# Notices

## OF THE AMERICAN MATHEMATICAL SOCIETY

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February 1976
Issue No. 168

# Calendar

This Calendar lists all of the meetings which have been approved by the Council up to the date this issue of the *Notices* was sent to press. The summer and annual meetings are joint meetings of the Mathematical Association of America and the American Mathematical Society. The meeting dates which fall rather far in the future are subject to change; this is particularly true of meetings to which no numbers have yet been assigned.

Abstracts should be submitted on special forms which are available in most departments of mathematics; forms can also be obtained by writing to the headquarters of the Society. Abstracts to be presented at the meeting *in person* must be received at the headquarters of the Society in Providence, Rhode Island, on or before the deadline for the meeting.

| Meeting Number | Date | Place | Deadline for Abstracts* and News Items |
|---|---|---|---|
| 734 | April 11-14, 1976 | New York, New York | Feb. 17, 1976 |
| 735 | April 23-24, 1976 | Reno, Nevada | Feb. 17, 1976 |
| 736 | June 18, 1976 | Portland, Oregon | April 27, 1976 |
| 737 | August 24-28, 1976 (80th Summer Meeting) | Toronto, Canada | June 15, 1976 |
| | November 6, 1976 | Ann Arbor, Michigan | |
| | November 19-20, 1976 | Columbia, South Carolina | |
| | November 19-20, 1976 | Albuquerque, New Mexico | |
| | January 27-31, 1977 (83rd Annual Meeting) | St. Louis, Missouri | |
| | March 31-April 1, 1977 | Huntsville, Alabama | |
| | April 22-23, 1977 | Hayward, California | |
| | November 11-12, 1977 | Memphis, Tennessee | |

*Deadline for abstracts not presented at a meeting (by title) June 1976 issue: April 20
August 1976 issue: June 8

OTHER EVENTS

| | |
|---|---|
| February 24, 1976 | Symposium on Some Mathematical Questions in Biology, Boston, Massachusetts |
| March 15-18, 1976 | Symposium on Probability, Urbana, Illinois |
| April 11-12, 1976 | Symposium on Asymptotic Methods and Singular Perturbations, New York, New York |
| April 12, 1976 | Short Course on Introduction to Computer Science for Mathematicians, New York, New York |
| August 22-23, 1976 | Short Course on Mathematical Economics, Toronto, Canada |

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# Notices

## OF THE

## AMERICAN MATHEMATICAL SOCIETY

Everett Pitcher and Gordon L. Walker, Editors
Hans Samelson, Associate Editor


## CONTENTS




FEBRUARY, 1976

# The Seven Hundred Thirty-Second Meeting
# Florida Agricultural and Mechanical University
# Tallahassee, Florida
# March 4 – 5, 1976

The seven hundred thirty-second meeting of the American Mathematical Society will be held at the Florida Agricultural and Mechanical University in Tallahassee, Florida, from noon Thursday, March 4 until noon, Friday, March 5, 1976. The meeting of the American Mathematical Society will be followed by a meeting of the Florida Section of the Mathematical Association of America.

By invitation of the Committee to Select Hour Speakers for the Southeastern Sectional Meetings there will be three one-hour addresses. B.J. Ball of the University of Georgia will present a lecture entitled "Geometric topology and shape theory: A survey of problems and results". L. Carlitz of Duke University will lecture on "Functions and correspondences in a finite field", and the lecture by R. Kalman of the University of Florida will be "On the global theory of the Riccati equation". All of the invited addresses will be held in Room 200A of the Gore Education Complex.

There will be four special sessions at this meeting. HERON COLLINS of Louisiana State University has organized a special session on Strict topologies and related topics. Participants in this special session will include S. F. Bellenot, W.H. Graves, F. Dennis Sentilles, W.H. Summers, D. C. Taylor, and R.F. Wheeler. ROBERT GILMER and JOE MOTT of Florida State University have organized a special session on Commutative rings. D. D. Anderson, Jimmy T. Arnold, Paul M. Eakin, Eloise Hamann, Stephen McAdam, Matthew O'Malley, and Judith Sally will be included in this special session. MARY-ELIZABETH HAMSTROM of the University of Illinois has organized a special session on Geometric topology. Participants in this special session will be Fredric D. Ancel, Joan S. Berman, J. L. Bryant, Robert Craggs, Robert J. Daverman, Julian R. Eisner, J. G. Hollingsworth, Marvin Israel, R. C. Lacher, Martin Scharlemann, R.B. Sher, D. W. Sumners, and J. M. Woods. LEONARD L. SCOTT, Jr. of the University of Virginia has organized a special session on Finite groups. Included in this special session will be Mark Benard, Arnold Feldman, Pam Ferguson, Mark Hale, Jr., Peter Hoefsmit, Wayne Jones, Brian Parshall, and H. M. Ward.

There will also be sessions for contributed papers on Thursday afternoon and Friday morning.

The registration desk will be located in Room 104A of the Gore Education Complex and will be open from 10:00 a.m. to 5:00 p.m. on Thursday, March 4, and from 8:30 a.m. to 5:00 p.m. on Friday, March 5.

There are a number of hotels and motels in the area which are listed alphabetically on this page. All prices are subject to change without notice. Participants should make their own reservations and request a written receipt. Participants arriving by plane are encouraged to register at either the Hilton Inn, Holiday Inn (Downtown) or Ramada Inn as these will provide airport limousine service and a shuttle service to FAMU campus.

DAYS INN SOUTH (904) 877-6121
3100 Apalachee Parkway (U.S. 27 South)

| | |
|---|---|
| Single | $ 9.88 |
| Double | 12.88 |

(4 miles from campus)

HILTON INN (904) 224-5000
Capital Center Downtown

| | |
|---|---|
| Single | $17.00-$26.00 |
| Double | 23.00- 32.00 |

(1 mile from campus)

HOLIDAY INN DOWNTOWN (904) 222-8000
316 West Tennessee Street (U.S. 90 West)

| | |
|---|---|
| Single | $15.50 |
| Double | 20.00 |
| Extra person | 3.00 |

(2 miles from campus)

HOLIDAY INN PARKWAY (904) 877-3141
1302 Apalachee Parkway (U.S. 27 South)

| | |
|---|---|
| Single | $13.00 |
| Double | 17.00 |
| Extra person | 3.00 |

(3 miles from campus)

HOWARD JOHNSON'S EAST (904) 224-2181
722 Apalachee Parkway (U.S. 27 South)

| | |
|---|---|
| Single | $13.00 |
| Double | 16.00 |

(2 1/2 miles from campus)

QUALITY INN PARKWAY (904) 877-6171
1027 Apalachee Parkway (U.S. 27 South)

| | |
|---|---|
| Single | $12.00 |
| Double | 14.00 |

(3 miles from campus)

RAMADA INN (904) 576-6121
2121 West Tennessee Street (U.S. 90 West)

| | |
|---|---|
| Single | $16.00 |
| Double | 22.00 |

(4 miles from campus)

RODEWAY INN (904) 877-3171
1355 Apalachee Parkway (U.S. 27 South)

| | |
|---|---|
| Single | $13.00 |
| Double | 18.00 |

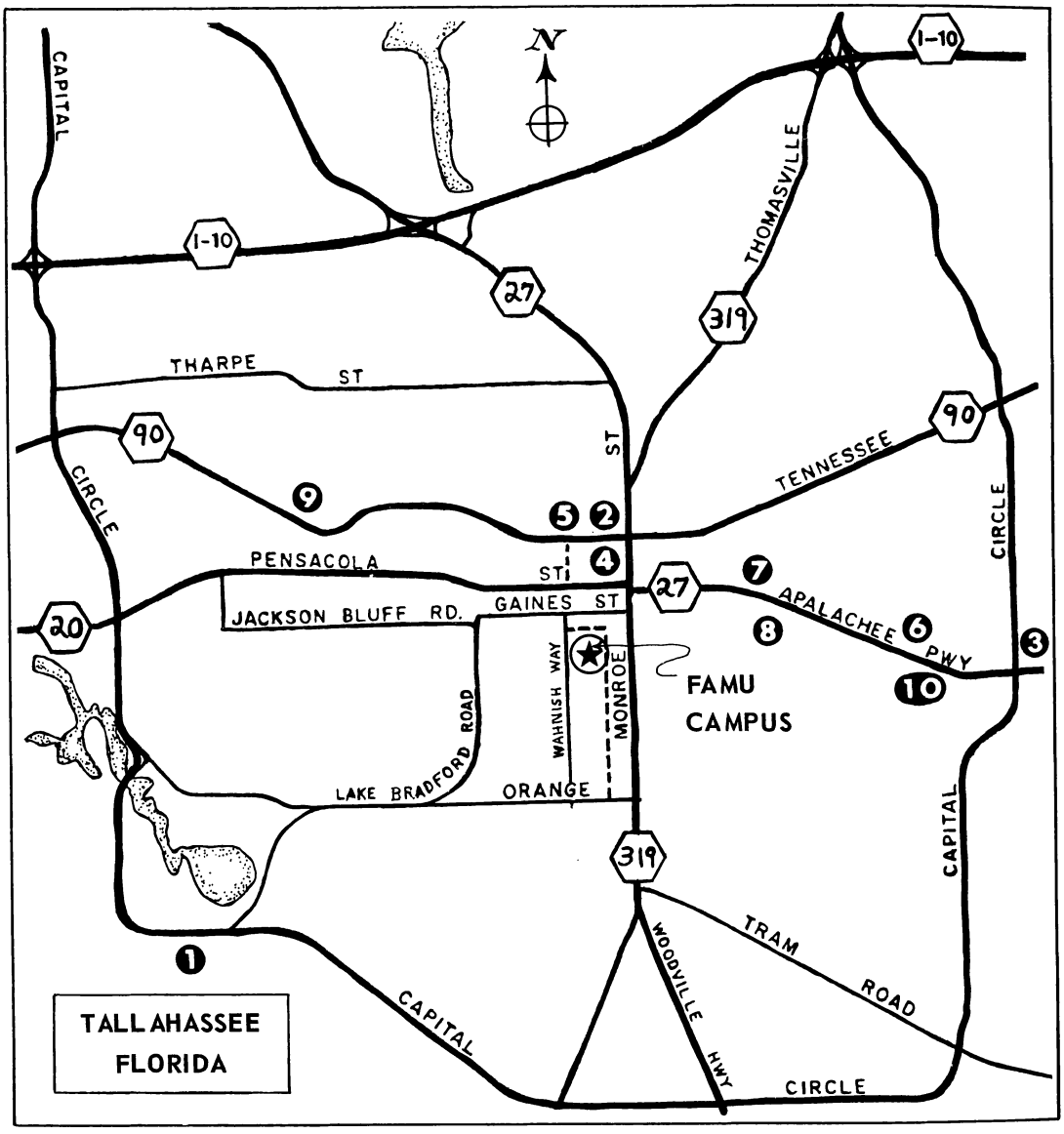
(3 miles from campus)

Tallahassee is served by National, Eastern, and Southern Airlines, as well as by Greyhound and Trailways Bus Lines. The city is accessible by highway on Routes U.S. 90, 27, 319, and Interstate 10.

Emergency messages may be left at the registration desk; telephone (904) 222-8030.

There will be a Social Hour Friday evening. Details will be available at the registration desk.

The University Union Cafeteria will be open for the meeting. It has a special section for faculty. Information about other restaurants in the area will be available at the registration desk.




★ FAMU Campus — AMS–MAA Meetings

1. Airport
2. Bus Stations
3. Days Inn South
4. Hilton Inn
5. Holiday Inn–Downtown
6. Holiday Inn–Parkway
7. Howard Johnson's East
8. Quality Inn Parkway
9. Ramada Inn
10. Rodeway Inn

PROGRAM OF SESSIONS

The time limit for each contributed paper in the general sessions is ten minutes and in the special session is twenty minutes. To maintain this schedule, the time limits will be strictly enforced.

THURSDAY, 1:00 P. M.

Invited Address, Room 200A of the Gore Education Complex

(1) Functions and correspondences in a finite field. Professor LEONARD CARLITZ, Duke University (732-A27)

THURSDAY, 2:10 P. M.

Special Session on Strict Topologies and Related Topics, I. Room 100A

2:10- 2:30 (2) Weak compactness in the space of continuous functions. Preliminary report. Dr. ROBERT F. WHEELER, Northern Illinois University (732-B2)

2:35- 2:55 (3) The strong bidual of $\Gamma(K)$. Preliminary report. Professor DONALD C. TAYLOR, Montana State University (732-B8)

3:00- 3:20 (4) Boolean algebras and $L^1$ and $L^\infty$ spaces. Preliminary report. DENNIS SENTILLES, University of Missouri (732-B4)

THURSDAY, 2:10 P. M.

Special Session on Polynomial and Power Series Rings over a Commutative Ring, I. Room 103A

2:10- 2:30 (5) Transcendence degree in power series rings. Preliminary report. Professor J. T. ARNOLD* and Dr. D. W. BOYD, Virginia Polytechnic Institute and State University (732-A9)

2:35- 2:55 (6) Reduced symmetric powers and projectivity. PAUL M. EAKIN, University of Kentucky (732-A24)

3:00- 3:30 (7) Informal session for presentation of some problem areas and discussion.

3:35- 3:55 (8) The cancellation problem. Preliminary report. Dr. ELOISE HAMANN, North Central College (732-A22)

4:00- 4:20 (9) The upper conjecture: A melodrama in one indeterminate. Preliminary report. Professor STEPHEN McADAM, University of Texas at Austin (732-A1)

4:25- 4:45 (10) Lurüth's problem for rings. Professor JUDITH D. SALLY, Northwestern University (732-A23)

THURSDAY, 2:10 P. M.

Special Session in Geometric Topology, I. Room 101B

2:10- 2:30 (11) Non-PL imbeddings of 3-manifolds. MARTIN SCHARLEMANN, University of Georgia (732-G9)

2:35- 2:55 (12) Some connections between 2, 3 and 4-manifold topology. JOAN S. BIRMAN*, Columbia University, and R. CRAGGS, University of Illinois (732-G8)

3:00- 3:20 (13) On the monodromy of reducible plane curves. D. W. SUMNERS*, Florida State University, and J. M. WOODS, Oklahoma Baptist University (732-G10)

3:25- 3:45 (14) A characterization of nonfibered knots. Professor JULIAN R. EISNER, Columbia University (732-G7)

3:50- 4:10 (15) PL isotopy of balls by linear moves. Preliminary report. MARVIN ISRAEL, St. Mary's College of Maryland (732-G13)

4:15- 4:35 (16) Acyclic homotopy equivalences. DAVID E. GALEWSKI and JOHN G. HOLLINGSWORTH*, University of Georgia (732-G14)

THURSDAY, 2:10 P. M.

Special Session on Finite Groups, I. Room 103B

2:10- 2:30 (17) Representations of generic algebras corresponding to classical Weyl groups. Professor PETER HOEFSMIT, University of Virginia (732-A2)

2:35- 2:55 (18) Multilinear invariants for the Weil representation. Professor HAROLD N. WARD, University of Virginia (732-A6)

3:00- 3:20 (19) Schur indices and defect groups. Preliminary report. Professor MARK BENARD, Tulane University (732-A5)

3:25- 3:45 (20) Fitting height of certain solvable groups admitting $\mathbb{Z}_p$. Preliminary report. Dr. ARNOLD D. FELDMAN, Louisiana State University, Baton Rouge (732-A7)

3:50- 4:10 (21) On 3-closure of 3-homogeneous finite groups. Dr. PAMELA A. FERGUSON, University of Miami (732-A12)

*For papers with more than one author, an asterisk follows the name of the author who plans to present the paper at the meeting.

THURSDAY, 2:10 P. M.

Session on Algebra, Room 104B

2:10- 2:20 (22) Monic free ideals in a polynomial semiring in several variables. Dr. LOUIS DALE, University of Alabama in Birmingham (732-A10)

2:25- 2:35 (23) Quasi-injective S-systems and their S-endomorphism semigroup. Mr. ANTONIO M. LOPEZ, Jr.* and Dr. JOHN K. LUEDEMAN, Clemson University (732-A11)

2:40- 2:50 (24) Divided rings and going down. Professor DAVID E. DOBBS, University of Tennessee (732-A14)

2:55- 3:05 (25) The torsion product of valued vector spaces and abelian p-groups. Professor JOHNETTE HASSELL, Xavier University (732-A15)

3:10- 3:20 (26) Fully invariant subgroups of totally projective groups. RONALD C. LINTON*, University of South Alabama, and CHARLES MEGIBBEN, Vanderbilt University (732-A16) (Introduced by Dr. Richard Vinson)

3:25- 3:35 (27) Splitting of inseparable field extensions. Preliminary report. Professor JAMES K. DEVENEY, Virginia Commonwealth University (732-A17)

3:40- 3:50 (28) F-hypercentral automorphisms. Professor W. E. DESKINS and Professor ELAYNE A. IDOWU*, University of Pittsburgh (732-A18)

3:55- 4:05 (29) Cyclic extensions of rings. Preliminary report. Professor H. F. KREIMER, Florida State University (732-A19)

4:10- 4:20 (30) The spanning subgraphs of Eulerian graphs. Dr. F. T. BOESCH, Bell Telephone Laboratories, Holmdel, New Jersey, and Professor C. SUFFEL and Professor R. TINDELL*, Stevens Institute of Technology (732-A20)

THURSDAY, 4:30 P. M.

Invited Address, Room 200A of the Gore Education Complex

(31) Geometric topology and shape theory. Professor B. J. BALL, University of Georgia (732-G11)

FRIDAY, 9:00 A. M.

Invited Address, Room 200A of the Gore Education Complex

(32) On the global theory of the Riccati equation. Professor R. KALMAN, University of Florida (732-C3)

FRIDAY, 10:10 A. M.

Special Session on Strict Topologies and Related Topics, II. Room 100A

10:10-10:30 (33) Mazur spaces and completeness. Preliminary report. Professor STEVEN F. BELLENOT, Florida State University (732-B3)

10:35-10:55 (34) The strict topology, weighted spaces, and weighted approximation. W. H. SUMMERS, University of Arkansas (732-B5)

11:00-11:20 (35) Strict topologies and abstract measures: A universal measure. Professor WILLIAM H. GRAVES, University of North Carolina, Chapel Hill (732-B6)

FRIDAY, 10:10 A. M.

Special Session on Polynomial and Power Series Rings over a Commutative Ring, II. Room 103A

10:10-10:30 (36) Homomorphisms of power series rings. Preliminary report. Professor MATTHEW J. O'MALLEY, University of Houston (732-A3)

10:35-10:55 (37) Multiplication ideals, multiplication rings and the ring R(X). Professor D. D. ANDERSON, Virginia Polytechnic Institute and State University (732-A13)

11:00-11:30 (38) Informal discussion, questions and comments

FRIDAY, 10:10 A. M.

Special Session on Geometric Topology, II. Room 101B

10:10-10:30 (39) A Hopf-like invariant for mappings between odd-dimensional manifolds. Professor J. L. BRYANT and Professor R. C. LACHER*, Florida State University (732-G1)

10:35-10:55 (40) Any embedding of $S^{n-1}$ in $S^n$ $(n \geq 5)$ can be approximated by locally flat embeddings. Mr. FREDRIC D. ANCEL*, University of Wisconsin, and Professor J. W. CANNON, Utah State University (732-G2)

11:00-11:20 (41) Some bad embeddings of Q in Q. Professor R. B. SHER, University of North Carolina at Greensboro (732-G3)

11:25-11:45 (42) Side approximations of codimension one spheres. Professor ROBERT J. DAVERMAN, University of Tennessee (732-G6)

11:50-12:10 (43) 4-manifolds and their Heegaard diagrams. Preliminary report. ROBERT CRAGGS, University of Illinois (732-G15)

FRIDAY, 10:10 A. M.

Special Session on Finite Groups, II. Room 103B

10:10-10:30 (44) On the 1-cohomology of finite groups of Lie type. Preliminary report. Professor WAYNE R. JONES, University of Virginia (732-A4)

10:35-10:55 (45) Cohomology of finite forms of semisimple algebraic groups. Professor BRIAN PARSHALL, University of Virginia (732-A8)

11:00-11:20 (46) Synthetic theory of dual affine spaces. Preliminary report. Dr. MARK P. HALE, Jr., University of Florida (732-D1)

FRIDAY, 10:10 A. M.

General Session, Room 104B

10:10-10:20 (47) Function algebras isomorphic to subalgebras of A(D). Preliminary report. Professor BRUCE LUND, University of New Brunswick (732-B7)

10:25-10:35 (48) Generalized logarithmic tests for series. CARLOS A. INFANTOZZI, Universidad de la Republica, Atlantico, Montevideo, Uruguay (732-B10)

10:40-10:50 (49) Inert extensions of Krull domains. Professor DOUGLAS L. COSTA, University of Virginia, and JON L. JOHNSON*, University of Kentucky (732-A25)

10:55-11:05 (50) Algebras with modular subalgebra lattices. DONALD R. PEEPLES, Emory University (732-A26)

11:10-11:20 (51) On boundary layer flow past a porous plate with variable suction or blowing. Dr. SUBHA SENGUPTA, University of Calcutta, India, and Dr. LOKENATH DEBNATH*, East Carolina University (732-C1)

11:25-11:35 (52) On the nonexistence of continuous canonical forms for real linear dynamical systems. Professor MICHIEL HAZEWINKEL, Erasmus University, Rotterdam, The Netherlands (732-C2)

11:40-11:50 (53) On the hypercommutative nucleus of an alternative ring. Preliminary report. Professor TAE-IL SUH, East Tennessee State University (732-A21)

FRIDAY, 10:10 A. M.

Analysis and Topology Session, Room 102A

10:10-10:20 (54) Hadamard products of convex functions. Professor JOSEPH A. CIMA, University of North Carolina at Chapel Hill (732-B1)

10:25-10:35 (55) Some topologies on $\bigcup_{0<p<1} L_p$. Preliminary report. RICHARD A. GAYLER, Florida State University (732-B9)

10:40-10:50 (56) On compactness of infinitely divisible measures on an Orlicz space. Preliminary report. Dr. MOU-HSIUNG CHANG, University of Alabama, Huntsville (732-F1)

10:55-11:05 (57) Cross products and closed mappings. Preliminary report. S. A. STRICKLEN, Jr., Southern Technical Institute (732-G12)

11:10-11:20 (58) Homotopies and intersection sequences. Professor JOHN R. QUINE, Florida State University (732-G4)

11:25-11:35 (59) Approximate fibrations and a movability condition for maps. Professor D. S. CORAM* and P. F. DUVALL, Jr., Oklahoma State University (732-G5)

11:40-11:50 (60) Approximating approximate fibrations. Preliminary report. Mr. ROBERT E. GOAD, University of Georgia (732-D2)

O. G. Harrold
Associate Secretary

Tallahassee, Florida

## PRESENTORS OF PAPERS

Following each name is the number corresponding to the speaker's position on the program

• Invited one-hour lecturers

*Ancel, F. D. #40
*Anderson, D. D. #37
*Arnold, J. T. #5
•Ball, B. J. #31
*Bellenot, S. F. #33
*Benard, M. #19
*Birman, J. S. #12
•Carlitz, L. #1
Chang, M.-H. #56
Cima, J. A. #54
Coram, D. S. #59
*Craggs, R. #43
Dale, L. #22
*Daverman, R. J. #42
Debnath, L. #51
Deveney, J. K. #27
Dobbs, D. E. #24
*Eakin, P. M. #6
*Eisner, J. R. #14
*Feldman, A. D. #20
*Ferguson, P. A. #21
Gayler, R. A. #55
Goad, R. E. #60
*Graves, W. H. #35
*Hale, M. P., Jr. #46
*Hamann, E. #8
Hassell, J. #25
Hazewinkel, M. #52
*Hoefsmit, P. #17
*Hollingsworth, J. G. #16
Idowu, E. A. #28
Infantozzi, C. A. #48
*Israel, M. #15
Johnson, J. L. #49
*Jones, W. R. #44
•Kalman, R. #32
Kreimer, H. F. #29
*Lacher, R. C. #39
Linton, R. C. #26

* Special session speakers

Lopez, A. M., Jr. #23
Lund, B. #47
*McAdam, S. #9
*O'Malley, M. J. #36
*Parshall, B. #45
Peeples, D. R. #50
Quine, J. R. #58
*Sally, J. D. #10
*Scharlemann, M. #11
*Sentilles, D. #4
*Sher, R. B. #41
Stricklen, S. A., Jr. #57
Suh, T.-I. #53
*Summers, W. H. #34
*Sumners, D. W. #13
*Taylor, D. C. #3
Tindell, R. #30
*Ward, H. N. #18
*Wheeler, R. F. #2

# The Seven Hundred Thirty-Third Meeting
# University of Illinois at Urbana-Champaign
# Urbana, Illinois
# March 15 – 20, 1976

The seven hundred thirty-third meeting of the American Mathematical Society will be held at the University of Illinois at Urbana-Champaign from Monday, March 15, through Saturday, March 20, 1976. The sessions of the meeting will be held in Altgeld Hall, the headquarters of the Department of Mathematics, and in other nearby classroom buildings. All the buildings involved are located on the Urbana side of Wright Street, which is the dividing line between Urbana on the east and Champaign on the west.

The period March 15–18 will be devoted to a symposium on Probability, which is supported by the National Science Foundation under a grant to the American Mathematical Society. The topic of the symposium was selected by the 1974 Committee to Select Speakers for Western Sectional Meetings, which consisted of Richard A. Askey, Paul T. Bateman (chairman), and Donald J. Lewis. The Organizing Committee for the symposium, responsible for selecting the speakers and arranging the symposium program, consists of Kai Lai Chung, Joseph L. Doob (chairman), Richard M. Dudley, Ronald K. Getoor, Frank B. Knight, and Frank L. Spitzer. The symposium will consist of sixteen half-hour lectures and four one-hour lectures. The list of speakers will include Donald L. Burkholder, Hans Föllmer, Jean Jacod, Naresh C. Jain, Harry Kesten, Frank B. Knight, Janós Komlós, Oscar E. Lanford III, Bernard Maisonneuve, Paul-André Meyer, P. Warwick Millar, Steven Orey, Mark A. Pinsky, Gilles Pisier, William E. Pruitt, Daniel Revuz, Daniel W. Stroock, John B. Walsh, Shinzo Watanabe, and David Williams.

The period March 19–20 will be devoted to three one-hour addresses, six special sessions of selected twenty-minute papers, and five sessions of contributed ten-minute papers.

By invitation of the Committee to Select Hour Speakers for Western Sectional Meetings there will be the following one-hour addresses. Paul Erdös of the Hungarian Academy of Sciences will address the Society at 11:00 a.m. on Friday, March 19; his subject is "Probability methods in combinatorial analysis and number theory". Stephen Wainger of the University of Wisconsin and the Institute for Advanced Study will give an hour talk at 1:45 p.m. on Friday, March 19; his topic is "Some problems in harmonic analysis related to curves". Hugh L. Montgomery of the University of Michigan will speak at 11:00 a.m. on Saturday, March 20; the title of his talk is "The large sieve for the mathematician in the street".

By invitation of the same committee there will be the following special sessions of twenty-minute papers. JAY R. GOLDMAN of the University of Minnesota and the University of California at San Diego has organized a special session on Enumerative combinatorics to be held Friday morning, Friday afternoon, and Saturday morning; the speakers will be George E. Andrews, Richard A. Askey, Leonard Carlitz, Adriano M. Garsia, Curtis Greene, Lawrence H. Harper, David A. Klarner, Daniel J. Kleitman, Albert Nijenhuis, David L. Reiner, David P. Roselle, Seymour Sherman, Richard P. Stanley, Paul R. Stein, William T. Tutte, Dennis E. White, Herbert S. Wilf, and Stanley G. Williamson. ROLF JELTSCH of the University of Kentucky has organized a special session on Numerical solutions of ordinary differential equations to be held Friday morning, Friday afternoon, Saturday morning, and Saturday afternoon; the speakers will be David A. Archer, R. Leonard Brown, George D. Byrne, Frederic H. Chipman, Julio Cesar Diaz, Byron L. Ehle, Rolf Jeltsch, Paul S. Jensen, J. Douglas Lawson, Bengt Lindberg, Werner Liniger, Farouk M. Odeh, Victor L. Pereyra, Jerrold S. Rosenbaum, Robert D. Russell, R. Bruce Simpson, Robert D. Skeel, H. A. Watts, Daniel D. Warner, Daniel S. Watanabe, Mary Fanett Wheeler, Peter B. Worland, and R. V. M. Zahar. ANDREW LENARD of Indiana University has organized a special session on Inequalities in mathematical physics to be held Friday morning and afternoon; the speakers will be Richard S. Ellis, Richard A. Holley, Cornelius O. Horgan, Lawrence E. Payne, and Loren D. Pitt. PETER A. LOEB of the University of Illinois at Urbana-Champaign has organized a special session on Potential theory to be held Friday morning and afternoon; the speakers will be Thomas E. Armstrong, Maynard G. Arsove, Moses Glasner, Myron Goldstein, Kohur N. Gowrisankaran, Peter A. Loeb, John C. Taylor, and Bertram Walsh. RALPH E. SHOWALTER of the University of Texas has organized a special session on Partial differential equations of Sobolev type, to be held Friday morning, Friday afternoon, and Saturday morning; the speakers will be Jerry L. Bona, John R. Cannon, Paul L. Davis, Richard E. Ewing, David W. Fox, John E. Lagnese, Howard A. Levine, V. R. Gopala Rao, Martin M. Rooney, William Rundell, Zeev Schuss, Lars B. Wahlbin, and Margaret C. Waid. DAVID SLEPIAN of Bell Telephone Laboratories and the University of Hawaii has organized a two-part special session entitled Tutorial on information theory; Part I (Friday morning) will be devoted to Probabilistic theory and will have as speakers Toby Berger, Robert G. Gallager, Jacob Wolfowitz, and Aaron D. Wyner; Part II (Friday afternoon) will be devoted to Algebraic coding

theory and will have as speakers Edward F. Assmus, Jr., Ian F. Blake, James L. Massey, and Neil J. A. Sloane.

