VOLUME 63 NUMBER 207 JULY 1994

MATHEMATICS OF COMPUTATION

AMERICAN MATHEMATICAL SOCIETY

EDITED BY

James H. Bramble
Susanne C. Brenner
E. W. Cheney
James W. Demmel
Walter Gautschi, *Managing Editor*
Eugene Isaacson
James N. Lyness
Harald Niederreiter
Jorge J. Nocedal
Syvert P. Nørsett
Andrew M. Odlyzko
Frank W. J. Olver
John E. Osborn
Stanley Osher
Carl Pomerance
René Schoof
L. Ridgway Scott
Daniel Shanks
Chi-Wang Shu
Frank Stenger
Hans J. Stetter
G. W. Stewart
Nico M. Temme
Vidar Thomée
Lars B. Wahlbin
Hugh C. Williams
John W. Wrench, Jr.

PROVIDENCE, RHODE ISLAND USA

ISSN 0025-5718

Mathematics of Computation

This journal publishes research articles in computational mathematics. Areas covered include numerical analysis, the application of computational methods, algorithms for advanced computer architectures, computational number theory and algebra, and related fields. Table errata and reviews of books in areas related to computational mathematics are also included.

Subscription information. *Mathematics of Computation* is published quarterly. Subscription prices for Volumes 62 and 63 (1994) are $262 list; $210 institutional member; $170 member of CBMS organizations; $157 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 $9; subscribers in India must pay a postage surcharge of $18. Expedited delivery to destinations in North America $13; elsewhere $40.

Back number information. For back issues see the *AMS Catalog of Publications.*

Subscriptions and orders should be addressed to the American Mathematical Society, P. O. Box 5904, Boston, MA 02206-5904. *All orders must be accompanied by payment.* Other correspondence should be addressed to P. O. Box 6248, Providence, RI 02940-6248.

Unpublished Mathematical Tables. The editorial office of the journal maintains a repository of Unpublished Mathematical Tables (UMT).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.

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 Manager of Editorial Services, American Mathematical Society, P. O. Box 6248, Providence, RI 02940-6248. Requests can also be made by e-mail to `reprint-permission@math.ams.org`.

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 the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923. This consent does not extend to other kinds of copying, such as copying for general distribution, for advertising or promotional purposes, for creating new collective works, or for resale.

Mathematics of Computation is published quarterly by the American Mathematical Society at 201 Charles Street, Providence, RI 02904-2213. Second-class postage is paid at Providence, Rhode Island. Postmaster: Send address changes to Mathematics of Computation, American Mathematical Society, P. O. Box 6248, Providence, RI 02940-6248.

© Copyright 1994 by the American Mathematical Society. All rights reserved.
Printed in the United States of America.
⊗ The paper used in this book is acid-free and falls within the guidelines established to ensure permanence and durability.
♻ Printed on recycled paper.

This publication was typeset using $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX,
the American Mathematical Society's TEX macro system.
10 9 8 7 6 5 4 3 2 1 99 98 97 96 95 94

Editorial Information

As of May 5, 1994, the backlog for this journal was approximately 1 issue. This estimate is the result of dividing the number of manuscripts for this journal in the Providence office that have not yet gone to the printer on the above date by the average number of articles per issue over the previous twelve months, reduced by the number of issues published in six months (the time necessary for editing and composing a typical issue).

A Copyright Transfer Agreement is required before a paper will be published in this journal. By submitting a paper to this journal, authors certify that the manuscript has not been submitted to nor is it under consideration for publication by another journal, conference proceedings, or similar publication.

Information for Authors and Editors

The first page must consist of a *descriptive title*, followed by an *abstract* that summarizes the article in language suitable for workers in the general field (algebra, analysis, etc.). The *descriptive title* should be short, but informative; useless or vague phrases such as "some remarks about" or "concerning" should be avoided. The *abstract* must be brief and reasonably self-contained. Included with the footnotes to the paper, there should be the 1991 *Mathematics Subject Classification* representing the primary and secondary subjects of the article. This may be followed by a list of *key words and phrases* describing the subject matter of the article and taken from it. A list of the numbers may be found in the annual index of *Mathematical Reviews*, published with the December issue starting in 1990, as well as from the electronic service e-MATH [**telnet e-MATH.ams.com** (or **telnet 130.44.1.100**). Login and password are **e-math**]. For journal abbreviations used in bibliographies, see the list of serials in the latest *Mathematical Reviews* annual index. When the manuscript is submitted, authors should supply the editor with electronic addresses if available. These will be printed after the postal address at the end of each article.

