# **PROCEEDINGS**

OF THE

# AMERICAN MATHEMATICAL SOCIETY

# EDITED BY

FRED G. BRAUER
W. H. J. FUCHS
IRVING GLICKSBERG

ERNEST A. MICHAEL
JOSEPH J. ROTMAN
GEORGE B. SELIGMAN

**EMERY THOMAS** 

WITH THE COOPERATION OF

W. W. Boone

Joshua Chover

Allen Shields

VOLUME 26, NUMBER 4 DECEMBER, 1970

CODEN: PAMYAR

PUBLISHED BY THE AMERICAN MATHEMATICAL SOCIETY PROVIDENCE, RHODE ISLAND

# Proceedings of the American Mathematical Society

This Journal is devoted entirely to research in pure and applied mathematics, and the publication of original papers of moderate length. The maximum length of an acceptable paper is about 8 printed pages. Since a page of the Proceedings contains about 400 words, a rule of thumb is that under 10 typed pages is probably within the limit, but that over 12 typed pages is probably too long.

SHORTER NOTES. Very short notes not to exceed 1 printed page of an unusual nature are also accepted, and appear under the heading SHORTER NOTES. Items deemed suitable include an elegant new proof of an important and well-known theorem, an illuminating example or counterexample, or a new viewpoint on familiar results. New results, if of a brief and striking character, might also be acceptable, though in general a paper which is merely very short will not be suitable for the SHORTER NOTES department.

Preparation of the manuscript. Articles for insertion should be typewritten and double spaced. Ditto is not generally satisfactory, although other modes of multiple reproduction may be. The *Manual for Authors*, available from the Society, should be consulted for symbols and style conventions. Authors should take the greatest possible care in preparing the original manuscript. Hand drawn symbols are satisfactory, if clearly done; directions to the printer should be included where necessary on a separate sheet, not in the accompanying letter. Authors must keep a complete copy of their manuscript, and editors will acknowledge receipt; manuscripts can therefore be sent by ordinary mail and any other kind (registered, certified) is entirely unnecessary.

FORM OF MANUSCRIPT. The first page should consist of a descriptive title, followed by an abstract which 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. Also avoid proper names unless mathematical usage associates them with the work. The abstract should be at least one complete sentence, and at most 150 words. Included with the footnotes to your paper, but placed before the first footnote, there should be first the AMS (MOS) subject classification numbers representing the primary and secondary subjects of the article, followed by a list of key words and phrases describing the subject matter of the article and taken from it. The AMS (MOS) Subject Classification Scheme (1970) with instructions for its use can be found as an appendix to Mathematical Reviews, Index to Volume 39 (June 1970). See the June 1970 Notices for more details, as well as illustrative examples.

SUBMISSION OF MANUSCRIPTS. See the last page of this issue.

SUBSCRIPTION INFORMATION. Three volumes of four issues are planned for 1970. The subscription price is \$60 for the three volumes. Back issues of Volumes 1-16 are available at a price of \$14 each. Volumes 17-19 at a price of \$18 each, and Volumes 20-25 at a price of \$30 each.

The Proceedings of the American Mathematical Society is published monthly. Subscriptions, orders for back numbers and inquiries in regard to nondelivery of current numbers should be addressed to the American Mathematical Society, P. O. Box 6248, Providence, R.I. 02904.

Second-class postage paid at Providence, Rhode Island, and additional mailing offices.

Copyright ©, American Mathematical Society, 1970
Printed in the United States of America

# AMS (MOS) MAJOR SUBJECT HEADINGS (1970)

The letters in parentheses indicate groupings which are used in the table of contents of each issue and in the volume index.

- 00 (H) General
- 01 (H) History and Biography
- 02 (E) Logic and Foundations
- 04 (E) Set Theory
- 05 (A) Combinatorics
- 06 (A) Order, Lattices, Ordered Algebraic Structures
- 08 (A) General Mathematical Systems
- 10 (A) Number Theory
- 12 (A) Algebraic Number Theory, Field Theory and Polynomials
- 13 (A) Commutative Rings and Algebras
- 14 (A) Algebraic Geometry
- 15 (A) Linear and Multilinear Algebra; Matrix Theory (finite and infinite)
- 16 (A) Associative Rings and Algebras
- 17 (A) Nonassociative Rings and Algebras
- 18 (A) Category Theory, Homological Algebra
- 20 (A) Group Theory and Generalizations
- 22 (G) Topological Groups, Lie Groups
- 26 (B) Real Functions
- 28 (B) Measure and Integration
- 30 (B) Functions of a Complex Variable
- 31 (B) Potential Theory
- 32 (B) Several Complex Variables and Analytic Spaces
- 33 (B) Special Functions
- 34 (B) Ordinary Differential Equations
- 35 (B) Partial Differential Equations
- 39 (B) Finite Differences and Functional Equations
- 40 (B) Sequences, Series, Summability
- 41 (B) Approximations and Expansions
- 42 (B) Fourier Analysis
- 43 (B) Abstract Harmonic Analysis
- 44 (B) Integral Transforms, Operational Calculus
- 45 (B) Integral Equations
- 46 (B) Functional Analysis
- 47 (B) Operator Theory
- 49 (B) Calculus of Variations and Optimal Control
- 50 (D) Geometry
- 52 (D) Convex Sets and Geometric Inequalities
- 53 (D) Differential Geometry
- 54 (G) General Topology
- 55 (G) Algebraic Topology
- 57 (G) Manifolds and Cell Complexes
- 58 (G) Global Analysis, Analysis on Manifolds
- 60 (F) Probability Theory and Stochastic Processes
- 62 (F) Statistics

