Editorial Committee

JAMES H. BRAMBLE, Chairman. Center for Applied Mathematics, 275 Olin Hall, Cornell Univ., Ithaca, NY 14853
WALTER GAUTSCHI, Computer Sciences Dept., Purdue Univ., Lafayette, IN 47907
ALSTON S. HOUSEHOLDER, 6235 Tapia Drive, Malibu, California 90265
JOHN W. WRENCH, JR., Route 5, Box 237, Frederick, MD 21701

Technical Editor

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

Board of Associate Editors

JAMES W. DANIEL, Dept. of Mathematics, Univ. of Texas at Austin, Austin, TX 78712
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. LYNNESS, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439
MORRIS NEWMAN, Mathematics Division, National Bureau of Standards, Washington, DC 20234
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
DAN'EL SHANKS, Mathematics Division, National Bureau of Standards, Washington, DC 20234
HANS J. STETTER, Institut für Numerische Mathematik, Technische Hochschule Wien, Karlsplatz 13, A-1040, Wien, Austria
VIDAR C. THOMÉE, Mathematics Dept., Chalmers Univ. of Technology, Göteborg, Sweden

Information for Subscribers

The journal is published quarterly in one volume per year, with issues numbered serially since Volume 1, Number 1. Subscription prices for Volume 30 (1976) are list $48.00, institutional member $32.00, individual price $13.00, member of CBMS organizations are $20.00. Back number prices per volume for Volumes 1—27 (1943—1973) are list $36.00, AMS member $27.00; Volumes 28—29 (1974—1975) are list $54.00, AMS member $40.50.

Volumes 1—29 (1943—1975) are available on 16 mm microfilm either as negatives or positives and may be mounted either on spools or in Eastman or 3M cartridges. Prices are $360.00 for spools and $375.00 for cartridges. Only current subscribers will be eligible to purchase back volumes on microfilm.

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.

Subscriptions and orders for publications of the American Mathematical Society should be addressed to American Mathematical Society, 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.

Copyright © 1976, American Mathematical Society
Second-class postage paid at Providence, Rhode Island, and at additional mailing offices
Optimal $L^\infty$ Estimates for the Finite Element Method on Irregular Meshes

**Ridgway Scott**

A Finite Element Method for the Stationary Stokes Equations Using Trial Functions Which Do Not Have to Satisfy $\text{div} \, u = 0$ ........................................... **Richard S. Falk**

Dissipative Two-Four Methods for Time-Dependent Problems

**David Gottlieb & Eli Turkel**

Hybrid Difference Methods for the Initial Boundary-Value Problem for Hyperbolic Equations ................................................................. **Joseph Oliger**

A Necessary Condition for $A$-Stability of Multistep Multiderivative Methods

**Rolf Jeltsch**

On Solving Weakly Singular Volterra Equations of the First Kind with Galerkin Approximations ................................................................. **John M. Bownds**

Improvement by Iteration for Compact Operator Equations ........ **Ian H. Sloan**

A Bound on the $L_\infty$-Norm of $L_2$-Approximation by Splines in Terms of a Global Mesh Ratio ............................................................. **Carl de Boor**

Reorthogonalization and Stable Algorithms for Updating the Gram-Schmidt QR Factorization .... **J. W. Daniel, W. B. Gragg, L. Kaufman & G. W. Stewart**

Factorized Variable Metric Methods for Unconstrained Optimization

**Donald Goldfarb**

A Note on Extended Gaussian Quadrature Rules .................. **Giovanni Monegato**

A Rational Approximation to Weierstrass' $\wp$-Function ........ **Ulrich Eckhardt**

Rational Chebyshev Approximations for the Inverse of the Error Function

**J. M. Blair, C. A. Edwards & J. H. Johnson**

Asymptotic Normality in Monte Carlo Integration .............. **Masashi Okamoto**

Asymptotic Formulas Related to Free Products of Cyclic Groups

**Morris Newman**

Explicit Criteria for Quintic Residuacity ....................... **Kenneth S. Williams**

Dyadotropic Polynomials .............................................. **Harvey Cohn**

Zeros of Hurwitz Zeta Functions ................................... **Robert Spira**

Some Algorithms for Prime Testing Using Generalized Lehmer Functions

**H. C. Williams & J. S. Judd**

A Computational Technique for Evaluating $L(1, \chi)$ and the Class Number of a Real Quadratic Field ........................................... **H. C. Williams & J. Broere**