Electronically prepared manuscripts. The AMS encourages submission of electronically prepared manuscripts in $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX or $\mathcal{A}\mathcal{M}\mathcal{S}$-LATEX because properly prepared electronic manuscripts save the author proofreading time and move more quickly through the production process. To this end, the Society has prepared "preprint" style files, specifically the amsppt style of $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX and the amsart style of $\mathcal{A}\mathcal{M}\mathcal{S}$-LATEX, which will simplify the work of authors and of the production staff. Those authors who make use of these style files from the beginning of the writing process will further reduce their own effort. Electronically submitted manuscripts prepared in plain TEX or LATEX do not mesh properly with the AMS production systems and cannot, therefore, realize the same kind of expedited processing. Users of plain TEX should have little difficulty learning $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX, and LATEX users will find that $\mathcal{A}\mathcal{M}\mathcal{S}$-LATEX is the same as LATEX with additional commands to simplify the typesetting of mathematics.

Guidelines for Preparing Electronic Manuscripts provides additional assistance and is available for use with either $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX or $\mathcal{A}\mathcal{M}\mathcal{S}$-LATEX. Authors with FTP access may obtain *Guidelines* from the Society's Internet node `e-MATH.ams.org` (130.44.1.100). For those without FTP access *Guidelines* can be obtained free of charge from the e-mail address `guide-elec@math.ams.org` (Internet) or from the Customer Services Department, American

Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248. When requesting *Guidelines*, please specify which version you want.

At the time of submission, authors should indicate if the paper has been prepared using $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX or $\mathcal{A}\mathcal{M}\mathcal{S}$-LATEX. The *Manual for Authors of Mathematical Papers* should be consulted for symbols and style conventions. The *Manual* may be obtained free of charge from the e-mail address `cust-serv@math.ams.org` or from the Customer Services Department, American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248. The Providence office should be supplied with a manuscript that corresponds to the electronic file being submitted.

Electronic manuscripts should be sent to the Providence office immediately after the paper has been accepted for publication. They can be sent via e-mail to `pub-submit@math.ams.org` (Internet) or on diskettes to the Publications Department, American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248. When submitting electronic manuscripts please be sure to include a message indicating in which publication the paper has been accepted. No corrections will be accepted electronically. Authors must mark their changes on their proof copies and return them to the Providence office. Authors and editors are encouraged to make the necessary submissions of electronically prepared manuscripts and proof copies in a timely fashion.

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. 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.

Any inquiries concerning a paper that has been accepted for publication should be sent directly to the Editorial Department, American Mathematical Society, P. O. Box 6248, Providence, RI 02940-6248.

Editorial Committee

WALTER GAUTSCHI, Chairman. Department of Computer Sciences, Purdue University, West Lafayette, IN 47907; *E-mail*: `wxg@cs.purdue.edu`

ANDREW M. ODLYZKO, AT&T Bell Laboratories, 600 Mountain Avenue, Murray Hill, NJ 07974; *E-mail*: `amo@research.att.com`

FRANK W. J. OLVER, Institute for Physical Science and Technology, University of Maryland, College Park, MD 20742; *E-mail*: `olver@bessel.umd.edu`

LARS B. WAHLBIN, Department of Mathematics, Cornell University, Ithaca, NY 14853; *E-mail*: `wahlbin@math.cornell.edu`

Technical Editor

ERIKA GAUTSCHI, Department of Computer Sciences, Purdue University, West Lafayette, IN 47907; *E-mail*: `exg@cs.purdue.edu`

Board of Associate Editors

JAMES H. BRAMBLE, Department of Mathematics, Cornell University, Ithaca, NY 14853; *E-mail*: `bramble@math.cornell.edu`