- 65 (C) Numerical Analysis
- 68 (C) Computer Science
- 70 (C) Mechanics of Particles and Systems
- 73 (C) Mechanics of Solids
- 76 (C) Fluid Mechanics
- 78 (C) Optics, Electromagnetic Theory
- 80 (C) Classical Thermodynamics, Heat Transfer
- 81 (C) Quantum Mechanics
- 82 (C) Statisticsl Physics, Structure of Matter
- 83 (C) Relativity
- 85 (C) Astronomy and Astrophysics
- 86 (C) Geophysics
- 90 (C) Economics, Operations Research, Programming, Games
- 92 (C) Biology and Behavioral Sciences
- 93 (C) Systems, Control
- 94 (C) Information and Communication, Circuits, Automata
- 96 (H) Mathematical Education, Elementary
- 97 (H) Mathematical Education, Secondary
- 98 (H) Mathematical Education, Collegiate

# INDEX TO VOLUME 26

### SUBJECT INDEX

\* Starred items are "Shorter Notes"

#### A. Algebra and Theory of Numbers

#### 05. Combinatorics

Behzad, M. A characterization of total graphs, 383.

Eaves, B. Curtis. An odd theorem, 509.

Howard, F. T. A combinatorial problem and congruences for the Rayleigh function, 574.

Rosenfeld, M. Graphs with a large capacity, 57.

Sharp, Henry, Jr. The permanent of a transitive relation, 153.

#### 08. General Mathematical Systems

Fraser, Grant A. and Horn, Alfred. Congruence relations in direct products, 390. Shafaat, Ahmad. Subcartesian products of finitely many finite algebras, 401.

#### 10. Number Theory

Hagis, Peter, Jr. A root of unity occurring in partition theory, 579.

Howard, F. T. A combinatorial problem and congruences for the Rayleigh function, 574.

Spira, Robert. Another zero-free region for  $\zeta^{(k)}(s)$ , 246.

Subbarao, M. V. and Vidyasagar, M. On Watson's quintuple product identity, 23.

#### 12. Algebraic Number Theory, Field Theory and Polynomials

Accola, Robert D. M. Strongly branched coverings of closed Riemann surfaces, 315.

Hilliker, D. L. and Straus, E. G. Some p-adic versions of Polya's theorem on integer valued analytic functions, 395.

# 13. Commutative Rings and Algebras

Brown, W. C. and Ingraham, E. C. A characterization of semilocal inertial coefficient rings, 10.

Canfell, M. J. Uniqueness of generators of principal ideals in rings of continuous functions, 574.

Efroymson, Gustave. The cohomology ring of a finite group scheme, 567.

Evans, E. Graham, Jr. A generalization of Zariski's main theorem, 45.

Jenkins, Terry L. and Kreiling, Daryl. Semisimple classes and upper-type radical classes of narings, 378.

Mattuck, Arthur. Complete ideals and monoidal transforms, 555.

## 14. Algebraic Geometry

Efroymson, Gustave. The cohomology ring of a finite group scheme, 567.

Evans, E. Graham, Jr. A generalization of Zariski's main theorem, 45.

Mattuck, Arthur. Complete ideals and monoidal transforms, 555.

Roberts, Leslie G. K1 of projective r-space, 587.

# 15. Linear and Multilinear Algebra; Matrix Theory (finite and infinite)

Block, H. D. and Levin, S. A. On the boundedness of an iterative procedure for solving a system of linear inequalities, 229.

Radjavi, Heydar. Errata to "Products of Hermitian matrices and symmetries," 701.

Thompson, Gerald L. and Weil, Roman L. Reducing the rank of  $(A - \lambda B)$ , 548. Yeh, R. Z. A geometric proof of Markov ergodic theorem, 335.

### 16. Associative Rings and Algebras

Białynicki-Birula, A. On the equivalence of integral representations of groups, 371.

Jenkins, Terry L. and Kreiling, Daryl. Semisimple classes and upper-type radical classes of narings, 378.

Megibben, Charles. Absolutely pure modules, 561.

Sandomierski, F. L. Some examples of right self-injective rings which are not left self-injective, 244.

Ware, R. and Zelmanowitz, J. The Jacobson radical of the endomorphism ring of a projective module, 15.

### 17. Nonassociative Rings and Algebras

Jenkins, Terry L. and Kreiling, Daryl. Semisimple classes and upper-type radical classes of narings, 378.

Kass, Seymour and Witthoft, William G. Irreducible polynomial identities in anticommutative algebras, 1.

## 20. Group Theory and Generalizations

Amberg, Bernhard and Scott, W. R. Products of Abelian subgroups, 541.

Białynicki-Birula, A. On the equivalence of integral representations of groups, 371.

Cornelius, E. F., Jr. Note on quasi-decompositions of irreducible groups, 33. Cutler, Doyle O. Another summable  $C_{\Omega}$ -group, 43.

Formanek, Edward. A short proof of a theorem of Jennings, 405.

Inagaki, Nobuo. On F-normalizers and F-hypercenter, 21.

Karrass, A. and Solitar, D. On the free product of two groups with an amalgamated subgroup of finite index in each factor, 28.

Mukherjee, N. P. The hyperquasicenter of a finite group. I, 239.

Orlik-Pflugfelder, Hala. A special class of Moufang loops, 583.

Stebe, P. F. A residual property of certain groups, 37.

Stitzinger, Ernest L. On elementary groups, 236.

Yasuhara, Ann. The solvability of the word problem for certain semigroups, 645. Yen, Ti. On F-normalizers, 49.

### B. ANALYSIS

# 28. Measure and Integration

Dinculeanu, N. and Lewis, Paul W. Regularity of Baire measures, 92.

\*Mansfield, R. The solution to one of Ulam's problems concerning analytic sets.

