

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 60 and 61 (1993) are \$249 list; \$199 institutional member; \$162 member of CBMS organizations; \$149 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Unpublished Mathematical Tables. The editorial office of the journal maintains a repository of Unpublished Mathematical Tables (UMT).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., 27 Congress Street, Salem, MA 01970. 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 1993 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.

This publication was typeset using AMS-TEX ,
the American Mathematical Society's TEX macro system.

10 9 8 7 6 5 4 3 2 1 98 97 96 95 94 93

Editorial Information

As of August 4, 1993, 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 $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{T}\mathcal{E}\mathcal{X}$ or $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ 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 $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{T}\mathcal{E}\mathcal{X}$ and the amsart style of $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$, 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 $\mathcal{T}\mathcal{E}\mathcal{X}$ or $\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ do not mesh properly with the AMS production systems and cannot, therefore, realize the same kind of expedited processing. Users of plain $\mathcal{T}\mathcal{E}\mathcal{X}$ should have little difficulty learning $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{T}\mathcal{E}\mathcal{X}$, and $\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ users will find that $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ is the same as $\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ with additional commands to simplify the typesetting of mathematics.

Guidelines for Preparing Electronic Manuscripts provides additional assistance and is available for use with either $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{T}\mathcal{E}\mathcal{X}$ or $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$. 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 \LaTeX or \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 and Computer Science, Clarkson University, Potsdam, NY 13699-5815; *E-mail*: brenner@sun.mcs.clarkson.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, Department of Mathematics, University of California, Berkeley, CA 94720; *E-mail*: demmel@robal.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.oew.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@joe.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@sinc.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

Proceedings of Symposia in APPLIED MATHEMATICS

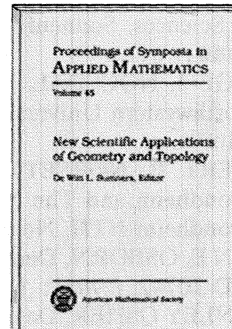
New Scientific Applications of Geometry and Topology

De Witt L. Sumners, *Editor*

Based on an AMS Short Course held in January 1992, this book contains articles by a chemist and a biologist about mathematics, and four articles by mathematicians writing about science. All are expository and require no specific knowledge of the science and mathematics involved. Because this book communicates the excitement and utility of mathematics research at an elementary level, it is an excellent textbook in an advanced undergraduate mathematics course.

1991 *Mathematics Subject Classification*: 53, 57; 82, 92
ISBN 0-8218-5502-6, 250 pages (hardcover), November 1992
List price \$49, Individual member \$29, Institutional member \$39
To order, please specify PSAPM/45MC

Volume 45



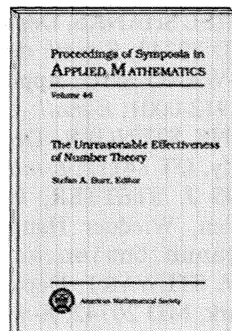
The Unreasonable Effectiveness of Number Theory

Stefan A. Burr, *Editor*

This book is based on the AMS Short Course, "The Unreasonable Effectiveness of Number Theory", held in Orono, Maine, in August 1991. This short course provided some views into the great breadth of applications of number theory outside cryptology and highlighted the power and applicability of number theoretic ideas. This book will appeal to a general mathematical audience as well as to researchers in other areas of science and engineering who wish to learn how number theory is being applied outside of mathematics. All of the chapters are written by leading specialists in number theory and provide excellent introductions to various applications.

1991 *Mathematics Subject Classification*: 11
ISBN 0-8218-5501-8, 125 pages (hardcover), November 1992
List price \$37, Individual member \$22, Institutional member \$30
To order, please specify PSAPM/46MC

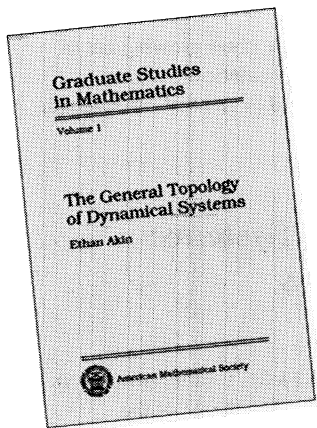
Volume 46



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.

Introducing...

Graduate Studies in Mathematics



The Series...

Graduate Studies in Mathematics is the first graduate text series to be published by the AMS. This exciting new series incorporates the same high quality and distinguished authorship as other AMS publications at an affordable price for the graduate student. This series is useful to professors looking for graduate-level textbooks for class use and to librarians wishing to recommend suitable books to graduate students.

