technique.....	1195
Wolf-Jürgen Beyn , The Exact Order of Convergence for Finite Difference Approximations to Ordinary Boundary Value Problems.....	1213
Robert D. Skeel , Equivalent Forms of Multistep Formulas.....	1229
G. K. Gupta , A Polynomial Representation of Hybrid Methods for Solving Ordinary Differential Equations.....	1251
R. S. Stepleman and N. D. Winarsky , Adaptive Numerical Differentiation.....	1257
Fred T. Krogh , Recurrence Relations for Computing With Modified Divided Differences.....	1265
Steven Pruess , Alternatives to the Exponential Spline in Tension.....	1273
Stephen Demko , On Bounding $\ A^{-1}\ _{\infty}$ for Banded A	1283
Dianne P. O'Leary, G. W. Stewart and James S. Vandergraft , Estimating the Largest Eigenvalue of a Positive Definite Matrix.....	1289
Dominique Dumont , A Combinatorial Interpretation for the Schett Recurrence on the Jacobian Elliptic Functions.....	1293
K. V. Leung and S. S. Ghaderpanah , An Application of the Finite Element Approximation Method to Find the Complex Zeros of the Modified Bessel Function $K_n(z)$	1299
Harvey Cohn , Cyclic-Sixteen Class Fields for $\mathbf{Q}(-p)^{1/2}$ by Modular Arithmetic....	1307
H. C. Williams and Daniel Shanks , A Note on Class-Number One in Pure Cubic Fields.....	1317
William W. Adams , On a Relationship Between the Convergents of the Nearest Integer and Regular Continued Fractions.....	1321
Robert Baillie , New Primes of the Form $k \cdot 2^n + 1$	1333
H. C. Williams and E. Seah , Some Primes of the Form $(a^n - 1)/(a - 1)$	1337
Emil Grosswald and Peter Hagis, Jr. , Arithmetic Progressions Consisting Only of Primes.....	1343
Joseph L. Gerver and L. Thomas Ramsey , Sets of Integers With No Long Arithmetic Progressions Generated by the Greedy Algorithm.....	1353
Richard P. Brent , On the Zeros of the Riemann Zeta Function in the Critical Strip.....	1361

Reviews and Descriptions of Tables and Books	1373
Exton 6, Larsen 7	
Table Errata	1377
GradshTEyn and Ryzhik 565	
Indices to Volume XXXIII	1378

Information for Contributors

Manuscripts should be typewritten double-spaced 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 James H. Bramble, Chairman, Editorial Committee, Mathematics of Computation, Center for Applied Mathematics, 275 Olin Hall, Cornell University, Ithaca, New York 14853. 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 AMS (MOS) subject classification 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 Index to Mathematical Reviews, Volume 39 (June 1970).

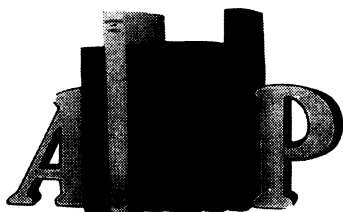
The research journals of the American Mathematical Society carry a page charge of \$40.00 per page to help defray the cost of publication. This amount is charged to the institution or to a contract supporting the research reported in the published paper. The publication charge policy of the United States 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 acknowledgment 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, 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 copier pay the stated per copy fee through the Copyright Clearance Center, Inc., Operations Center, P.O. Box 765, Schenectady, New York 12301. 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.



Numerical Solution of Differential Equations

A volume in the *Computer Science and Applied Mathematics Series*

by ISAAC FRIED

CONTENTS: Finite Differences. Two-Point Boundary Value Problems. Variational Formulations. Finite Elements. Discretization Accuracy. Eigenproblems. Algebraic Properties of the Global Matrices. Equation of Heat Transfer. Equation of Motion. Wave Equation. Index. Exercises and Suggestions for further reading at the end of each chapter.

1979, 288 pp., \$23.50
ISBN: 0-12-267780-3

Future volumes in COMPUTER SCIENCE AND APPLIED MATHEMATICS SERIES are now available on a Continuation Order basis. Your Continuation Order authorizes us to ship and bill each future volume in the series automatically, immediately upon publication. This order will remain in effect until cancelled.

Send payment with order and save postage and handling charge.

Prices are subject to change without notice.

ACADEMIC PRESS, INC.

A Subsidiary of
Harcourt Brace Jovanovich, Publishers
111 FIFTH AVE., NEW YORK, N.Y. 10003
24-28 OVAL ROAD, LONDON NW1 7DX



SIAM-AMS PROCEEDINGS
(ISSN 0080-5084)

FRACTURE MECHANICS
edited by Robert Burridge

This volume contains expanded versions of ten of the twelve invited papers given at a joint AMS/SIAM Symposium on Mathematical Problems in Fracture Mechanics, New York, March 28-29, 1978. The Symposium was supported by the NSF and ERDA. Its purpose was to interest applied mathematicians in this area of mechanics, which is currently of growing interest both in engineering and in the theory of earthquake mechanisms.