# 30. Functions of a Complex Variable

Accola, Robert D. M. Strongly branched coverings of closed Riemann surfaces, 315.

Arora, K. L. and Kulshreshtha, S. K. An infinite integral involving Meijer G-function, 121.

Başgöze, T. and Keogh, F. R. The Hardy class of a spiral-like function and its derivative, 266.

Bosch, W. and Krajkiewicz, P. The big Picard theorem for polyanalytic functions, 145.

Garnett, John. Errata to "Positive length but zero analytic capacity," 701.

Parnes, Milton N. A distortion theorem for doubly connected regions, 85.

Salehi, H. and Taylor, G. D. Positive matrix H<sup>1/2</sup> and Hermitian matrix H<sup>1</sup> functions are constant, 469.

Shaffer, Dorothy Browne. On the convexity of lemniscates, 619.

Weitsman, Allen. A growth property of the Nevanlinna characteristic, 65.

Yang, Chung-chun. A generalization of a theorem of P. Montel on entire functions, 332.

#### 31. Potential Theory

Chow, Kwang-nan and Glasner, Moses. Bounded in the mean solutions of  $\Delta u = Pu$  on Riemannian manifolds, 261.

Hebert, D. J., Jr. Generalized balayage and a Radon-Nikodym theorem, 165.

### 32. Several Complex Variables and Analytic Spaces

Hoffmann, Laurence, D. Pseudo-uniform convexity of  $H^1$  in several variables,

Weinstock, Barnet M. An approximation theorem for  $\bar{\partial}$ -closed forms of type (n, n-1), 625.

#### 33. Special Functions

Arora, K. L. and Kulshreshtha, S. K. An infinite integral involving Meijer G-function, 121.

#### 34. Ordinary Differential Equations

Abramowich, John. Stability of solutions of linear systems with retarded arguments, 60.

Benson, Donald C. and Kreith, Kurt. On abstract Pruefer transformations, 137.

Deo, S. G. and Murdeshwar, M. G. On a system of integral inequalities, 141.

Ebin, David G. Completeness of Hamiltonian vector fields, 632. Galbraith, A. S. Lower bounds to the zeros of solutions of y'' + p(x)y = 0, 111.

Gollwitzer, H. E. Nonoscillation theorems for a nonlinear differential equation,

Gordon, William B. On the completeness of hamiltonian vector fields, 329.

Hughes, David K. Linear differential-difference operators and their adjoints, 408.

Kim, W. J. Oscillatory properties of linear third-order differential equations, 286. Kreith, Kurt. Oscillation criteria for nonlinear matrix differential equations, 270.

Lovelady, David Lowell. A variation-of-parameters inequality, 598.

Martin, R. H., Jr. A global existence theorem for autonomous differential equations in a Banach space, 307.

Onose, H. Oscillation theorems for nonlinear second order differential equations,

Schmitt, Klaus. Periodic solutions of linear second order differential equations with deviating argument, 282.

Strauss, Aaron and Yorke, James A. Linear perturbations of ordinary differential equations, 255.

Utz, W. R. Oscillating solutions of third order differential equations, 273.

Weinstein, Alan and Marsden, Jerrold. A comparison theorem for Hamiltonian vector fields, 629.

Zettl, Anton. Square integrable solutions of Ly = f(t, y), 635.

#### 39. Finite Differences and Functional Equations

Brydak, Dobiesław. On the stability of the functional equation  $\varphi[f(x)] = g(x)\varphi(x)$ +F(x), 455.

## 40. Sequences, Series, Summability

Atalla, Robert E. On the multiplicative behavior of regular matrices, 437.

Shawyer, B. L. R. and Yang, G. S. On the relation between the Abel-type and Borel-type methods of summability, 323.

### 41. Approximations and Expansions

Byrnes, J. S. and Newman, D. J. A lower Jackson bound on  $(-\infty, \infty)$ , 71.

#### 42. Fourier Analysis

Schwartz, Alan. On the ideal structure of the algebra of radial functions, 621.

# 44. Integral Transforms, Operational Calculus

Arora, K. L. and Kulshreshtha, S. K. An infinite integral involving Meijer G-function, 121.

#### 45. Integral Equations

Gollwitzer, H. E. and Hager, R. A. The nonexistence of maximum solutions of Volterra integral equations, 301.

Miranda, Guillermo. Regularization of singular systems of integral equations with kernels of finite double-norm on L<sub>∞</sub>, 423.

#### 46. Functional Analysis

Chou, Ching. On a conjecture of E. Granirer concerning the range of an invariant mean, 105.

Clancey, Kevin. Seminormal operators with compact self-commutators, 447.

Cochran, Allan C. Weak A-convex algebras, 73.

Hoffmann, Laurence, D. Pseudo-uniform convexity of  $H^1$  in several variables, 609.

Ito, Takashi and Schreiber, Bert M. Multiplicative properties of Jensen measures, 305.

Johnson, William B. No infinite dimensional P space admits a Markuschevich basis, 467.

Kalton, N. J. A barrelled space without basis, 465.

Merryman, Emory Hughes. An arcwise connected dense Hamel basis for Hilbert space, 126.

Saworotnow, Parfeny P. Trace-class and centralizers of an H\*-algebra, 101.

Saworotnow, Parfeny P. and Friedell, John C. Trace-class for an arbitrary H\*-algebra. 95.

Sidney, S. J. An example concerning core measure, 428.

——. Peak points for hypo-Dirichlet algebras, 431.

Sommese, Joseph E. On a maximal ideal space separated by a peak point, 471. Stein, J. D., Jr. Several theorems on boundedness and equicontinuity, 415.

Torrance, Ellen. Strictly convex spaces via semi-inner-product space orthogonality, 108.