SUSANNE C. BRENNER, Department of Mathematics, University of South Carolina, Columbia, SC 29208; *E-mail*: brenner@math.scarolina.edu
E. W. CHENEY, Department of Mathematics, University of Texas at Austin, Austin, TX 78712-1082; *E-mail*: cheney@cs.utexas.edu
JAMES W. DEMMEL, Computer Science Division, University of California, Berkeley, CA 94720; *E-mail*: demmel@cs.berkeley.edu
EUGENE ISAACSON, Courant Institute of Mathematical Sciences, New York University, 251 Mercer Street, New York, NY 10012; *E-mail*: isaacson@acf7.nyu.edu
JAMES N. LYNESS, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439; *E-mail*: lyness@mcs.anl.gov
HARALD NIEDERREITER, Institute for Information Processing, Austrian Academy of Sciences, Sonnenfelsgasse 19, A-1010 Vienna, Austria; *E-mail*: nied@qiinfo.oeaw.ac.at
JORGE J. NOCEDAL, Department of Electrical Engineering and Computer Science, Northwestern University, Evanston, IL 60208-3118; *E-mail*: nocedal@eecs.nwu.edu
SYVERT P. NØRSETT, Division of Numerical Mathematics, The University of Trondheim and The Norwegian Institute of Technology, Alfred Getz vei 1, N-7034 Trondheim-NTH, Norway; *E-mail*: norsett@imf.unit.no
JOHN E. OSBORN, Department of Mathematics, University of Maryland, College Park, MD 20742; *E-mail*: jeo@julia.umd.edu
STANLEY OSHER, Department of Mathematics, University of California, Los Angeles, CA 90024; *E-mail*: sjo@math.ucla.edu
CARL POMERANCE, Department of Mathematics, The University of Georgia, Athens, GA 30602; *E-mail*: carl@math.uga.edu
RENÉ SCHOOF, Dipartimento di Matematica, Università degli Studi di Trento, I-38050 Povo (Trento), Italy; *E-mail*: schoof@itnvax.cineca.it
L. RIDGWAY SCOTT, Department of Mathematics, University of Houston, Houston, TX 77204-3476; *E-mail*: scott@casc.math.uh.edu
DANIEL SHANKS, Department of Mathematics, University of Maryland, College Park, MD 20742; *E-mail*: dns@gaby.umd.edu
CHI-WANG SHU, Applied Mathematics Division, Brown University, Providence, RI 02912-0001; *E-mail*: shu@cfm.brown.edu
FRANK STENGER, Department of Computer Science, University of Utah, Salt Lake City, UT 84112; *E-mail*: stenger@cs.utah.edu
HANS J. STETTER, Institut für Numerische Mathematik, Technische Universität Wien, Wiedner Hauptstrasse 6-10, A-1040, Wien, Austria; *E-mail*: stetter@uranus.tuwien.ac.at
G. W. STEWART, Department of Computer Science, University of Maryland, College Park, MD 20742; *E-mail*: stewart@thales.cs.umd.edu
NICO M. TEMME, Stichting Mathematisch Centrum, Centrum voor Wiskunde en Informatica, Kruislaan 413, 1098 SJ Amsterdam, The Netherlands; *E-mail*: nicot@cwi.nl
VIDAR THOMÉE, Mathematics Department, Chalmers University of Technology, S-412 96 Göteborg, Sweden; *E-mail*: thomee@math.chalmers.se
HUGH C. WILLIAMS, Department of Computer Science, University of Manitoba, Winnipeg, Manitoba, Canada R3T 2N2; *E-mail*: Hugh_Williams@csmail.cs.umanitoba.ca
JOHN W. WRENCH, JR., 102 Mt. Olivet Boulevard, Frederick, MD 21701

FIELDS INSTITUTE COMMUNICATIONS

New Series!

Fields Institute Communications features proceedings and lecture notes growing out of the various activities at The Fields Institute for Research in Mathematical Sciences located in Waterloo, Ontario, Canada. The publications evolve from each year's main program. Control Theory, the 1992 program, produced interdisciplinary work in applied mathematics, computer science, control theory, aerospace, civil, electrical, mechanical and systems engineering, and physics. For 1993 the program focused on dynamical systems. For 1994 the main program is *L*-functions.

Volume 1

Dynamics and Control of Mechanical Systems: The Falling Cat and Related Problems

Michael J. Enos, *Editor*

This book contains a collection of papers presented at the Fields Institute workshop, "The Falling Cat and Related Problems," held in March 1992. The theme of the workshop was the application of methods from geometric mechanics and mathematical control theory to problems in the dynamics and control of freely rotating systems of coupled rigid bodies and related nonholonomic mechanical systems. This book is useful in providing insight into this new and exciting area of research.