Volume 1

The General Topology of Dynamical Systems

Ethan Akin

- is an essential text for students studying dynamical systems and numerical analysis;
- contains straightforward proofs (guided by hints) for less experienced readers;
- has over 60 exercises and 50 supplemental exercises;
- builds a natural foundation for all aspects of dynamical systems theory, using both old and new research;
- is a valuable reference tool for students and researchers alike.

***60-day examination
copy available***

1991 *Mathematics Subject Classification*: 58, 34; **ISBN 0-8218-3800-8**, 261 pages (hardcover), 1993
List price \$50, Individual mem. \$30, Institutional mem. \$40. To order, please specify **GSM/IMC**



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.



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. Interdisciplinary titles are featured in areas of mechanical, civil, and aerospace engineering, control theory, and physics.

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.

(Continued from back cover)

Michael Clausen and Ulrich Baum , Fast Fourier transforms for symmetric groups: theory and implementation	833
Bert van Geemen and Duco van Straten , The cusp forms of weight 3 on $\Gamma_2(2, 4, 8)$	849
Johannes Buchmann, David Ford, and Michael Pohst , Enumeration of quartic fields of small discriminant	873
Kurt Girstmair , The relative class numbers of imaginary cyclic fields of degrees 4, 6, 8, and 10	881
Meinolf Geck , The decomposition numbers of the Hecke algebra of type E_6^*	889
M. Mignotte and N. Tzanakis , Arithmetical study of a certain ternary recurrence sequence and related questions	901
Gerhard Jaeschke , On strong pseudoprimes to several bases	915
Harvey Dubner , Generalized repunit primes	927
Matti K. Sinisalo , Checking the Goldbach conjecture up to $4 \cdot 10^{11}$	931
David Moews and Paul C. Moews , A search for aliquot cycles and amicable pairs	935
Reviews and Descriptions of Tables and Books	939
Lambert 35, Dongarra, Kennedy, Messina, Sorensen, and Voigt, Editors 36, Daubechies 37, Korneichuk 38, Hagen, Editor 39, Hagen, Editor 40, Naudin and Quitté 41, Moews and Moews 42	
Supplement to "The relative class numbers of imaginary cyclic fields of degrees 4, 6, 8, and 10" by Kurt Girstmair	S25

No microfiche supplement in this issue

MATHEMATICS OF COMPUTATION

TABLE OF CONTENTS

Vol. 61, No. 204

OCTOBER 1993

Harald Berger and Miloslav Feistauer , Analysis of the finite element variational crimes in the numerical approximation of transonic flow . . .	493
John W. Barrett and W. B. Liu , Finite element approximation of the p -Laplacian	523
Lucia Gastaldi , Uniform interior error estimates for the Reissner-Mindlin plate model	539
Charalambos G. Makridakis , Finite element approximations of nonlinear elastic waves	569
Dongwoo Sheen , Second-order absorbing boundary conditions for the wave equation in a rectangular domain	595
Gui-Qiang Chen and Jian-Guo Liu , Convergence of second-order schemes for isentropic gas dynamics	607
Gui-Qiang Chen, Qiang Du, and Eitan Tadmor , Spectral viscosity approximations to multidimensional scalar conservation laws	629
Pravir K. Dutt and A. K. Singh , Spectral methods for periodic initial value problems with nonsmooth data	645
G.-H. Cottet and L. Germain , Image processing through reaction combined with nonlinear diffusion	659
Paul Muir and Brynjulf Owren , Order barriers and characterizations for continuous mono-implicit Runge-Kutta schemes	675
Man-Chung Yeung and Raymond H. Chan , Circulant preconditioners for Toeplitz matrices with piecewise continuous generating functions . .	701
Ivo Marek and Daniel B. Szyld , Iterative and semi-iterative methods for computing stationary probability vectors of Markov operators	719
G. Alefeld, F. A. Potra, and Yixun Shi , On enclosing simple roots of nonlinear equations	733
Knut S. Eckhoff , Accurate and efficient reconstruction of discontinuous functions from truncated series expansions	745
Walter Van Assche and Ingrid Vanherwegen , Quadrature formulas based on rational interpolation	765
H. Brass , Asymptotically optimal error bounds for quadrature rules of given degree	785
J. N. Lyness and T. Søravik , Lattice rules by component scaling	799
Stephen Joe , Bounds on the lattice rule criterion R	821

(Continued on inside back cover)



0025-5718(199310)61:204;1-2