## Mathematics of Computation



## EDITED BY

James H. Bramble
Bille C. Carlson
James W. Demmel
Walter Gautschi, Managing Editor
Donald Goldfarb
Eugene Isaacson
Heinz-Otto Kreiss
James N. Lyness
Harald Niederreiter
Syvert P. Nørsett
Andrew M. Odiyzko
Frank W. J. Olver
John E. Osborn
Stanley Osher
Carl Pomerance
René Schoof
Larry L. Schumaker
Ridgway Scott
Daniel Shanks
Frank Stenger
Hans J. Stetter
G. W. Stewart

Vidar Thomée
Lars B. Wahlbin
Hugh C. Williams
John W. Wrench, Jr.
October 1989
Volume 53, Number 188, Pages 455-794
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
ANDREW M. ODLYZKO, AT\&T Bell Laboratories, 600 Mountain Avenue, Murray Hill, NJ 07974
JOHN E. OSBORN, Dept. of Mathematics, Univ. of Maryland, College Park, MD 20742

## Technical Editor

ERIKA GAUTSCHI, 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
JAMES W. DEMMEL, Courant Institute of Mathematical Sciences, New York Univ., 251 Mercer Street, New York, NY 10012
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. LYNESS, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439
HARALD NIEDERREITER, Mathematical Institute, Austrian Academy of Sciences, Dr.-Ignaz-SeipelPlatz 2, A-1010 Vienna, Austria
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
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
CARL POMERANCE, Dept. of Mathematics, The Univ. of Georgia, Athens, GA 30602
RENÉ SCHOOF, Mathematisch Instituut, Rijksuniversiteit Utrecht, Budapestlaan 6, Postbus 80.010, 3508 TA Utrecht, The Netherlands
LARRY L. SCHUMAKER, Dept. of Mathematics, Vanderbilt Univ., Nashville, TN 37235
RIDGWAY SCOTT, Dept. of Mathematics, Pennsylvania State Univ., University Park, PA 16802
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 THOMÉE, Mathematics Dept., Chalmers Univ. of Technology, S-412 96 Göteborg, Sweden
LARS B. WAHLBIN, Dept. of Mathematics, Cornell Univ., Ithaca, NY 14853
HUGH C. WILLIAMS, Dept. of Computer Science, Univ. of Manitoba, Winnipeg, Manitoba, Canada R3T 2N2
JOHN W. WRENCH, JR., 102 Mt. Olivet 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 52 and 53 (1989) are $\$ 183.00$ list; $\$ 146.00$ institutional member; $\$ 119.00$ member of CBMS organizations; $\$ 110.00$ individual AMS member. A late charge of $10 \%$ of the subscription price will be imposed upon orders received from nonmember institutions and organizations 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 $\$ 243.00$ list; $\$ 195.00$ 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, $\$ 82.00$ list, $\$ 66.00$ member; for Volumes $22-33$, $\$ 124.00$ list, $\$ 99.00$ institutional member; for Volumes $34-43, \$ 82.00$ list, $\$ 64.00$ institutional member; Volumes $44-45, \$ 113.00$ list, $\$ 90.00$ institutional member; Volumes 46-47, $\$ 127.00$ list, $\$ 102.00$ institutional member; Volumes $48-49, \$ 135.00$ list, $\$ 108.00$ institutional member; Volumes $50-51, \$ 136.00$ list, $\$ 109.00$ 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 02940. 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 (C) 1989, 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

