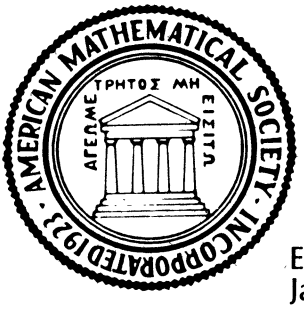
Mathematics of Computation



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.

July 1979
Volume 33, Number 147, Pages 849–1124
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. LYNESS, 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

July 1979

Dianne P. O'Leary and Olof Widlund, Capacitance Matrix Methods for the Helmholtz Equation on General Three-Dimensional Regions 849

Louis W. Ehrlich, A Marching Technique for Nonseparable Equations 881

P. Lesaint and P. A. Raviart, Finite Element Collocation Methods for First Order Systems 891

Marie-Noëlle Le Roux, Semidiscretization in Time for Parabolic Problems 919

R. A. Nicolaides, On Some Theoretical and Practical Aspects of Multigrid Methods 933

Sukumar Chakravarthy and Dale Anderson, Numerical Conformal Mapping 953

T. D. Bui, A Note on the Rosenbrock Procedure 971

David G. Korn and Jules J. Lambiotte, Jr., Computing the Fast Fourier Transform on a Vector Computer 977

G. Monegato and J. N. Lyness, On the Numerical Evaluation of a Particular Singular Two-Dimensional Integral 993

Elise de Doncker, New Euler-Maclaurin Expansions and Their Application to Quadrature Over the s-Dimensional Simplex 1003

Roland Kusterer and Manfred Reimer, Stable Evaluation of Polynomials in Time $\log n$ 1019

Stanley E. Babb, Jr. and James W. Cafky, Operational Evaluation of Certain Infinite Bessel Function Integrals 1033

Robert L. Pexton and Arno D. Steiger, Degenerate Roots of Three Transcendental Equations Involving Spherical Bessel Functions 1041

Bruno Gabutti, On High Precision Methods for Computing Integrals Involving Bessel Functions 1049

Henry E. Fettis, An Asymptotic Expansion for the Upper Percentage Points of the χ^2-Distribution 1059

John F. Monahan, Extensions of von Neumann's Method for Generating Random Variables 1065

Dan Zwillinger, A Goldbach Conjecture Using Twin Primes 1071

Samuel S. Wagstaff, Jr., Greatest of the Least Primes in Arithmetic Progressions Having a Given Modulus 1073

J. C. Lagarias and A. M. Odlyzko, On Computing Artin L-Functions in the Critical Strip 1081

Samuel S. Wagstaff, Jr., Solution of Nathanson's Exponential Congruence 1097

Brendan D. McKay, Transitive Graphs With Fewer Than Twenty Vertices 1101

Reviews and Descriptions of Tables and Books 1123

Baker and Christopher **5**

Microfiche Supplements

Robert L. Pexton and Arno D. Steiger, Degenerate Roots of Three Transcendental Equations Involving Spherical Bessel Functions

Brendan D. McKay, Transitive Graphs With Fewer Than Twenty Vertices

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 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, 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.