The Proceedings are divided into four sections which correspond to the four sessions at the Symposium.

Part I. Dynamic fracture problems

- J. D. Achenbach, *Elastodynamic fracture mechanics*
- L. B. Freund, *A one-dimensional dynamic crack propagation model*
- R. Burridge, G. Conn, and L. B. Freund, *The stability of a rapid shear crack with finite cohesive traction* (Abstract only)

Part II. Seismic source theory

- K. Aki, *Evolution of quantitative models of earthquakes*
- R. Madariaga, *Seismic radiation from earthquake models based on fracture mechanics*

Part III. Nonlinear fields and integral conservation laws

- J. K. Knowles, *Crack problems in finite elastostatics*
- J. R. Willis, *The solution of elastoplastic fracture problems by matched asymptotic expansions*
- L. B. Freund, *Stress intensity factor calculations based on the M-integral conservation law*

Part IV. Rate-dependent and nonelastic crack growth

- J. C. Amazigo, *Some mathematical problems of elastic-plastic crack growth*
- R. A. Schapery, *On the analysis of crack initiation and growth in nonhomogeneous viscoelastic media*
- D. A. Simons, *The analysis of propagating slip zones in porous elastic media*

Volume 12

170 + vi pages

List \$13.60; institutional member \$10.20;

individual member \$6.80

ISBN 0-8218-1332-3; LC 78-24473

Publication date: March 22, 1979

To order, please specify SIAMS/12

Prepayment is required. Send to AMS,
P.O. Box 1571, Annex Station, Providence, RI 02901

Reviews and Descriptions of Tables and Books	1373
Exton 6, Larsen 7	
Table Errata	1377
Gradshteyn and Ryzhik 565	
Indices to Volume XXXIII	1378

MATHEMATICS OF COMPUTATION

TABLE OF CONTENTS

October 1979

Richard E. Ewing and Richard S. Falk, Numerical Approximation of a Cauchy Problem for a Parabolic Partial Differential Equation.....	1125
Saul Abarbanel and David Gottlieb, Stability of Two-Dimensional Initial Boundary Value Problems Using Leap-Frog Type Schemes.....	1145
Tsutomu Ikeda and Tomoyasu Nakagawa, On the SHASTA FCT Algorithm for the Equation $\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x} (v(\rho)\rho) = 0$	1157
David Hoff, A Finite Difference Scheme for a System of Two Conservation Laws with Artificial Viscosity.....	1171
Peter Alfeld, A Special Class of Explicit Linear Multistep Methods as Basic Methods for the Correction in the Dominant Space Technique.....	1195
Wolf-Jürgen Beyn, The Exact Order of Convergence for Finite Difference Approximations to Ordinary Boundary Value Problems.....	1213
Robert D. Skeel, Equivalent Forms of Multistep Formulas.....	1229
G. K. Gupta, A Polynomial Representation of Hybrid Methods for Solving Ordinary Differential Equations.....	1251
R. S. Stepleman and N. D. Winarsky, Adaptive Numerical Differentiation.....	1257
Fred T. Krogh, Recurrence Relations for Computing With Modified Divided Differences.....	1265
Steven Pruess, Alternatives to the Exponential Spline in Tension.....	1273
Stephen Demko, On Bounding $\ A^{-1}\ _{\infty}$ for Banded A	1283
Dianne P. O'Leary, G. W. Stewart and James S. Vandergraft, Estimating the Largest Eigenvalue of a Positive Definite Matrix.....	1289
Dominique Dumont, A Combinatorial Interpretation for the Schett Recurrence on the Jacobian Elliptic Functions.....	1293
K. V. Leung and S. S. Ghaderpanah, An Application of the Finite Element Approximation Method to Find the Complex Zeros of the Modified Bessel Function $K_n(z)$	1299
Harvey Cohn, Cyclic-Sixteen Class Fields for $\mathbb{Q}(-p)^{1/2}$ by Modular Arithmetic.....	1307
H. C. Williams and Daniel Shanks, A Note on Class-Number One in Pure Cubic Fields.....	1317
William W. Adams, On a Relationship Between the Convergents of the Nearest Integer and Regular Continued Fractions.....	1321
Robert Baillie, New Primes of the Form $k \cdot 2^n + 1$	1333
H. C. Williams and E. Seah, Some Primes of the Form $(a^n - 1)/(a - 1)$	1337
Emil Grosswald and Peter Hagis, Jr., Arithmetic Progressions Consisting Only of Primes.....	1343
Joseph L. Gerver and L. Thomas Ramsey, Sets of Integers With No Long Arithmetic Progressions Generated by the Greedy Algorithm.....	1353
Richard P. Brent, On the Zeros of the Riemann Zeta Function in the Critical Strip.....	1361