Williams, Vernon. Operators from Banach spaces to complex interpolation spaces, 248.

Zippin, M. Existence of universal members in certain families of bases of Banach spaces, 294.

#### 47. Operator Theory

Atalla, Robert E. On the multiplicative behavior of regular matrices, 437.

Berberian, S. K. Some conditions on an operator implying normality. II, 277.

Brydak, Dobiesław. On the stability of the functional equation  $\varphi[f(x)] = g(x)\varphi(x) + F(x)$ , 455.

Chow, T. R. The spectral radius of a direct integral of operators, 593.

Clancey, Kevin. Seminormal operators with compact self-commutators, 447.

Douglas, R. G. and Sarason, Donald. Fredholm Toeplitz operators, 117.

Guseman, L. F., Jr. Fixed point theorems for mappings with a contractive iterate at a point, 615.

Kantorovitz, Shmuel. On the operational calculus for groups of operators, 603.

Keane, Michael. Contractibility of the automorphism group of a nonatomic measure space, 420.

Schmitt, Klaus. Periodic solutions of linear second order differential equations with deviating argument, 282.

Williams, J. P. Finite operators, 129.

Williams, Vernon. Operators from Banach spaces to complex interpolation spaces, 248.

#### C. APPLIED MATHEMATICS

#### 65. Numerical Analysis

Block, H. D. and Levin, S. A. On the boundedness of an iterative procedure for solving a system of linear inequalities, 229.

Thompson, Gerald L. and Weil, Roman L. Reducing the rank of  $(A - \lambda B)$ , 548.

#### 81. Quantum Mechanics

Prosser, Reese T. A brief derivation of the Heisenberg commutation relations, 640.

## 94. Information and Communication, Circuits, Automata

Amoroso, S. and Cooper, G. The Garden-of-Eden theorem for finite configurations, 158.

#### D. GEOMETRY

# 52. Convex Sets and Geometric Inequalities

Chui, Charles K. and Parnes, Milton N. Measures of N-fold symmetry for convex sets, 480.

#### 53. Differential Geometry

Chen, Bang-yen. On an inequality of T. J. Willmore, 473.

Karcher, Hermann. A short proof of Berger's curvature tensor estimates, 642. Weinstein, Alan. Positively curved deformations of invariant Riemannian

metrics, 151.

#### E. LOGIC AND FOUNDATIONS

#### 02. Logic and Foundations

Amoroso, S. and Cooper, G. The Garden-of-Eden theorem for finite configurations, 158.

Halpern, J. D. and Howard, Paul E. Cardinals m such that 2m = m, 487.

Jorgensen, Murray. An equivalent form of Lévy's axiom schema, 651.

Yasuhara, Ann. The solvability of the word problem for certain semigroups, 645.

#### 04. Set Theory

Halpern, J. D. and Howard, Paul E. Cardinals m such that 2m = m, 487.

\*Mansfield, R. The solution to one of Ulam's problems concerning analytic sets. II. 539.

Sharp, Henry, Jr. The permanent of a transitive relation, 153.

# F. STATISTICS AND PROBABILITY

# 60. Probability Theory and Stochastic Processes

Herbert, D. J., Jr. Generalized balayage and a Radon-Nikodym theorem, 165. Stackelberg, Olaf P. An upper asymptotic estimate of Brownian path variation, 168.

Yeh, R. Z. A geometric proof of Markov ergodic theorem, 335.

#### G. TOPOLOGY

### 22. Topological Groups, Lie Groups

Brown, Robert F. Divisible H-spaces, 185.

Hall, C. E. F-projective objects, 193.

\*Jenkins, Joe W. Subsemigroups of an amenable group, 226.

Lee, D. H. and Wu, T. S. On existence of compact open normal subgroups of 0dimensional groups, 526.

Poguntke, Detlev. Epimorphisms of compact groups are onto, 503.

Schochetman, I. Dimensionality and the duals of certain locally compact groups, 514.

#### 54. General Topology

Bennett, H. R. On Arhangel'skii's class MOBI, 178.

Berney, E. S. A regular Lindelöf semimetric space which has no countable network, 361.

Brown, Robert F. Divisible H-spaces, 185.

Canfell, M. J. Uniqueness of generators of principal ideals in rings of continuous functions, 574.

Chew, Kim-Peu. A characterization of N-compact spaces, 679.

Eaves, B. Curtis, An odd theorem, 509.

\*Edwards, J. R. A sufficient condition that the limit of a sequence of continuous functions be an embedding, 224.

Fuller, R. V. Semiuniform spaces and topological homeomorphism groups, 365. Guseman, L. F., Jr. Fixed point theorems for mappings with a contractive iterate

at a point, 615.

Hagan, Melvin R. A note on connected and peripherally continuous functions, 219.

Herrlich, H. Regular-closed, Urysohn-closed and completely Hausdorff-closed spaces, 695.

Janos, Ludvik. On representations of selfmappings, 529.

Jones, Gary D. An embedding theorem for homeomorphisms of the closed disc, 352.

Mattson, Don A. Extensions of proximity functions, 347.

Miller, Gary Glenn. Countable connected spaces, 355.

Rubin, Leonard R. Recognizing certain factors of E4, 199.

Rushing, T. B. Adjustment of topological concordances and extensions of homeomorphisms over pinched collars, 174.

Schmitt, Klaus. Periodic solutions of linear second order differential equations with deviating argument, 282.

Shapiro, Leonard. Proximality in minimal transformation groups, 521.

Sher, R. B. Determining the cellularity of a 1-complex by properties of its arcs, 491.

Smythe, N. Handlebodies in 3-manifolds, 534.

Summerhill, R. Richard. Tree-like continua and cellularity, 201.