On Friday morning there will be sessions of contributed papers on probability, combinatorics, algebra, and complex analysis. On Friday afternoon there will be a session of contributed papers on topology and analysis.

## REGISTRATION

The registration desk will be located inside the north entrance of Altgeld Hall. The desk will be open from 8:30 a.m. to 5:00 p.m. on Monday; 9:00 a.m. to 4:00 p.m. on Tuesday; 9:00 a.m. to 12:00 noon on Wednesday; 9:00 a.m. to 4:00 p.m. on Thursday; 8:00 a.m. to 4:00 p.m. on Friday; and 8:00 a.m. to 11:00 a.m. on Saturday.

## ACCOMMODATIONS

The hotel headquarters for the meeting will be the Century 21 Hotel, 302 E. John Street, Champaign, Illinois, which is exactly four blocks west of Altgeld Hall. Reservations by March 1 are essential, since there will be a high school basketball tournament in Urbana-Champaign on Friday and Saturday, March 19–20. A reservation form may be found on page A-264 of the January issue of these *Notices*. The rates for the Century 21 Hotel are:

Singles, $18–$22, Single occupancy
Twins/Doubles, $24–$28, Double occupancy

Dormitory accommodations will also be available, but only for Monday, Tuesday, Wednesday, and Thursday nights. These may be obtained by going to the Housing Office in Clark Hall, 1215 South Fourth Street, Champaign, Illinois, which is three blocks west and four blocks south of Altgeld Hall. The dormitory rates are

Singles, $6.80, Single occupancy
Twins, $5.50 per person, Double occupancy.

No reservations are required, since plenty of dormitory space is available for Monday through Thursday nights. However, a 9:00 a.m. checkout is essential on Friday morning if one wishes to avoid entanglement with teenage basketball fans.

All the rates quoted are subject to a five percent tax.

## FOOD SERVICE

Meals will be available in the cafeteria in the Illini Union, which is adjacent to Altgeld Hall. Of course the Century 21 Hotel has food service. A list of other local restaurants will also be available at the registration desk.

## TRAVEL AND LOCAL INFORMATION

Urbana-Champaign is served by Amtrak and by Ozark Air Lines. Amtrak has direct train service from New Orleans and Chicago. Ozark Air Lines has direct flights from New York, Chicago, St. Louis, and Washington.

## ENTERTAINMENT

Those attending the meeting are invited to attend a special enlarged session of the Urbana Probability Pizza Club, to be held on Tuesday, March 16, at noon.

The Saturday Hiking Club of Urbana will have a special extra meeting on Wednesday, March 17, at 2:00 p.m. for the convenience of those attending the meeting. Old clothes and heavy shoes are recommended for this event. Dinner will be served around an open fire. By a singular coincidence the Commissar of the Hiking Club is a member of the organizing committee of the symposium.

On Thursday, March 18, from 5:00 p.m. to 6:00 p.m. there will be a cash bar in the Levis Faculty Center, which is located three blocks east of Altgeld Hall.

On Friday, March 19, from 8:30 p.m. to 10:30 p.m. there will be a beer party in the Century 21 Hotel at a cost of one dollar per person. Tickets may be purchased at the registration desk.

## PARKING

Those staying in the Century 21 Hotel should park at the hotel. Those staying in the dormitories will receive parking instructions upon check-in. Others may obtain detailed parking information at the registration desk. In particular there is metered parking on the uppermost level of the parking structure at the corner of Sixth and John Streets, one block west of Altgeld Hall. Since the university is not in session at the time of the meeting, parking will not be a major problem; however, visitors are cautioned that parking in an individually rented parking space may lead to a towing charge.

PROGRAM FOR THE SYMPOSIUM ON PROBABILITY

All sessions will be held in 314 Altgeld Hall

MONDAY, MARCH 15

| | |
|---|---|
| 9:30 a.m.-10:00 a.m. | On prediction processes. FRANK B. KNIGHT, University of Illinois at Urbana-Champaign |
| 10:15 a.m.-11:15 a.m. | A representation of BMO functions. PAUL-ANDRÉ MEYER, Centre Nationale Recherches Scientifiques, France |
| 11:30 a.m.-noon | Some Q-matrix problems. DAVID WILLIAMS, University of College, Wales |
| 2:00 p.m.- 2:30 p.m. | The last exit process. BERNARD MAISONNEUVE, University of Social Sciences, Grenoble, France |
| 2:45 p.m.- 3:15 p.m. | Zero-one laws and random times. P. WARWICK MILLAR, University of California, Berkeley |
| 3:30 p.m.- 4:00 p.m. | (Title not available.) JOHN P. WALSH, University of British Columbia |

TUESDAY, MARCH 16

| | |
|---|---|
| 9:30 a.m.-10:00 a.m. | Dual processes for infinite particle systems and their applications. DANIEL W. STROOCK, University of Colorado, Boulder |
| 10:15 a.m.-11:15 a.m. | Brownian motion and classical analysis. DONALD L. BURKHOLDER, University of Illinois at Urbana-Champaign |
| 11:30 a.m.- 2:30 p.m. | Some sample path properties of the asymmetric Cauchy processes. WILLIAM E. PRUITT, University of Minnesota, Minneapolis |
| 2:00 p.m.- 2:30 p.m. | Small random perturbations of dynamical systems with reflecting boundary. STEVEN OREY, University of Minnesota, Minneapolis |
| 2:45 p.m.- 3:15 p.m. | On the recurent boundary for random walks. DANIEL REVUZ, University of Paris VII, France |
| 3:30 p.m.- 4:00 p.m. | A renewal theorem for random walk in a random environment. HARRY KESTEN, Cornell University |

WEDNESDAY, MARCH 17

| | |
|---|---|
| 9:30 a.m.-10:00 a.m. | Stochastic stability and boundary problems. MARK A. PINSKY, Northwestern University |
| 10:15 a.m.-11:15 a.m. | A derivation of the Boltzmann equation from classical mechanics. OSCAR LANFORD, University of California, Berkeley |
| 11:30 a.m.-noon | Poisson point processes of Brownian excursions and their application to diffusion processes. SHINZO WATANABE, Kyoto University, Japan |

THURSDAY, MARCH 18

| | |
|---|---|
| 9:30 a.m.-10:00 a.m. | A new embedding theorem and its bounds. JANÓS KOMLÓS, Hungary Academy of Science |
| 10:15 a.m.-11:15 a.m. | Central limit theorem and related questions in Banach space. NARESH C. JAIN, University of Minnesota, Minneapolis |
| 11:30 a.m.-noon | Representation of martingales—a general result and applications. JEAN JACOD, Ecole des Mines de Paris, France |
| 2:45 p.m.- 3:15 p.m. | The central limit theorem and the law of itereated logarithm in Banach spaces. GILLES PISIER, Ecole Polytechnique, France |
| 3:30 p.m.- 4:00 p.m. | On the potential theory of stochastic control. H. FÖLLMER, University of Frankfort, West Germany |

PROGRAM OF THE SESSIONS

THE SEVEN HUNDRED THIRTY-THIRD MEETING

The time limit for each contributed paper in the general sessions is ten minutes and in the special sessions is twenty minutes. To maintain this schedule, the time limits will be strictly enforced.

FRIDAY, 8:00 A. M.

Special Session on Enumerative Combinatorics I, 192 Lincoln Hall

8:00- 8:20 (1) Inequalities between rearrangements with side conditions. Preliminary report. Professor RICHARD ASKEY, University of Wisconsin (733-A7)

8:30- 8:50 (2) Some permutation problems. Professors L. CARLITZ* and RICHARD SCOVILLE, Duke University (733-A9)

9:00- 9:20 (3) Rook theory and the chromatic structure of graphs. Professors JAY R. GOLDMAN, J. T. JOICHI, and DENNIS E. WHITE*, University of Minnesota (733-A6)

9:30- 9:50 (4) On the zeros of rook polynomials. Preliminary report. Professor ALBERT NIJENHUIS, University of Pennsylvania (733-A5)

10:00-10:20 (5) Algorithms for a problem of Frobenius. Professor HERBERT S. WILF, University of Pennsylvania (733-A4)

10:30-10:50 (6) The rotor effect in the theory of chromatic polynomials. Professor WILLIAM T. TUTTE, University of Waterloo (733-A27)

FRIDAY, 8:00 A. M.

Special Session on Numerical Solutions of Ordinary Differential Equations I, 151 Electrical Engineering Building

8:00- 8:20 (7) Necessary condition for A-stability of multistep multiderivative methods. Mr. ROLF JELTSCH, University of Kentucky (733-C3)

8:30- 8:50 (8) Special purpose linear multi-step formulas. Preliminary report. Mr. PAUL S. JENSEN, Lockheed Research Laboratory (733-C32) (Introduced by Rolf Jeltsch)

9:00- 9:20 (9) On Liapunov stability of non-linear multistep difference equations. Dr. WERNER LINIGER, IBM Thomas J. Watson Research Center, Yorktown Heights, New York (733-C28)

9:30- 9:50 (10) Non-linear fixed-h stability of linear multistep formulae. F. ODEH, IBM Thomas J. Watson Research Center, Yorktown Heights, New York (733-C18)

10:00-10:20 (11) Testing computer codes for ordinary differential equations. Preliminary report. Dr. G. D. BYRNE*, University of Pittsburgh, Dr. A. C. HINDMARSH, Lawrence Livermore Laboratory, Livermore, California, Mr. K. R. JACKSON, University of Toronto, and Mr. H. G. BROWN, Northeast Louisiana University (733-C29)

10:30-10:50 (12) Stability of variable step linear multistep methods. Preliminary report. Professor ROBERT D. SKEEL*, University of Illinois, and Professor L. WAYNE JACKSON, University of Alberta (733-C6)

FRIDAY, 8:30 A. M.

Special Session on Potential Theory I, 141 Electrical Engineering Building

8:30- 8:50 (13) An almost everywhere regular boundary supporting the maximal representing measure for bounded and quasibounded harmonic functions. Professor PETER A. LOEB, University of Illinois (733-B5)

9:00- 9:20 (14) Lattice-theoretic methods in axiomatic potential theory. Professor MAYNARD ARSOVE*, University of Washington, and Dr. HEINZ LEUTWILER, University of Erlangen, West Germany (733-B18)

9:30- 9:50 (15) Multiply harmonic presheaves and product sweeping systems. Preliminary report. Professor THOMAS E. ARMSTRONG, University of Minnesota (733-B10)

10:00-10:20 (16) Multiply superharmonic functions. Professor KOHUR N. GOWRISANKARAN, McGill University (733-B34)

10:30-10:50 (17) Discussion period (chaired by Joseph L. Doob)

FRIDAY, 8:30 A. M.

Special Session on Partial Differential Equations of Sobolev Type I, 196 Lincoln Hall

8:30- 8:50 (18) Some questions concerning quasi-linear parabolic systems of equations. Professor JOHN R. CANNON, University of Texas at Austin (733-B9)

9:00- 9:20 (19) Backward and degenerate parabolic equations. Preliminary report. Professor ZEEV SCHUSS, Rensselaer Polytechnic Institute (733-B2)

*For papers with more than one author, an asterisk follows the name of the author who plans to present the paper at the meeting.

9:30- 9:50 (20) Differential inequalities for systems of degenerate parabolic operators. Preliminary report. Dr. MARGARET C. WAID, University of Delaware (733-B16)

10:00-10:20 (21) A maximum principle for equations of Sobolev type. WILLIAM RUNDELL, Texas A & M University (733-B33)

10:30-10:50 (22) Perturbations in degenerate variational inequalities. Professor JOHN LAGNESE, Georgetown University (733-B20)

FRIDAY, 8:30 A. M.

Session on Probability, 106 Lincoln Hall

8:30- 8:40 (23) Convergence of reversed martingales with multidimensional indices. ALLAN GUT, Duke University (733-F2) (Introduced by Morris Weisfeld)

8:45- 8:55 (24) Stability of the classification of stopping times. Preliminary report. Professor PHILIP PROTTER, Duke University (733-F4)

FRIDAY, 9:00 A. M.

Special Session on Inequalities in Mathematical Physics I, 106 Lincoln Hall

9:00- 9:20 (25) Necessary and sufficient conditions for the GHS inequality with applications to differential equations. Professor RICHARD S. ELLIS*, University of Massachusetts, and Professor CHARLES M. NEWMAN, Technion, Haifa, Israel (733-F3)

9:30- 9:50 (26) A strong cluster property for lattice systems at high temperatures or low densities. RICHARD A. HOLLEY* and DANIEL W. STROOCK, University of Colorado (733-C5)

10:00-10:20 (27) A Gaussian correlation inequality for even convex sets. Preliminary report. Dr. LOREN D. PITT, University of Virginia (733-F1)

10:30-10:50 (28) Discussion period

FRIDAY, 9:00 A. M.

Tutorial Session on Information Theory I: Probabilistic Theory, 314 Altgeld Hall

9:00- 9:20 (29) Overview of information theory. Professor R. G. GALLAGER, Massachusetts Institute of Technology (733-C8) (Introduced by J. Wolfowitz)

9:30- 9:50 (30) The classical channel. Professor JACOB WOLFOWITZ, University of Illinois (733-C9)

10:00-10:20 (31) Rate-distortion theory and $\epsilon$-entropy. Professor TOBY BERGER, Cornell University (733-C10) (Introduced by J. Wolfowitz)

10:30-10:50 (32) Multiple-user Shannon theory. Mr. AARON D. WYNER, Bell Laboratories, Murray Hill, New Jersey (733-C11) (Introduced by J. Wolfowitz)

FRIDAY, 9:00 A. M.

Session on Algebra, 243 Altgeld Hall

9:00- 9:10 (33) The local integral representation of symmetric bilinear forms. Preliminary report. Dr. J. PETER STONITSCH, University of Notre Dame (733-A12)

9:15- 9:25 (34) Selberg trace formula applied to Ramanujan's tau function. Professor H. R. P. FERGUSON, Brigham Young University (733-A20)

9:30- 9:40 (35) Extensions of pairs of linear transformations between infinite-dimensional vector spaces. Preliminary report. Professor URI FIXMAN and Dr. FRANK OKOH*, Queen's University (733-A2)

9:45- 9:55 (36) A characterization of odd order extensions of some orthogonal simple groups. Professor HARIHARAN K. IYER, University of Utah (733-A21)

FRIDAY, 9:30 A. M.

Session on Combinatorics, 241 Altgeld Hall

9:30- 9:40 (37) An application of n-partitions to coding theory. Preliminary report. Dr. GENE A. BERG, Virginia Commonwealth University (733-A10)

9:45- 9:55 (38) The number of indecomposable error correcting codes. Professor KENNETH P. BOGART, Dartmouth College (733-A15)

10:00-10:10 (39) On the existence of [M,n] group codes for the Gaussian channel with M and n odd. Professors CHARLES P. DOWNEY* and J. K. KARLOF, University of Nebraska at Omaha (733-C16)

10:15-10:25 (40) Enumeration of interval orders without duplicated holdings. Mr. T. LOCKMAN GREENOUGH, Dartmouth College (733-A14)

10:30-10:40 (41) On the uniqueness of the tetrahedral association scheme. Preliminary report. Dr. PETER ROLLAND, Pima College, West Campus (733-A19)

FRIDAY, 10:00 A. M.

Session on Complex Analysis, 243 Altgeld Hall

10:00-10:10 (42) Hypernormal meromorphic functions. Preliminary report. Dr. J. M. ANDERSON, University College, London, England, and Professor LEE A. RUBEL*, University of Illinois (733-B17)

10:15-10:25 (43) A directional cluster set example. Preliminary report. Professor CHARLES L. BELNA, Professor MICHAEL J. EVANS, and Professor PAUL D. HUMKE*, Western Illinois University (733-B21)

10:30-10:40 (44) Most directional cluster sets have common values. Preliminary report. Professor CHARLES L. BELNA, Professor MICHAEL J. EVANS*, and Professor PAUL D. HUMKE, Western Illinois University (733-B22)

10:45-10:55 (45) Green's potentials on Lipschitz domains. Preliminary report. Dr. JANG-MEI G. WU, University of Illinois (733-B23)

FRIDAY, 11:00 A. M.

Invited Address, 314 Altgeld Hall

(46) Applications of probability methods to combinatorial analysis and number theory. Professor PAUL ERDÖS, Hungarian Academy of Sciences (733-F5)

FRIDAY, 1:45 P. M.

Invited Address, 314 Altgeld Hall

(47) Some problems in harmonic analysis related to curves. Professor STEPHEN WAINGER, University of Wisconsin and Institute for Advanced Study (733-B19)

FRIDAY, 3:00 P. M.

Special Session on Enumerative Combinatorics II, 192 Lincoln Hall

3:00- 3:20 (48) Cluster-star inversion and Möbius formula. SEYMOUR SHERMAN, Indiana University (733-C36)

3:25- 3:45 (49) Symmetric magic squares and commutative algebra. Professor RICHARD P. STANLEY, Massachusetts Institute of Technology (733-A3)

3:50- 4:10 (50) Computer searches for Rogers-Ramanujan type identities. Preliminary report. Professor GEORGE E. ANDREWS, University of Wisconsin (733-A11)

4:15- 4:35 (51) Enumeration of plane trees with certain forbidden subtrees. DAVID A. KLARNER, SUNY, Center at Binghamton (733-A25)

4:40- 5:00 (52) Binary search trees. ADRIANO M. GARSIA, University of California, San Diego (733-A26)

5:05- 5:25 (53) Lexicographic order isomorphism for partitions. Professor S. G. WILLIAMSON, University of Minnesota (733-A17)

5:30- 5:50 (54) A $n \times \log n$ lower bound on synchronous combinational complexity. L. H. HARPER, University of California, Riverside (733-A29)

FRIDAY, 3:00 P. M.

Special Session on Potential Theory II, 141 Electrical Engineering Building

3:00- 3:20 (55) Properties of harmonic spaces preserved under perturbation. Professor BERTRAM WALSH, Rutgers University (733-B29)

3:30- 3:50 (56) LIG domains. Professor MYRON GOLDSTEIN, Arizona State University (733-B28)

4:00- 4:20 (57) The Martin compactification of a bounded Lipschitz domain in a Riemannian manifold X. JOHN C. TAYLOR, McGill University (733-B32)

4:30- 4:50 (58) The roles of nondensity points. Professor MOSES GLASNER*, Pennsylvania State University, and Professor MITSURU NAKAI, Nagoya Institute of Technology, Nagoya, Japan (733-B14)

FRIDAY, 3:00 P. M.

Special Session on Inequalities in Mathematical Physics II, 106 Lincoln Hall

3:00- 3:20 (59) Korn's inequalities in continuum mechanics. Professor CORNELIUS O. HORGAN, University of Houston (733-B8)

3:30- 3:50 (60) Some remarks on isoperimetric inequalities and their applications. Professor LAWRENCE E. PAYNE, Cornell University (733-B25)

FRIDAY, 3:00 P. M.

Special Session on Partial Differential Equations of Sobolev Type II, 196 Lincoln Hall

3:00- 3:20 (61) Model equations for the two-way propagation of waves. Dr. JERRY BONA, University of Chicago (733-B4)

3:30- 3:50 (62) An initial value problem for slow flow in stratified fluids. Dr. DAVID W. FOX, The Johns Hopkins University (733-B12)

4:00- 4:20 (63) Galerkin approximation of Sobolev equations for nonlinear waves. Mr. MARTIN ROONEY, University of Texas, Austin (733-C20)

4:30- 4:50 (64) On finite element methods for numerical solution of some Sobolev equations. Preliminary report. Professor LARS B. WAHLBIN, Cornell University (733-C2)

FRIDAY, 3:00 P. M.

Special Session on Numerical Solutions of Ordinary Differential Equations II, 151 Electrical Engineering Building

3:00- 3:20 (65) Adaptive mesh modification for the box scheme. Professor R. BRUCE SIMPSON, University of Waterloo (733-C33)

3:25- 3:45 (66) Estimation of errors for discretization algorithms for nonlinear functional equations. Preliminary report. Dr. BENGT LINDBERG, University of Illinois (733-C22) (Introduced by Rolf Jeltsch)

3:50- 4:10 (67) A one-step 4k order method for nonlinear two-point boundary value problems. Professor V. PEREYRA, University of Southern California (733-C7) (Introduced by Rolf Jeltsch)

4:15- 4:35 (68) The solution of two-point boundary-value problems by initial-value methods. Preliminary report. Dr. H. A. WATTS* and Dr. M. R. SCOTT, Sandia Laboratories, Albuquerque, New Mexico (733-B24) (Introduced by Rolf Jeltsch)

4:40- 5:00 (69) Adaptive mesh selection strategies for solving boundary value problems. Preliminary report. Dr. ROBERT D. RUSSELL* and Mr. JAN C. CHRISTIANSEN, Simon Fraser University (733-C23) (Introduced by Rolf Jeltsch)

5:05- 5:25 (70) Some collocation-finite element methods for 2m-th order boundary value problems. Preliminary report. Professor MARY FANETT WHEELER, Rice University (733-C31)

5:30- 5:50 (71) Collocation-Galerkin solutions of the two point boundary value problem. Professor JULIO CESAR DIAZ, University of Kentucky (733-C4)

FRIDAY, 3:00 P. M.

Tutorial Session on Information Theory II: Algebraic Coding Theory, 314 Altgeld Hall

3:00- 3:20 (72) Overview of coding theory. Preliminary report. Professor JAMES L. MASSEY, University of Notre Dame (733-C12) (Introduced by J. Wolfowitz)

3:30- 3:50 (73) Error-correcting codes and invariant theory: New applications of a nineteenth-century technique. Dr. N. J. A. SLOANE, Bell Laboratories, Murray Hill, New Jersey (733-C13)

4:00- 4:20 (74) Block designs. Professor E. F. ASSMUS, Jr.*, Lehigh University, and Professor H. F. MATTSON, Jr., Syracuse University (733-A8)

4:30- 4:50 (75) Group characters and representation in coding theory. Professor IAN F. BLAKE, IBM Thomas J. Watson Research Center, Yorktown Heights, New York (733-C14) (Introduced by J. Wolfowitz)

FRIDAY, 3:00 P. M.

Session on Topology and Analysis, 241 Altgeld Hall

3:00- 3:10 (76) Hereditarily locally connected continua and the Hahn-Mazurkiewicz problem. Preliminary report. Mr. JOSEPH SIMONE, University of Missouri at Kansas City (733-G1)

3:15- 3:25 (77) On a useful economy in the formation of Riemann sums. Professor ALEXANDER ABIAN, Iowa State University (733-B7)

3:30- 3:40 (78) Vector-valued variational equations of infinite order. Dr. THOMAS A. W. DWYER III, Northern Illinois University (733-B27)

3:45- 3:55 (79) Multipliers and singular integrals over local fields. Preliminary report. Professor JAMES E. DALY, University of Oregon (733-B31)

4:00- 4:10 (80) Function algebras and badly approximable functions. Preliminary report. Mr. DANIEL H. LUECKING, University of Illinois (733-B26)

4:15- 4:25 (81) Semigroup perturbation theorems with application to a singular perturbation problem in non-linear o.d.e.'s. Dr. ROBERT P. KERTZ, Georgia Institute of Technology (733-B13)

4:30- 4:40 (82) Solving Theodorsen's integral equation for conformal maps with the fast Fourier transform. Preliminary report. Dr. MARTIN H. GUTKNECHT, University of British Columbia (733-C15) (Introduced by Professor Rolf Jeltsch)

4:45- 4:55 (83) A study of perturbation effect on spectra of operators. Preliminary report. Mr. ALAN DI CENZO, Case Western Reserve University (733-C19) (Introduced by Gerald Hedstrom)

SATURDAY, 8:00 A. M.

Special Session on Enumerative Combinatorics III, 192 Lincoln Hall

8:00- 8:20 (84) The extended Simon Newcomb problem. Professor F. B. DRANE, Department of Defense, Fort Meade, Maryland, and Professor D. P. ROSELLE*, Virginia Polytechnic Institute and State University (733-A18)

8:30- 8:50 (85) Sequences of polynomials of fractional binomial type. Professor DAVID L. REINER, Trinity College (733-A1)

9:00- 9:20 (86) Acyclic orientations of graphs. Professor CURTIS GREENE, Massachusetts Institute of Technology (733-A22)

9:30- 9:50 (87) Asymptotic enumeration of linear extensions of Boolean algebras. DANIEL J. KLEITMAN, Massachusetts Institute of Technology (733-A16)

10:00-10:20 (88) A brief history of enumeration. Preliminary report. PAUL R. STEIN, Los Alamos Scientific Laboratory (733-A28)

SATURDAY, 8:00 A. M.

Special Session on Numerical Solutions of Ordinary Differential Equations III, 314 Altgeld Hall

8:00- 8:20 (89) A comparison of the effectiveness of various methods for solving stiff equations. Dr. BYRON L. EHLE, University of Victoria (733-C34) (Introduced by Professor Rolf Jeltsch)

8:30- 8:50 (90) A family of one-parameter, B-stable, R-K methods. Preliminary report. FRED CHIPMAN, Acadia University (733-C21) (Introduced by Rolf Jeltsch)

9:00- 9:20 (91) Padé-Walsh arrays for exp(-z) on $[0,\infty)$ with applications to the numerical solution of heat conduction problems. Professor J. D. LAWSON, University of Waterloo (733-C35)

9:30- 9:50 (92) Block implicit formulas for stiff equations. Preliminary report. Professor DANIEL S. WATANABE* and Mr. BRUCE D. LINK, University of Illinois (733-C24) (Introduced by Rolf Jeltsch)

10:00-10:20 (93) An exponentially fitted trapezoidal rule. Dr. DANIEL D. WARNER, Bell Laboratories, Murray Hill, New Jersey (733-C26)

10:30-10:50 (94) Parallel methods for the numerical solution of ordinary differential equations. Dr. PETER B. WORLAND, Gustavus Adolphus College (733-B1) (Introduced by Professor Rolf Jeltsch)

SATURDAY, 9:00 A. M.

Special Session on Partial Differential Equations of Sobolev Type III, 196 Lincoln Hall

9:00- 9:20 (95) An equipartition of energy theorem for weak solutions of evolutionary equations in Hilbert space. Professor HOWARD A. LEVINE, University of Rhode Island (733-B6)

9:30- 9:50 (96) A coupled non-linear hyperbolic-Sobolev system. Preliminary report. Professor RICHARD E. EWING, Oakland University (733-B11)

10:00-10:20 (97) Higher order and related hyperbolic equations. Preliminary report. Professor PAUL L. DAVIS, Manhattanville College (733-B3)

10:30-10:50 (98) A Cauchy problem for pseudo-parabolic systems. Preliminary report. Professor V. R. GOPALA RAO, Lehigh University (733-B15)

SATURDAY, 11:00 A.M.

Invited Address, 314 Altgeld Hall

(99) The large sieve for the mathematician in the street. Professor HUGH MONTGOMERY, University of Michigan (733-A23)

SATURDAY, 1:30 P. M.