**Reviews and Descriptions of Tables and Books** ........................................... **Brameller, Allan & Haman 36, Carasso & Stone, Editors 41, Goos, Hartmanis & Marchuk, Editors 37, Goos, Hartmanis & Nickel, Editors 34, Hubbard, Editor 38, Ockendon & Hodgkins, Editors 39, Parkin & Shanks 42, Pinzur 43, Richtmyer, Editor 40, Strang 35**
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 one copy 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.
Table Errata ................................................................. 899
  Gradshteyn & Ryzhik 528, Abramowitz & Stegun 529, Kaye 530
Corrigenda ....................................................................... 900
  Shanks, Shanks, Schoenfeld
Indices to Volume XXX .................................................... 901
Microfiche Supplements
  Rational Chebyshev Approximations for the Inverse of the Error Function
    J. M. Blair, C. A. Edwards & J. H. Johnson
<table>
<thead>
<tr>
<th>Title</th>
<th>Author(s)</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimal $L^\infty$ Estimates for the Finite Element Method on Irregular Meshes</td>
<td>Ridgway Scott</td>
<td>681</td>
</tr>
<tr>
<td>A Finite Element Method for the Stationary Stokes Equations Using Trial Functions Which Do Not Have to Satisfy $\text{div} , v = 0$</td>
<td>Richard S. Falk</td>
<td>698</td>
</tr>
<tr>
<td>Dissipative Two-Four Methods for Time-Dependent Problems</td>
<td>David Gottlieb &amp; Eli Turkel</td>
<td>703</td>
</tr>
<tr>
<td>Hybrid Difference Methods for the Initial Boundary-Value Problem for Hyperbolic Equations</td>
<td>Joseph Oliger</td>
<td>724</td>
</tr>
<tr>
<td>A Necessary Condition for $A$-Stability of Multistep Multiderivative Methods</td>
<td>Rolf Jeltsch</td>
<td>739</td>
</tr>
<tr>
<td>On Solving Weakly Singular Volterra Equations of the First Kind with Galerkin Approximations</td>
<td>John M. Bownds</td>
<td>747</td>
</tr>
<tr>
<td>Improvement by Iteration for Compact Operator Equations</td>
<td>Ian H. Sloan</td>
<td>758</td>
</tr>
<tr>
<td>A Bound on the $L_\infty$-Norm of $L_2$-Approximation by Splines in Terms of a Global Mesh Ratio</td>
<td>Carl de Boor</td>
<td>765</td>
</tr>
<tr>
<td>Reorthogonalization and Stable Algorithms for Updating the Gram-Schmidt QR Factorization</td>
<td>J. W. Daniel, W. B. Gragg, L. Kaufman &amp; G. W. Stewart</td>
<td>772</td>
</tr>
<tr>
<td>Factorized Variable Metric Methods for Unconstrained Optimization</td>
<td>Donald Goldfarb</td>
<td>796</td>
</tr>
<tr>
<td>A Note on Extended Gaussian Quadrature Rules</td>
<td>Giovanni Monegato</td>
<td>812</td>
</tr>
<tr>
<td>A Rational Approximation to Weierstrass' $\wp$-Function</td>
<td>Ulrich Eckhardt</td>
<td>818</td>
</tr>
<tr>
<td>Rational Chebyshev Approximations for the Inverse of the Error Function</td>
<td>J. M. Blair, C. A. Edwards &amp; J. H. Johnson</td>
<td>827</td>
</tr>
<tr>
<td>Asymptotic Normality in Monte Carlo Integration</td>
<td>Masashi Okamoto</td>
<td>831</td>
</tr>
<tr>
<td>Asymptotic Formulas Related to Free Products of Cyclic Groups</td>
<td>Morris Newman</td>
<td>838</td>
</tr>
<tr>
<td>Explicit Criteria for Quintic Residuacity</td>
<td>Kenneth S. Williams</td>
<td>847</td>
</tr>
<tr>
<td>Dyadotropic Polynomials</td>
<td>Harvey Cohn</td>
<td>854</td>
</tr>
<tr>
<td>Zeros of Hurwitz Zeta Functions</td>
<td>Robert Spira</td>
<td>863</td>
</tr>
<tr>
<td>Some Algorithms for Prime Testing Using Generalized Lehmer Functions</td>
<td>H. C. Williams &amp; J. S. Judd</td>
<td>867</td>
</tr>
<tr>
<td>A Computational Technique for Evaluating $L(1, \chi)$ and the Class Number of a Real Quadratic Field</td>
<td>H. C. Williams &amp; J. Broere</td>
<td>887</td>
</tr>
</tbody>
</table>

**Reviews and Descriptions of Tables and Books**

- Brameller, Allan & Haman 36, Carasso & Stone, Editors 41, Goos, Hartmanis & Marchuk, Editors 37, Goos, Hartmanis & Nickel, Editors 34, Hubbard, Editor 38, Ockendon & Hodgkins, Editors 39, Parkin & Shanks 42, Pinzur 43, Richtmyer, Editor 40, Strang 35