Tondra, Richard J. Surfaces of finite domain rank, 181.

Williams, Richard K. Some results on expansive mappings, 655.

Wong, Yim-Ming. Lattice-invariant properties of topological spaces, 206.

Zenor, Phillip. On the completeness of the space of compact subsets, 190.

#### 55. Algebraic Topology

Boardman, J. M. Stable homotopy theory is not self-dual, 369.

Feustel, C. D. M<sup>3</sup> admitting a certain embedding of P<sup>2</sup> is a pseudo P<sup>3</sup>, 215.

Haslam, H. B. H-spaces and the suspension homomophism, 689.

Kahn, Donald W. A note on stable homotopy modules, 683.

Kibler, Dennis. Isotopy and homeomorphism, 499.

\* Meyer, Jean-Pierre. The Künneth formula and abelian monoids, 699.

Mitchell, George E. The image of  $\mathfrak{U}_*(X) \rightarrow \mathfrak{I}_*(X)$ , 505.

Rees, Elmer. An example on embedding up to homotopy type, 217.

Rushing, T. B. Adjustment of topological concordances and extensions of homeomorphisms over pinched collars, 174.

Smith, Mi-Soo Bae and Smith, Larry. On the cohomology Chern classes of the K-theory Chern classes, 209.

Smythe, N. Handlebodies in 3-manifolds, 534.

Whitten, W. C., Jr. On noninvertible links with invertible proper sublinks, 341. Williams, F. D. Higher homotopy commutativity and extension of maps, 664.

#### 57. Manifolds and Cell Complexes

Chen, Kuo-Tsai. A sufficient condition for nonabelianness of fundamental groups of differentiable manifolds, 196.

Iwata, Koichi. Span of lens spaces, 687.

Loveland, L. D. A 2-sphere of vertical order 5 bounds a 3-cell, 674.

Mitchell, George E. The image of  $\mathfrak{U}_*(X) \rightarrow \mathfrak{N}_*(X)$ , 505.

Rubin, Leonard R. Recognizing certain factors of E<sup>4</sup>, 199.

Rushing, T. B. Adjustment of topological concordances and extensions of homeomorphisms over pinched collars, 174.

Sher, R. B. Determining the cellularity of a 1-complex by properties of its arcs, 491.

Smith, Mi-Soo Bae and Smith, Larry. On the cohomology Chern classes of the K-theory Chern classes, 209.

Smythe, N. Handlebodies in 3-manifolds, 534.

Tollefson, Jeffrey L. Imbedding free cyclic group actions in circle group actions, 671.

Tondra, Richard J. Surfaces of finite domain rank, 181.

#### AUTHOR INDEX

# \* Starred items are "Shorter Notes"

Abramowich, John. Stability of solutions of linear systems with retarded arguments, 60.

Accola, Robert D. M. Strongly branched coverings of closed Riemann surfaces, 315.

Amberg, Bernhard and Scott, W. R. Products of Abelian subgroups, 541.

Amoroso, S. and Cooper, G. The Garden-of-Eden theorem for finite configurations, 158.

Arora, K. L. and Kulshreshtha, S. K. An infinite integral involving Meijer G-function, 121.

Atalla, Robert E. On the multiplicative behavior of regular matrices, 437.

Başgöze, T. and Keogh, F. R. The Hardy class of a spiral-like function and its deriva-

Behzad, M. A characterization of total graphs, 383.

Bennett, H. R. On Arhangel'skii's class MOBI, 178.

Benson, Donald C. and Kreith, Kurt. On abstract Pruefer transformations, 137.

Berberian, S. K. Some conditions on an operator implying normality. II, 277.

Berney, E. S. A regular Lindelöf semimetric space which has no countable network, 361.

Białynicki-Birula, A. On the equivalence of integral representations of groups, 371.

Block, H. D. and Levin, S. A. On the boundedness of an iterative procedure for solving a system of linear inequalities, 229.

Boardman, J. M. Stable homotopy theory is not self-dual, 369.

Bosch, W. and Krajkiewicz, P. The big Picard theorem for polyanalytic functions, 145.

Brown, Robert F. Divisible H-spaces, 185.

Brown, W. C. and Ingraham, E. C. A characterization of semilocal inertial coefficient rings, 10.

Brydak, Dobiesław. On the stability of the functional equation  $\varphi[f(x)] = g(x)\varphi(x) + F(x)$ , 455.

Byrnes, J. S. and Newman, D. J. A lower Jackson bound on  $(-\infty, \infty)$ , 71.

Canfell, M. J. Uniqueness of generators of principal ideals in rings of continuous functions, 571.

Chen, Bang-yen. On an inequality of T. J. Willmore, 473.

Chen, Kuo-Tsai. A sufficient condition for nonabelianness of fundamental groups of differentiable manifolds, 196.

Chew, Kim-Peu. A characterization of N-compact spaces, 679.

Chou, Ching. On a conjecture of E. Granirer concerning the range of an invariant mean, 105.

Chow, Kwang-nan and Glasner, Moses. Bounded in the mean solutions of  $\Delta u = Pu$  on Riemannian manifolds, 261.

Chow, T. R. The spectral radius of a direct integral of operators, 593.

Chui, Charles K. and Parnes, Milton N. Measures of N-fold symmetry for convex sets,

Clancey, Kevin. Seminormal operators with compact self-commutators, 447.

Cochran, Allan C. Weak A-convex algebras, 73.

Cooper, G. See Amoroso, S.

Cornelius, E. F., Jr. Note on quasi-decompositions of irreducible groups, 33.

Cutler, Doyle O. Another summable  $C_{\Omega}$ -group 43.

Deo, S. G. and Murdeshwar, M. G. On a system of integral inequalities, 141.