Special Session on Numerical Solutions of Ordinary Differential Equations IV, 314 Altgeld Hall

1:30- 1:50 (100) Modified collocation methods for two point boundary value problems. Professor D. A. ARCHER*, University of North Carolina, and Professor J. C. DIAZ, University of Kentucky (733-C25)

1:55- 2:15 (101) Numerical integration of differential equations for real time simulation. Professor JERROLD ROSENBAUM, Virginia Commonwealth University (733-C27)

2:20- 2:40 (102) Numerical integration techniques for real time simulation-part II. Dr. R. LEONARD BROWN, University of Virginia (733-C30) (Introduced by Rolf Jeltsch)

2:45- 3:05 (103) Recurrence algorithms for series solutions of differential equations. Dr. R. V. M. ZAHAR, Pennsylvania State University (733-B30) (Introduced by Rolf Jeltsch)

Urbana, Illinois

Paul T. Bateman
Associate Secretary

Following each name is the number corresponding to the speaker's position on the program

• Invited one-hour lectures

* Special session speakers

Abian, A. #77
*Andrews, G. E. #50
*Archer, D. A. #100
*Armstrong, T. E. #15
*Arsove, M. #14
*Askey, R. #1
*Assmus, E. F., Jr. #74
Berg, G. A. #37
*Berger, T. #31
*Blake, I. F. #75
Bogart, K. P. #38
*Bona, J. #61
*Brown, R. L. #102
*Byrne, G. D. #11
*Cannon, J. R. #18
*Carlitz, L. #2
*Chipman, F. #90
Daly, J. E. #79
*Davis, P. L. #97
*Diaz, J. C. #71
Di Cenzo, A. #83
Downey, C. P. #39
Dwyer, T. A. W. III #78
*Ehle, B. L. #89
*Ellis, R. S. #25
•Erdös, P. #46
Evans, M. J. #44
*Ewing, R. E. #96
Ferguson, H.R. P. #34
*Fox, D. W. #62
*Gallager, R. G. #29
*Garsia, A. M. #52
*Glasner, M. #58
*Goldstein, M. #56
*Gowrisankaran, K. N. #16
*Greene, C. #86
Greenough, T. L. #40
Gut, A. #23
Gutknecht, M. H. #82
*Harper, L. H. #54
*Holley, R. A. #26
*Horgan, C. O. #59
Humke, P. D. #43
Iyer, H. K. #36
*Jeltsch, R. #7
*Jensen, P. S. #8
Kertz, R. P. #81
*Klarner, D. A. #51
*Kleitman, D. J. #87
*Lagnese, J. #22
*Lawson, J. D. #91
*Levine, H. A. #95
*Lindberg, B. #66
*Liniger, W. #9
*Loeb, P. A. #13
Luecking, D. H. #80
*Massey, J. L. #72
•Montgomery, H. #99
*Nijenhuis, A. #4
*Odeh, F. #10
Okoh, F. #35
*Payne, L. E. #60
*Pereyra, V. #67
*Pitt, L. D. #27
Protter, P. #24
*Rao, V. R. G. #98
*Reiner, D. L. #85
Rolland, P. #41
*Rooney, M. #63
*Roselle, D. P. #84
*Rosenbaum, J. #101
Rubel, L. A. #42
*Rundell, W. #21
*Russell, R. D. #69
*Schuss, Z. #19
*Sherman, S. #48
Simone, J. #76
*Simpson, R. B. #65
*Skeel, R. D. #12
*Sloane, N. J. A. #73
*Stanley, R. P. #49
*Stein, P. R. #88
Stonitsch, J. P. #33
*Taylor, J. C. #57
*Tutte, W. T. #6
*Wahlbin, L. B. #64
*Waid, M. C. #20
•Wainger, S. #47
*Walsh, B. #55
*Warner, D. D. #93
*Watanabe, D. S. #92
*Watts, H. A. #68
*Wheeler, M. F. #70
*White, D. E. #3
*Wilf, H. S. #5
*Williamson, S. G. #53
*Wolfowitz, J. #30
*Worland, P. B. #94
Wu, J.-M. G. #45
*Wyner, A. D. #32
*Zahar, R. V. M. #103

# INVITED SPEAKERS AT AMS MEETINGS

This section of these *Notices* lists regularly the individuals who have agreed to address the Society at the times and places listed below. For some future meetings, the lists of speakers are incomplete.

New York, New York, April 1976

W. Wistar Comfort
John S. Lew

Reno, Nevada, April 1976

Robert T. Powers

# ORGANIZERS AND TOPICS OF SPECIAL SESSIONS

Abstracts of contributed papers to be considered for possible inclusion in special sessions should be submitted to Providence by the deadlines given below and should be clearly marked "For consideration for special session on (title of special session)." Those papers not selected for special sessions will automatically be considered for regular sessions unless the author gives specific instructions to the contrary.

| | Deadline |
|---|---|
| New York, New York, April 1976 | Expired |
| John F. Kennison, Sheaves and Other Topoi | |
| Gangaram S. Ladde, Applicable Differential Equations (title tentative) | |
| Edgar R. Lorch, Functional Analysis and Allied Topics | |
| Reno, Nevada, April 1976 | Expired |
| Bruce E. Blackadar, C*-Algebras and Related Topics | |
| Peter A. Griffin, Mathematics of Gambling | |
| Darrell C. Kent, Convergence Spaces | |
| Ralph N. McKenzie, Varieties of Algebras | |

# PRELIMINARY ANNOUNCEMENTS OF MEETINGS

## The Seven Hundred Thirty-Fourth Meeting
## Biltmore Hotel
## New York, New York
## April 11 – 14, 1976

The seven hundred thirty-fourth meeting of the American Mathematical Society will be held at the Biltmore Hotel, Madison Avenue at 43rd Street, New York, New York, from Sunday, April 11, through Wednesday, April 14, 1976.

By invitation of the Committee to Select Hour Speakers for Eastern Sectional Meetings, there will be two one-hour addresses on Tuesday, April 13. The speakers will be W. Wistar Comfort of Wesleyan University and John S. Lew of the IBM Thomas J. Watson Research Center.

There will be three special sessions on Tuesday, April 13, or Wednesday, April 14. JOHN F. KENNISON of Clark University is organizing a special session on Sheaves and other topoi. G. S. LADDE of SUNY College at Potsdam is organizing a special session on Applicable differential equations (title tentative). EDGAR R. LORCH of Columbia University is organizing a special session on Functional analysis and allied topics.

Sessions for contributed ten-minute papers will be scheduled on Tuesday, April 13, and Wednesday, April 14. No provision will be made for late papers. Abstracts should be submitted to the American Mathematical Society, P. O. Box 6248, Providence, Rhode Island 02940, so that they will be received prior to the deadline of February 17, 1976. The final program of the meeting will appear in the April issue of these *Notices*.

The Council of the Society will meet on Sunday, April 11, at 5:00 p.m. in Suite L & M of the Biltmore Hotel.

### SYMPOSIUM ON ASYMPTOTIC METHODS AND SINGULAR PERTURBATIONS

With the support of the Energy Research and Development Administration and the National Science Foundation, a symposium on Asymptotic Methods and Singular Perturbations is scheduled to be held on Sunday and Monday, April 11–12, 1976. This topic was selected by the AMS-SIAM Committee on Applied Mathematics, whose members are Earl A. Coddington, Donald S. Cohen, Richard C. DiPrima, Lester E. Dubins, J. Barkley Rosser, Stephen Smale, and W. Gilbert Strang.

The purpose of the symposium is to help bring this active and productive field of applied analysis to the attention of a larger mathematical audience, and emphasis will be put on recent advances in analytical techniques and problems emerging from particular physical situations featuring singular perturbation phenomena. The organizing committee, comprised of Donald S. Cohen, California Institute of Technology; Joseph B. Keller, New York University, Courant Institute of Mathematical Sciences; Robert E. O'Malley, Jr., University of Arizona (chairman); and M. D. Van Dyke, Stanford University, has organized the symposium into four sessions. To the greatest extent possible the lectures will identify the principal lines of current research. It is hoped that the lectures will enable the audience to appreciate some areas where they could use such techniques in their own research. The broad spectrum of applications to be discussed should make the symposium valuable to both specialists and the general mathematical audience.

Lecturers and the titles of their talks are: Paul C. Fife (University of Arizona) "Singular perturbation and wave-front techniques applied to reaction-diffusion problems"; Frank C. Hoppensteadt (New York University, Courant Institute of Mathematical Sciences) "Biological applications"; David R. Kassoy (University of Colorado, Boulder) "Extremely rapid transient phenomena in combustion: ignition and explosion"; Petar Kokotovic (University of Illinois, Urbana) "How singular perturbation ideas apply to control and how control concepts could be useful in singular perturbations"; H. O. Kreiss (University of Uppsala and New York University, Courant Institute of Mathematical Sciences) "On numerical methods and singular perturbations"; Donald Ludwig (University of British Columbia) "The validity of the diffusion approximation to discrete stochastic processes"; Frank W. J. Olver (University of Maryland, College Park) "Uniform asymptotic expansions and singular perturbations"; Mark A. Pinsky (Northwestern University) "Asymptotic analysis of the linearized Boltzmann equation"; Keith Stewartson (University College, London) "Some asymptotic problems in fluid mechanics"; and Wolfgang R. Wasow (University of Wisconsin, Madison) "Adiabatic invariants".

A novel feature of the symposium will be a session on open problems; information regarding this session was contained in the January issue of these *Notices*. For further details please contact R. E. O'Malley, Jr., Department of Mathematics, University of Arizona, Tucson, Arizona 85721.

### SHORT COURSE ON INTRODUCTION TO COMPUTER SCIENCE FOR MATHEMATICIANS

The American Mathematical Society will present a one-day Short Course on Introduction to Computer Science for Mathematicians on Monday, April 12, 1976 in the Grand Ballroom of the Biltmore Hotel. The course is designed to give

substantial introductions to three important topics in computer science. It is intended primarily for mathematicians trained in other areas who wish a concentrated introduction to this field. However, the course is open to all who wish to participate, upon payment of the registration fee.

The program is under the direction of Shmuel Winograd of the IBM T. J. Watson Research Center.

There will be three lecturers, each of whom will give two fifty-minute talks. Robert L. Constable (Department of Computer Science, Cornell University) will speak on "Proving the correctness of programs"; Nicholas Pippenger (IBM T. J. Watson Research Center) will speak on "The complexity of algebraic and order-theoretic computations"; and Michael Rabin (Hebrew University and Massachusetts Institute of Technology) will speak on "Exponential explosions in computations."

Summaries of these talks and accompanying reading lists appear on pages A-333 through A-335 of these *Notices*.

## ASSOCIATION FOR WOMEN IN MATHEMATICS

There will be a concurrent meeting of the Association for Women in Mathematics, organized by Lenore Blum.

## REGISTRATION

The registration desk will be located in the Key Room of the Biltmore Hotel on the nineteenth floor adjacent to the Grand Ballroom. The desk will be open from 8:30 a.m. to 4:30 p.m. on Sunday, April 11, through Tuesday, April 13; and from 8:30 a.m. to 3:30 p.m. on Wednesday, April 14.

The registration fees for the meeting are as follows:

| | |
|---|---|
| Member | $ 3 |
| Student and unemployed | 1 |
| Nonmember | 5 |
| Short Course on Computer Science | 12 |

## ACCOMMODATIONS

Persons intending to stay at the Biltmore Hotel should make their own reservations with the hotel. A reservation form and a listing of room rates will be found on the last page of these *Notices*. The deadline for receipt of reservations is March 28, 1976.

## TRAVEL

The Biltmore Hotel is located on Madison Avenue at 43rd Street on the east side of New York City. Walkways to Grand Central Station are located under the hotel and signs are posted directing persons to the lobby of the hotel.

Those arriving by bus may take the Independent Subway System from the Port Authority Bus Terminal. There is shuttle bus service from LaGuardia and Kennedy Airports directly to Grand Central Station. Starters can direct participants to the correct bus.

Air passengers arriving at Newark Airport can take a shuttle bus to the Port Authority Bus Terminal and take a subway, taxi, or bus to the hotel.

Those arriving by car will find many parking facilities in the neighborhood, in addition to those at the hotel. Parking service can be arranged through the hotel doorman at a cost of $9 for the 24-hour period. There will be an additional charge for extra pickup and delivery service if it is required. The parking fee is subject to New York City taxes.

## MAIL ADDRESS

Registrants at the meeting may receive mail addressed in care of the American Mathematical Society, The Biltmore Hotel, Madison Avenue at 43rd Street, New York, New York 10017.

# The Seven Hundred Thirty-Fifth Meeting
# University of Nevada
# Reno, Nevada
# April 23 – 24, 1976

The seven hundred thirty-fifth meeting of the American Mathematical Society will be held at the University of Nevada in Reno, Nevada, on Friday and Saturday, April 23 and 24, 1976. The Association for Symbolic Logic will hold a meeting in conjunction with this meeting of the Society. The Association for Symbolic Logic has scheduled two invited one-hour talks. Gabriel Sabbagh of the University of Paris VII and the University of California, Berkeley, will lecture on "First order properties of linear groups." Yiannis N. Moschovakis of the University of California, Los Angeles, will give a survey lecture entitled "Inductive definability." The Association will also schedule four invited one-half hour talks and sessions of contributed twenty-minute papers.

By invitation of the Committee to Select Hour Speakers for Far Western Sectional Meetings, there will be one invited hour address. Robert T. Powers of the University of Pennsylvania and the University of California, Berkeley, will lecture on Saturday at 11:00 a.m. The title of his lecture is "KMS states of UHF algebras with applications to quantum statistical mechanics."

There will be four special sessions. BRUCE E. BLACKADAR of the University of Nevada, Reno, is organizing a special session on C*-Algebras and related topics. Participants will include Bruce A. Barnes, Bruce E. Blackadar, Lawrence G. Brown, Man-Duen Choi, John A. Ernest, Ramesh A. Gangolli, Philip P. Green III, Peter Florin Hahn, Calvin C. Moore, Marc A. Rieffel, and Jonathan Rosenberg. PETER A. GRIFFIN of California State University, Sacramento, is organizing a special session of thirty-minute talks on Mathematics of gambling. Among the speakers will be Thomas M. Cover, William H. Cutler, Thomas S. Ferguson, and Peter A. Griffin. DARRELL C. KENT of Washington State University is organizing a special session on Convergence spaces. Among the speakers will be Allan C. Cochran, Ralph E. DeMarr, William Alan Feldman, Ray J. Gazik, Darrell C. Kent, Terrence S. McDermott, Gary D. Richardson, and Edwin F. Wagner. The following are tentatively scheduled to speak: E. Binz, H. P. Butzmann, and Gerhard Grimeisen. The proceedings of these sessions on Convergence Spaces will be published by the University of Nevada. RALPH N. McKENZIE of the University of California, Berkeley, is organizing a special session on Varieties of algebras. Among the speakers will be Kirby A. Baker, George M. Bergman, Alan Day, George Grätzer, and Alden F. Pixley. The following are tentatively scheduled to speak: Trevor Evans, Bjarni Jonsson, and Alfred Tarski.

There will be sessions for contributed ten-minute papers on Saturday, April 24. Abstracts for contributed papers should be sent to the American Mathematical Society, P.O. Box 6248, Providence, Rhode Island 02940, so as to arrive prior to the deadline of February 17, 1976. Late papers will be accepted for presentation at the meeting, but will not be listed in the printed program of the meeting.

The registration area will be on the first floor of the Physics Building. Registration on Friday, April 23, will be from 1:00 p.m. until 3:00 p.m. and on Saturday, April 24, from 8:30 a.m. until noon and from 1:00 p.m. until 2:30 p.m.

There are many hotels and motels not far from the university campus. The following is a selection of a few convenient ones. The rates are projected for spring 1976 and are subject to change. They do not include the six percent hotel-motel tax. In some instances special rates may be allowed for participants in university conventions.

MOTEL CAPRI (702) 323-8398
895 North Virginia Street (89501)

| | |
|---|---|
| Single | $18 up |
| Double | 18 up |

COED LODGE (702) 329-2742
800 North Virginia Street (89501)

| | |
|---|---|
| Single | $14 up |
| Double | 18 up |

FLYING J MOTEL (702) 329-3464
1651 North Virginia Street (89503)

| | |
|---|---|
| Single | $10 up |
| Double | 12 up |

ELDORADO HOTEL (702) 786-5700
345 North Virginia Street (89501)

| | |
|---|---|
| Single | $25 |
| Double | 32 |

GOLDEN WEST MOTOR LODGE (702) 329-2192
530 North Virginia Street (89501)

| | |
|---|---|
| Single | $20 up |
| Double | 22 up |

HEART O'TOWN MOTEL (702) 322-4066
520 North Virginia Street (89501)

| | |
|---|---|
| Single | $14 up |
| Double | 16 up |

JACKPOT MOTEL (702) 329-2591
730 North Virginia Street (89501)

| | |
|---|---|
| Single | $16 |
| Double | 18 |

SHOWBOAT INN (702) 786-4032
660 North Virginia Street (89501)

| | |
|---|---|
| Single | $12 |
| Double | 14 |

SUNDOWNER HOTEL (800) 648-5490 (toll free)
450 North Arlington (89501)

| | |
|---|---|
| Single | $20 |
| Double | 24 |

TINY'S MOTEL (702) 329-9248
850 North Virginia Street (89501)

| | |
|---|---|
| Single | $18 |
| Double | 20 |

UPTOWN MOTEL (702) 323-8906
570 North Virginia Street (89501)

| | |
|---|---|
| Single | $18 |
| Double | 18 |

The following motel is one-and-one-half miles from both downtown and the airport.

MOTEL 6 (702) 825-8401
1901 South Virginia Street (89502)

| | |
|---|---|
| Single | $ 8.95 |
| Double | 10.95 up |

The only eating facility on campus which will be open on Saturday is the Jot Travis Student Union cafeteria. A list of restaurants off and near campus will be available at the registration desk.

The southwest corner of the campus is at Ninth Street and North Virginia Street, one block north of the Interstate 80 east-west freeway. Persons driving from the west should take the Sierra Street-Virginia Street exit (Exit 13), and from the east, the Virginia Street-Business exit (Exit 13). Persons driving from either north or south on Highway 395 should travel on Virginia Street which is Business Highway 395. Parking will be available in the campus lot accessible from about 1500 North Virginia Street.

Reno International Airport is approximately three miles from the campus. Taxi fare to the campus and motel area is about $3.

The final program of the meeting will appear in the April issue of these *Notices*.

Kenneth A. Ross
Eugene, Oregon — Associate Secretary

# The Seven Hundred Thirty-Sixth Meeting
# Portland State University
# Portland, Oregon
# June 18 – 19, 1976

The seven hundred thirty-sixth meeting of the American Mathematical Society will be held at Portland, Oregon, on Friday, June 18, 1976. The Mathematical Association of America and the Society for Industrial and Applied Mathematics will hold Northwest Sectional Meetings in conjunction with this meeting of the Society. Some of their sessions will be held on Saturday, June 19. There will also be a session sponsored by Pi Mu Epsilon; for further information, contact John R. Reay, Western Washington State College, Bellingham, Washington 98225.

There will be sessions for contributed papers. Abstracts should be submitted to the American Mathematical Society, P. O. Box 6248, Providence, Rhode Island 02940, so as to arrive prior to the deadline of April 27, 1976. Late papers will be accepted for presentation at the meeting, but will not appear in the printed program of the meeting.

Further information will appear in the April issue of these *Notices*, and the final program will appear in the June *Notices*.

Kenneth A. Ross
Eugene, Oregon — Associate Secretary

# 1976 Summer Institute on Algebraic and Geometric Topology
# August 2 – 21, 1976

The twenty-fourth Summer Research Institute of the American Mathematical Society will be devoted to the topic "Algebraic and Geometric Topology", and will be held at Stanford University, Stanford, California, for a period of three weeks from August 2–21, 1976. The organizing committee consists of Raoul Bott, William Browder (cochairman), Pierre Connor, Wu Chung Hsiang, Robion Kirby, Richard Lashof, R. James Milgram (chairman), Daniel Quillen, and P. Emery Thomas (cochairman). It is expected that the institute will be supported by a grant from the National Science Foundation.

The scientific program of the institute will concentrate on three major areas in which there have been interesting and significant new developments. These are: surgery theory and its applications, algebraic K-theory and its relations with topology, and the structure of topological manifolds. The organizing committee is planning several series of lectures to cover these topics, to be complemented by a number of seminars conducted by leading experts and devoted to more detailed discussion of these topics.

Information on speakers, travel, and accommodations will be available in subsequent announcements.

Funds for participants will be limited, and it is hoped that a number of participants will locate their own sources for support. The institute is open to all mathematicians specializing in algebraic and geometric topology, and to advanced graduate students in this field. Those wishing to participate should write to Dr. Gordon L. Walker, American Mathematical Society, P.O. Box 6248, Providence, Rhode Island 02940. Recent Ph.D.'s and advanced graduate students who wish to be considered for support should write before March 10, 1976.

# CURRENT TRENDS IN GRADUATE EDUCATION IN PH. D. GRANTING MATHEMATICS DEPARTMENTS

by Wendell H. Fleming

This article is a report of trends in graduate enrollments, financial aid, and related matters affecting Ph.D. programs in mathematics. It is based on recent numerical data, together with impressions obtained from departments through a questionnaire and other sources. We focus on mathematics departments in the U.S. which grant the Ph.D. A briefer report is given concerning other mathematical science departments granting the Ph.D., for which the data available were less complete, and for Canadian departments.

One of the most striking trends is the steady decline in mathematics graduate enrollments, from a peak which occurred around 1969. In the last three years alone, graduate enrollments in Ph.D. granting mathematics departments fell overall by 17% with a larger drop among certain departments (Table 1 below). The decline has been accompanied by a drop in numbers of applicants for graduate study and increased attrition from Ph.D. programs. Falling graduate enrollments may lead to a continuing decline in numbers of Ph.D. degrees, which would tend to improve job prospects for young Ph.D. mathematicians in the difficult job market expected during the early 1980s. On the other hand, the trend is producing stresses in many Ph.D. programs, particularly those for which the decline in graduate enrollments has been more severe than the nationwide average. Our capacity to produce Ph.D. mathematicians trained for traditional careers in university teaching and research exceeds the demand. There is need to achieve more diversity among graduate programs. For instance, some departments are reorienting their programs to better meet needs of industry and government, with emphasis on the master's degree.

The downward trend in graduate mathematics enrollments parallels that in the physical sciences. For mathematics and the physical sciences, there is strong evidence that future employment prospects, as perceived by students, are important considerations in decisions about pursuing graduate study. In contrast, graduate enrollments in humanities and social sciences remain strong despite job prospects, which are often bleak. Better employment prospects for applied mathematicians have stimulated an interest in applications among mathematics graduate students. Many continue toward the Ph.D. in pure mathematics while taking applied courses; others choose thesis topics in applied areas.

As regards financial support, the important change is the drastic decline since 1968 in U.S. Federal Government support of graduate students. Earlier fears that this might shift Ph.D. production from strong programs to weaker ones have proved unfounded.

In recent years total numbers of teaching assistants have not changed much nationwide, although individual departments have reported significant increases or decreases. Some departments now have serious difficulty finding enough qualified teaching assistants, and several have deliberately converted teaching assistantships into junior faculty positions (see the related article by Martha K. Smith, p. 366 of the November 1975 *Notices*).

Graduate enrollments, fall 1969–fall 1974. Table 1 shows total enrollments by full-time graduate students and by first-year students, in U.S. mathematics departments which grant the Ph.D. These departments have been divided into three groups: I, II, III, according to the American Council on Education ratings as explained on the following page. Table 1 is based on enrollment counts by department from the 1970, 1972, and 1975 editions of the Mathematical Association of America Guidebook. First year student enrollments in Table 1 may be slightly high, since some departments appear to have included part-time students in the data.

Full-time Graduate Enrollment in 155 Ph.D. Granting Mathematics Departments

| Total Full-time | Fall 1969 | Fall 1971 | Fall 1974 |
|---|---|---|---|
| Group I (Top 27 ACE Ranked) | 3,060 | 2,760 | 2,490 |
| Group II (38 other ACE Rated) | 3,020 | 2,860 | 2,090 |
| Group III (90 Unrated) | 3,060 | 3,160 | 2,920 |
| Total | 9,140 | 8,780 | 7,500 |

| First-year Full-time | Fall 1969 | Fall 1971 | Fall 1974 |
|---|---|---|---|
| Group I | 1,035 | 775 | 685 |
| Group II | 1,150 | 945 | 675 |
| Group III | 1,175 | 1,175 | 1,015 |
| Total | 3,350 | 2,895 | 2,375 |

Source: MAA Guidebook 1970, 1972, 1975.

TABLE 1

In this article Ph.D. granting departments in the mathematical sciences are classified as below. Groups I–V are departments in the U.S.

Group I: the top 27 ACE ranked mathematics departments
Group II: the other 38 ACE rated mathematics departments
Group III: 90 ACE unrated mathematics departments
Group IV: statistics, biostatistics and biometry departments
Group V: other mathematical science departments
Group VI: departments in the mathematical sciences in Canadian universities

For an account of the ACE ratings referred to above see "A Rating of Graduate Programs" by Kenneth D. Roose and Charles J. Andersen, American Council of Education, Washington, D.C., 1969, 115 pp. The information on mathematics was reprinted by the Society and can be found on pages 338–340 of the February 1971 issue of these *Notices*.

Table 1 shows an enrollment decline from fall 1969 to fall 1974 in all three Groups I–III, with an especially pronounced drop in Group II since fall 1971. Enrollment trends varied considerably from department to department. A few Group I and II departments reported modest increases in graduate enrollments. Over one quarter of Group III departments reported increases; often these were departments with rather new programs. However, these new programs are generally smaller and produce relatively few Ph.D.'s. Several departments in Groups II and III experienced a drop in graduate enrollments by half or more between fall 1969 and fall 1974. No significant difference was noted in overall graduate enrollment trends between mathematics departments in public vs. private universities.

The numbers in Table 1 were compared with AMS Survey data, and with NSF data on graduate enrollments included in Table 5 below. These sources confirm the trend shown in Table 1. It appears that the enrollment drop continued into the present academic year. AMS Survey data collected during summer 1975 show an estimated drop of about 2% in total full-time graduate student enrollments for Groups I–III, and of about 5% in first-year student enrollments, between fall 1974 and fall 1975. The actual decline for fall 1975 was probably greater, since corresponding estimates in previous AMS Surveys have subsequently turned out to be high.

Table 2 shows estimated enrollments for 157 other Ph.D.-granting departments. Not included in Table 2 are departments for which no graduate enrollment data appear in recent MAA Guidebooks. Some Group V departments are part of engineering divisions, and their mathematical science graduate enrollments are not always clearly separated. Moreover, for many departments included in Table 2, graduate enrollment data did not appear in each edition of the MAA Guidebook. Table 2 is less reliable than Table 1, both as an indicator of enrollment totals and trends. This is particularly true for Group V departments.

Estimated Full-time Graduate Enrollment in 157 other Ph.D.-Granting Mathematical Science Departments, and Canadian Departments.

| Total Full-time | Fall 1969 | Fall 1971 | Fall 1974 |
|---|---|---|---|
| Group IV (54 statistics related departments) | 1,700 | 1,620 | 1,670 |
| Group V (76 other mathematical science departments) | 3,150 | 4,050 | 4,250 |
| Group VI (27 Canadian departments) | 1,260 | 1,290 | 1,110 |
| **First-year Full-time** | | | |
| Group IV | 510 | 530 | 580 |
| Group V | 1,450 | 1,530 | 1,530 |
| Group VI | 510 | 430 | 410 |

Source: MAA Guidebook 1970, 1972, 1975.

TABLE 2

In contrast to the departments in Table 1, Table 2 shows enrollment increases among the applications-oriented departments in Groups IV and V. AMS Survey data for the last three years show a similar trend. However, those data show larger increases in first-year graduate enrollments for Group IV (nearly 15% per year), and also in total full-time enrollments for Group V (about 7% per year). For Canadian departments, AMS Survey data show somewhat more pronounced recent enrollment declines than Table 2.

Trends in numbers of applicants, attrition, and shifts toward applied mathematics. In spring 1975 chairmen of departments in Groups I, II, III were asked for impressions of current trends in their departments. The purpose of this questionnaire was to supplement numerical data already available. Questions concerned trends in numbers and quality of applicants for admission to graduate study, attrition from Ph.D. programs, graduate student involvement with applied mathematics, and teaching assistantships. Responses were received from 125 of 155 departments currently in Groups I–III.

Applicants. 24% of the departments responding reported a significant decline during the last three years in numbers of applicants for admission to graduate study. Another 40% reported a slight decline, 27% reported the number of applicants as about the same, and 9% reported an increase. No discernable trend regarding the quality of applicants was found from responses to a question on this matter. The number of departments reporting that applicant quality had improved was about the same as the number reporting it had declined. Many reported little change in quality of applicants.

Attrition. Two questions were asked, one regarding attrition during the first two years of graduate study, the other about later attrition. Nearly 50% of the departments reported an increase in numbers of students leaving the department after two years or less of graduate study. However, fewer than 30% reported an increase in numbers of students past the second year leaving without the Ph. D. The discouraging job market was most often cited as a reason for increased attrition. Changes in the quality, attitudes, and objectives of graduate students were also considered important. A number of respondents cited toughened standards for the Ph. D. as a cause for increased attrition. However, decreased financial aid was generally reported as unimportant in graduate student attrition.

Student involvement with applied mathematics. Departments were asked about trends in (a) the number of students planning a Ph. D. thesis in pure mathematics, but taking applied courses; and (b) the number planning a Ph. D. thesis in applied mathematics.

Percentage of Group I–III Departments Reporting Indicated Change

| Number of students who | Increasing significantly | Increasing slightly | No change or decreasing |
|---|---|---|---|
| (a) Plan a Ph. D. thesis in pure mathematics but take applied courses | 42% | 39% | 19% |
| (b) Plan a Ph. D. thesis in applied mathematics | 19% | 44% | 37% |

TABLE 3

Table 3 shows that 81% of departments reported an increase in (a), and 63% an increase in (b). This trend can be at least partly attributed to students' perceptions of job prospects, which are currently better for people with applied skills. However, some students find a natural fit between a Ph. D. thesis topic in mathematics and an area of application. See an article by John Nohel, December 1975 *Notices*, p. 380.

The responses to (b) in Table 3 can be compared with recent data on Ph. D. production. The total number of mathematical science Ph. D.'s has recently remained fairly constant, in the range of 1,200–1,300 per year. However, the percentage of pure mathematics Ph. D.'s has declined to about half the total, with a corresponding rise in numbers of Ph. D. degrees classified as applied. In the academic year 1974–1975, Group I–III departments produced roughly 600 Ph. D.'s in pure mathematics and 170 in applied mathematics, besides those Ph. D.'s from Groups IV-VI. As reported by R. D. Anderson, November 1975 *Notices*, p. 359, there was a distinct shift toward Ph. D.'s in applied areas among Group II and III departments. Among departments reporting both years, there were among Groups II and III, 35 fewer Ph. D.'s in pure mathematics during 1974–1975 than during 1973–1974, and 33 more in applied mathematics. On the other hand, Group I produced 51 more Ph. D.'s in pure mathematice and 4 fewer in applied mathematics.