1991 *Mathematics Subject Classification*: 70, 58, 93, 49. ISBN 0-8218-9200-2, 280 pages (hardcover)
July 1993. **Individual member $52**, List price $87, Institutional member $70.
To order, please specify FIC/1MC

Volume 2

Control of Flexible Structures

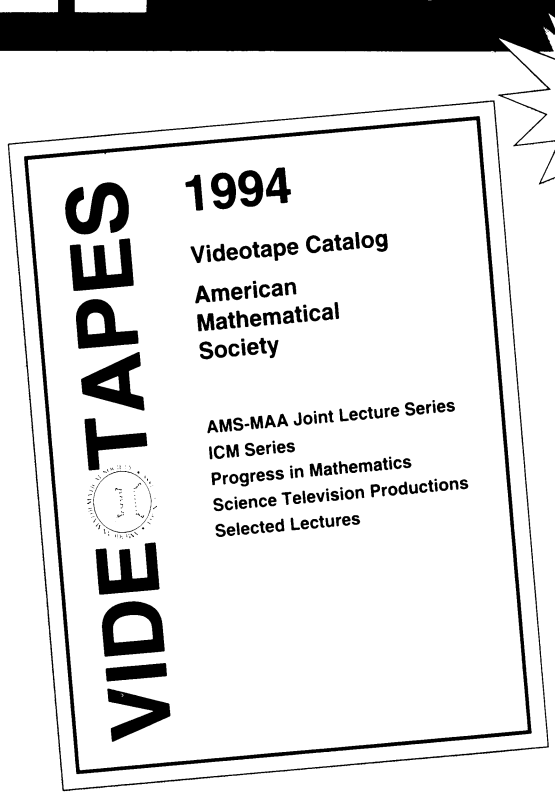
K. A. Morris, *Editor*

This book contains papers presented at the workshop "Problems in Sensing, Identification, and Control of Flexible Structures," held in June 1992 at the Fields Institute. Topics range from theoretical research on the well-posedness of systems to experimental implementations of various controllers. This book is a useful resource for control theorists, engineers, and mathematicians interested in this important field of research.

1991 *Mathematics Subject Classification*: 93, 70. ISBN 0-8218-9201-0, 243 pages (hardcover)
July 1993. **Individual member $49**, List price $82, Institutional member $66.
To order, please specify FIC/2MC

All prices subject to change. Free shipment by surface: for air delivery, please add $6.50 per title. *Prepayment required.* Order from: American Mathematical Society, P.O. Box 5904, Boston, MA 02206-5904, or **call toll free 800-321-4AMS** in the U.S. and Canada to charge with VISA or MasterCard. Residents of Canada, please include 7% GST.

FREE Videotape Catalog!



Great Teaching Tools!

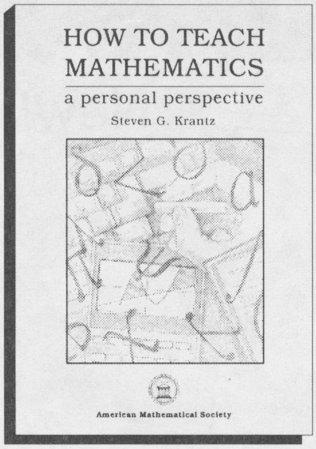
This broad collection of videotaped lectures helps to preserve a portrait of today's distinguished mathematicians while capturing the interest and enthusiasm of the speakers as they present material in their fields of expertise. The lectures are expository and are useful in courses, seminars, and general assemblies for students as well as researchers in the mathematical sciences community.

Order your FREE Catalog Today!

1-800-321-4AMS

American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248

An essential teaching tool!



HOW TO TEACH MATHEMATICS

a personal perspective

Steven G. Krantz
Washington University

Intended primarily for the graduate student or novice instructor, this book is also appropriate for those who have been teaching for many years because it highlights the finer points of excellent mathematics teaching. Professor Krantz addresses

- specific methods for successful *mathematics* teaching
- how to deal with students who beg for grades
- how to use applications effectively
- proper ways to choose a textbook
- how to deal with sensitive issues such as cheating, bribery, sexual harassment, and much more!

Lively and humorous, yet serious and sensible, this book is a practical guide to teaching mathematics. With an emphasis on the classroom, *How to Teach Mathematics* addresses specific objectives, situations, and problems in the teaching process. This book is an essential teaching tool.