Dinculeanu, N. and Lewis, Paul W. Regularity of Baire measures, 92.

Douglas, R. G. and Sarason, Donald. Fredholm Toeplitz operators, 117.

Eaves, B. Curtis. An odd theorem, 509.

Ebin, David G. Completeness of Hamiltonian vector fields, 632.

\*Edwards, J. R. A sufficient condition that the limit of a sequence of continuous functions be an embedding, 224.

Efroymson, Gustave. The cohomology ring of a finite group scheme, 567.

Evans, E. Graham, Jr. A generalization of Zariski's main theorem, 45.

Feustel, C. D.  $\mathfrak{M}^{3}$  admitting a certain embedding of  $P^{2}$  is a pseudo  $P^{3}$ , 215.

Formanek, Edward. A short proof of a theorem of Jennings, 405.

Fraser, Grant A. and Horn, Alfred. Congruence relations in direct products, 390.

Friedell, John C. See Saworotnow, Parfeny P.

Fuller, R. V. Semiuniform spaces and topological homeomorphism groups, 365.

Galbraith, A. S. Lower bounds to the zeros of solutions of y'' + p(x)y = 0, 111.

Garnett, John. Errata to "Positive length but zero analytic capacity," 701.

Glasner, Moses. See Chow, Kwang-nan.

Gollwitzer, H. E. Nonoscillation theorems for a nonlinear differential equation, 78.

Gollwitzer, H. E. and Hager, R. A. The nonexistence of maximum solutions of Volterra integral equations, 301.

Gordon, William B. On the completeness of hamiltonian vector fields, 329.

Guseman, L. F., Jr. Fixed point theorems for mappings with a contractive iterate at a point, 615.

Hagan, Melvin R. A note on connected and peripherally continuous functions, 219.

Hager, R. A. See Gollwitzer, H. E.

Hagis, Peter, Jr. A root of unity occurring in partition theory, 579.

Hall, C. E. F-projective objects, 193.

Halpern, J. D. and Howard, Paul E. Cardinals m such that 2m = m, 487.

Haslam, H. B. H-spaces and the suspension homomorphism, 689.

Hebert, D. J., Jr. Generalized balayage and a Radon-Nikodym theorem, 165.

Herrlich, H. Regular-closed, Urysohn-closed and completely Hausdorff-closed spaces, 695.

Hilliker, D. L. and Straus, E. G. Some p-adic versions of Polya's theorem on integer valued analytic functions, 395.

Hoffmann, Laurence D. Pseudo-uniform convexity of  $H^1$  in several variables, 609.

Horn, Alfred. See Fraser, Grant A.

Howard, F. T. A combinatorial problem and congruences for the Rayleigh function, 574.

Howard, Paul E. See Halpern, J. D.

Hughes, David K. Linear differential-difference operators and their adjoints, 408.

Inagaki, Nobuo. On F-normalizers and F-hypercenter, 21.

Ingraham, E. C. See Brown, W. C.

Ito, Takashi and Schreiber, Bert M. Multiplicative properties of Jensen measures, 305. Iwata, Koichi. Span of lens spaces, 687.

Janos, Ludvik. On representations of selfmappings, 529.

\*Jenkins, Joe W. Subsemigroups of an amenable group, 226.

Jenkins, Terry L. and Kreiling, Daryl. Semisimple classes and upper-type radical classes of narings, 378.

Johnson, William B. No infinite dimensional P space admits a Markuschevich basis, 467.

Jones, Gary D. An embedding theorem for homeomorphisms of the closed disc, 352.

Jorgensen, Murray. An equivalent form of Lévy's axiom schema, 651.

Kahn, Donald W. A note on stable homotopy modules, 683.

Kalton, N. J. A barrelled space without a basis, 465.

Kantorovitz, Shmuel. On the operational calculus for groups of operators, 603.

Karcher, Hermann. A short proof of Berger's curvature tensor estimates, 642.

Karrass, A. and Solitar, D. On the free product of two groups with an amalgamated subgroup of finite index in each factor, 28.

Kass, Seymour and Witthoft, William G. Irreducible polynomial identities in anticommutative algebras, 1.

Keane, Michael. Contractibility of the automorphism group of a nonatomic measure space, 420.

Keogh, F. R. See Başgöze, T.

Kibler, Dennis. Isotopy and homeomorphism, 499.

Kim, W. J. Oscillatory properties of linear third-order differential equations, 286.

Krajkiewicz, P. See Bosch, W.

Kreiling, Daryl. See Jenkins, Terry L.

Kreith, Kurt. Oscillation criteria for nonlinear matrix differential equations, 270.

----. See Benson, Donald C.

Kulshreshtha, S. K. See Arora, K. L.

Lee, D. H. and Wu, T. S. On existence of compact open normal subgroups of 0-dimensional groups, 526.

Levin, S. A. See Block, H. D.

Lewis, Paul W. See Dinculeanu, N.

Lovelady, David Lowell. A variation-of-parameters inequality, 598.

Loveland, L. D. A 2-sphere of vertical order 5 bounds a 3-cell, 674.

\*Mansfield, R. The solution to one of Ulam's problems concerning analytic sets. II, 539. Marsden, Jerrold. See Weinstein, Alan.

Martin, R. H., Jr. A global existence theorem for autonomous differential equations in a Banach space, 307.

Mattson, Don A. Extensions of proximity functions, 347.

Mattuck, Arthur. Complete ideals and monoidal transforms, 555.

Megibben, Charles. Absolutely pure modules, 561.

Merryman, Emory Hughes. An arcwise connected dense Hamel basis for Hilbert space, 126.

\*Meyer, Jean-Pierre. The Künneth formula and abelian monoids, 699.

Miller, Gary Glenn. Countable connected spaces, 355.