Discussion. It is interesting to compare trends in mathematics with other fields. Graduate School Adjustments to the "New Depression" in Higher Education, by David W. Breneman, National Board on Graduate Education Technical Report November 3, 1975, presents an interesting study of trends in a number of fields. The trend in mathematics is similar to that in the physical sciences. NSF data for fiscal years 1968–1973 reported in that study (see also Table 5 below) show nearly as great a percentage enrollment decline in mathematics as the widely publicized drop in physics graduate enrollments. In contrast, graduate enrollments and Ph. D. production have remained strong in the humanities and social sciences despite general dismal job prospects. For example, a Modern Language Association Survey showed that, of some 1,000 doctorates in English seeking employment for 1974–1975, no more than half had any realistic expectation of an academic job. On the other hand, such fields as economics and clinical psychology have not been experiencing serious employment problems for Ph. D.'s.

Mathematics students, like those in the physical sciences, tend to view graduate study as an investment in preparation for a lifetime career. Some will wish to pursue mathematics under any circumstances, through love of it. The most gifted of them should be encouraged to do so. Many other students have reacted to changed career prospects in one of several ways. Some have declined to enter graduate study in mathematics. Others have left graduate school short of the Ph. D. or switched out of mathematics. Still others have chosen to continue toward the Ph. D. in mathematics, but to broaden their employment possibilities either by gaining experience in applied mathematics or by other means.

It is the responsibility of the mathematics community, and mathematics departments in particular, to insure that students are told the best current estimates of employment prospects for mathematicians. In this connection see the letter from the President of the AMS, Lipman Bers, December 1975 *Notices*, Inside Front Cover. This letter was addressed to chairmen of Ph. D. granting mathematics departments at the request

of the AMS Council.

Mathematics faculties have greatly expanded in recent years, and have become stronger. Some younger departments have become as strong in certain areas as more prestigious ones. As a result, our capability to produce young mathematicians geared to traditional university careers in teaching and research well exceeds the demand. It is estimated that during the early 1980s there may be as few as 75 tenured openings per year among all 155 departments in Groups I, II, and III. This roughly equals the expected number of vacancies due to deaths and retirements, estimated to be during this period about 1 1/2 % per year of the approximately 5,000 faculty members in Group I, II, and III departments. Mathematics departments not granting the Ph. D. may have around 200 such openings per year during the same period. (See December 1975 *Notices*, pp. 377–380.) In this situation young mathematicians will need to be prepared, educationally and psychologically, for a variety of tasks. Some of these will be of the traditional sort, in mathematics departments or in laboratories devoted to long-term basic research. Many others will use their talents in nontraditional ways, for instance through industrial research related to shorter term company goals or in working with educationally disadvantaged groups.

In a period of declining graduate enrollments, it seems wasteful for all departments simply to retrench simultaneously, trying to maintain all present Ph. D. programs on a reduced scale. A reassessment of the scope and objectives of graduate programs in mathematics is in order. Departments have different strengths, both in terms of faculty and in terms of job markets where their graduates are successfully placed. These suggest directions in which the various programs might advantageously evolve. Some departments have chosen to emphasize master's degree programs oriented toward employment in industry or government. In a forthcoming issue of these *Notices*, a report is expected on the panel discussion "The changing role of the master's degree", held at the San Antonio AMS meeting, January 1976.

Graduate student financial support. Table 4 shows the percentage of full-time graduate students in Group I–VI departments with various types of support during fall 1974. Among mathematics departments, especially those in Groups II and III, teaching assistantships are currently by far the most important source of graduate student support.

Graduate Student Financial Support, Fall 1974, in Ph. D. Granting Mathematical Science Departments

| Group | Fellowship or Scholarship | Teaching Fellowship or Teaching Assistantship | Research Assistantship | Other |
|---|---|---|---|---|
| I | 16% | 51% | 7% | 26% |
| II | 9 | 68 | 3 | 20 |
| III | 6 | 71 | 2 | 21 |
| IV | 21 | 30 | 22 | 27 |
| V | 12 | 24 | 24 | 40 |
| VI | 28 | 47 | 19 | 6 |

Source: MAA Guidebook.
The data in Tables 1, 2, and 4 were compiled from the MAA Guidebooks by Ernest Davis.

TABLE 4

Other data show trends in financial support. Table 5 is based on NSF data for 120 Ph. D. granting mathematics departments, tabulated by the staff of the Board on Graduate Education. Of these 120 departments, 24 belong to Group I, 38 to Group II, and 54 to Group III. Enrollment totals in Table 5 for Fiscal Years 1970 and 1972 are lower than the corresponding totals for fall 1969 and fall 1971 in Table 1, since fewer departments are included.

Full-Time Graduate Students in 120 Ph. D. Granting Mathematics Departments

| Source of Support | Fiscal Year 1968 | 1970 | 1972 | 1973 |
|---|---|---|---|---|
| Federal Government | 2,564 | 2,144 | 1,331 | 903 |
| Institution, state, or local government | 4,420 | 4,570 | 4,560 | 4,553 |
| Self, loans, and family | 1,586 | 1,477 | 1,612 | 1,617 |
| Other | 388 | 302 | 267 | 211 |
| TOTAL Full-time Enrollment | 8,958 | 8,493 | 7,770 | 7,284 |

Source: Data from NSF Graduate Student Support Surveys.

TABLE 5

The striking feature in Table 5 is the drastic decline in U.S. Federal Government support for mathematics graduate students, through fellowships, traineeships, and research assistantships. The total number of students federally supported was down by 1,661 from FY 1968 to FY 1973. Of this total, the drop was 699 among Group I departments, 587 among Group II, and 375 among Group III. This counts, of course, only departments among the 120 included in Table 5. During this period there was a great decline in federally funded graduate fellowships and traineeships in all fields,

down from 51,500 in FY 1968 to 6,600 in FY 1974. The decline in Federal support for graduate students appears to have affected some kinds of departments more than others. For departments in some private universities, with high tuition and relatively few teaching assistantships, availability of financial support for graduate students has become a real constraint. Moreover, without federally funded fellowships and traineeships, lower ranked departments often find it more difficult to compete for top students with more prestigious departments.

In addition to kinds of Federal support presently remaining for graduate students, the U. S. Federal government may be expected to have a continuing interest in support for training related to selected areas of special national concern (e.g. energy).

Support from institutions' own funds, state, or local governments shown in Table 5, is mainly through teaching assistantships in the case of mathematics. Numbers of students with such support showed little change between FY 1968 and FY 1973. More recent AMS Survey data show that total numbers of teaching assistants have not changed significantly since FY 1973. However, there is considerable variation from department to department. About 30% of departments responding to the questionnaire mentioned above reported either a significant increase or significant decrease in numbers of teaching assistants. (Apparently the increases and decreases offset each other, so that nationwide totals remain about the same.) Higher undergraduate enrollments were frequently cited as a reason by those reporting increases in numbers of teaching assistants; budget cuts and fewer graduate students were cited by those reporting decreases. Sixteen departments were identified as having deliberately converted teaching assistantships into junior faculty positions. The numbers of assistantships converted ranged from 1 or 2 up to 25 in the case of one department.

At present departments are competing for teaching assistants from a diminishing nationwide pool of graduate students. As graduate enrollments continue to decline, more departments encounter shortages of well-qualified teaching assistants. There are at least three ways in which institutions can respond to the shortage. One is to make teaching assistantships more attractive to prospective students. If this strategy succeeds, it may be optimal for the individual department. However, if successfully pursued by many departments, more young people will be attracted into the teaching profession with no long-term prospects of remaining in it. There is expected to be difficulty placing each year, as mathematics teachers at any level, numbers of the magnitude of the number of first-year students shown in Table 1 as entering fall 1974. A second possibility is to make do with available teaching assistants, even those marginally qualified or unqualified. This does not make educational sense, when well qualified Ph.D.'s are available to teach. The third alternative is to convert teaching assistantships into faculty positions. As already mentioned, this has been done at several institutions. Sometimes the conversion was made with no increase in cost. In other cases, additional funds for conversion were found. The article by Martha K. Smith (November 1975 *Notices*), cited earlier, discusses this matter further.

# NEWS ITEMS AND ANNOUNCEMENTS

## NOMINATIONS FOR APPOINTMENTS

The Council has instructed the Committee on Committees to "assemble and maintain a roster of members of the Society who are available to fill appointed positions." In order to carry out this duty the Committee is now soliciting the names of those individuals who would be both willing and qualified to serve on Society committees or in other positions that are appointed by the president.

Members wishing to suggest such names, or to volunteer themselves, should send a letter to the secretary of the Society, Professor Everett Pitcher, Christmas-Saucon Hall 14, Lehigh University, Bethlehem, Pennsylvania 18015, or to any member of the Committee. This letter should include the name, the proposed assignment, and a brief statement of the qualifications of the individual. The Committee will collate these names and advise the president-elect in May on the appointments he will make for his term (1977–1978). The president-elect will of course appoint committees that are appropriately sized and balanced, and that can function effectively as a unit. It may, therefore, not be possible for him to accept all of the suggestions made by the members. The members of the committee are Richard D. Anderson (Louisiana State University), R. H. Bing (University of Texas at Austin), Phyllis J. Cassidy (Northampton, Massachusetts), W. Wistar Comfort (Wesleyan University), Chandler Davis (University of California, Berkeley), Everett Pitcher (ex officio), and J. Ernest Wilkins, Jr., Chairman (Howard University).

## ROYAL SOCIETY OF EDINBURGH PROCEEDINGS A NOW A MATHEMATICAL JOURNAL

The Royal Society of Edinburgh Proceedings A (Mathematics), a journal which previously consisted of papers in the mathematical and physical sciences, now publishes only papers in mathematics. For the present time, it will be published approximately six times a year. Proceedings A (Mathematics) has an Editorial Board and twenty Consulting Editors who are active in securing contributions for consideration of publication. Further information may be obtained from Professor W. N. Everitt, Department of Mathematics, University of Dundee, Dundee, DD1 4HN, Scotland.

# BACKLOG OF MATHEMATICS RESEARCH JOURNALS

Information on the backlog of papers for research journals is published in the February and August issues of these *Notices* with the cooperation of the respective editorial boards. Since all columns in the table are not self-explanatory, we include further details on their meaning.

Column 3. This is an estimate of the number of printed pages which have been accepted but are not necessary to maintain copy editing and printing schedules.

Column 5. The first ($Q_1$) and third ($Q_3$) quartiles are presented to give a measure of normal dispersion. They do not include misleading extremes, the result of unusual circumstances arising in part from the refereeing system.

The observations are made from the latest issue of each journal received at the Headquarters Offices before the deadline for the appropriate issue of these *Notices*. Waiting times are measured in months from receipt of manuscript in final form to receipt of final publication at the Headquarters Offices. When a paper is revised, the waiting time between an editor's receipt of the final revision and its publication may be much shorter than is the case otherwise, so these figures are low to that extent.

| | 1 | 2 | 3 | | 4 | 5 | | |
|---|---|---|---|---|---|---|---|---|
| JOURNAL | Number Issues per Year | Approximate Number Pages per Year | BACKLOG 12/15/75 | BACKLOG 5/31/75 | Estimated Time for Paper Submitted Currently to be Published (In Months) | Observed Waiting Time in Latest Published Issue (In Months) $Q_1$ | $Q_2$ | $Q_3$ |
| Acta Informatica | 4 | 384 | 0 | 0 | 8 | 11 | 15 | 18 |
| Aequationes Math. | 3-6 | 400-640 | 450 | * | 18 | 23 | 24 | 28 |
| American J. of Math. | 4 | 1200 | 2000 | 1500 | 24 | 32 | 33 | 34 |
| Annals of Math. | 6 | 1200 | 600 | 300 | 6 | 6 | 8 | 10 |
| Annals of Probability | 6 | 1050 | 0 | 0 | 12 | 8 | 9 | 10 |
| Annals of Statistics | 6 | 1200 | 0 | 0 | 15 | 7 | 8 | 9 |
| Appl. Math. and Optimization | 4 | 384 | 0 | 9 | ** | | | |
| Arch. History of Exact Scis. | 2 | 170 | 0 | 0 | 7-8 | | *** | |
| Arch. Rational Mech. Anal. | 11 | 1075 | 0 | 0 | 9-10 | 9 | 11 | 13 |
| Canad. J. of Math. | 6 | NR# | NR# | 1200 | NR# | 10 | 17 | 22 |
| Comm. Math. Physics | 19 | 1915 | 0 | 210 | 6-7 | 9 | 11 | 12 |
| Duke Math. J. | 4 | 800 | 40 | 125 | 8 | 5 | 6 | 7 |
| Houston J. of Math. | 4 | 800 | 200 | * | 6 | 6 | 8 | 9 |
| Illinois J. of Math. | 4 | 700 | 300 | 0 | 15 | 11 | 16 | 23 |
| Indiana Univ. Math. J. | 12 | 1200 | 1000 | 1000 | 18 | 18 | 18 | 19 |
| Inventiones Math. | 11 | 1056 | NR# | NR# | 10 | 9 | 10 | 12 |
| J. Amer. Stat. Assoc. | 4 | 1004 | 84 | 201 | 12 | 8 | 9 | 10 |
| J. Assoc. for Comp. Mach. | 4 | 700 | 100 | 0 | 6-9 | 8 | 9 | 10 |
| J. Comp. & Sys. Scis. | 6 | 1200 | 600 | NR# | 12 | 17 | 23 | 32 |
| J. Diff. Geometry | 4 | 660 | 1200 | 900 | 21-24 | 15 | 20 | 24 |
| J. Math. Physics | 12 | 2555 | 0 | 0 | 8 | 5 | 6 | 8 |
| J. Symbolic Logic | 4 | 900 | 0 | 0 | 10 | 16 | 20 | 26 |
| Linear Algebra & Appl. | 8 | 912 | 450 | 100 | 9 | 9 | 12 | 14 |
| manuscripta math. | 13 | 1300 | 0 | 400 | 4-5 | 5 | 7 | 9 |
| Math. Biosciences | 10 | 1920 | 1000 | 300 | 9 | | ## | |
| Math. Systems Theory | 4 | 384 | 0 | NR# | 12-14 | 9 | 13 | 14 |
| Math. of Comp. | 4 | 1320 | 0 | 0 | 12 | 10 | 11 | 12 |
| Math. Annalen | 9 | 864 | 180 | 68 | 6-7 | 6 | 7 | 8 |
| Math. Zeitschrift | 17 | 1643 | 0 | 0 | 7-8 | 8 | 9 | 10 |
| Memoirs of AMS | 6 | 2000 | 200 | 800 | 5-6 | 8 | 12 | 16 |
| Michigan Math. J. | 4 | 400 | 160 | 100 | 11 | 9 | 10 | 13 |
| Numerische Math. | 8 | 928 | 0 | 0 | 8 | 10 | 14 | 25 |
| Operations Research | 6 | 1200 | NR# | 500 | 12-15 | 9 | 9 | 11 |
| Pacific J. of Math. | 12 | 3600 | 0 | NR# | 11 | 9 | 11 | 16 |
| Proceedings of AMS | 12 | 4160 | 200 | 1100 | 10 | 14 | 15 | 15 |
| Quarterly of Appl. Math. | 4 | 420 | 475 | 500 | 12-15 | 17 | 19 | 20 |
| Semigroup-Forum | 8 | 768 | 0 | 0 | 4-6 | 5 | 6 | 6 |
| SIAM J. Appl. Math. | 8 | 1550 | 0 | 0 | 11-13 | 14 | 15 | 18 |
| SIAM J. Computing | 4 | 800 | 0 | 0 | 8-10 | 12 | 13 | 14 |
| SIAM J. on Control | 6 | 1150 | 0 | 0 | 8-9 | 11 | 13 | 15 |
| SIAM J. on Math. Anal. | 6 | 950 | 0 | 0 | 11-13 | 9 | 10 | 12 |
| SIAM J. on Numer. Anal. | 6 | 1150 | 0 | 0 | 8-10 | 10 | 13 | 16 |
| SIAM Review | 4 | 650 | 0 | 0 | 11-13 | 10 | 11 | 12 |
| Transactions of AMS | 12 | 4000 | 1000 | 400 | 16 | 12 | 14 | 17 |
| Z. Wahrscheinlichkeitstheorie | 12 | 1050 | NR# | NR# | 10-11 | 6 | 7 | 12 |

*This journal is new to the compilation. Figures regarding backlog 5/31/75 are not available.
**Not computable for this journal.
***No new issue received since last survey.
#NR means that no response was received to a request for information.
##Date of receipt of manuscript not indicated in this journal.

# SUMMER GRADUATE COURSES

The following is a list of graduate courses being offered in the mathematical sciences during the summer of 1976. Another list will appear in the April issue of these *Notices*.

## ILLINOIS

UNIVERSITY OF ILLINOIS, URBANA-CHAMPAIGN
Urbana, Illinois 61801
Application deadline: June 7
Information: Graduate Supervisor, Department of Mathematics

June 9 - July 31
UNDERGRADUATE AND GRADUATE

Advanced Aspects of Euclidean Geometry
Linear Transformations and Matrices
Introduction to Abstract Algebra
Applied Modern Algebra
Advanced Calculus
Differential Equations and Orthogonal Functions
Complex Variables and Applications
Real Variables
Elementary Theory of Numbers
Introduction to Probability Theory
Mathematical Statistics and Probability, I and II
Linear Programming
Mathematical Methods in Engineering and Science
Switching Theory

GRADUATE ONLY

Partial Differential Equations
Mathematical Methods of Physics, I
Reading Course

## INDIANA

BALL STATE UNIVERSITY
Muncie, Indiana 47306
Application deadline: Open
Information: Duane E. Deal, Chairman, Department of Mathematical Sciences

June 7 - July 9
Methods of Mathematical Analysis
Abstract Algebra
Theory of Numbers 1
Topics in Statistics 1
Higher Geometry
Geometry for Teachers
History of Mathematics 1
Numerical Analysis 1
Elements of Analysis
Advanced Calculus 1
Scientific Computer Programming
Machine Language and Systems Programming 1
Computer Graphics
Systems Analysis

July 12 - August 12
Linear Algebra
Theory of Numbers 2
Topics in Statistics 2
Foundations of Geometry
History of Mathematics 2
Numerical Analysis 2
Elements of Analysis
Scientific Computer Programming
Machine Language and Systems Programming 2
Seminar in Computer Science

## MASSACHUSETTS

HARVARD UNIVERSITY
677 Huntington Avenue, Boston, Massachusetts 02115
Application deadline: Open
Information: Jane Worcester, Department of Biostatistics, School of Public Health

July 12 - August 20
Course offerings include elementary and intermediate biostatistics, demography, sampling methods, actuarial statistics, analysis of categorical data, health facility statistics, research design, program evaluation, and design of experiments.

## MISSOURI

UNIVERSITY OF MISSOURI–COLUMBIA
Columbia, Missouri 65201
Application deadline: May 1
Information: J. L. Zemmer, Department of Mathematics

June 7 - July 30
Matrix Theory
Analytic Projective Geometry
An Introduction to Boolean Algebras

July 6 - July 30
Theory of Numbers

## NEBRASKA

UNIVERSITY OF NEBRASKA
Lincoln, Nebraska 68588
Application deadline: May 15
Information: Thomas S. Shores, Vice Chairman, Department of Mathematics

June 7 - July 9
Probability
Special Functions
General Topology

July 12 - August 13
Topics in Applied Mathematics

## VIRGINIA

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
Blacksburg, Virginia 24061
Application deadline: Six weeks before Session
Information: Kenneth B. Hannsgen, Department of Mathematics

June 21 - July 23
Matrix Theory I
Topics in Applied Mathematics (System Stability and Control Theory I)

July 28 - August 31
Matrix Theory II
Topics in Applied Mathematics (System Stability and Control Theory II)

## ENGLAND

NEWCASTLE UNIVERSITY
Newcastle upon Tyne NE1 7RU, England
Application deadline: March 31
Information: Mr. R. M. White, School of Mathematics

July 11 - 31
Theory of a Single Hilbert Space Operator
Several Complex Variables and Commutative Banach Algebra Theory
C*-Algebras
von Neumann Algebras
Group Representations

# ASSISTANTSHIPS AND FELLOWSHIPS IN MATHEMATICS IN 1976–1977

## Supplementary List

## FOR GRADUATE STUDY AT UNIVERSITIES

| TYPE of financial assistance (with number anticipated 1976-1977) | STIPEND amount in dollars | STIPEND 9 or 12 months | TUITION if not included in stipend (dollars) | SERVICE REQUIRED hours per week | SERVICE REQUIRED type of service | DEGREES AWARDED Academic year 1974-1975 |
|---|---|---|---|---|---|---|
| **CALIFORNIA** | | | | | | |
| **University of California, Berkeley 94720** | | | | | | |
| DEPARTMENT OF BIOSTATISTICS<br>E. L. Scott and C. L. Chiang, Cochair Persons | | | | | | Bachelor's by inst. 5673<br>Master's by dept. 3 |
| Fellowship (12) | | | 697.50 | | | Ph.D. (1973-1975 incl.) |
| Teaching Assistantship (3) | 1550 | 3 | | 20 | Teaching | P&S 7. Total: 7 |
| DEPARTMENT OF INDUSTRIAL ENGINEERING AND OPERATIONS RESEARCH<br>Ronald W. Shephard, Chairman | | | Applications due: * | | | Bachelor's by inst. 5673<br>Bachelor's by dept. 14<br>Master's by dept. 26 |
| Fellowship (5) | ** | 9 | 500/qtr. | | | |
| Teaching Assistantship (21) | 5040 | 9 | | 10 | Teaching | Ph.D. (1973-1975 incl.) |
| Research Assistantship (17) | 3735 | 9 | | 20 | Research, teaching | Other 27. Total: 27 |
| Tuition Fee Waiver (28) | 500 | 3 | | | | |
| Readership (24) | 1350 | 9 | | 6 | Grade papers | |

*Fellowships: 12/1/75; Assistantships: Early before each quarter.
**$700 for residents; $2200 for nonresidents.

**CONNECTICUT**

**Yale University, New Haven 06520**

| | | | | | | |
|---|---|---|---|---|---|---|
| DEPARTMENT OF ENGINEERING AND APPLIED SCIENCE<br>Charles A. Walker, Chairman | | | Applications due: 1/20/76 | | | Bachelor's by inst. 1135<br>Bachelor's by dept. 28<br>Master's by dept. 12* |
| Fellowship (15) | 1500-2500** | 9 | | 12 | | |
| Teaching Fellowship (15) | 340- 680*** | 4.5 mo. | | 5 | | Ph.D. (1973-1975 incl.) |
| Research Assistantship (32) | 1500-3600# | 9 | | | | Other 45. Total: 45 |
| Scholarship (3) | 3400** | | | | | |
| NSF (3) | | | | | | |
| NIH (1) | | | | | | |
| Kent (1) | | | | | | |

*Not a terminal master degree. Student continuing study for advanced degree.
**Stipends are plus tuition: $1500 tuition for academic year after three years, $750 per term.
***Appointments are in addition to a University Fellowship or Research Assistantship.
#Plus tuition and family support.

**ILLINOIS**

**Northwestern University, Evanston 60201**

| | | | | | | |
|---|---|---|---|---|---|---|
| DEPARTMENT OF COMPUTER SCIENCES<br>S. S. Yau, Chairman | | | Applications due: 2/1/76 | | | Bachelor's by inst. 861<br>Bachelor's by dept. 6<br>Master's by dept. 24 |
| Fellowship (5) | 280-400/mo. | 9 | | | | Ph.D. (1973-1975 incl.) |
| Teaching Assistantship (9) | 400/mo. | 9 | | 15 | Teaching | CS&NA 16. Total: 16 |
| Research Assistantship (20) | 300-400/mo. | 12 | | 20 | Research | |
| Scholarship (7) | | 9 | | | Full-time study | |
| NIH Traineeship (2) | 325/mo. | 12 | | | Full-time study | |

Note: See December 1975 *Notices* for a definition of all abbreviations.

| TYPE of financial assistance (with number anticipated 1976-1977) | STIPEND amount in dollars | 9 or 12 months | TUITION if not included in stipend (dollars) | SERVICE REQUIRED hours per week | type of service | DEGREES AWARDED Academic year 1974-1975 |
|---|---|---|---|---|---|---|

## MICHIGAN

**Michigan State University, East Lansing 48823**

| | | | | | | |
|---|---|---|---|---|---|---|
| DEPARTMENT OF STATISTICS AND PROBABILITY<br>V. Mandrekar, Chairman | | | | Applications due: 3/1/76 | | Bachelor's by inst. 6984<br>Bachelor's by dept. 12<br>Master's by dept. 8 |
| Teaching Assistantship (5) | 3960 | 9 | * | 15 | | Ph. D. (1973-1975 incl.)<br>P&S 9. Total: 9 |

*Resident: $22; out-of-state resident $43. Fees may be increased Winter and Spring terms by $1.00 per credit contingent upon a further reduction of state appropriations.

## NEW JERSEY

**Fairleigh Dickinson University, Teaneck 07666**

| | | | | | | |
|---|---|---|---|---|---|---|
| DEPARTMENT OF MATHEMATICS AND COMPUTER SCIENCE<br>Gilbert Steiner, Chairman | | | | Applications due: 3/1/76 | | Bachelor's by inst. 1242<br>Bachelor's by dept. 14<br>Master's by dept. 25 |
| Fellowship (9) | 3000-4000 | 12 | | 6[c] | | |

## NEW MEXICO

**University of New Mexico, Albuquerque 87131**

| | | | | | | |
|---|---|---|---|---|---|---|
| DEPARTMENT OF COMPUTING AND INFORMATION SCIENCE<br>Donald R. Morrison, Director | | | | | | Bachelor's by inst. 2156<br>Master's by dept. 6 |
| Teaching Assistantship (3) | 3000-3200 | 9 | | 20 | | |
| Cancer Research Center<br>Assistantship (1) | | 12 | | 20 | | |

## NEW YORK

**State University of New York at Buffalo, Amherst 14226**

| | | | | | | |
|---|---|---|---|---|---|---|
| DEPARTMENT OF STATISTICS<br>Norman C. Severo, Chairman | | | | Applications due: 2/15/76 | | Bachelor's by inst. 3200<br>Bachelor's by dept. 20<br>Master's by dept. 2 |
| Teaching Assistantship (3) | 2900-3500 | 9 | | 10-15 | Recitation, grading | Ph. D. (1973-1975 incl.)<br>P&S 10. Total: 10 |

## OHIO

**John Carroll University, Cleveland 44118**

| | | | | | | |
|---|---|---|---|---|---|---|
| DEPARTMENT OF MATHEMATICS<br>Leo J. Schneider, Chairman | | | | Applications due: 3/1/76 | | Bachelor's by inst. 450<br>Bachelor's by dept. 22<br>Master's by dept. 8 |
| Teaching Assistantship (7) | 2600 | 9 | | 20 | | |

## PENNSYLVANIA

**Temple University, Philadelphia 19122**

| | | | | | | |
|---|---|---|---|---|---|---|
| DEPARTMENT OF APPLIED STATISTICS<br>B. R. Siskin, Chairman | | | | Applications due: 3/1/76 | | Master's by dept. 5 |
| Fellowship (2) | 2700 | 9 | | | | |
| Teaching Fellowship (1) | 3000 | 9 | | 20 | Teaching, research | |
| Teaching Assistantship (3) | 3000 | 9 | | | | |
| Research Assistantship (1) | 3000 | | | | | |

**University of Pennsylvania, Philadelphia 19174**

| | | | | | | |
|---|---|---|---|---|---|---|
| DEPARTMENT OF COMPUTER AND INFORMATION SCIENCE<br>Aravind K. Joshi, Chairman | | | | Applications due: 2/1/76 | | Bachelor's by inst. 2185<br>Bachelor's by dept. 18<br>Master's by dept. 10 |
| Teaching Fellowship (4) | 3150 | 9 | | 15[c] | Teaching | |
| Research Fellowship (2) | 4200-5200 | 12 | | 15 | Research | Ph. D. (1973-1975 incl.)<br>CS&NA 12. Total: 12 |

## TEXAS

**Rice University, Houston 77001**

| | | | | | | |
|---|---|---|---|---|---|---|
| DEPARTMENT OF MATHEMATICS<br>Salomon Bochner, Chairman | | | | Applications due: 3/15/76 | | Bachelor's by inst. 410<br>Bachelor's by dept. 13<br>Master's by dept. 3 |
| Fellowship (22) | 2750-3750 | 9 | | 6 | Teaching, research | Ph. D. (1973-1975 incl.)<br>A&NT 2; G&T 4; A&FA 6.<br>Total: 12 |
| Scholarship (5) | | | | | | |

| TYPE of financial assistance (with number anticipated 1976-1977) | STIPEND amount in dollars | 9 or 12 months | TUITION if not included in stipend (dollars) | SERVICE REQUIRED hours per week | type of service | DEGREES AWARDED Academic year 1974-1975 |
|---|---|---|---|---|---|---|

**Texas Tech University, Lubbock 79409**

DEPARTMENT OF MATHEMATICS — Applications due: 4/1/76*
Dalton Tarwater, Chairman

| | | | | | |
|---|---|---|---|---|---|
| Teaching Assistantship (40) | 3200-4200 | 9 | 109/sem. | 6 | Teaching |
| Part-time Instructor (15)** | 3600-5000 | 9 | 109/sem. | 6 | Teaching |

*Desired, no formal deadline.
**With Master's

Bachelor's by inst. 3719
Bachelor's by dept. 39
Master's by dept. 11
Ph.D. (1973-1975 incl.)
A&NT 4; A&FA 4; P&S 11; CS&NA 3; AM 1. Total: 23

**University of Houston, Houston 77004**

DEPARTMENT OF COMPUTER SCIENCE — Applications due: 3/15/76
O. G. Johnson, Chairman

| | | | | | |
|---|---|---|---|---|---|
| Teaching Assistantship (13) | 3051 | 9 | | 20 | Teaching |
| Research Assistantship (4) | 4800 | 12 | | 20 | Research |

Bachelor's by inst. 7000
Bachelor's by dept. 100
Master's by dept. 10

## CANADA

**University of British Columbia, Vancouver, British Columbia**

DEPARTMENT OF COMPUTER SCIENCE — Applications due: 4/1/76
John E. L. Peck, Head

| | | | | | |
|---|---|---|---|---|---|
| Fellowship (14) | 2000-5000 | 12 | About 500 | 0 | |
| Teaching Assistantship (13) | 3680 | 8 | About 500 | 12 | Teaching |
| Research Assistantship (6) | 4500 | 12 | About 500 | Varies | Research |

Bachelor's by inst. 2500
Bachelor's by dept. 35
Master's by dept. 6

**University of Saskatchewan, Saskatoon, Saskatchewan**

DEPARTMENT OF MATHEMATICS — Applications due: 3/15/76
G. H. M. Thomas, Head

| | | | | | |
|---|---|---|---|---|---|
| Teaching Assistantship (10) | 3500 | 12 | 450 | 3 | |

Bachelor's by inst. 2035
Bachelor's by dept. 83
Master's by dept. 2
Ph.D. (1973-1975 incl.)
A&NT 1; G&T 1; A&FA 2, CS 1. Total: 5

# SPECIAL MEETINGS INFORMATION CENTER

The purpose of this center is to maintain a file on prospective symposia, colloquia, institutes, seminars, special years, and meetings of other associations, and to alert the organizers if conflicts in subject matter, dates, or geographical area become apparent. An announcement will be published in these *Notices* if it contains a call for papers, place, date, subject (when applicable), and speakers; a second full announcement will be published only if there are changes or necessary additional information. Once an announcement has appeared, the event will be briefly noted in each issue until it has been held and a reference will be given in parentheses to the volume and page of the issue in which the complete information appeared.