About the author: Stephen G. Krantz is currently a Professor at Washington University in St. Louis, Missouri. Professor Krantz was awarded the UCLA Alumni Foundation Distinguished Teaching Award in 1979, has authored 80 scholarly papers and 7 books, was awarded the Chauvenet Prize for expository writing by the Mathematical Association of America, and is an internationally recognized scholar.

Call for information about bulk order discounts.

ISBN 0-8218-0197-X, 76 pages (softcover), July 1993
List price $21, Individual member $13, Institutional member $17
To order, please specify HTM/MC

All prices subject to change. Free shipment by surface: for air delivery, please add $6.50 per title. *Prepayment required.* **Order from:** American Mathematical Society, P.O. Box 5904, Boston, MA 02206-5904, or call toll free 800-321-4AMS in the U.S. and Canada to charge with VISA or MasterCard. Residents of Canada, please include 7% GST.

(*Continued from back cover*)

Bernd Souvignier, Irreducible finite integral matrix groups of degree 8 and 10 335
Ulrich Baum and Michael Clausen, Computing irreducible representations of supersolvable groups 351
A. Schwarz, M. Pohst, and F. Diaz y Diaz, A table of quintic number fields 361
Guoqiang Ge, Recognizing units in number fields 377
Richard P. Brent, On the periods of generalized Fibonacci recurrences .. 389
Zhenxiang Zhang, Finding finite B_2-sequences with larger $m - a_m^{1/2}$ 403
Aaron Schlafly and Stan Wagon, Carmichael's conjecture on the Euler function is valid below $10^{10,000,000}$ 415
Reviews and Descriptions of Tables and Books 421
Stoer and Bulirsch **18**, Werschulz **19**, Hatcher and Quinn **20a**, Mehrotra, Saltz, and Voigt, Editors **20b**, Simon, Editor **20c**, Neittaanmäki, Editor **21**, Dierckx **22**, Hansen **23**, Evans and Minieka **24**, Walker **25**
Table Errata 433
Fung and Williams **615**
Microfiche Supplement
Bernd Souvignier, Irreducible finite integral matrix groups of degree 8 and 10

MATHEMATICS OF COMPUTATION

CONTENTS

Vol. 63, No. 207 **July 1994**

James H. Bramble and J. Thomas King, A robust finite element method for nonhomogeneous Dirichlet problems in domains with curved boundaries 1

M. P. Lebaud, Error estimate in an isoparametric finite element eigenvalue problem 19

Ching Lung Chang, An error estimate of the least squares finite element method for the Stokes problem in three dimensions 41

Bernardo Cockburn and Ioana Triandaf, Error estimates for a finite element method for the drift-diffusion semiconductor device equations: the zero diffusion case 51

Bernardo Cockburn, Frédéric Coquel, and Philippe LeFloch, An error estimate for finite volume methods for multidimensional conservation laws 77

N. Al Shenk, Uniform error estimates for certain narrow Lagrange finite elements 105

M. Crouzeix, S. Larsson, and V. Thomée, Resolvent estimates for elliptic finite element operators in one dimension 121

Anwei Liu and Barry Joe, On the shape of tetrahedra from bisection ... 141

Kent McCormick and Raymond O. Wells, Jr., Wavelet calculus and finite difference operators 155

Eric Grosse and John D. Hobby, Improved rounding for spline coefficients and knots 175

Oscar P. Bruno and Fernando Reitich, Approximation of analytic functions: a method of enhanced convergence 195

Qazi Ibadur Rahman and Gerhard Schmeisser, A quadrature formula for entire functions of exponential type 215

Andrew H. Van Tuyl, Acceleration of convergence of a family of logarithmically convergent sequences 229

Pengyuan Chen, Approximate zeros of quadratically convergent algorithms 247

W. McLean, Numerical evaluation of some trigonometric series 271

Gerhard Larcher and Claudia Traunfellner, On the numerical integration of Walsh series by number-theoretic methods 277

Jürgen Eichenauer-Herrmann, On generalized inversive congruential pseudorandom numbers 293

Miodrag Zivković, Table of primitive binary polynomials, II 301

Adel Faridani, A generalized sampling theorem for locally compact abelian groups 307

Henri Cohen and Jacques Martinet, Heuristics on class groups: some good primes are not too good 329

(*Continued on inside back cover*)