Miranda, Guillermo. Regularization of singular systems of integral equations with kernels of finite double-norm on  $L_{\infty}$ , 423.

Mitchell, George E. The image of  $\mathfrak{U}_*(X) \to \mathfrak{N}_*(X)$ , 505.

Mukherjee, N. P. The hyperquasicenter of a finite group. I, 239.

Murdeshwar, M. G. See Deo, S. G.

Newman, D. J. See Byrnes, J. S.

Onose, H. Oscillation theorems for nonlinear second order differential equations, 461.

Orlik-Pflugfelder, Hala. A special class of Moufang loops, 583.

Parnes, Milton N. A distortion theorem for doubly connected regions, 85.

-----. See Chui, Charles K.

Poguntke, Detlev. Epimorphisms of compact groups are onto, 503.

Prosser, Reese T. A brief derivation of the Heisenberg commutation relations, 640.

Radjavi, Heydar. Errata to "Products of Hermitian matrices and symmetries," 701.

Rees, Elmer. An example on embedding up to homotopy type, 217.

Roberts, Leslie G. K<sub>1</sub> of projective r-space, 587.

Rosenfeld, M. Graphs with a large capacity, 57.

Rubin, Leonard R. Recognizing certain factors of E<sup>4</sup>, 199.

Rushing, T. B. Adjustment of topological concordances and extensions of homeomorphisms over pinched collars, 174.

Salehi, H. and Taylor, G. D. Positive matrix  $H^{1/3}$  and Hermitian matrix  $H^1$  functions are constant, 469.

Sandomierski, F. L. Some examples of right self-injective rings which are not left self-injective, 244.

Sarason, Donald. See Douglas, R. G.

Saworotnow, Parfeny P. Trace-class and centralizers of an H\*-algebra, 101.

Saworotnow, Parfeny P. and Friedell, John C. Trace-class for an arbitrary H\*-algebra, 95.

Schmitt, Klaus. Periodic solutions of linear second order differential equations with deviating argument, 282.

Schochetman, I. Dimensionality and the duals of certain locally compact groups, 514. Schreiber, Bert M. See Ito, Takashi.

Schwartz, Alan. On the ideal structure of the algebra of radial functions, 621.

Scott, W. R. See Amberg, Bernhard.

Shafaat, Ahmad. Subcartesian products of finitely many finite algebras, 401.

Shaffer, Dorothy Browne. On the convexity of lemniscates, 619.

Shapiro, Leonard. Proximality in minimal transformation groups, 521.

Sharp, Henry, Jr. The permanent of a transitive relation, 153.

Shawyer, B. L. R. and Yang, G. S. On the relation between the Abel-type and Borel-type methods of summability, 323.

Sher, R. B. Determining the cellularity of a 1-complex by properties of its arcs, 491. Sidney, S. J. An example concerning core measures, 428.

Peak points for hypo-Dirichlet algebras, 431.

Smith, Larry. See Smith, Mi-Soo Bae.

Smith, Mi-Soo Bae and Smith, Larry. On the cohomology Chern classes of the K-theory Chern classes, 209.

Smythe, N. Handlebodies in 3-manifolds, 534.

Solitar, D. See Karrass, A.

Sommese, Joseph E. On a maximal ideal space separated by a peak point, 471.

Spira, Robert. Another zero-free region for  $\zeta^{(k)}(s)$ , 246.

Stackelberg, Olaf P. An upper asymptotic estimate of Brownian path variation, 168. Stebe, P. F. A residual property of certain groups, 37.

Stein, J. D., Jr. Several theorems on boundedness and equicontinuity, 415.

Stitzinger, Ernest L. On elementary groups, 236.

Straus, E. G. See Hilliker, D. L.

Strauss, Aaron and Yorke, James A. Linear perturbations of ordinary differential equations, 255.

Subbarao, M. V. and Vidyasagar, M. On Watson's quintuple product identity, 23.

Summerhill, R. Richard. Tree-like continua and cellularity, 201.

Taylor, G. D. See Salehi, H.

Thompson, Gerald L. and Weil, Roman L. Reducing the rank of  $(A - \lambda B)$ , 548.

Tollefson, Jeffrey L. Imbedding free cyclic group actions in circle group actions, 671.

Tondra, Richard J. Surfaces of finite domain rank, 181.

Torrance, Ellen. Strictly convex spaces via semi-inner-product space orthogonality, 108.

Utz, W. R. Oscillating solutions of third order differential equations, 273.

Vidyasagar, M. See Subbarao, M. V.

Ware, R. and Zelmanowitz, J. The Jacobson radical of the endomorphism ring of a projective module, 15.

Weil, Roman L. See Thompson, Gerald L.

Weinstein, Alan. Positively curved deformations of invariant Riemannian metrics, 151.

Weinstein, Alan and Marsden, Jerrold. A comparison theorem for Hamiltonian vector fields, 629.

Weinstock, Barnet M. An approximation theorem for  $\bar{\partial}$ -closed forms of type (n, n-1),

Weitsman, Allen. A growth property of the Nevanlinna characteristic, 65.

Whitten, W. C., Jr. On noninvertible links with invertible proper sublinks, 341.

Williams, F. D. Higher homotopy commutativity and extension of maps, 664.

Williams, J. P. Finite operators, 129.

Williams, Richard K. Some results on expansive mappings, 655.

Williams, Vernon. Operators from Banach spaces to complex interpolation spaces, 248.

Witthoft, William G. See Kass, Seymour.

Wong, Yim-Ming. Lattice-invariant properties of topological spaces, 206.

Wu, T. S. See Lee, D. H.

Yang, Chung-chun. A generalization of a theorem of P. Montel on entire functions, 332.