In general, SMIC announcements of meetings held in the United States and Canada carry only date, title of meeting, place of meeting, speakers (or sometimes general statement on the program), deadline dates for abstracts or contributed papers, and name of person to write for further information. Meetings held outside the North American area may carry slightly more detailed information. Information on the pre-preliminary planning will be stored in the files, and will be available to anyone desiring information on prospective conferences. All communications on special meetings should be sent to the Special Meetings Information Center of the American Mathematical Society. Deadlines for particular issues of the *Notices* are the same as the deadlines for abstracts which appear on the inside front cover of each issue.

January 1–December 16, 1976
MATHEMATISCHES FORSCHUNGS INSTITUT OBERWOLFACH, Federal Republic of Germany (Weekly Conferences)(22, p. 295)

1976–1977
ARNE BEURLING YEAR, Institut Mittag-Leffler, Djursholm, Sweden (23, p. 82)

March 4–6, 1976
CONFERENCE ON PROGRAMMING SYSTEMS IN THE SMALL PROCESSOR ENVIRONMENT, New Orleans, Louisiana (22, p. 296)

March 8–12, 1976
NSF REGIONAL CONFERENCE ON SYMPLECTIC MANIFOLDS, University of North Carolina, Chapel Hill, North Carolina (22, p. 368)

March 11–13, 1976
RING THEORY CONFERENCE, University of Oklahoma, Norman, Oklahoma (23, p. 83)

March 12–13, 1976
ALGEBRAIC AND TOPOLOGICAL PROPERTIES OF SINGULARITIES, The University of Western Ontario, London, Ontario, Canada (23, p. 83)

EUROMECH KOLLOQUIA 1976
EUROMECH 70 - March 16–19, 1976
Title: Liquid-metal magnetohydrodynamics with strong magnetic fields.
Location: Grenoble, France.
Chairmen: R. Moreau, Institut de Mécanique, B.P. 53, Centre de Tri, 38041 Grenoble-Cedex, France; and J.C.R. Hunt, Cambridge, England.

EUROMECH 71 - March 29–April 1, 1976
Title: The bulk properties of composite materials.
Location: Bath, England.
Chairmen: N. Laws, Department of Mathematics, Cranfield, Bedford MK43 0AL, England; and J. R. Willis, Bath, England.

EUROMECH 72 - March 30–April 1, 1976
Title: Boundary layers and turbulence in internal flows.
Location: Salford, England.
Chairmen: J. L. Livesey, University of Salford, Salford M5 4WT, England; and J. H. Horlock, Salford, England.

EUROMECH 74 - April 12–14, 1976
Title: Lifting wings and bodies at supersonic and hypersonic speeds.
Location: Cambridge, England.
Chairmen: J. L. Stollery, Cranfield Institute of Technology, Cranfield, Bedford MK43 0AL, England; and L.C. Squire, Cambridge, England.

EUROMECH 73 - April 13–15, 1976
Title: Oscillatory flows in ducts.
Location: Aix-en-Provence, France.
Chairman: E. Brocher, Institute de Mécanique des Fluides 1, Rue Honnorat, 13003 Marseille, France.

EUROMECH 75 - May 10–13, 1976
Title: The calculation of flow fields by means of panel-methods.
Location: Braunschweig, Germany.
Chairmen: H. Körner, DFVLR-Institut für Aerodynamik, D-33 Braunschweig/Flughafen, Germany; and E. H. Hirschel, Porz-Wahn, Germany.

EUROMECH 84 - July 13–17, 1976
Title: Mechanics of granular materials.
Location: Jabłonna, Poland.
Chairman: Z. Mróz, Institute of Fundamental Technological Research, Polish Academy of Sciences, ul. Swietokrzyska 21, 00-049 Warsaw, Poland.

EUROMECH 76 - August 16–19, 1976
Title: Creep rupture in structures.
Location: Gothenburg, Sweden.
Chairman: J. Hult, Division of Solid Mechanics, Chalmers University of Technology, S-40220 Gothenburg, Sweden.

EUROMECH 77 - September 6–8, 1976
Title: Three-dimensional problems in fracture mechanics.
Location: Paris, France.
Chairmen: R. Labbens, Directeur Scientifique, Creusot-Loire, 15 rue Pasquier, 75383 Paris-Cedex 08, France; and D. Radenkovic, Paris, France.

EUROMECH 80 - September 6–9, 1976
Title: Separation phenomena in gasmixture flows.
Location: Freiburg, Germany.
Chairman: K. Roesner, Institut für Angewandte Mathematik, Universität Freiburg, 78 Freiburg, Hebelstrasse 40, Germany.

EUROMECH 78 - September 7–9, 1976
Title: Dynamics of the planetary boundary layer and ocean thermoclinic.
Location: Paris, France.
Chairmen: A. Berrior, Laboratoire de Meteorologie Dynamique, E.N., 24, rue Lhomond, 75 231 Paris-Cedex 05, France; and P. Morel, Paris, France.

EUROMECH 79 - September 7–10, 1976
Title: Solutions to basic problems in nonlinear continua.
Location: Darmstadt, Germany.
Chairmen: E. Bürger, Institut für Mechanik, Technische Hochschule, D-61 Darmstadt, Hochschulstrasse 1, Germany; and W. A. Green, Nottingham, England.

EUROMECH 81 - September 13–17, 1976
Title: Impact loading on bodies.
Location: Liblice Castle, Czechoslovakia.

Chairman: Ladislav Pust, Institute of Thermomechanics, Czechoslovak Academy of Sciences, Praha 6, Puskinovo nam. 9, Czechoslovakia.

EUROMECH 82 - October 18–21, 1976
Title: Uncontrolled blast and explosions in industry and mining.
Location: Jabłonna, Poland.
Chairman: S. Wojcicki, Technical University, 00-665 Warsaw, ul. Nowowiejska 25, Poland.

EUROMECH 83 - November 1–3, 1976
Title: Dynamic response of plastic structures and continua.
Location: Matrafüred, Hungary.
Chairman: S. Kaliszky, Technical University Budapest, Műegyetem rkp. 3. K. mf. 35, Budapest XI, Hungary.

March 18–20, 1976
TOPOLOGY CONFERENCE, Auburn University, Auburn, Alabama (23, p. 83)

March 26–27, 1976
CONFERENCE ON INNOVATIVE TEACHING METHODS IN INTRODUCTORY COLLEGE MATHEMATICS, Tucson, Arizona (23, p. 83)

March 28–31, 1976
SEVENTH NATIONAL MATHEMATICS CONFERENCE OF IRAN, Azarabadgan University, Tabriz, Iran (22, p. 296)

March 29–31, 1976
THE SECOND NATIONAL SYMPOSIUM ON COMPUTERIZED STRUCTURAL ANALYSIS AND DESIGN, George Washington University, Washington, D.C. (22, p. 296)

March 30–April 2, 1976
CONFERENCE ON THE THEORY OF ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS, University of Dundee, Dundee, Scotland (22, p. 249)

March 31–April 2, 1976
CONFERENCE ON INFORMATION SCIENCES AND SYSTEMS, The Johns Hopkins University, Baltimore, Maryland (22, p. 296)

Spring, 1976
SECOND CANADIAN SYMPOSIUM ON FLUID DYNAMICS, University of British Columbia, Vancouver, British Columbia, Canada (22, p. 249)

April 1–2, 1976
THIRD ICASE CONFERENCE ON SCIENTIFIC COMPUTING: COMPUTER SCIENCE AND SCIENTIFIC COMPUTING, Williamsburg, Virginia (22, p. 297)

April 3, 1976
FIFTEENTH ALGEBRA DAY (Trends in Algebra)
Carleton University, Ottawa, Ontario, Canada
Invited Speakers: Jonathan L. Alperin (Chicago), Serge Lang (Yale), and Robert V. Moody (Saskatchewan).
Information: L. Ribes, Department of Mathematics, Carleton University, Ottawa K1S 5B6, Canada.

April 5–9, 1976
ANNUAL SCIENTIFIC CONFERENCE OF THE GESELLSCHAFT FÜR ANGEWANDTE MATHEMATIK UND MECHANIK
Graz, Austria
Program: Expository lectures will be given by J. J. Kalker (Delft), O. Krafft (Hamburg), F. Lempio (Würzburg), E. Meister (Darmstadt), I. Müller (Düsseldorf), H. Neunzert (Kaiserslautern), E. Pestel (Hannover) and O. C. Zienkiewicz (Swansea/Wales). There will also be short reports followed by discussion on the following subjects: Mechanics of rigid bodies, Vibration and stability problems, Mechanics of elastic and plastic bodies, Fluid mechanics, Applied analysis and mathematical physics, Numerical analysis, Computer science, and Optimization, Stochastic processes and mathematical methods in economics.
Papers: Manuscripts should be submitted directly to G. Schmidt, Zentralinstitut für Mathematik und Mechanik der Akademie der Wissenschaften der DDR, Mohrenstrasse 39, DDR 108, Berlin. Manuscripts must be submitted by May 15, 1976 in the form described by the editor in the ZAMM 53 (1973), following the table of contents. No manuscript (including figures) may exceed the limit of four typewritten pages.
Information: GAMM Conference Office, Institute für Strömungslehre und Gasdynamik, Technische Universität Graz, GAMM–Tagung 1976, Kopernikusgasse 24, A-8010 Graz, Austria.

April 6–10, 1976
THE TWENTY-EIGHTH BRITISH MATHEMATICAL COLLOQUIUM, University College of Wales, Aberystwyth, Wales (22, p. 297)

April 7–9, 1976
SYMPOSIUM ON ALGORITHMS AND COMPLEXITY: NEW DIRECTIONS AND RECENT RESULTS, Computer Science Department, Carnegie-Mellon University, Pittsburgh, Pennsylvania (23, p. 83)
Program Committee: A. Borodin (University of Toronto), R. M. Karp (University of California, Berkeley), D. E. Knuth (Stanford University), and J. F. Traub (Carnegie-Mellon University)
Program: The emphasis is on algorithms and complexity results relevant to actual computation. There will be survey papers summarizing the state of the art and research papers announcing new results. The interest is in recent results in areas which have traditionally been subject to algorithmic analysis and new areas which may now be amenable to such analysis.
Invited Papers: The invited speakers are: E. Berlekamp (University of California), R. Brent (Australian National University), W. Gosper (Stanford University), D. Johnson (Bell Laboratories), R. M. Karp ( University of California), H. T. Kung (Carnegie-Mellon University), E. D. Knuth (Stanford University) and A. Yao (Massachusetts Institute of Technology), J. Moses (Massachusetts Institute of Technology), D. J. Rose (Harvard University), M. O. Rabin (Hebrew University and Massachusetts Institute of Technology), M. Shamos (Carnegie-Mellon University), H. A. Simon and J. B. Kadane (Carnegie-Mellon University), R. Tarjan (Stanford University), J. Ullman (Princeton University), and H. Wozniakowski (University of Warsaw).
Contributed Papers: There will be fifteen-minute presentations of all appropriate papers. To contribute a paper, send title, author, affiliation, and abstract on one side of a single 8 1/2 by 11 inch sheet of paper by March 1, 1976. Titles and abstracts of contributed papers will be distributed at the symposium. A text of invited papers and titles and abstracts of contributed papers will appear in Symposium Proceedings.
Information: J. F. Traub, Department of Computer Science, Carnegie-Mellon University, Pittsburgh, Pennsylvania 15213.

April 9–10, 1976
STATISTICS DAYS
Ball State University, Muncie, Indiana
Speakers: D.A.S. Fraser, S. S. Gupta, Marcel Neuts, M. L. Puri, and Albert Shulte will be among the speakers.
Information: Mir Masoom Ali, Department of Mathematical Sciences, Ball State University, Muncie, Indiana 47306.

April 10, 1976
NINTH ILLINOIS NUMBER THEORY CONFERENCE
Illinois State University, Normal, Illinois
Program: Eighteen-minute talks on current research (including partial results) or open problems are invited.
Abstracts: Two-sentence abstracts should be sent to the address below by March 26, 1976.
Information: L. C. Eggan, Mathematics Department, Illinois State University, Normal, Illinois 61761.

April 10, 1976
NUMBER THEORY DAY
Carleton University, Ottawa, Ontario, Canada
Program: There will be three or four principal lectures and also a number of short presentations representing a broad spectrum of interests in number theory.
Speakers: Principal lecturers are P. X. Gallagher (Columbia), John Selfridge (Northern Illinois University), D. G. James (Pennsylvania State University), P. Erdös (Budapest)(tentative). Other speakers will include R.T. Bumby, S. L. Segal et al.
Information: Kenneth S. Williams and Philip A. Leonard, Department of Mathematics, Carleton University, Ottawa, Ontario K1S 5B6, Canada.

April 12–13, 1976
CONFERENCE ON RATIONAL APPROXIMATION
Yeshiva University, Belfer Graduate School of Science, New York
Information: J. Bak, Department of Mathematics, City College of New York, 138th Street and Convent Avenue, New York, New York 10031; or A. R. Reddy, School of Mathematics, Institute for Advanced Study, Princeton, New Jersey 08540.

April 12–15, 1976
SYMPOSIUM ON FUNCTION THEORETICAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS
Darmstadt, Germany
Organizers: E. Meister and W. Wendland in connection with the GAMM committee for applied analysis and mathematical physics.
Information: W. Wendland, Fachbereich Mathematik der Technischen Hochschule, D-61 Darmstadt, Schlossgartenstr. 7, Germany.

April 20–23, 1976
THIRD EUROPEAN MEETING ON CYBERNETICS AND SYSTEMS RESEARCH, University of Vienna, Vienna, Austria (22, p. 249)

April 22–23, 1976
J. J. SYLVESTER SYMPOSIUM IN ALGEBRAIC GEOMETRY
The Johns Hopkins University, Baltimore, Maryland
Program: The program is given in honor of the University's first Professor of Mathematics and the founder of The American Journal of Mathematics. Invited talks will be given by Michael Artin (Massachusetts Institute of Technology), Enrico Bombieri (University of Pisa), Bernard Dwork (Princeton University), Phillip Griffiths (Harvard University), Heisuke Hironaka (Harvard University), David Mumford (Harvard University), and Oscar Zariski (Harvard University).
Support: The National Science Foundation and The Wallace King Memorial Fund.
Information: J.-I. Igusa, Department of Mathematics, The Johns Hopkins University, Baltimore, Maryland 21218.

April 22–24, 1976
COLLOQUE STRUCTURES ECONOMIQUES ET ECONOMETRIE
Lyon, France
Subject: Econometrie, Economie Mathématique, Théorie des Jeux.

April 26–27, 1976
ACM SIGPLAN/SIGGRAPH SYMPOSIUM ON GRAPHIC LANGUAGES, Miami, Florida (23, p. 83)

April 26–30, 1976
TABLE RONDE C.N.R.S. SUR COMBINATOIRE ET REPRÉSENTATION DU GROUPE SYMÉTRIQUE
Université de Strasbourg, Strasbourg, France
Participants: G. E. Andrews, L. Comtet, H. O. Foulkes, L. Geissinger, C. Greene, G. James, A. Kerber, A. Lascoux, A. O. Morris, W. Oberschelp, G. de B. Robinson, M. P. Schützenberger, R. Stanley, G. P. Thomas, G. Viennot, and S. G. Williamson.
Information: D. Foata, Département de Mathématique, Université de Strasbourg, 7 rue René Descartes, 67084 Strasbourg, France.

April 27–30, 1976
SECOND EUROPEAN CONFERENCE ON COMPUTATIONAL PHYSICS
Max-Planck-Institut für Plasmaphysik, Garching, Germany
Organizers: The Computational Physics Group of the EPS, in collaboration with the divisions of plasma physics and physics in astronomy, is organizing its second European conference.
Areas: Computing in plasma physics and astrophysics.
Information: D. Biskamp, Max-Planck-Institut für Plasmaphysik, D-8046 Garching, Germany.

April 29–May 1, 1976
THE JOHN H. BARRETT MEMORIAL LECTURES
University of Tennessee, Knoxville, Tennessee
Program: Paul E. Waltman (University of Iowa) will be the principal lecturer. There will be a session of 30-minute contributed papers on ordinary differential equations on April 30.
Abstracts and Information: Jack Heidel, Department of Mathematics, University of Tennessee, Knoxville, Tennessee 37916.

May 3–5, 1976
EIGHTH ANNUAL ACM SYMPOSIUM ON THEORY OF COMPUTING, Hershey, Pennsylvania (22, p. 297)

May 3–5, 1976
ADVANCED SEMINAR ON CLASSIFICATION AND CLUSTERING, University of Wisconsin-Madison, Madison, Wisconsin (23, p. 84)

May 3–7, 1976
CONFERENCE ON OPTIMAL CONTROL THEORY OF SYSTEMS GOVERNED BY PARTIAL DIFFERENTIAL EQUATIONS
Naval Surface Weapons Center, Silver Spring, Maryland
Program: Invited speakers will lecture on theory and applications of the control of distributed-parameter systems. J. L. Lions will give a series of eight one-hour lectures. There will also be periods for discussion and contributed papers.
Principal Lecturer: J. L. Lions, IRIA, France.
Invited Lecturers: A. V. Balakrishnan, E. R. Barnes, H. O. Fattorini, W. H. Ray, and D. L. Russell.
Sponsor: Office of Naval Research.
Information: J. W. Wingate, Mathematical Analysis Branch, Naval Surface Weapons Center, White Oak, Silver Spring, Maryland 20910.

May 6–7, 1976
OPTIMIZATION DAYS 1976, McGill University, Montreal, Canada (23, p. 84)

May 10–14, 1976
47 ANZAAS CONGRESS, SECTION 8 (Mathematical Sciences), Hobart, Tasmania (23, p. 84)

May 11–15, 1976
INTERNATIONAL GRAPH THEORY CONFERENCE
Western Michigan University, Kalamazoo, Michigan (22, p. 368)

May 14–15, 1976
APPLIED TIME SERIES ANALYSIS SYMPOSIUM
University of Tulsa, Tulsa, Oklahoma
Program: Invited lectures on current developments in time series analysis, with emphasis on those applicable to geophysical sciences.
Speakers: Tentatively the speakers will include H. Akaike, R. H. Jones, J. H. Justice, R. T. LaCoss, S. J. Laster, A. V. Oppenheim, E. Parzen, E. Robinson, S. Treitel, and G. S. Watson.
Information: David F. Findley, Division of Mathematical Sciences, University of Tulsa, Tulsa, Oklahoma 74104.

May 19–22, 1976
COMPLEX ANALYSIS
University of Kentucky, Lexington, Kentucky
Information: John Lewis, Mathematics Department, University of Kentucky, Lexington, Kentucky 40506.

May 25–26, 1976
APPLICATIONS OF STATISTICS–INTERDISCIPLINARY INVESTIGATIONS
State University College, Brockport, New York
Program: Invited lectures on topics of current research interest, which utilize statistical methodology, in a number of different fields including management science, psychology, and biology. Discussion periods will be held after each presentation. There will be four half-day sessions beginning May 25 at 9:00 a.m.
Sponsor: The Research Foundation of the State University of New York–Conversation in the Discipline Program.
Speakers: J.C.G. Boot (SUNY at Buffalo), R. S. Lehman (Franklin and Marshall), E. Nouri (State University College, Oneonta), S. W. Lagakos (SUNY at Buffalo), J. Michalak (Syracuse University), W. Schefler (State University College, Buffalo), R. Johnson (Monroe Community College), and E. Klimka (SUNY at Binghamton).
Information: Ronald F. Barnes, Department of Mathematics, State University College, Brockport, New York 14420.

May 25–28, 1976
1976 INTERNATIONAL SYMPOSIUM ON MULTIPLE-VALUED LOGIC, Utah State University, Logan, Utah (22, p. 297)

June 7–8, 1976
SUNY CONFERENCE ON COMPLEX ANALYSIS
State University of New York, Brockport, New York
Program: Malcolm S. Robertson will be the principal lecturer for a series of lectures on univalent function theory. There will also be talks by the invited lecturers and other participants, dealing with recent advances in univalent function theory and other areas of complex analysis.
Invited Lecturers: L. Brickman, W. H. Fuchs, J. A. Jenkins, F. R. Keogh, W. E. Kirwan, R. Libera, Z. Nehari, T. H. MacGregor, T. J. Suffridge, and M. O. Reade.
Sponsor: State University of New York Conversations in the Disciplines Grant.
Support: Travel and subsistence allowance for a limited number of participants.
Participants: Persons interested in attending should include a brief vita and indications of research interests. Those wishing to present a paper are invited to do so and should submit an abstract.
Information: Sanford S. Miller, Department of Mathematics, State University of New York, Brockport, New York 14420.

June 7–9, 1976
SECOND KINGSTON CONFERENCE ON DIFFERENTIAL GAMES AND CONTROL THEORY
University of Rhode Island, Kingston, Rhode Island
Theme: Stochastic problems and applications.
Invited Speakers: Michael Athans (Massachusetts Institute of Technology), A. Bensoussan (Institut Recherche Informatique Automatique), Howard Blum (Rutgers-State University of New Jersey), R. S. Bucy (University of Southern California), John Danskin (Universität Bonn), R. J. Elliott (University of Hull), Wendell H. Fleming (Brown University), Rufus Isaacs (Johns Hopkins University), Henry J. Kelley (Analytical Mechanics Associates, Inc.), George Leitmann (University of California at Berkeley), Pan-Tai Liu (University of Rhode Island), Allen G. Lindgren (University of Rhode Island), William J. Palm (University of Rhode Island), T. Parthasarathy (University of Illinois at Chicago Circle), Emilio O. Roxin (University of Rhode Island), Ronald J. Stern (McGill University), Donald W. Tufts (University of Rhode Island), and Musa Yildiz (University of New Hampshire).
Call for Contributed Papers: Sessions for short contributed papers will also be held and persons wishing to present such papers should submit abstracts at their earliest convenience.
Information: Robert L. Sternberg, Conference Chairman, Department of Ocean Engineering, University of Rhode Island, Kingston, Rhode Island 02881; Emilio Roxin and Pan-Tai Liu, Program Committee, Department of Mathematics, University of Rhode Island, Kingston, Rhode Island 02881; or Helen M. Sternberg, Secretary, Department of Mathematics, Southeastern Branch, University of Connecticut, Groton, Connecticut 06340.

June 7–11, 1976
THIRTEENTH YUGOSLAV CONGRESS OF RATIONAL MECHANICS, Sarajevo, Yugoslavia (22, p. 197)

June 7–11, 1976
SIXTH CONFERENCE ON STOCHASTIC PROCESSES AND THEIR APPLICATIONS, Israel (23, p. 84)

June 9–11, 1976
MATHEMATICAL LANGUAGE AND MATHEMATICAL THOUGHT
Centre Universitaire, Luxembourg
Organizers: Seminar for philosophy and mathematics (M. Loi), Ecole Normale Supérieure, Paris.
Guest Speakers: Dieudonné (Paris), Gauthier (Montréal), Hirsch (Brussels), Kleene (Madison), Kuratowski (Warsaw), Lévy-Leblond (Strasbourg), Marzin-Löf (Stockholm), Gert Müller (Heidelberg), Papy (Brussels), and Thom (Paris).
Information: Jean-Paul Pier, Séminaire de Mathématique, Centre Universitaire, 162 A, Avenue de la Faïencerie, Luxembourg.

June 14–16, 1976
SEVENTH ANNUAL CONFERENCE ON COMPUTERS IN THE UNDERGRADUATE CURRICULA, Computer Center, State University of New York, Binghamton, New York (23, p. 84)

June 14–16, 1976
IEEE COMPUTER SOCIETY CURRICULA WORKSHOP
Illinois State University, Bloomington-Normal, Illinois
Program: The objective of this workshop on Model Curricula Implementation techniques is to conduct working sessions on ways in which the new Model Curricula materials can be implemented. College teachers of computer science and computer engineering attending will learn special techniques for implementing CS and CE curricula in undergraduate colleges; use of laboratory and projects manuals in undergraduate CS and CE programs; demonstration of logic and microcomputer lab materials or equipment; and analyses of curricula materials. The main topics will be: Digital Logic, Computer Organization, Operating Systems and Software Engineering Methodology, Theory of Computing, and Curricula Overviews.
Sponsor: IEEE Computer Society
Information: For workshop information relating to programs, registration, topics, short participant presentations, materials, and deadlines, contact David Rice, Workshop Chairman, Regional HELP Subcommittee, Computer Science, West Virginia University, Morgantown, West Virginia 26506.

June 14–18, 1976
SYMPOSIUM ON APPLICATIONS OF STATISTICS, Dayton, Ohio (23, p. 84)

June 14–18, 1976
SYMPOSIUM ON THE USE OF OPTIMIZATION IN STATISTICS
The Johns Hopkins University, Baltimore, Maryland
Program: Richard Tapia and James Thompson, Rice University, will give a series of lectures on "Applications of optimization theory to the estimation of densities". Contributed paper sessions are also planned.
Sponsors: The Johns Hopkins University Press and the Department of Mathematical Sciences.
Information: David A. Pyne, Department of Mathematical Sciences, The Johns Hopkins University, Baltimore, Maryland 21218.

June 14–July 9, 1976
CONFERENCE/SUMMER SCHOOL ON APPLICATIONS OF DIFFERENTIAL AND ALGEBRAIC GEOMETRY TO SYSTEMS THEORY
Moffett Field (near Stanford), California
Program: Daily pedagogical lectures and research seminars with broad emphasis on the mathematics of nonlinear systems theory.
Speakers: R. Brockett (Harvard), R. Hermann (Rutgers), A. Krener (University of California at Davis), C. Martin (Harvard), and H. Sussman (Rutgers).
Information: C. Martin, Pierce Hall, Harvard University, Cambridge, Massachusetts 02138.