# MATHEMATICS OF COMPUTATION TABLE OF CONTENTS 

## October 1989

Ricardo H. Nochetto, A Stable Extrapolation Method for Multidimensional Degenerate Parabolic Problems ..... 455
Milan Miklavcic, Approximations for Weakly Nonlinear Evolution Equations ..... 471
P. Degond and S. Mas-Gallic, The Weighted Particle Method for Convection- Diffusion Equations. Part 1: The Case of an Isotropic Viscosity ..... 485
P. Degond and S. Mas-Gallic, The Weighted Particle Method for Convection- Diffusion Equations. Part 2: The Anisotropic Case ..... 509
Anders Szepessy, Convergence of a Shock-Capturing Streamline Diffusion Finite Element Method for a Scalar Conservation Law in Two Space Dimensions ..... 527
P. Dutt, Stability and Convergence of Spectral Methods for Hyperbolic Initial- Boundary Value Problems ..... 547
Glenn R. Luecke, Numerical Approximation of Minimum Norm Solutions of $K f=g$ for Special $K$ ..... 563
Hermann Brunner, Collocation Methods for Nonlinear Volterra Integro- Differential Equations with Infinite Delay ..... 571
D. D. Ang, John Lund, and Frank Stenger, Complex Variable and Regulariza- tion Methods of Inversion of the Laplace Transform ..... 589
Ch. Großmann and H.-G. Roos, Uniform Enclosure of High Order for Bound- ary Value Problems by Monotone Discretization ..... 609
Gene H. Golub and Mark D. Kent, Estimates of Eigenvalues for Iterative Methods ..... 619
J. N. Lyness and I. H. Sloan, Some Properties of Rank-2 Lattice Rules ..... 627
Claude Brezinski, Procedures for Estimating the Error in Padé Approximation ..... 639
David H. Bailey and Helaman R. P. Ferguson, Numerical Results on Relations Between Fundamental Constants Using a New Algorithm ..... 649
B. A. Troesch, The Validity of Shapiro's Cyclic Inequality ..... 657
Jean-Pierre Massias, Jean-Louis Nicolas, and Guy Robin, Effective Bounds for the Maximal Order of an Element in the Symmetric Group. ..... 665
Johannes Buchmann and H. C. Williams, On the Computation of the Class Number of an Algebraic Number Field ..... 679
I. Gaál and N. Schulte, Computing All Power Integral Bases of Cubic Fields ..... 689
Erich Kaltofen and Heinrich Rolletschek, Computing Greatest Common Divi- sors and Factorizations in Quadratic Number Fields ..... 697
Su Hee Kim and Carl Pomerance, The Probability that a Random Probable Prime is Composite ..... 721
Jonathan W. Tanner and Samuel S. Wagstaff, Jr., New Bound for the First Case of Fermat's Last Theorem ..... 743
Günter Löh, Long Chains of Nearly Doubled Primes ..... 751

# Reviews and Descriptions of Tables and Books <br> Allen III, Herrera and Pinder 20, Pironneau 21, Smith and Griffiths 22, Spekreijse 23, Leguillon and Sanchez-Palencia 24, Sewell 25, Fletcher 26, Papalambros and Wilde 27, Bini, Capovani and Menchi 28, Blake and Zisserman 29, Edwards 30, Hadjidimos, Editor 31, McKenna and Teman, Editors 32, Glowinski, Golub, Meurant and Périaux 33, Alfaro, Dehesa, Marcellan, Rubio de Francia and Vinuesa, Editors 34, Rodrigue, Editor 35 <br> Indexes to Volumes 52 and 53 

## Information for Contributors

Authors are encouraged to prepare articles electronically with the $A M S-T_{E} X$ 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 $\mathrm{T}_{\mathrm{E}} \mathrm{X}$ itself without $\mathcal{A M S}-\mathrm{T}_{\mathrm{E}} \mathrm{X}$, currently prevents cost-effective use of the existing electronic form. Before sending an $\mathcal{A M S}-\mathrm{T}_{\mathrm{E} X}$ manuscript for typesetting, contact the AMS Composition department for details.

Manuscripts prepared by some means other than $\mathcal{A M S}-\mathrm{TEX}_{\mathrm{E}}$ should be doubled-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.

Each article submitted for publication must be accompanied by a brief and reasonably selfcontained 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. Authors are also encouraged to supply electronic addresses when available. These will be printed after the postal address at the end of each article.

## 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 addessed 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.

## ■ MATHEMATICAL REVIEWS

Since 1940, Mathematical Reviews has been the recognized reviewing and abstracting journal covering published mathematical research literature. Over 40,000 reviews or abstracts, by 12,000 international reviewers, are published each year. The reviews in each issue are arranged according to the 1980 Mathematics Subject Classification (1985 Revision). Subscriptions include annual author and subject indexes. Published monthly.

## 1990 subscription rate:

Either paper or microfiche subscriptions:
List \$3791; Inst member \$3033; Indiv member \$455*; MR Reviewer \$303*
Postage surcharge: India $\$ 153$; other foreign $\$ 60$
Combination paper and microfiche subscriptions:
List \$5042; Inst member \$4034
$\$ 200$ late charge applies
Optional delivery: First class \$70, airmail \$190
*Add $\$ 10$ for subscriptions in the I's: $\$ 60$ for subscriptions outside the I's

## $\square$ CURRENT MATHEMATICAL PUBLICATIONS

This current awareness journal. which is published every three weeks, is a subject index of recent and forthcoming mathematical publications which have been classified by the editors of Mathematical Reviews. (The classification scheme used is the 1980 Mathematics Subject Classification (1985 Revision), published in the most recent annual index of Mathematical Reviews.) Each issue contains an author and key index; author and key indexes covering a half year are included in issues 9 and 17 . Each issue contains a list of the serials represented in that issue and a separate listing of serial additions and changes, as well as a section containing the tables of contents of certain journals. Starting in 1990. issue years will be used in place of volume numbers.