Yang, G. S. See Shawyer, B. L. R.

Yasuhara, Ann. The solvability of the word problem for certain semigroups, 645.

Yeh, R. Z. A geometric proof of Markov ergodic theorem, 335.

Yen, Ti. On F-normalizers, 49.

Yorke, James A. See Strauss, Aaron.

Zelmanowitz, J. See Ware, R.

Zenor, Phillip. On the completeness of the space of compact subsets, 190.

Zettl, Anton. Square integrable solutions of Ly = f(t, y), 635.

Zippin, M. Existence of universal members in certain families of bases of Banach spaces, 294.

#### STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION

Act of October 23, 1962; Section 4369, Title 39, United States Code

- Date of Filing: October 1, 1970.
   Title of Publication: Proceedings of the
- American Mathematical Society.

  3. Frequency of Issue: Monthly.

  4. Location of Known Office of Publication: 321 South Main Street, P.O. Box 6248, Providence, Rhode Island 02904
  5. Location of the Headquarters of General Business Offices of the Publishers: Same
- Business Offices of the Publishers: Same
  6. Names and Addresses of Publisher, Editor,
  and Managing Editor: Publisher, American
  Mathematical Society, 321 South Main
  Street, P.O. Box 6248, Providence, Rhode
  Island 02904; Editor, W. H. J. Fuchs, Department of Mathematics, White Hall,
  Cornell University, Ithaca, New York 14850.
- Managing Editor, Mrs. Sandra Scott, American Mathematical Society, P.O. Box 6248, Providence, Rhode Island 02904.
- Owner: American Mathematical Society, P.O. Box 6248, 321 South Main Street, Provi-
- dence, Rhode Island 02004.

  8. Known Bondholders, Mortgages and Other Security Holders Owning or Holding 1 Percent or More of Total Amount of Bonds, Mortgages or Other Securities: None.
- The purpose, function, and nonprofit status of this organization and the exempt status for Federal income tax purposes have not Federal income tax purposes have changed during the preceding 12 months.

Actual No. Copies

10. Extent and Nature of Circulation:

		Average No. Copies Each Issue During Preceding 12 Months	of Single Issue Published Nearest to Filing Date
A.	Total No. Copies Printed	3536	3700
В.	Paid Circulation		
	<ol> <li>Sales through dealers and carriers, street</li> </ol>		
	venders and counter sales	767	826
	2. Mail Subscriptions	1360	1466
C.	Total Paid Circulation	2127	2292
D.	Free Distribution	12	13
	Total Distribution	2139	2305
F.	Office Use, Left-over, Unaccounted, Spoiled		
	After Printing	1397	1395
G.	Total	3536	3700

I certify that the statements made by me above are correct and complete.—Lincoln K. Durst

# CONTENTS—Continued from back cover

# E. LOGIC AND FOUNDATIONS

The solvability of the word problem for certain semigroups. By Ann Yasuhara	645
An equivalent form of Lévy's axiom schema. By Murray Jorgen-	651
G. Topology	
Some results on expansive mappings. By RICHARD K. WILLIAMS (Higher homotopy commutativity and extension of maps. By F. D.	655
WILLIAMS	664
JEFFREY L. TOLLEFSON	671
	574
	679
	683
	687
H-spaces and the suspension homomorphism. By H. B. HASLAM (Regular-closed, Urysohn-closed and completely Hausdorff-closed	689
	695
SHORTER NOTES	
The Künneth formula and abelian monoids. By Jean-Pierre Meyer.	599
AMS (MOS) Major Subject Headings (1970)	701 703 705

# CONTENTS\*

Vol. 26, No. 4	DECEMBER, 1970	Whole I	No. 138
----------------	----------------	---------	---------

	Page				
A. Algebra and Number Theory					
Products of Abelian subgroups. By Bernhard Amberg and W. R. Scott	541				
Reducing the rank of $(A - \lambda B)$ . By Gerald L. Thompson and Roman L. Weil.	548				
Complete ideals and monoidal transforms. By Arthur Mattuck	555				
Absolutely pure modules. By Charles Megibben	561				
Uniqueness of generators of principal ideals in rings of continuous	567				
functions. By M. J. CANFELL	571				
By F. T. Howard	574				
A root of unity occurring in partition theory. By Peter Hagis, Jr A special class of Moufang loops. By Hala Orlik-Pflugfelder	579 583				
K <sub>1</sub> of projective r-space. By LESLIE G. ROBERTS	587				
B. Analysis					
The spectral radius of a direct integral of operators. By T. R. Сноw	593				
A variation-of-parameters inequality. By DAVID LOWELL LOVELADY On the operational calculus for groups of operators. By SHMUEL	598				
KANTOROVITZ	603				
D. HOFFMANN	609				
Fixed point theorems for mappings with a contractive iterate at a point. By L. F. Guseman, Jr	615				
On the convexity of lemniscates. By Dorothy Browne Shaffer	619				
On the ideal structure of the algebra of radial functions. By Alan Schwartz	621				
An approximation theorem for $\overline{\partial}$ -closed forms of type $(n, n-1)$ . By	605				
BARNET M. WEINSTOCK	625				
STEIN and JERROLD MARSDEN	629				
Completeness of Hamiltonian vector fields. By DAVID G. EBIN Square integrable solutions of $Ly=f(t, y)$ . By ANTON ZETTL	632 635				
C. APPLIED MATHEMATICS					
A brief derivation of the Heisenberg commutation relations. By REESE T. PROSSER	640				
D. Geometry					
A short proof of Berger's curvature tensor estimates. By Hermann Karcher	642				
* The volume index will contain a mapping showing the correspondence be	tween				

sections A-G and the AMS (MOS) subject classification numbers.