June 16–20, 1976
IFAC SYMPOSIUM ON LARGE SCALE SYSTEMS, THEORY AND APPLICATIONS, Udine, Italy (22, p. 161)

June 28–July 2, 1976
COLING 76: INTERNATIONAL CONFERENCE ON COMPUTATIONAL LINGUISTICS, University of Ottawa, Ottawa, Ontario, Canada (22, p. 161)

June 28–July 3, 1976
FIFTH HUNGARIAN COLLOQUIUM ON COMBINATORICS, Szombathely, Hungary (22, p. 297)

June 29–July 1, 1976
THIRD SYMPOSIUM ON MACHINE PROCESSING OF REMOTELY SENSED DATA, Purdue University, West Lafayette, Indiana (23, p. 84)

July 2–12, 1976
LMS DURHAM SYMPOSIUM ON POTENTIAL THEORY AND CONFORMAL MAPPING, Durham University, England (22, p. 368)

July 11–17, 1976
THIRD LATIN AMERICAN SYMPOSIUM ON MATHEMATICAL LOGIC
University of Campinas, Brazil
Program: There will be three sessions on: model theory, nonclassical logics and applied logic (in the fields of computing sciences, linguistics, and philosophy).
Abstracts: Authors are invited to submit papers of five to thirty pages in length (typewritten double-spaced) with abstracts of no more than 300 words.
Deadline for Papers: May 30, 1976.
Information: Ayda I. Arruda, Instituto de Matemática, Universidade Estadual de Campinas, C.P. 1170, 13100 Campinas, Brazil.

July 12–23, 1976
LMS DURHAM SYMPOSIUM ON PARTIAL DIFFERENTIAL EQUATIONS, Durham University, England (22, p. 368)

July 14–24, 1976
ST. ANDREWS COLLOQUIUM, University of St. Andrews, Scotland (22, p. 297)

July 18–31, 1976
1976 EUROPEAN SUMMER MEETING OF THE ASL
University of Oxford, England
Information: Dana Scott or R. O. Gandy, Mathematical Institute, 24-29 St. Giles, Oxford, England.

July 19–23, 1976
NONLINEAR SYSTEMS AND APPLICATIONS TO LIFE SCIENCES, The University of Texas at Arlington, Texas (23, p. 84)

July 19–30, 1976
NATO ADVANCED STUDY INSTITUTE ON COMPUTER-BASED SCIENCE INSTRUCTION, Université Catholique de Louvain, Louvain-la-Neuve, Belgium (23, p. 85)

July 25–31, 1976
CONFERENCE ON HARMONIC ANALYSIS OF FUNCTIONS, MEASURES AND CONVOLUTION OPERATORS ON GROUPS, Jabłonna, Poland (23, p. 85)

July 26–August 20, 1976
M.A.A. WORKSHOP ON MODULES IN APPLIED MATHEMATICS, Cornell University, Ithaca, New York (22, p. 297)

August 4–11, 1976
TRANSFORMATION GROUPS
University of Newcastle upon Tyne, England
Information: Czes Kosniowski, School of Mathematics, University of Newcastle upon Tyne, Newcastle upon Tyne, NE1 7RU England. Please state if you would like to give a talk.

August 9–12, 1976
FIRST CONFERENCE ON THE EUROPEAN CO-OPERATION IN INFORMATICS
Ansterdam, The Netherlands
Subject Areas: Computer architecture and computer systems structure, concepts and techniques of data base management, program development and verification in practice and theory.
Information: M. Paul, Institut für Informatik der Technischen Universität München, D-8 München 2, Postfach 202420, Germany.

August 10–12, 1976
1976 ACM SYMPOSIUM ON SYMBOLIC AND ALGEBRAIC COMPUTATION, IBM Thomas J. Watson Research Center, Yorktown Heights, New York (23, p. 85)

August 11–13, 1976
SECOND CAPE TOWN SYMPOSIUM ON CATEGORICAL TOPOLOGY, University of Cape Town, Cape Town, Republic of South Africa (22, p. 368)

August 16–20, 1976
CONFERENCE ON NUMERICAL ANALYSIS, Trinity College, Dublin, Ireland (23, p. 85)

August 16–21, 1976
THIRD INTERNATIONAL CONGRESS ON MATHEMATICAL EDUCATION (ICME), Karlsruhe, Federal Republic of Germany (22, p. 197)

August 23–28, 1976
EIGHTH AICA INTERNATIONAL CONGRESS ON SIMULATION OF SYSTEMS, Delft, The Netherlands (22, p. 297)

August 24–27, 1976
FIFTH AUSTRALIAN CONFERENCE ON COMBINATORIAL MATHEMATICS, Royal Melbourne Institute of Technology, Melbourne, Victoria, Australia (22, p. 369)

August 30–September 4, 1976
FOURTEENTH INTERNATIONAL CONGRESS OF THEORETICAL AND APPLIED MECHANICS
Delft University of Technology, Delft, The Netherlands (21, p. 279)
Program: The Congress will encompass the entire field of science of analytical, solid and fluid mechanics, including applications.
Deadline for Papers: Participants are asked to submit five copies of an extended summary (about 500 words) and one copy of an abstract to IUTAM 1976 c/o Klvl, 23 Prinsessegracht, The Hague, The Netherlands by March 1, 1976, and simultaneously two copies of the summary and one copy of the abstract to S. H. Crandall, Department of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139. The U. S. National Committee on Theoretical and Applied Mechanics will evaluate all U. S. contributed papers as a guide for the final selection by the International Papers Committee.
Information: R. Y. Dow, Staff Officer, USNC/TAM, National Research Council, 2101 Constitution Avenue, N.W., Washington, D. C. 20418.

September 5–10, 1976
CONFERENCE ON FINITE GROUPS AND GEOMETRIES
Vrije Universiteit Brussel, Brussels, Belgium
Program: Invited lectures on topics of current research on the relations between finite (simple) groups, finite

geometries and combinatorics.
Participation: Participation is limited to about 60 attenders. Some limited financial support will be available.
Information: J. Van Buggenhaut, C.S.O.O. Vrije Universiteit Brussel, Pleinlaan, 2 B-1040 Brussels, Belgium.

September 6–11, 1976
EUROPEAN MEETING OF STATISTICIANS, Université Scientifique et Médicale de Grenoble, France (23, p. 85)

September 6–11, 1976
EIGHTH INTERNATIONAL CONGRESS ON CYBERNETICS Namur, Belgium (22, p. 298)
Program: Lectures (followed by discussion) will be given on Principles of Cybernetics and General Theory of Systems, and Cybernetics in Social Systems, Mechanical Systems, and Biology and Medicine. The opening conference will be given by Helmar Frank (Berlin Institute of Cybernetics). There will be two symposia respectively devoted to Pedagogy and Cybernetics and to The diverse aspects of the concept of information. The official languages of the Congress will be French and English. The proceedings of the Congress will be published at the end of 1977.
Sponsor: International Association for Cybernetics.
Information: Secretariat of the International Association for Cybernetics, Palais des Expositions, Place André Rijckmans, B-5000 Namur, Belgium.

September 6–17, 1976
NATO ADVANCED STUDY INSTITUTE ON BOUNDARY-VALUE PROBLEMS FOR EVOLUTION PARTIAL DIFFERENTIAL EQUATIONS, University of Liège, Sart Tilman Campus, Belgium (22, p. 369)

September 20–24, 1976
THE SECOND COMPSTAT SYMPOSIUM ON COMPUTATIONAL STATISTICS, Berlin, Germany (22, p. 298)

October 20–22, 1976
ACM 1976 ANNUAL CONFERENCE, Regency Hyatt House, Houston, Texas (23, p. 85)

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August 7–13, 1977
EIGHTH INTERNATIONAL CONFERENCE ON GENERAL RELATIVITY AND GRAVITATION, University of Waterloo, Waterloo, Ontario, Canada (23, p. 85)

August 16–27, 1977
INTERNATIONAL CONFERENCE ON COMBINATORIAL THEORY, Australian National University, Canberra, Australia (23, p. 85)

# VISITING MATHEMATICIANS

## Supplementary List

The list of visiting mathematicians includes both foreign mathematicians visiting in the United States and Canada, and Americans visiting abroad.

## Visiting Foreign Mathematicians

| | | | |
|---|---|---|---|
| Bibikov, Yuri (USSR) | Brown University | Group Theory and Lie Algebras | 1/76 - 6/76 |
| Ghoshal, Sudhanshu (India) | Harvard University | Management Science | 1/76 - Indefinite |
| Hookings, Gordon A. (New Zealand) | University of California, Berkeley | Atmospheric Convection | 1/76 - 12/76 |
| Lapisto, Timo Valter (Finland) | University of California, Los Angeles | Number Theory and Formal Languages | 9/75 - 6/76 |
| O'Brian, Nigel Robert (United Kingdom) | Massachusetts Institute of Technology | Complex Analysis and Algebraic Geometry | 6/75 - 5/76 |
| O Muircheartaigh, Iognaid G. (Ireland) | Stanford University | Multivariate Analysis | 10/75 - 7/76 |
| Phatak, Avadhoot Gangadhar (India) | University of Wyoming | Simulation and Curtailed Acceptance Sampling Plans | 9/75 - 5/76 |
| Read, Kenneth L. Q. (United Kingdom) | University of North Carolina at Chapel Hill | Biostatistics | 8/75 - 7/76 |
| Rootzen, Holger (Sweden) | University of North Carolina at Chapel Hill | Extreme Values of Stochastic Processes | 7/75 - 6/76 |
| Schmid, Peter (Germany) | Tulane University | Theory of Groups and Topological Groups | 1/76 - 9/76 |
| Verstraelen, Leopold (Belgium) | Michigan State University | Differential Equations and Riemann's Functions | 9/75 - 8/76 |

## American and Canadian Mathematicians Visiting Abroad

| Name and Home Country | Host Institution | Field of Interest | Period of Visit |
|---|---|---|---|
| Beran, R. J. (U.S.A.) | University of Melbourne, Australia | Statistics | 9/75 - 4/76 |
| Berger, Thomas R. (U.S.A.) | Australian National University | Theory of Groups | 6/75 - 7/76 |
| Gulliver, Robert (U.S.A.) | University of Bonn, West Germany | Differential Geometry and Partial Differential Equations | 3/76 - 7/76 |
| Ludford, G.S.S. (U.S.A.) | University of Queensland, Australia | Fluid Dynamics and Mathematical Theory of Chemically Reacting Flows | 2/76 - 6/76 |
| Resnick, S. (U.S.A.) | CSIRO, Canberra and Australian National University | Probability | 9/75 - 3/76 |
| Roberts, Joel (U.S.A.) | University of Bergen, Norway | Algebraic Geometry | 4/76 - 6/76 |
| Rosenblatt, Murray (U.S.A.) | Australian National University | Probability and Statistics | 12/75 - 4/76 |
| Schubert, Cedric Felix (U.S.A.) | Australian National University | Differential Equations | 8/75 - 5/76 |

# QUERIES

## Edited by Hans Samelson

This column welcomes questions from AMS members regarding mathematical matters such as details of, or references to, vaguely remembered theorems, sources of exposition of folk theorems, or the state of current knowledge concerning published conjectures. When appropriate, replies from readers will be edited into a composite answer and published in a subsequent column. All answers received to questions will ultimately be forwarded to the questioner. The queries themselves, and responses to such queries, should be typewritten if at all possible and sent to Professor Hans Samelson, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.

### QUERIES

85. F. S. Cater (Department of Mathematics, Portland State University, Portland, Oregon 97207). a. Does there exist a left Artinian ring (without unity) which is not a (ring) direct sum of a nilpotent ring with a left Noetherian ring? b. Does there exist a left ideal I in a left Artinian ring such that I, as a ring, is not a direct sum of a nilpotent ring and a left Artinian ring? c. Same question as b, with "Noetherian" in place of "Artinian".

86. Josef Wichmann (Department of Mathematics, Louisiana State University, Baton Rouge, Louisiana 70803). a. A linear functional p on a *-algebra A is said to be positive if $p(a^*a) \geqq 0$ for all elements a in A. Does there exist a nonzero positive linear functional on the *-algebra C(x) of fractions of complex polynomials in x, with involution defined by $x^* = x$? b. Let E be a (reflexive) Banach space and let $\ell^\infty(E)$ be the Banach space of all norm-bounded sequences $(x_n)$ in E with sup-norm. Does there exist a continuous linear map $L: \ell^\infty(E) \to E$ such that $L(x_n) = \lim x_n$ for all convergent sequences $(x_n)$? c. In the standard proof of the analytic form of the Hahn-Banach theorem (e.g. R. Larsen, Functional analysis, Marcel Dekker, New York, 1973, pp. 80-83) the following is shown: Let V be a linear space over $\mathbb{R}$ with seminorm p and let W be a linear subspace of V with a linear functional f such that $f(x) \leqq p(x)$ for all $x \in W$. Then for any fixed $x_0 \in V$ the following inequality holds:

$$\sup_{x \in W}\{-p(x + x_0) - f(x)\} \leqq \inf_{x \in W}\{p(x + x_0) - f(x)\}.$$

Is it true that equality holds if and only if $\inf_{x \in W} p(x + x_0) = 0$?

87. R. Raphael (Mathématiques, Université de Poitiers, Poitiers, 8600, France). For rings the conditions given x there is a unique y such that $x = xyx$ and $y = yxy$ imply that idempotents are central. Is this true for semigroups or is there a counterexample?

88. Henry E. Heatherly (Department of Mathematics, The University of Southwestern Louisiana, Lafayette, Louisiana 70501). What group(s) has lowest order among the groups for which the commutator subgroup contains an element which is not a commutator? Other examples of groups with this property on the commutator subgroup and which would be understandable to a senior level class would also be of interest, e.g. free groups, Carmichael's example.

89. H. R. P. Ferguson (314 TMCB, Department of Mathematics, Brigham Young University, Provo, Utah 84602). Given the polynomial equation $\sum_{1 \leqq i \leqq k} a_i x_i^{n_i} = 0$ for integers $a_i$, positive integers $n_i$, $1 \leqq i \leqq k$, are the Betti numbers of the (complex) variety known in terms of the $a_i$'s and $n_i$'s? Even the middle Betti numbers?

90. S. Zaidman (Department of Mathematics, Université de Montreal, Montreal, P.Q., Canada). In his lecture at the International Congress in Amsterdam (1954), Professor Gelfand proposed several problems in functional analysis and algebra; since then, more than 20 years passed by, so I would like to know the present status of knowledge concerning these problems; in particular, the ones concerning generalized functions, differential operators and analysis in functional spaces.

Addition to Query 75 (vol. 22, p. 302, Oct. 1975, Guza). What is wanted is a nonabelian simple group and explicit polynomials.

### RESPONSES TO QUERIES

Replies have been received to queries published in recent issues of these *Notices*, as follows: The editor would like to thank all who have replied.

77. (vol. 22, p. 374, Nov. 1975, Mirabal). Two more references follow: R. Sikorski, The determinant theory in Banach spaces, Colloq. Math. 8(1961), pp. 141-198 (MR 25 # 1454); L. Gross, Integration and nonlinear transformations in Hilbert space, Trans. Amer. Math. Soc. 94(1960), pp. 404-440 (MR 22 # 2883). (Contributed by Peter Dierolf and R. M. Dudley.)

78. (vol. 22, p. 374, Nov. 1975, Ukadgaonker). I assume that the query asks for conformal mappings. The answer is that there is no known function or easy series or similar representation of such a mapping function and none is likely to be found because of the complicated geometry involved. For two extreme cases the solution is known: One is that the two ellipses degenerate into straight line slits. The mapping functions—basically elliptic integrals—for various positions of the slits are found in my book, W. v. Koppenfels and F. Stallmann, Praxis der konformen Abbildung, Springer-Verlag 1959, pp. 340-360 (MR 21 # 6421). If the outside of the two slits is mapped onto an annulus, say $r < |z| < R$, then a smaller annulus $r' < |z| < R'$ $r < r' < R' < R$ corresponds to the plane minus two holes which may be nearly elliptical under the same mapping function. Such mappings may be used as first approximation which can be improved by numerical methods. (See, for instance, D. Gaier, Konstruktive Methoden der konformen Abbildung, Springer-Verlag, Berlin 1964 (MR 33 # 7507).) If the two ellipses in question are circles then of course a Moebius transform solves the problem. (Contributed by F. Stallmann.)

79. (vol. 23, p. 80, Jan. 1976, Anshel). Let S be a finitely generated commutative semigroup, and k any field in which we know how to compute, e.g. $\mathbb{Q}$ or $\mathbb{Z}/2$. Then the word problem in S is clearly equivalent to the word problem in the semigroup algebra kS. But this is a finitely generated commutative k-algebra, i.e., a polynomial ring modulo an ideal, and it has long been known how to compute whether an element lies in such an ideal I, given a finite generating set for I (see [1], [2]). For a simple description of such an algorithm on commutative k-algebras or semigroups, but without an explicit bound on the number of steps, see [3, §10.3 (this section can be read after skimming §§0,1 and reading §5.3)]. I don't know about the isomorphism problem.

References


1. G. Hermann, Die Frage der endlich viele Schritte in der Theorie der Polynomideale, Math. Ann. 95(1926), pp. 736-788.

2. A. Seidenberg, Constructions in algebra, Trans. Amer. Math. Soc. 197(1974), pp. 273-313.

3. G. Bergman, The diamond lemma in ring theory (to appear; preprint available, Univ. of Calif., Berkeley). (Constributed by George M. Bergman.)


80. (vol. 23, p. 80, Jan. 1976, Raphael). Consider the semigroup $\{1,2,3,\infty\}$, i.e., the additive semigroup of positive integers modulo the congruence identifying all integers $> 3$. Here the relation described by the querier ($a \leqq b \Leftrightarrow a + b = a + a$ in additive notation) is neither antisymmetric nor transitive: $2 \leqq 3 \leqq 2$ but $2 \neq 3$, and $2 \leqq \infty \leqq 1$, but $2 \not\leqq 1$. (Contributed by George M. Bergman.)

82. (vol. 23, p. 80, Jan. 1976, Schein). Let us say that a group G has $\alpha$-DCC if every decreasing sequence of subgroups indexed by the ordinal $\alpha$ is eventually constant. For regular $\alpha$, this condition is weaker the larger $\alpha$ is. $\omega$-DCC is just ordinary DCC. Any group G has $\alpha$-DCC for any regular ordinal $\alpha > |G|$.
Proposition. A sufficient condition for a group G to be linearly $\alpha$-compact is that it have $\alpha$-DCC. For $\alpha = \omega$, this condition is also necessary.
Proof. The first assertion is clear. Now suppose G is a group without DCC on subgroups. Say $G_0 \supsetneqq G_1 \supsetneqq \ldots$ ($G_i$ a subgroup of G). For each $n \in \omega$ choose $x_n \in G_n - G_{n-1}$. Let $F_n$ denote the subgroup of G generated by $\{x_n, x_{n+1}, \ldots\}$. Then $F_n \subseteq G_n$, so $x_n \notin F_{n+1}$, so $F_0 \subseteq F_1 \subseteq \ldots$; and the $F_n$ are countable. Now for every sequence of zeroes and ones, $s = (s(0), \ldots, s(n), \ldots) \in 2^\omega$, consider the chain $C(s)$ of cosets, $F_0 \subseteq x_0^{s(0)} F_1 \subseteq x_0^{s(0)} x_1^{s(1)} F_2 \subseteq \ldots$. We see that if $s \neq t \in 2^\omega$, then $\bigcap C(s)$ and $\bigcap C(t)$ will be disjoint. (In fact, if $s(n) \neq t(n)$, then the $n+1$st terms of the two chains are disjoint.) Since there are uncountably many such chains, but only countably many elements in $F_0$, at least one such chain must have empty intersection, so G is not linearly $\omega$-compact.‖

I don't know whether linearly $\alpha$-compact is equivalent to $\alpha$-DCC for larger regular $\alpha$. I also don't know whether for regular cardinals $\alpha < \beta$, linearly $\alpha$-compact implies linearly $\beta$-compact, though we see from the above proposition that this is so for $\alpha = \omega$. We also see that every group is linearly $\alpha$-compact for all sufficiently large regular $\alpha$. (In particular, for large regular $\alpha$ a linearly $\alpha$-compact group need not be periodic as the querier claims. He was probably thinking of the condition "linearly $\beta$-compact for all $\beta \leqq \alpha$", equivalently "all totally ordered families of $\leqq \alpha$ cosets have nonempty intersection." It follows from the proposition that this condition is equivalent to $\omega$-DCC on subgroups, for any infinite $\alpha$.) An example of an infinite group with $\omega$-DCC is $\mathbb{Z}_{p^\infty}$. I don't know whether an uncountable group can have $\omega$-DCC. Such a group must be nonabelian. A minimal uncountable subgroup thereof would be an uncountable group such that every proper subgroup is countable, with $\omega$-DCC. Whether there exists an uncountable group every proper subgroup of which is countable is an open problem of Kurosh. (Contributed by George M. Bergman.)

84. (vol. 23, p. 80, Jan. 1976, Rosinger). The set A will be closed neither under addition nor under multiplication. To see this, note that a function f has the stated property at every point where it is analytic, while the function u defined by $u(0) = 0$, $u(x) = (\sin x^{-1})(\exp -x^{-2})$ $(x \neq 0)$ does not have that property at 0, since it changes sign infinitely many times near 0. Let f be any nonpolynomial function analytic on the real line. Then f and $u - f$ both lie in A. (The only nontrivial case is $u - f$ at 0, and here the idea is that $D^p(-f)$ looks like $c_0 + c_1 x^n + \ldots$ with $c_1 \neq 0$, and $c_1 x^n$ majorizes $D^p(u)$ because $\exp -x^{-2}$ is so small.) But $f + (u - f) = u \notin A$. Likewise, if we take a nowhere-zero nonpolynomial analytic function f, we have $f^{-1}$ and $f \cdot (1 + u)$ both in A, but not their product, $1 + u$. (Contributed by George M. Bergman.)

# LETTERS TO THE EDITOR

Editor, the *Notices*

Currently in the Soviet Union there are a number of mathematicians who have applied to emigrate from the USSR and have been refused permission. When they apply to emigrate they are dismissed from their positions, removed from editorial boards, denied permission to publish mathematical papers and, in general, denied access to the mathematical community of the USSR.

Ilya Pjatetsky-Shapiro is the best known of these mathematicians but Alexander Luntz, Anatoly Sheransky, Irina Brailovsky and others receive similar treatment.

At the Kalamazoo meeting signatures were collected on a petition protesting the exclusion of these colleagues from the mathematical life of the Soviet Union. Copies of this petition were sent to L. S. Pontryagin, the Soviet representative of the International Math union, as well as to Soviet officials and to Secretary of State Kissinger. No reply has, as of yet, been received from the USSR. I have, however, received a letter from the State Department indicating their awareness of the situation and advising us that it would be appropriate for us to continue to express our concern directly to Soviet authorities.

G. J. Porter

Editor, the *Notices*

We are taking this opportunity to report on the activities of the Scientists and Engineers Emigrant Fund (SEEF). In 1973 a group of physicists began sending small sums of money by regular bank draft to a few colleagues in the Soviet Union who had lost their jobs and were in need, as a result of applying for exit visas. As time passed, and more information arrived here about the "refuseniks", we added engineers, chemists, and mathematicians to the list of those being helped.

In 1974 SEEF was organized, chartered in the Commonwealth of Massachusetts as a charitable trust. In our role as Trustees, we the undersigned, have received (tax exempt) contributions from over 1000 members of the U.S. scientific and engineering community, solicited primarily from the Fellows of the American Physical Society and from the Members of the American Mathematical Society. These funds have made it possible to send gifts averaging $50 a month to some 30 different individuals—usually heads of families—for a total of about $20,000. Communications from recipients still in the USSR, and from those who have managed to emigrate, have told of the importance of this financial and moral help, not least as an indication of support by the international scientific community.

Recently the Soviet Government announced two rulings that will seriously hinder our efforts and those of others: 1) a new 30% tax in addition to the approximately 35% now deducted will be imposed on all foreign currency gifts, starting January 1, 1976; 2) even more important, there will be a drastic reduction in the effective exchange rate applied to such gifts. The combination of these two makes an almost confiscatory effective exchange rate. This will cripple our efforts, and also those of many individuals, especially emigrés who try to support their families in the USSR with periodic remittances.

Given the very small magnitude of the sums involved in gifts compared with that of the Soviet economy, we conclude that the purpose of these new regulations is to discourage emigration further by imposing even more difficult sanctions on those individuals who claim this basic right.

As the Trustees of SEEF, we are concerned by this new turn of events that is so contrary to the announced spirit, if not the letter, of the Helsinki agreement; and we call it to the attention of our colleagues, especially those who deal directly with the Soviet Union.

Herman Chernoff  Philip M. Morse
Peter T. Demos  Louis D. Smullin
David H. Frisch, Chairman SEEF

Editor, the *Notices*

Dr. Ing. Danilo Rašković, Professor of Mechanics at the University of Belgrade, has been arrested by the Yugoslav government for expressing his private opinion about an artistic film which dealt with national problems in Yugoslavia. (Novosti, March 17, 1975)

Dr. Rašković, who is 65, was sentenced to 16 months at hard labor. He is presently kept in subhuman condition in a medieval jail built centuries ago by Turks in the town of Mostar, Yugoslavia.

By that action the Yugoslav government violated the Resolution of Human Rights (articles 18 and 19) of which the Yugoslav government is a signatory. Dr. Raskovic is adopted as a prisoner of conscience by the Amnesty International (International secretariat, 53 Theobald's Road, London WCiX 8SP, G.B., from 22 April, 1975).

We urge the members of A.M.S. to write a letter of concern to the President of the Republic of Yugoslavia, Mr. Josip Broz-Tito, Belgrade, Yugoslavia, as well as to any member of the mathematical community in Yugoslavia.

Michael Shaskevich

Editor, the *Notices*

I should like to take issue with Lynn Arthur Steen's article on "Public Understanding of Mathematics". For the most part he is absolutely right, but he may not aspire high enough nor in the right directions.

To be sure, what excites most mathematicians cannot be made even comprehensible to the public. For that matter, most mathematicians are a bit befuddled by work remote from their specialties.

It is almost hopeless to rely on science writers to communicate with the public. Few have any of the necessary background, and their editors

tend to underrate the intelligence and curiosity of the readers. In 1958, being pretty much my own boss, I wrote a series of two articles about mathematics for Fortune. The editor had them printed on pure faith, remarking on the galley (which he had not read): "I trust this is okay, although I don't understand it." He was a Rhodes Scholar. Strange to say, the articles elicited more favorable comment from hundreds of readers than any Fortune had ever published on a non-controversial topic.

Both articles were written at the level of Shen's level of scientific literacy. That is to say, they promised to solve no problems nor to teach the reader how to use a tool. Yet they found favor with a readership that Steen seems to disdain.

Please let us not consider that Harper's, Atlantic, and other such magazines are receptive to mathematical ideas. Typically, they employ editors who boast that they flunked algebra and are proud of it. Scientific American is another case; more than half their publications on mathematics have been in the remote field of logic. They too mistrust and dislike mathematics.

Frankly I don't know what the solutions are. More than editors realize, many of their readers do want to understand what mathematics is all about. Maybe the "attractive nontechnical monthly publication" would help greatly. Maybe also some of SIMS work could arouse interest. But I still think the trouble is that editors of so-called intellectual publications are mathematical ignoramuses and sell their readers short.

Having been trained as a mathematician before I took to science writing, I should like to be of service.

George A. W. Boehm

Editor, the *Notices*

I think Dr. Boehm's assertions do not so much "take issue" with the opinions expressed in my article as they do support them. I agree fully with his diagnosis, and appreciate his offer of assistance. Indeed, he has already made a major contribution by collaborating in editing the CBMS collection The Mathematical Sciences: A Collection of Essays (MIT Press, 1969).

I would like, however, to clarify one point that led Dr. Boehm to conclude that I disdained those who would read about mathematics on a cultural rather than on a pragmatic level. When I said that "a cultural approach will hardly contribute to 'public' understanding," I was simply concluding the obvious from the data regarding the reading habits of the American public: information communicated in a medium (the intellectual monthlies) that reach less than one-percent of the population of the U.S. does not make much of a dent on the general public that is attuned more to television than to scholarly magazines. The readers of these magazines are, nevertheless, a most valuable audience because of the leverage they represent in reaching beyond their own bounds.

Because mathematicians are accustomed to audiences measured in the hundreds, they often believe that audiences in the tens of thousands represent the "general public." But NSF and Congress, among others, think of a public measured in the tens of millions. If we ever intend to convince that public that what mathematicians do is worthwhile—pragmatically or culturally—we will need a communications strategy far more powerful than any yet tried by the mathematical community.

Lynn Arthur Steen

Editor, the *Notices*

I have just recently returned from a meeting of the AMS. One of the more interesting events aside from the mathematics was the evening I spent observing the meeting of the Council of the AMS. Although I would not recommend it as a steady diet, I think every member of the Society would find attendance at these open meetings at least once to be educational.

Stephen Meskin

Editor, the *Notices*

Last week I received my third letter from a "top 25" mathematics department member soliciting my assistance in securing "qualified" minority applicants for positions his department desires to fill. If last year can be an indication, I shall receive at least twice this many letters during the next three months. Since a department can superficially satisfy state or federal regulations for Affirmative Action and Equal Opportunity Programs by simply producing a list of names of minority applicants who have not qualified, it is entirely possible that a hoax is being perpetrated. My goal in this letter is to make the mathematics community aware of some of the problems faced by minorities in mathematics and to offer some solutions.

In an elementary Physics course, we are asked to neglect friction when considering the acceleration of a particle falling from rest. Similarly, during public schooling, the minority student must ignore intense social and psychological pressures and/or poor teaching and/or poor counseling. Should this friction be surpassed, it has been traditionally difficult for that student to obtain a good and sympathetic college education outside of the social sciences and within the natural sciences and mathematics.