# 1990 subscription rate: <br> List \$297; Inst member \$238; Indiv \$178; MR Reviewer $\$ 119$ <br> Postage surcharge: India \$38; other foreign $\$ 25$ 

Optional delivery: First class $\$ 30$; airmail $\$ 60$
$10 \%$ late charge applies

Subscriptions are sold only on a calendar year basis: split year and multiple year subscriptions are not accepted. Subscription orders received from nonmember institutions and organizations after January 1 of the subscription year will be sold at list price plus a $10 \%$ late charge (rounded): the maximum late charge for any subscription is $\$ 200$
Microfiche Subscriptions: Microfiche editions of subscriptions are mailed (first class or airmail) before the issue is sent by the printer. All fiche are negative. 105 mm by 148 mm , have a 24 to 1 reduction ratio, and contain 98 frames per fiche.

PREPAYMENT REQUIRED. Send orders to: American Mathematical Society, P. (). Box 1571, Annex Station, Providence, Rhode Island 02901-1571 USA, or call 800-556-7774 in the continental US to use VISA or MasterCard.

## ANNOUNCING...

## MathSci ${ }^{\text {sM }}$ on CD-ROM

Now you can access Mathematical Reviews (MR) and Current Mathematical Publications (CMP) on CD-ROM (Compact Disc-Read Only Memory). The CD, called MathSci Disc, combines the searching features of online MathSci with the browsing ease of printed MR. For a fixed annual fee, MathSci Disc can be used at leisure without access charges or telephone connections.

## Semi-Annual Issue

MathSci Disc is produced by SilverPlatter and is issued semi-annually. The first MathSci Disc became available in January 1989 and contains all the reviews and abstracts from MR 1985 through 1988 and over 68,000 entries from CMP. The July disc has all the information on the January disc plus the January-June updates. Access to current information between successive CD issues is available online from MathSci, which is updated monthly on DIALOG, BRS, and ESA.

## Easy-to-Operate

MathSci Disc is available for the IBM PC and will be available for the Macintosh. SilverPlatter's user-friendly CD software with help screens and menus makes MathSci Disc easy to use. Words and phrases in the text of the reviews and abstracts are searchable with an adjacency operator. Records can be downloaded from the CD to the hard disk for editing or for processing with $\mathrm{T}_{\mathrm{E}} X$ software into typeset form with mathematics.

## Fixed Cost

The MathSci Disc annual lease fee includes the January and the July issues of MathSci Disc, the SilverPlatter search software for the IBM or the Macintosh, the SilverPlatter search manual with a MathSci Disc chapter, and a toll-free help line.

The 1990 MathSci Disc is available at a low annual lease fee, equal to that of the printed MR:

Nonmembers: List price - $\$ 3,791^{*}$
additional leases - $\$ 2,275^{*}$

AMS members \& $M R$ subscribers:
AMS Members: $\$ 3,033^{*}$
MR subscribers: $\$ 2,275^{*}$
AMS members with an MR or first MathSci Disc subscription: $\$ 1,820^{*}$

Individuals at institutions subscribing to MathSci Disc can order a copy for personal use at a $90 \%$ discount: $\$ 379^{*}$. (*Plus shipping \& handling for addresses outside the U.S. and Canada.)

For more information on MathSci Disc or to receive a copy of the lease agreement, please contact Taissa Kusma, Database Services Manager, American Mathematical Society, P. O. Box 6248, Providence, RI 02940 or call (800) 556-7774 in the continental U.S. or (401) 272-9500. Internet: TTK@MATH.AMS.COM; Telex: 797192; FAX: 401-331-3842.

## A New Translation Journal in Mathematics

SUGAKU EXPOSITIONS

Sugaku Expositions is a new translation journal now available from the American Mathematical Society. The journal is published biannually, and began in 1988. Volume 3 is the 1990 volume. Each issue of Sugaku Expositions contains several expository articles, translated from the Japanese journal Sūgaku, which provide highly informative accounts of a variety of current areas of research.

As with all AMS publications, Sugaku Expositions is printed on acid-free paper to ensure long life for your mathematical collection.