Graduate school in mathematics epitomizes these hardships. However, should one persevere with the predominantly conscious or unconscious racist professors and earn a Ph.D., his ability is still suspect:

Ex. 1. Although I earned my degree six years ago and I look my age, 32, most mathematicians outside of my area of research meeting me for the first time will ask if I am a graduate student.

Ex. 2. Last year a department chairman of a Ph.D. granting institution wrote to the department chairman and Full Professor of a Black college asking whether he would like to apply for a junior position.

Ex. 3. In 1974, a Navajo mathematician, well-known to Combinatorists, left a Full Professor post at a major institution after attacks on his person and ability by some of his colleagues.

Thus, naive and overt racism continue to underline current policies in mathematics.

For each 1,000 American mathematicians with a Ph.D., less than 5 are American Indian, Black, Mexican American, or Puerto Rican. Needless to say each of these has had to be incredibly lucky, a psychological fortress, as well as a comparative prodigy in intellectual achievement. This year, all except 15 are employed in institutions where the teaching load (averaging 13 hours a week), committee work, library facilities, and budget are extremely prohibitive of research opportunity. All of these 15 have found themselves besieged with requests to join or head committees in their research institutions, for the demand of minority input is deemed important (especially, where minorities are concerned) while the supply of minorities is "limited", where committee work has little value when promotion and tenure is considered in those institutions. To my knowledge, there are only 8 tenured minority mathematicians in our major universities.

It comes as no surprise that none of the institutions who wrote to me last year found a "qualified" minority. The statement made to me by many mathematicians, "Job opportunities are better for your people than whites, you have great mobility," is a hoax, especially to the minorities found "not qualified" for jobs at departments with Affirmative Action programs.

A long range solution to the difficulties of minorities in mathematics is suggested by a program initiated by Dr. Clarence Stephens, at Morgan State College in the early 1960's. Better-than-average students were given special classes and tutoring outside of the usual departmental offerings during each semester and summer of their last 2 1/2 years. Of the 8 students who began in the program in 1962, all have earned Master's degrees and three earned Ph.D.'s in the years 1968 through 1970. Prior to this program, Morgan State College had no graduates who earned a Ph.D. and rarely a graduate attaining a Master's degree in mathematics. A similar program to this, perhaps on a one-to-one basis, could benefit minority students at any level and would be an excellent component of any Affirmative Action program.

A short range solution to the aforementioned difficulties for the major universities would be to consider factors other than research accomplishments for the hiring, promotion, and tenuring of minorities. Factors such as research potential, teaching ability, and university and community service must be considered equal to that of publishing. The incentive of minority students to achieve in mathematics at my institution seems to rise when they are aware of my presence, and their ability rises with the type of communication skills I can provide through similarity in cultural background.

It is clear that Mathematics has had a tradition of being the most difficult area of academic achievement for minorities in this nation, a difficulty having only a negative connection with physical characteristics and mental abilities. The present Affirmative Action programs are generally unsuccessful and in effect are maintaining this tradition through naiveté. I would suggest positive measures rather than impersonal letters and advertisements.

Scott W. Williams

# NEWS ITEMS AND ANNOUNCEMENTS

## FULBRIGHT-HAYS AWARDS FOR 1977–1978

More than 500 awards for university lecturing and postdoctoral research in over seventy-five countries will be made to Americans for the academic year 1977–1978, the thirtieth year of the senior Fulbright-Hays program. (Applications for 1976–1977 are presently being reviewed, but some awards remain open. The Council for International Exchange of Scholars welcomes inquiries concerning remaining openings.)

An American citizen who has a doctorate or college teaching experience may request an announcement of openings in a specific field, indicating preferred countries or geographic areas and probable dates of availability. Those with a continuing interest in Fulbright-Hays and other educational programs may complete a two-page form for the Council's Register of Scholars. In April 1976, each registrant will be sent an announcement of opportunities under the 1977-1978 program. Further information is available from the Council for International Exchange of Scholars (CIES), Eleven Dupont Circle, Washington, D.C. 20036.

CIES also administers a program for foreign senior scholars who receive Fulbright-Hays grants from agencies in their home countries. Each year approximately 500 foreign scholars are awarded grants to come to the United States for lecturing or research assignments at American institutions. Universities interested in having a foreign Fulbright-Hays scholar on campus or as a guest lecturer during 1976–1977 should write to the Council as soon as possible.

## NSF SEEKS PARTICIPANTS FOR US-USSR PROGRAM

The National Science Foundation is seeking qualified persons to participate in a US-USSR program in the application of computers to management. The activities include econometric modeling, computer analysis applied to the economics and management of large systems, applications of computers to the management of large cities, theoretical foundations for software for applications in economics and management, and computer-aided refinement of decision-making and education of high-level executives. For more information, write to US-USSR Activities, Division of Mathematical and Computer Sciences, National Science Foundation, Washington, D.C. 20550.

## CORPORATE MEMBERS AND INSTITUTIONAL ASSOCIATES

The Society acknowledges with gratitude the support rendered by the following corporations who held either Corporate Memberships or Institutional Associateships in the Society during the calendar year 1975.

### Corporate Members

Bell Telephone Laboratories
Ford Motor Company
General Motors Corporation
International Business Machines Corporation
Rockwell International

### Institutional Associates

Chelsea Publishing Company
Princeton University Press
Prindle, Weber & Schmidt
Shell Development Company
Springer-Verlag New York Incorporated
Springer-Verlag, Heidelberg
Daniel H. Wagner, Associates

## AMS RESEARCH FELLOWSHIP FUND
### Request for Contributions

The Council and the Trustees of the Society have voted to continue the Research Fellowship Program, begun in 1973, on the same terms as at present with one exception. Starting with the AMS Postdoctoral Research Fellowships to be awarded for 1976–1977 candidates for the fellowships shall be citizens or permanent residents of a country in North America. The Society will continue to contribute a minimum of $9,000 each year, matching one-half the funds in excess of $18,000 raised from other sources, up to a total contribution by the Society of $20,000.

Three Research Fellowships were awarded for 1975–1976. The Society hopes that this number can be increased for 1976–1977. The Fellowships are intended to support Research Fellows for one year and, under the restrictions above, will continue to be awarded strictly on mathematical merit. Each Fellowship for 1976–1977 will carry a partially tax exempt stipend of approximately $10,500.

The Research Fellowship Program demonstrates the importance the Society and its members attach to research. The survival of the Program depends on the contributions the Society receives for the Research Fellowship Fund. It is hoped that every member of the Society will be willing to contribute to the Fund. A contribution of at least $3.00 from each employed member would make this Program a highly successful one. Contributions are tax deductible. Checks should be made payable to the American Mathematical Society, clearly marked "AMS Research Fellowship Fund", and sent to the American Mathematical Society, P. O. Box 1571, Annex Station, Providence, Rhode Island 02901.

## AMS RESEARCH FELLOWSHIPS
### Invitation for Applications

The American Mathematical Society invites applications for the AMS Research Fellowships. These are postdoctoral fellowships to be awarded for research in mathematics during the year 1976–1977. They are open to individuals who hold the Ph.D. degree, and who are citizens or permanent residents of a country in North America. The stipend will be approximately $10,500, of which a portion will be tax exempt.

Completed applications must be received by March 15, 1976. A small number of fellowships will be awarded, the number depending on the amount contributed to the AMS Research Fellowship Fund. Notification of awards will be made by April 15, 1976.

For further information and application forms write to Dr. Gordon L. Walker, Executive Director, American Mathematical Society, P.O. Box 6248, Providence, Rhode Island 02940.

## COLLOQUIUM LECTURES

One series of colloquium lectures was presented at the annual meeting in San Antonio, Texas, in January 1976. A limited number of copies of the lecture notes prepared by Professor I. M. Singer, "Connections between geometry, topology, and analysis", are still available.

Requests for copies should be accompanied by a check for one dollar per copy to cover the cost of handling; requests should be mailed to the Society, P. O. Box 1571, Annex Station, Providence, Rhode Island 02901. Please note that informally distributed manuscripts and articles should be treated as personal communications and are not for library use. Reference to the contents in an informal publication should have the prior approval of the author.

## AMS-SIAM COMMITTEE ON APPLIED MATHEMATICS

Over the past years this committee has made recommendations for symposia held in conjunction with the AMS spring meeting in New York City, and for summer seminars held at different universities. The symposia are held annually and usually last two days. In April 1975, the topic was "Nonlinear Programming"; for the spring of 1976 the topic is "Asymptotic Methods and Singular Perturbations" with Robert E. O'Malley as chairman of the organizing committee. The summer seminars are held on the average every other summer and are of two to four weeks duration. During the summer of 1975 a two-week seminar on "Modern Modeling of Continuum Phenomena" was held at Rensselaer Polytechnic Institute. Proceedings of the symposia are published in the series SIAM-AMS Proceedings; lectures given at the summer seminars are published in the series Lectures in Applied Mathematics. A complete list of earlier symposia and seminars is given in these *Notices* (Vol. 21, August 1974, p. 233).

The AMS-SIAM Committee on Applied Mathematics would be very pleased to receive suggestions for topics for future symposia and seminars. Suggestions can be sent to any member of the committee or directly to the chairman: Donald S. Cohen, Department of Applied Mathematics, California Institute of Technology, Pasadena, California 91125. The members of the committee are R. C. DiPrima (Rensselaer), G. Strang (M.I.T.), S. Smale (Berkeley), E. Reiss (Courant), and D. Siegmund (Columbia).

NSF SUPPORTS NATO ADVANCED STUDY INSTITUTES

The National Science Foundation has announced plans to award international travel grants to approximately ninety United States scientists who wish to attend North Atlantic Treaty Organization Advanced Study Institutes in Europe during the summer of 1976. The institutes will provide advanced instruction on specific topics such as engineering and mathematics. They are conducted in an atmosphere which will promote international fellowship and cooperation in the scientific fields.

Junior faculty and advanced graduate and postdoctoral students who are citizens of the United States are eligible to apply for the grants. For more information, write to NATO Travel Grants, Fellowships and Traineeships, Division of Science Manpower Improvement, National Science Foundation, Washington, D.C. 20550.

MAA 1976 SUMMER MEETING UNIVERSITY OF TORONTO

The Mathematical Association of America will hold its fifty-sixth summer meeting at the University of Toronto from Thursday, August 26, through Saturday, August 28, 1976. This meeting will be held in conjunction with the eightieth summer meeting of the American Mathematical Society, which will take place during the period Tuesday, August 24, through Friday, August 27, 1976.

Participants should note that the two organizations are meeting in order opposite from the usual schedule for a summer meeting. The order in which the two organizations' sessions will take place follows:

| August 1976 | A.M. | P.M. |
|---|---|---|
| Sunday, 22 | Short Course | Short Course |
| Monday, 23 | Short Course | Short Course |
| Tuesday, 24 | AMS | AMS |
| Wednesday, 25 | AMS | AMS |
| Thursday, 26 | MAA | AMS |
| Friday, 27 | MAA | AMS |
| Saturday, 28 | MAA | MAA |

The meeting of the Board of Governors of the Association will be held on Wednesday, August 25.

# EXECUTIVE DIRECTOR AMERICAN MATHEMATICAL SOCIETY

With the retirement of Dr. Gordon L. Walker on or about October 29, 1977, the position of executive director of the American Mathematical Society will become vacant. Applications are now being accepted for this post. It is expected that the successful candidate will join the staff of the Society in June 1977 at the latest, if not already an employee. Candidates should have a Ph.D. in mathematics (or the equivalent), some published research in mathematics beyond the Ph.D., and significant administrative experience. Other desirable or alternative qualifications include experience in mathematical publishing, fiscal management, and computer utilization.

It is also conceivable that the post of deputy executive director may become vacant. Qualifications are similar, except that somewhat less experience in administration may be required.

The following quotations from the Bylaws of the Society are relevant:

ARTICLE II, Section 3. The Board of Trustees shall have the power to appoint such assistants and agents as may be necessary or convenient to facilitate the conduct of the affairs of the Society, and to fix the terms and conditions of their employment.

ARTICLE VI, Section 1. There shall be an executive director who shall be a paid employee of the Society. He shall have charge of the central office of the Society, and he shall be responsible for the general administration of the affairs of the Society in accordance with the policies that are set by the Board of Trustees and by the Council.

Section 2. The executive director shall be appointed by the Board of Trustees with the consent of the Council. The terms and conditions of his employment shall be fixed by the Board of Trustees.

Section 3. The executive director shall work under the immediate direction of a committee consisting of the president, the secretary, and the treasurer, of which the president shall be chairman ex officio. The executive director shall attend meetings of the Board of Trustees, the Council, and the Executive Committee, but he shall not be a member of any of these bodies. He shall be a voting member of the Committee to Monitor Problems in Communication, but shall not be its chairman.

Requests for application forms and letters suggesting possible candidates should be addressed to:

Professor Morton Curtis, Chairman
Search Committee for AMS Executive Director
Department of Mathematics
Rice University
Houston, Texas 77001

Applications received by April 1, 1976 will receive primary consideration.

The American Mathematical Society is an equal opportunity affirmative action employer.

# PERSONAL ITEMS

WILLIAM E. CUMMINS of the David W. Taylor Naval Ship Research & Development Center has been awarded the Navy Distinguished Civilian Service Award.

SUDHANSHU K. GHOSHAL of the Indian Institute of Operations Management has been appointed a distinguished visitor by the Graduate School of Business Administration, Harvard University.

LYLE E. MEHLENBACHER of the University of Detroit has retired and been granted the title of Professor Emeritus.

ELISHA NETANYAHU of the Technion-Israel Institute of Technology has been named this year's recipient of the Mahler Prize for research in Pure Mathematics.

RICHARD I. RESCH of the College of the Virgin Islands has been appointed a Latin American Teaching Fellow at the Instituto de Matemática e Física of the Universidade Federal de Goiás, Goiânia, Goiás, Brazil.

JAMIL A. SIDDIQI of the University of Sherbrooke has been appointed to a professorship at Laval University.

JONATHAN D. SONDOW of the City College of New York, CUNY, has been appointed to a visiting associate professorship at Pennsylvania State University for the academic year 1975–1976.

PROMOTIONS

To Dean, School of Physical Sciences. La Trobe University: BERTRAM MOND.

To Chairman, Department of Mathematics. Wayne State University: B. J. EISENSTADT.

To Associate Professor. Middlebury College: MICHAEL OLINICK; University of Rhode Island: HOWARD A. LEVINE; University of South Carolina, Columbia: WILLIAM T. TROTTER, Jr.

DEATHS

Professor CORNELIUS GOUWENS of Iowa State University died on July 26, 1975, at the age of 86. He was a member of the Society for 54 years.

Professor NORMAN LEVINSON of the Massachusetts Institute of Technology died on October 10, 1975, at the age of 63. He was a member of the Society for 38 years.

Professor Emeritus GEORGE E. RAYNOR of Lehigh University died on September 25, 1975, at the age of 80. He was a member of the Society for 54 years.

Professor KEEVE M. SIEGEL of Ann Arbor, Michigan died on March 14, 1975, at the age of 52. He was a member of the Society for 26 years.

Professor Emeritus J. REIFF K. STAUFFER of the University of Rhode Island died on September 2, 1975, at the age of 72. He was a member of the Society for 43 years.

# NEW AMS PUBLICATIONS

## MEMOIRS OF THE AMERICAN MATHEMATICAL SOCIETY

EXISTENCE AND REGULARITY ALMOST EVERYWHERE OF SOLUTIONS TO ELLIPTIC VARIATIONAL PROBLEMS WITH CONSTRAINTS by F.J. Almgren, Jr.

Number 165
199 pages; list price $8.40; member price $6.30;
ISBN 0-8218-1865-1
To order, please specify MEMO/165

The structure of m dimensional subsets of $\underline{\underline{R}}^n$ which are well behaved with respect to deformations of $\underline{\underline{R}}^n$ is studied as is the existence of such sets as solutions to geometric variational problems. A set whose m dimensional area does not decrease by a factor more than $\gamma$ under deformations of diameter no larger than $\delta$ is called $(\gamma, \delta)$ restricted, and an extensive repertoire of piecewise smooth deformations of $\underline{\underline{R}}^n$ is developed in order to show such a set is rectifiable, has upper and lower area density ratio bounds, and can be strongly approximated by a smoothly imbedded polyhedral complex. The additional hypothesis of $(\underline{\underline{F}}, \epsilon, \delta)$ minimality with respect to an elliptic integrand $\underline{\underline{F}}$ is shown to be sufficient to imply that such a set is almost everywhere a smooth m dimensional submanifold of $\underline{\underline{R}}^n$. The solutions of an extensive class of geometric variational problems with constraints are sets which satisfy these hypotheses of restrictedness and minimality, and are thereby proved to be almost everywhere regular. Also included in detail is the first existence proof of solutions to general minimal partitioning problems, the methods of which are representative of those required to show the existence of solutions to a great many geometric variational problems set in the context of geometric measure theory. Particular applications include surfaces of capillarity, minimal surfaces avoiding obstacles, problems with partially free boundaries, and a large class of problems involving minimal partitioning hypersurfaces which have arisen in mathematics, physics, and especially biology over the past few centuries, e.g. the geometric structure of compound soap bubbles, immiscible liquids in equilibrium, and certain organisms.

# ABSTRACTS PRESENTED TO THE SOCIETY

**Preprints are available from the author in cases where the abstract number is starred.**
**Invited addresses are indicated by •**



**The papers printed below were accepted by the American Mathematical Society for presentation by title. The abstracts are grouped according to subjects chosen by the author from categories listed on the abstract form. The miscellaneous group includes all abstracts for which the authors did not indicate a category.**

**An individual may present only one abstract by title in any one issue of the *Notices* but joint authors are treated as a separate category. Thus, in addition to abstracts from two individual authors, one joint abstract by them may also be accepted for an issue.**

## Algebra & Theory of Numbers

*76T-A33 JOHN H. COZZENS, Rider College, Trenton, New Jersey, 08602 and FRANK SANDOMIERSKI, Kent State University, Kent, Ohio, 44242. Residue Rings of Maximal Orders.

Let R be a bounded, maximal order with glb $R \leq 2$ and P, a height 1 prime of R. $ht_1(R)$ (max (R)) will denote the set of all height 1 primes (maximal ideals) of R. Theorem 1: R/P is an HNP (Dedekind prime) ring if and only if $R/Q^2 + P$ is serial (uniserial) for each $Q \in ht_1(R)$, $Q \neq P$. Moreover, we have Theorem 2: The following are equivalent for R/P: 1. R/P is a maximal order. 2. R/P is Dedekind prime. 3a. Each $M \in \max(R)$ above P is localizable. Equivalently, 3b. All $M \in \max(R)$ above P commute. 4a. $M/M^2 + P \approx R/M$ for all $M \in \max(R)$ above P. Equivalently, 4b. $M/M^2 \approx R/M \oplus R/M$ for all $M \in \max(R)$ above P and P is square free. These results are obtained by showing that R/P has "enough" localizable semi-primes, and that a generalized notion of cycle can be introduced in R/P. (Received September 19, 1975.)

*76T-A34 R.J. WARNE, University of Alabama, Birmingham, Alabama 35294. Strictly regular semigroups, II.

For definitions, notation, and the general structure theorem, see Abstract 75T-A258, these *Notices* 22(1975), A-704. Let S be a strictly regular semigroup. S is termed strictly orthodox ($\mathcal{L}$-unipotent) (inverse) if $T_y$ is a rectangular group (right group) (group) for each $y \in Y$. In all these cases "B" may be omitted in the general structure theorem. In the second and third cases, $I_y = \{e_y\}$, a single idempotent for each $y \in Y$. In the third case, $J_y = H_{e_y}$ for each $y \in Y$. S is termed a strictly regular semigroup of type $\omega Y$ if Y is an $\omega Y$-semilattice and $f_{(n,\delta)} \mathcal{D} f_{(m,\lambda)}$ ($f_{(n,\delta)} \in E(T_{(n,\delta)})$; $f_{(m,\lambda)} \in E(T_{(m,\lambda)})$) if and only if $\delta = \lambda$. In this case, "g(c, d)" may be omitted and V is given by [Jnanabha 3(1973), 104, Theorem 2.3]. Further specializations of this case are considered. We will change "strictly" to "strongly" to avoid confusion with previous terminology of Yamada. (Received September 4, 1975.)

76T-A35 M.DEZA, C.N.R.S. (Paris), R.C.MULLIN, University of Waterloo, and S.A.VANSTONE, St. Jerome's College, University of Waterloo. Room Squares and Equidistant Permutation Arrays.

An equidistant permutation array (E.P.A.) $A(r, \lambda; v)$ is a $v \times r$ array in which each row is a permutation of the integers $1, 2, \ldots, r$ and any two distinct rows have precisely $\lambda$ columns in common. D.W. Bolton defined the function $R(r, \lambda)$ to be the largest integer v for which there exists an $A(r, \lambda; v)$. Bolton showed $R(6, 1) = 10$ and posed the problem of determining when $R(r, \lambda) > r$. D. Woodall showed that $R(4n + 1, n + 1) \geq n^2$ where n is a prime power. It is shown that a Room square of side r implies the existence of an $A(r, 1; r + 1)$ from which we deduce $R(2t + 1, 1) > 2t + 1$ for any positive integer $t \neq 1,2$. Certain results are obtained about a special class of E.P.A.'s which we call k-uniform. These

arrays are equivalent to a generalization of the Room square concept. We also give an improvement on the known general upper bound for $R(r, \lambda)$ when $r - \lambda$ is not the order of a finite projective plane. (Received October 23, 1975.)

*76T-A36 R. A. Mollin, Computer Science Dept., Concordia University, 1455 De Maisonneuve Blvd. West, Montreal, P.Q., H3G 1M8, Canada. Generalized Uniform Distribution.

M. Benard and M. Schacher ("The Schur subgroup I", J. Algebra 22 (1972),374-377) proved that for a finite abelian extension K of the rationals Q, algebras representing elements in the Schur subgroup S(K) of the Brauer group B(K) satisfy the properties of uniform distribution of Hasse invariants.

In this paper we generalize this concept. Let K be a finite Galois extension of the number field F. We define $U_F(K)$ to consist of elements A in B(K) such that: (1) If A has index n then $\varepsilon_n$, a primitive nth root of unity, is in K and (2) If $\mathfrak{P}$ is any K-prime and $\sigma\varepsilon G(K/F)$ such that $\varepsilon_n^{\sigma}=\varepsilon_n^{b}$ then: $\mathrm{inv}_{\mathfrak{P}}(A)\equiv b\ \mathrm{inv}_{\mathfrak{P}^{\sigma}}(A) \pmod 1$; where $\mathrm{inv}_{\mathfrak{P}}(A)$ denotes the Hasse invariant of $A\otimes_K K_{\mathfrak{P}}$ and $K_{\mathfrak{P}}$ denotes the $\mathfrak{P}$ completion of K at $\mathfrak{P}$. If F=Q and K/Q is finite abelian we get Benard and Schacher's definition of uniform distribution. The author has noted that Benard and Schacher's aforementioned theorem as given in ("The Schur Subgroup of the Brauer Group", Lecture notes in mathematics, No.397, Springer-Verlag 1974,pp.89-92) generalizes to the case where K is a finite Galois extension of a number field F. Thus we get $S(K)\subseteq U_F(K)$. We generalize results obtained in (R. Mollin, Abstract 75T-A140 these Notices 22(1975) and A-448; Abstract 75T-A182 these Notices 22(1975), A-505). Moreover, we generalize theorem 1 of (B. Fein, "Embedding Finite Groups in Rational Division Algebras, III", J. Algebra 28 (1974), 304-310). Finally, we obtain a sufficient condition for a crossed product algebra to be in $U_F(K)$, based on the structure of the crossed product.
(Received October 24, 1975.)

*76T-A37 G.E. Hardy, University of Alberta, Edmonton, Alberta T6G 2G1. Some Results About the (k,r)-free Integers.

An integer is said to be (k,r)-free if, in it canonical representation, no exponent is in the interval $[r,k-1]$, $1 \le r < k \le \infty$. This definition includes as special cases the r-free integers $(k = \infty)$, the semi r-free integers $(k = r+1)$ and the k-full integers $(r = 1)$. The following 2 results (for $r \ge 2$) are among those found. First is that the number of representations of an integer n as the sum of a prime and a (k,r)-free integer is given by

$$\mathrm{Li}(n) \prod_{p|n} \left\{1 - \frac{1}{(p-1)}\left(\frac{1}{p^{r-1}} - \frac{1}{p^{k-1}}\right)\right\} + 0\left\{n\cdot\exp\left(-A\left(\frac{r-1}{r}\right)\sqrt{\log n}\right)\right\}.$$

The second result determines an asymptotic formula with error term for $\sum_{n\le x} \tau_{(k,r)}(n)$ where $\tau_{(k,r)}(n)$ is defined to be the number of (k,r)-free divisors of n. The main term is given by:

$$x\cdot\prod_p\left(1 - \frac{1}{p^r} + \frac{1}{p^k}\right)\cdot\left\{\log x - 2\gamma - 1 + k\left[\left(\frac{d}{dk}\prod_p\left(1 + \frac{1}{p^k}\right)\right)\Big/\prod_p\left(1 + \frac{1}{p^k}\right)\right] - \sum_p \log p/p^r(1+p^k)\left(1 - \frac{1}{p^r} + \frac{1}{p^k}\right)\right] +$$

$$-r\left[\frac{\zeta'(r)}{\zeta(r)} - \sum_p \log p/p^k(p^r-1)\left(1 - \frac{1}{p^r} + \frac{1}{p^k}\right)\right]\right\}.$$

(Received November 3, 1975.)

*76T-A38 Thomas O. Hand, Indiana State University, Terre Haute, Indiana 47809. On Boolean Rings.

Let R be a ring. If there exists a positive integer n such that $x^{2n} = x$, for all x in R, then R has characteristic 2. Let $n \ge 3$.

Theorem: If $x^{2n-2} = x$, for all x in R, then R is a Boolean ring.

Theorem: If $x^{2n + 2^{n-1}} = x$, for all x in R, then R is a Boolean ring.

(Received November 3, 1975.)

76T-A39 H.R.Fischer and G.T.Rüttimann, University of Massachusetts, Amherst, MA 01002

Fields of manuals. Preliminary report.

Manuals in the sense of D.J.Foulis and C.H.Randall (Operational statistics,I, J.Math.Physics,13(1972) 1667/75) are made into (concrete)categories in various ways by choosing suitable morphisms. Operation preserving maps $(X,\mathcal{O})\to(Y,\mathcal{O})$ seem to be a reasonable choice,leading to a category $\mathcal{M}$ whose basic properties have been investigated.In particular, $\mathcal{M}$ admits certain inductive limits:a field of manuals is an inductive system $((X_\alpha,\mathcal{O}_\alpha),\varphi^\alpha_\beta)_A$ where,for $\alpha\le\beta$, $\varphi^\alpha_\beta$ is an isomorphism of $(X_\alpha,\mathcal{O}_\alpha)$ into $(X_\beta,\mathcal{O}_\beta)$.For such

a field, there exists an inductive limit $((X_\infty, \varphi_\infty), \varphi_\alpha)$ with the usual properties; $(X_\infty, \varphi_\infty)$ is the global manual determined by the local manuals $(X_\alpha, \varphi_\alpha)$. Also, if $G$ is a group of order-automorphisms of $A$ such that $(X_\alpha, \varphi_\alpha) \cong (X_{g(\alpha)}, \varphi_{g(\alpha)})$ with evident coherence conditions, $G$ acts naturally on $(X_\infty, \varphi_\infty)$. Current questions mainly concern the functor V (signed weight space, a base normed space) and its topological dual $V^*$ (order unit space) on $\mathcal{M}$ as well as the associated "logic" and "observables". As an application, we are constructing an operational frame for Quantum Field Theories, using the bounded open sets in $\mathbb{R}^4$ for A (on which the Lorentz group acts in the obvious manner). Relations between the local (physical) and global ("non-physical") manuals as well as notions such as causality, relativistic dynamics, etc. are studied both at a mathematical and conceptual level. (Received November 4, 1975.)

*76T-A40 DAVID M. CLARK and PETER KRAUSS, SUNY New Paltz, N.Y., 12561,
Varieties generated by para primal algebras (Preliminary report)

For notation and terminology see Clark and Krauss, Para Primal Algebras. There it is proved that a finite algebra is para primal iff it generates a congruence permutable variety and has only simple subalgebras. Let $\mathfrak{A}$ be para primal and let $\mathfrak{M}$ be the class of simple algebras in $V\mathfrak{A}$.

Theorem 1 i) $\mathfrak{M}$ has up to isomorphism only finitely many members. ii) $\mathfrak{M}$ is exactly the class of para primal algebras in $V\mathfrak{A}$. iii) Every finite algebra in $V\mathfrak{A}$ is isomorphic to a direct product of members of $\mathfrak{M}$. iv) $V\mathfrak{A} = IP_s\mathfrak{M}$.

Theorem 2 Let $\mathfrak{B}$ be a member of $\mathfrak{M}$ not embeddable into $\mathfrak{A}$, $|B| = n$. Then there are nonisomorphic subalgebras $\mathfrak{A}_0, \mathfrak{A}_1, \cdots \mathfrak{A}_{m-1}$ of $\mathfrak{A}$ each having n elements and no proper subalgebras such that either i) $\mathfrak{B}$ has a trivial subalgebra and is a homomorphic image of $\mathfrak{A}_0 \times \mathfrak{A}_0$ or ii) $\mathfrak{B}$ has no trivial subalgebra and is a homomorphic image of $\mathfrak{A}_0 \times \mathfrak{A}_1 \times \cdots \times \mathfrak{A}_{m-1}$.