ISSN 0898-9583
1990 Subscription Prices
List price $\$ 70$, Institutional member $\$ 56$, Individual member $\$ 42$
To order, please specify 90SUGA/MC (Vol. 3)
1989 Subscription Prices
List price $\$ 60$, Institutional member $\$ 48$, Individual member $\$ 36$
To order, please specify 89SUGA/MC (Vol. 2)

## 1988 Back Volume Prices

List price $\$ 60$, Institutional member $\$ 48$, Individual member $\$ 36$
To order, please specify 88SUGA/MC (Vol. 1)

Add for postage: for destinations outside U.S. and India $\$ 8$, to India $\$ 13$; air delivery to North America \$12, elsewhere \$17.

Prepayment required. Mail to: American Mathematical Society, P. O. Box 1571, Annex Station, Providence, RI 02901-1571 or call 800-556-7774 to use VISA or MasterCard.

[^0]Reviews and Descriptions of Tables and Books ..... 761Allen III, Herrera and Pinder 20, Pironneau 21, Smith and Griffiths 22,Spekreijse 23, Leguillon and Sanchez-Palencia 24, Sewell 25, Fletcher26, Papalambros and Wilde 27, Bini, Capovani and Menchi 28, Blakeand Zisserman 29, Edwards 30, Hadjidimos, Editor 31, McKenna andTeman, Editors 32, Glowinski, Golub, Meurant and Périaux 33, Alfaro,Dehesa, Marcellan, Rubio de Francia and Vinuesa, Editors 34, Rodrigue,Editor 35
Indexes to Volumes 52 and 53 ..... 777

# MATHEMATICS OF COMPUTATION <br> TABLE OF CONTENTS 

## October 1989

Ricardo H. Nochetto, A Stable Extrapolation Method for Multidimensional Degenerate Parabolic Problems ..... 455
Milan Miklavcič, Approximations for Weakly Nonlinear Evolution Equations ..... 471
P. Degond and S. Mas-Gallic, The Weighted Particle Method for Convection- Diffusion Equations. Part 1: The Case of an Isotropic Viscosity ..... 485
P. Degond and S. Mas-Gallic, The Weighted Particle Method for Convection- Diffusion Equations. Part 2: The Anisotropic Case ..... 509
Anders Szepessy, Convergence of a Shock-Capturing Streamline Diffusion Finite Element Method for a Scalar Conservation Law in Two Space Dimensions ..... 527
P. Dutt, Stability and Convergence of Spectral Methods for Hyperbolic Initial- Boundary Value Problems ..... 547
Glenn R. Luecke, Numerical Approximation of Minimum Norm Solutions of $K f=g$ for Special $K$ ..... 563
Hermann Brunner, Collocation Methods for Nonlinear Volterra Integro- Differential Equations with Infinite Delay ..... 571
D. D. Ang, John Lund, and Frank Stenger, Complex Variable and Regulariza- tion Methods of Inversion of the Laplace Transform ..... 589
Ch. Großmann and H.-G. Roos, Uniform Enclosure of High Order for Bound- ary Value Problems by Monotone Discretization ..... 609
Gene H. Golub and Mark D. Kent, Estimates of Eigenvalues for Iterative Methods ..... 619
J. N. Lyness and I. H. Sloan, Some Properties of Rank-2 Lattice Rules ..... 627
Claude Brezinski, Procedures for Estimating the Error in Padé Approximation ..... 639
David H. Bailey and Helaman R. P. Ferguson, Numerical Results on Relations Between Fundamental Constants Using a New Algorithm ..... 649
B. A. Troesch, The Validity of Shapiro's Cyclic Inequality ..... 657
Jean-Pierre Massias, Jean-Louis Nicolas, and Guy Robin, Effective Bounds for the Maximal Order of an Element in the Symmetric Group ..... 665
Johannes Buchmann and H. C. Williams, On the Computation of the Class Number of an Algebraic Number Field ..... 679
I. Gaál and N. Schulte, Computing All Power Integral Bases of Cubic Fields ..... 689
Erich Kaltofen and Heinrich Rolletschek, Computing Greatest Common Divi- sors and Factorizations in Quadratic Number Fields ..... 697
Su Hee Kim and Carl Pomerance, The Probability that a Random Probable Prime is Composite ..... 721
Jonathan W. Tanner and Samuel S. Wagstaff, Jr., New Bound for the First Case of Fermat's Last Theorem ..... 743
Günter Löh, Long Chains of Nearly Doubled Primes ..... 751


[^0]:    Sample Copies: To request a sample copy, use order code SUGAEXAM/MC. Mail to AMS, ATTN: Customer Services, P. O. Box 6248, Providence, RI 02940-6248
    Note: Subscriptions to AMS journals are sold only on a calendar year basis (January-December). Split year and multiple year subscription orders will not be accepted.