We give an example of a nine element para primal algebra $\mathfrak{A}$ having exactly two proper subalgebras, $\mathfrak{A}_0 \not\cong \mathfrak{A}_1$, generating one algebra $\mathfrak{B}_0$ of type i) and one algebra $\mathfrak{B}_1$ of type ii), so that $V\mathfrak{A} = IP_s\{\mathfrak{A}, \mathfrak{A}_0, \mathfrak{A}_1, \mathfrak{B}_0, \mathfrak{B}_1\}$. (Received November 6, 1975.)

76T-A41 Thomas J. Ferguson, 8735 Contee Rd. #204, Laurel, MD 20811
Splitting Fields For Small Simple Groups

This paper is concerned with finding Schur indices for the irreducible characters of the minimal simple groups. It is shown that the irreducible characters of the 2-dimensional projective special linear groups, the Suzuki groups, and PSL (3,3) all have Schur index one over Q. Thus, the irreducible characters of any minimal simple group all have Schur index one over Q. However, this result cannot be extended to the larger class of N-groups; the character table of PSU (3,3) is found and it is shown that one of the irreducibles has Schur index 2 over Q.

To find the Schur index over Q it suffices to find all of the local indices; i.e., over R and over all Qp. The index over Q is simply the least common multiple of these local indices. Besides the usual methods of finding Schur indices, a result of Kronstein is used which relates the index over Qp of an irreducible character to the fields generated by its modular components and their multiplicities. (Received November 11, 1975.) (Introduced by Truman Prevatt.)

76T-A42 ALAN DAY, Lakehead University, Thunder Bay, Ontario, P7B 5E1
Finite Sublattices of Free Lattices, Preliminary Report

For a lattice L set J(L) be the set of its join-irreducible members. Consider the following classes of finite lattices: (1) $L \in P$ iff $|J(L)| = |J(Con(L))|$. (2) $L \in SD$ iff L satisfies $(u = a \vee x = a \vee y \Rightarrow u = a \vee (x \wedge y))$ and its dual. (3) $L \in B$ iff L is a bounded homomorphic image of a (finitely generated) free lattice. (4) $L \in F$ iff L is a (finite) sublattice of a free lattice. (5) $L \in W$ iff L satisfies Whitman's condition $(a \wedge b \leq c \vee d \Rightarrow \{a,b,c,d\} \cap [a \wedge b, c \vee d] \neq \emptyset)$. In McKenzie, Equational Bases and non-modular lattice varieties Trans. Amer. Math. Soc. 174 (1972), 1-43 the following results are shown: $F \subseteq B \subseteq SD$ and $F = B \cap W$. Theorem: $B = SD \cap P$. Corollary: $F = SD \cap P \cap W$. The result is an application of the author's splitting lattices generate all lattices (submitted Alg. Univ.) and Pudlak and Tuma, Yeast graphs and fermentation of algebraic lattices (submitted Alg. Univ.). (Received November 17, 1975.) (Author introduced by Professor J. Whitfield.)

76T-A43 G. GRÄTZER, Mathematics Department, University of Manitoba, Winnipeg, Manitoba, Canada. R3T 2N2. On the Amalgamation Property.

Let $\underset{\sim}{K}_0$ and $\underset{\sim}{K}_1$ be equational classes of lattices, let $\underset{\sim}{K}_0 \nsubseteq \underset{\sim}{K}_1$ and $\underset{\sim}{K}_1 \nsubseteq \underset{\sim}{K}_0$. Let $\underset{\sim}{K}$ be the smallest equational class containing $\underset{\sim}{K}_0$ and $\underset{\sim}{K}_1$. Theorem. $\underset{\sim}{K}$ does not have the Amalgamation Property. In other words, if an equational class $\underset{\sim}{K}$ of lattices has the Amalgamation Property, then $\underset{\sim}{K}$ is join-irreducible in the lattice of all equational classes of lattices. In fact, we prove somewhat more: $\mathfrak{S}_2 \notin \mathrm{Amal}(\underset{\sim}{K})$. Problem: Is $\underset{\sim}{M}$ join-irreducible? There is also a universal algebraic version of this theorem for congruence distributive equational classes satisfying an additional hypothesis of a technical nature. (Received November 17, 1975.)

76T-A44 G. GRÄTZER and T. TAN, Mathematics Department, University of Manitoba, Winnipeg, Manitoba, Canada. R3T 2N2. On $\underset{\sim}{D}$-transferability.

A distributive lattice K is called $\underset{\sim}{D}$-transferable iff, for any distributive lattice L and any embedding $\varphi$ of K into the lattice I(L) of ideals of L, there exists an embedding $\psi$ of K into L. If, in addition, $\psi$ can always be chosen to satisfy the condition: $a\psi \in b\varphi$ iff $a \leq b$, then K is called sharply $\underset{\sim}{D}$-transferable. H. Gaskill proved (Bull. Austral. Math. Soc. 7(1972), 377-385, see also E. Nelson, Algebra Univ. 4(1974), 135-140) that every finite distributive lattice is sharply $\underset{\sim}{D}$-transferable. Theorem. Let K be a distributive lattice. (i) If K is $\underset{\sim}{D}$-transferable, then $(a]$ and $\{b \mid b \succ a\}$ are finite, for all $a \in K$. (ii) If K is sharply $\underset{\sim}{D}$-transferable, then K does not contain a sublattice isomorphic to $\mathfrak{S}_2 \times \mathfrak{S}_\omega$. — We conjecture that K is sharply $\underset{\sim}{D}$-transferable iff K is a linear sum of type $\omega$ of finite distributive lattices. (Received November 17, 1975.)

76T-A45 Mary J. Cowles, The Pennsylvania State University, University Park, Pennsylvania 16802. A Reciprocity Law for Cubic Fields. Preliminary report.

Let $f(x) = x^3 + qx + r$, $q,r \in Z$ and irreducible over Q, have discriminant $\Delta$ a negative square free number. When the class number of $Q(\sqrt{\Delta})$ is divisible by 3 and if p is a prime with $(p,\Delta) = 1$;

i) f(x) will have exactly one linear factor modulo p if and only if p is not representable by any reduced binary quadratic form of discriminant $\Delta$.

ii) f(x) will have 3 linear factors modulo p if and only if p is representable by a form in a certain subset $\{Q_i\}$ of reduced binary quadratic forms of discriminant $\Delta$.

iii) f(x) will be irreducible modulo p if and only if p is representable by a reduced binary quadratic form of discriminant $\Delta$ not in $\{Q_i\}$.

Case i) was considered by Th. Skolem for arbitrary $\Delta$ prime to p. When $\Delta = -(27r^2+4q^3)$ is square free the class number of $Q(\sqrt{\Delta})$ appears always to be divisible by 3. (Received November 24, 1975.)

*76T-A46 George F. Clements, University of Colorado, Boulder, Colorado 80309. An existence theorem for antichains.

Let $k_1, k_2, \ldots, k_n$ be given integers, $1 \leq k_1 \leq k_2 \leq \ldots \leq k_n$, and let S be the set of vectors $\underline{x} = (x_1, \ldots, x_n)$ with integral coefficients satisfying $0 \leq x_i \leq k_i$, $i = 1,2,3,\ldots,n$. A subset H of S is an antichain (or Sperner family or clutter) if and only if for each pair of distinct vectors $\underline{x}$ and $\underline{y}$ in H the inequalities $x_i \leq y_i$, $i = 1,2,\ldots,n$, do not all hold. Let $|H|$ denote the number of vectors in H, let $K = k_1 + k_2 + \ldots + k_n$ and for $0 \leq \ell \leq K$ let $(\ell)H$ denote the subset of H consisting of vectors $\underline{h} = (h_1, h_2, \ldots, h_n)$ which satisfy $h_1 + h_2 + \ldots + h_n = \ell$.

In this paper we show that if $H$ is an antichain in $S$, then there exists an antichain $H'$ in $S$ for which $|(\ell)H'| = 0$ if $\ell < K/2$, $|(K/2)H'| = |(K/2)H|$ if $K$ is even and $|(\ell)H'| = |(\ell)H| + |(K-\ell)H|$ if $\ell > K/2$. The $k_1 = k_2 = \dots = k_n = 1$ special case of this theorem was conjectured by D. J. Kleitman and E. C. Milner [Discrete Mathematics 6(1973), p. 147] and was proved by D. E. Daykin, J. Godfrey and A. J. W. Hilton [J. Combinatorial Theory (A) 17(1974), Theorem 1, p. 245]. (Received November 24, 1975.)

*76T-A47 HOWARD KLEIMAN, Queensborough Community College, Bayside, N.Y. 11423.
On hamilton lines of planar graphs.

Call a graph simple if it is connected without loops, multiple edges, separating edges, or separating vertices. THEOREM 1. Let $G$ be a simple cubic planar graph of order $n$. Then $G$ has a hamilton line if and only if its dual graph $D$ is expressible as the triangulation of a maximal bipartite graph $B$ such that $D - E(B)$ has precisely two connected components. Furthermore, the number of hamilton lines of $G$ equals the number of distinct ways in which $D$ can be expressed in this manner. THEOREM 2. Let $G$ be a simple planar graph of order $n$ with $v_f$ faces. Then $G$ has a hamilton line if and only if the dual graph $D$ of $G$ is a subgraph of the triangulation $D'$ of a maximal bipartite planar graph $B(O',I')$ of order $v_f$ such that

(a) $|E(D \cap B)| = n$

and

(b) $D' - E(B)$ has precisely two connected components.

Furthermore, the number of hamilton lines of $G$ is precisely the number of ways in which $D$ can be expressed in such a manner. (Received November 25, 1975.)

*76T-A48 L. CARLITZ, Duke University, Durham, North Carolina 27706 and John H. Hodges, Clemson University, Clemson, South Carolina 29631. Enumeration of matrices of given rank.

By solving a two-term recursion formula, Brawley and Carlitz [J. Linear Algebra and Its Applications, 6(1973), 165-174] obtained a formula for the number $\phi(r,n,t,r+v)$ of $(n+m)\times t$ matrices $A^*$ of rank $r+v$, over a finite field $F$ of $q$ elements, whose last $m$ rows are those of a given matrix of rank $r$ over $F$. By use of similar methods, a three-term recursion formula is proved and solved to determine the number $\phi(r,n,t,u,r+v)$ of such matrices $A^*$ whose first $n$ rows constitute a matrix of rank $u$, $0 \leq u \leq n$. (Received November 26, 1975.)

*76T-A49 Robert H. LaGrange, University of Wyoming, Laramie, Wyoming 82071. On the cardinal sequence of a superatomic Boolean algebra.

The notion of cardinal sequence for a superatomic Boolean algebra is well known. It is natural to consider the problem of which (transfinite) sequences of cardinal numbers are cardinal sequences of Boolean algebras. Theorem: Let $C = \langle C_\alpha : \alpha < \beta \rangle$ be a sequence of cardinals with $\beta$ countable. There is a superatomic Boolean algebra whose cardinal sequence is $C$ if and only if

1) $\beta = \delta + 1$ for some $\delta$.
2) $C_\delta$ is finite and nonzero.
3) $\alpha < \delta$ implies $C_\alpha$ is infinite.
4) $\alpha < \gamma < \beta$ implies $C_\gamma \leq C_\alpha^{\aleph_0}$. (Received December 1, 1975.)

76T-A50 Gong-hwai Chen, William Paterson College, Wayne, N.J. 07470. On products of continuous self-maps on topological spaces. I.

A topological space $X$ is called retract extendable (RE) if any idempotent map $\rho' : A \cup B \to A$ on two disjoint retract subsets can be extended to an idempotent function $\rho : X \to A$. We denote $R(f)$=Range of the function and $Z(f)=X-R(f)$. Theorem 1. Let $Y$ be a retract subset of an RE-space $X$. Suppose $f$ is a continuous self-map on $X$ with which there are associated two proper idempotent functions $u$ and $v$ such that $f \circ v = f = u \circ f$ and $R(u)$ is homeomorphic to a retract of $Y$. Then (1) $f$ is a product of three idempotent functions if $Z(v)-R(u)$ contains a retract subset of $X$ which is homeomorphic to $Y$. (2) $f$ is a product of four idempotent functions if each of the two sets $R(v)-R(u)$ and $X-R(v)$ contains a retract subset of $X$ which is homemorphic to $Y$. Theorem 2. Suppose $X$ is one of the spaces: n-cube $I^n$, n-sphere $S^n$, space of real numbers, and 0-dimensional RE-space such that each non-empty open set $X$ contains a retract subset of $X$ which is homeomorphic to $X$ itself. Then a non-identity self-map is idempotentent generable if and only if it has a proper left unit and a proper right unit self-map. Theorem 3. Let $X$ be one of the spaces in Theorem 2, a non-identity regular self-map $f$ (i.e., $f \circ g \circ f = f$ for some $g$) on $X$ is

idempotent generable if and only if it is neither injective nor surjective. (Received December 1,1975) (Author introduced by H. Levinson.)

*76T-A51 THOMAS J. LAFFEY, University College Dublin, Ireland. Condition for an algebra of matrices to be normal. Preliminary report.

Let A,B be nxn (complex) matrices and let X be the algebra they generate over the field of real numbers. We have shown that X consists entirely of normal matrices if and only if A,B, AB, A+B and A+AB are all normal. This is used to show that if G is a finite group generated by a pair U,V of unitary matrices with U+V, U+UV normal then G has an abelian normal subgroup A with $[G : A]$ dividing $(60)^{19}.(12)^2.2$. The direct product of one copy of the quaternion group of order 8, two copies of SL(2,3) and nineteen copies of SL(2,5) can be generated by a pair U,V of 44 x 44 unitary matrices with U+V, U+UV normal, so this bound is best possible. (Received December 1, 1975.)

*76T-A52 Victor O. S. Olunloyo, University of Ibadan, Ibadan, Nigeria. Some observations on primality, admissibility and the natural number fifteen.

A certain property of the natural number 15 jointly discovered by the author leads to a near-characterisation of the primes. This and various classical characterisations are examined with respect to the multiplicative and additive structure of the natural number system. The logical status of admissibility and primality are critically examined. The connection with the Fundamental Theorem of Arithmetic and Mullin's theory on the existence of non-standard models are also treated. (Received December 2, 1975.) (Author introduced by Professor A. A. Mullin.)

*76T-A53 G.J. RIEGER, Techn. University, D-3 Hannover. Metric theory of continued fractions by nearest integers.

For continued fractions (by greatest integers), the corresponding shift operator is ergodic (Knopp (1926)) and for $0 \leq x < y \leq 1$ the measure $(\log 2)^{-1} \int_x^y (1+t)^{-1} dt$ is invariant (Gauss (1812)). For continued fractions by nearest integers, we prove: The corresponding shift operator is ergodic and for $-1/2 \leq x < y \leq 1/2$ the measure $(\log A)^{-1} \int_x^y \rho(t)dt$ is invariant, where $A := (1+\sqrt{5})/2$, $\rho(t) := (A+t)^{-1}$ $(0 \leq t \leq 1/2)$ and $\rho(t) := (A+1+t)^{-1}$ $(-1/2 \leq t < 0)$. According to Levy (1929), the formula $\int_0^1 (1+t)^{-1} \log t \, dt = -\pi^2/12$ is useful in metric theory of continued fractions. Instead we use $\int_{-1/2}^{1/2} \rho(t) \log|t| dt = -\pi^2/12$; this formula is a consequence of Abel's formula for Euler's dilogarithm. Now many metric results on continued fractions can be carried over to continued fractions by nearest integers. As in connection with Heilbronn's theorem (Abstract 75 T-A 138, these Notices 22(1975),A-448), very often only log 2 has to be replaced by log A. (Received December 2, 1975.)

*76T-A54 LAURENCE PINZUR, University of Illinois, Urbana, Illinois 61801. On a question of Rademacher concerning Dedekind sums.

Rademacher raised the following question at the Number Theory conference held in 1963 at the University of Colorado. Let $h_1/k_1$ and $h_2/k_2$ be consecutive Farey fractions with $s(h_1,k_1) > 0$ and $s(h_2,k_2) > 0$, where $s(h,k)$ denotes the ordinary Dedekind sum. Is it always true that $s(h_1+h_2, k_1+k_2) \geq 0$? The answer to this question is no, and the following pairs of Farey fractions are examples:

$$h_1/k_1 = [m+2,2,1], \quad h_2/k_2 = [m+2,2,1,m], \quad (m \in \mathbb{Z},\ m \geq 2).$$

Here $[a_1,\cdots,a_r]$ denotes the simple continued fraction expansion $[0;a_1,\cdots,a_r]$ with partial quotients $a_1,\cdots,a_r$. In fact, all such pairs of Farey fractions are characterized. (Received December 3, 1975.) (Author introduced by W. Philipp.)

76T-A55 PAUL C. EKLOF, Yale University, New Haven, Connecticut 06520. Ext in the constructible universe. Preliminary report.

Let $R$ be a countable hereditary ring and let $A,C$ be left $R$-modules such that $|A| = \kappa \geq \aleph_1$ and $|C| = \aleph_0$. Let $\lambda = cf(\kappa)$. Making use of ideas of Shelah [Is. J. Math. 18 (1974), 243-256, and these Notices 21 (1974), A-556] we prove the following results assuming the Axiom of Constructibility (V=L). (1) $Ext(A,C) = 0$ if and only if there is a continuous chain $\{A_\alpha:\alpha < \lambda\}$ of submodules of $A$ such that $Ext(A_0,C) = 0$ and $\forall\alpha < \lambda$, $|A_\alpha| < |A|$ and $Ext(A_{\alpha+1}/A_\alpha,C) = 0$; (2) $Ext(A,C) = 0$ if and only if for all $B \subseteq A$, there exists $B'$ such that $B \subseteq B' \subseteq A$, $|B'| = |B| + \aleph_0$ and $Ext(B',C) = 0 = Ext(A/B',C)$; (3) If $\lambda < \kappa$, $Ext(A,C) = 0$ if and only if $Ext(B,C) = 0$ for all $B \subseteq A$ such that $|B| < |A|$. Moreover for the case $R = \mathbb{Z}$, the ring of integers, we prove assuming $V = L$: (4) For any torsion group $T$ there is a countable torsion group $T'$ such that for any torsion-free $G$, $Ext(G,T) = 0$ if and only if $Ext(G,T') = 0$; $T'$ may be taken to be any torsion group whose Ulm invariants vanish precisely when the corresponding invariants of $T$ vanish. (1), (3) and (4) yield a solution to Problem 80 of L. Fuchs, Infinite Abelian Groups, vol. II (Academic Press, 1973), p. 214 (assuming $V = L$). For $R = \mathbb{Z}$, (1), (2) and (4) are not theorems of ZFC. For (3) the question is open. (Received December 5, 1975.)

*76T-A56 RABINDRA K. PATNAIK, Birla Institute of Technology and Science, Pilani, Rajasthan, 333031, India, The centre of a knot-like group.

Let $G$ be a knot-like group; that is $G \cong P = (x,a_1,\ldots,a_n;\ r_1,\ldots,r_n)$ with commutator quotient group, $G/G'$, infinite cyclic. If $P$ has at least three distinct generators then $G$ has a trivial centre. If $P$ has two distinct generators then the centre of $G$ is either trivial or infinite cyclic. The existence of nontrivial centre depends on the Alexander polynomial of $G$. (Received December 8, 1975.)

*76T-A57 E. C. Whitehead, Jr., University of Pittsburgh, Pittsburgh, Pennsylvania 15260. Non-periodic Autocorrelation of (+1,-1) Sequences.

It is shown that there are at most $f(n)$ distinct non-periodic autocorrelation function values on the (+1,-1) sequences of length $n$. For $n$ odd, $f(n) = \frac{1}{4}(2^n - 2^{\frac{1}{2}(n+1)}) + 2^{\frac{1}{2}(n-1)}$. For $n$ even, $f(n) = \frac{1}{4}(2^n - 2^{\frac{1}{2}n+1}) + 2^{\frac{1}{2}n}$. It is shown that if $n = n_1n_2\ldots n_k$ where $n_1,n_2,\ldots,n_k \geq 3$ and $k \geq 1$, then there exists a set of $2^{k+1}$ (+1,-1) sequences of length $n$, all members of which have the same non-periodic autocorrelation function value. (Received December 8, 1975.)

76T-A58 M. BHASKARAN, 9 - 18 Butterick Place, Girrawheen, W. Australia, 6064. Theory of genus field for any algebraic number field.

The genus field of any algebraic number field is described. The proof is not purely algebraic as it involves application of some density theorems. Previously, Ishida (J. Reine Angew Math. 268/269 ( 1974), pp. 165-173 ) described the genus field of an algebraic number field k when k satisfies the condition that for any rational prime p, (p) is not a p-th power of a k-divisor. This restriction is quite heavy in the sense that many of the number-theoretic problems are really difficult only when such a restriction is not imposed. The determination of genus field enables one to characterize rationally the principal genus of an arbitrary number field by a rational congruence group. Previously, Iyanaga and Tamagawa, Leopoldt, Fröhlich and Hasse discussed about principal genus for special cases such as cyclic, abelian or normal number fields. The results here indicate that many class field theoretic properties of normal number fields

could be extended to ordinary number fields. In particular, one may think of extending to any algebraic number field a recent criterion for 'Hasse principle' to hold.

(Received December 8, 1975.)

76T-A59 Robert E. Jamison, Institut für Angew. Math., Universität Bonn, 53 Bonn, Wegelerstr. 6. P-adic convexities. Preliminary report.

The concept of convexity admits a natural extension to vector spaces over p-adic fields via the notion of an algebraic interval -- which substitutes for the unit order interval in the real line. In any ring A with 1, a subset I is called an algebraic interval provided 0 is in I, 1-x is in I if x is in I, and xy is in I for each x and y in I. In any module over A, convexity can be defined in the expected way. Let $Q_p$ denote the field of p-adic numbers, $Z_p$ the p-adic integers, and $O_p$ the unique maximal ideal in $Z_p$. Then any compact interval in $Q_p$ is one of the following: i) $Z_p$, ii) $(O_p)^n$ $(1+(O_p)^n)$, iii) $\{0,1\}$. Analogues of the classical theorems of Carathéodory, Helly, and Radon for convex sets in real vector spaces can be proved for the interval convexities in vector spaces over $Q_p$. (Received December 8, 1975.)

*76T-A60 Antonio M. Lopez, Jr., Clemson University, Clemson, South Carolina 29631. A Note on the S-endomorphism Semigroup and Singular Congruence.

In studying S-systems with zero, $M_S$, E.H. Fellers and R.L. Gantos (Math. Nachr. 41, (1969) 37-48) considered the S-endomorphism semigroup, $\mathrm{Hom}_S(M,M)$, and defined a congruence $\eta$ on $\mathrm{Hom}_S(M,M)$ called the singular congruence. They showed that if $M_S$ is $\cap$-uniform then the factor semigroup $\mathrm{Hom}_S(M,M)/\eta$ is a right cancellation semigroup with zero. They asked the following question: In what case is $\mathrm{Hom}_S(M,M)/\eta$ also a left cancellation semigroup with zero? We propose the following:

Theorem Let $K=\mathrm{Hom}_S(M,M)$, where $M_S$ is $\cap$-uniform. If for all nonzero mappings $k \in K$ there exists a nonzero subsystem A of M such that on A, k is one-to-one and A is K-invariant then $K/\eta$ is a left cancellation semigroup with zero. (Received December 5, 1975.)

*76T-A61 **Naseem Ajmal, University of Delhi, Delhi, India 110 007.** **Intertwined groupoids and quasigroups. Preliminary report.**

**We have established a necessary and sufficient condition for an isotope of a given groupoid to be a semigroup or group, without assuming the presence of an identity element in the given groupoid. We have introduced the concepts of intertwined groupoids and intertwined quasigroups, in the course of deriving the conditions. We also deduce some important consequences of these concepts.**

(Received December 8, 1975.) (Author introduced by Professor S. K. Jain)

76T-A62 WITHDRAWN

76T-A63 G.V. CHOODNOVSKY, Tarasovskaya 10a, ap. 17, 252033, USSR. On Schanuel's hypothesis. Three algebraically independent numbers. I.

Let $\alpha_1,\ldots,\alpha_N$ and $\beta_1,\ldots,\beta_M$ be sequences from $C^N$ and $C^M$ with the following property. If $\bar{x} \in Z^N \setminus \{\bar{0}\}$ and $\bar{y} \in Z^M \setminus \{\bar{0}\}$, then $|(\bar{x},\bar{\alpha})| \geq \exp(-\tau_0 \|\bar{x}\|)$ and $|(\bar{y},\bar{\beta})| \geq \exp(-\tau_0 \|\bar{y}\|)$ for a constant $\tau_0 > 0$, where $(\cdot,\cdot)$ and $\|\cdot\|$ are a scalar product and a norm in $C^N, C^M$. Theorem 1. If $MN \geq 3.5(M+N)$, then in $S_1 = \{e^{\alpha_i \beta_j} : 1 \leq i \leq N,\ 1 \leq j \leq M\}$, there are 3 algebraically independent (a, i) numbers. Theorem 2. If $M(N+1) \geq 3.5(M+N)$, then in $S_2 = \{\beta_j, e^{\alpha_i \beta_j}\}$ there are 3 a. i. numbers. An analogical result takes place, if $MN \geq 2.5(M+N)$ is assumed and $S_2$ is substituted by $S_3 = \{\alpha_i, \beta_j, e^{\alpha_i \beta_j}\}$. An assumption on a measure of linear independence of $\alpha_i$ and $\beta_j$ in Theorem 2 can be omitted. (Received December 10, 1975.)

*76T-A64 ROBERT SPIRA, 4515 Chippewa Dr, Okemos, MI 48864. Some problems on the Riemann zeta function.

Problems and results on: 1) relations of the roots of the zeta function with logs of primes, 2) zero-free regions, 3) zeros of trigonometric integrals. (Received December 12, 1975.)
(Author introduced by Pat Doyle.)

*76T-A65 G.T. RÜTTIMANN, University of Massachusetts, Amherst, Mass.01002. The Jauch-Piron Condition in Finite Orthomodular Lattices. (pr.rep.)

Let $\{L,\leq,'\}$ be an orthomodular lattice. The set of states $\Omega(L)$ on L is said to be strong if $\{\mu\epsilon\Omega|\mu(x)=1\}\subseteq\{\mu\epsilon\Omega|\mu(y)=1\}$ implies that $x\leq y$. A state $\mu\epsilon\Omega(L)$ is called Jauch-Piron if $\mu(x)=\mu(y)=1$ implies that $\mu(x\wedge y)=1$.

Theorem: Let $\{L,\leq,'\}$ be a finite orthomodular lattice. Then $\Omega(L)$ is strong and every state $\mu\epsilon\Omega(L)$ is Jauch-Piron if and only if $\{L,\leq,'\}$ is Boolean.

Let H be a (complex or real) Hilbert space; denote $E^{\perp}:=1 - E$ for E a projection on H. An orthocomplemented sublattice $\{P,\leq,^{\perp}\}$ of projections in H is said to have the Gleason property provided for every $\mu\epsilon\Omega(P)$ there exists a von Neumann density operator W such that $\mu(E)=\mathrm{Tr}(WE)$ for all $E\epsilon P$.

Corollary: Let $\{P,\leq,^{\perp}\}$ be a finite orthocomplemented sublattice of projections in H. Then $\{P,\leq,^{\perp}\}$ has the Gleason property if and only if the elements of P commute pairwise. (Received December 12, 1975.)

76T-A66 PAUL EKLOF , Yale University, New Haven, Connecticut 06520 and ALAN MEKLER, Stanford University, Stanford, California 94305. Some independence results in group theory. Preliminary report.

If $\kappa$ is an uncountable cardinal, say that an abelian group A is strongly $\kappa$-free (or A is $L_{\infty\kappa}$-free) if every subset of A of cardinality $<\kappa$ is contained in a $\kappa$-pure free subgroup of A of cardinality $<\kappa$. Extending methods of Shelah we prove: Theorem 1. (V = L). If $\kappa\geq\aleph_1$ is regular but not weakly-compact there are $2^{\kappa}$ indecomposable strongly $\kappa$-free groups of cardinality $\kappa$. Theorem 2. (V = L). If $\kappa$ is a regular cardinal and A is a $\kappa$-free group of cardinality $\kappa$ which is not free, then $\mathrm{Ext}(A,\mathbb{Z})$ has cardinality $2^{\kappa}$. Theorem 3. $(MA + 2^{\aleph_0}>\aleph_1)$. If A is a strongly $\aleph_1$-free group of cardinality $\aleph_1$ then A is $\aleph_1$-separable and $\mathrm{Ext}(A,\mathbb{Z}) = 0$. By a result of Howard Hiller, it follows from Theorem 2 that it is consistent with ZFC that for any $n\geq 2$ there is no topological space X such that $H^n(X,\mathbb{Z})\cong\mathbb{Q}$, the group of rationals (cf. Kan-Whitehead, Proc. Amer. Math. Soc. v. 12 (1961), pp. 24-25). (Received December 17, 1975.)

76T-A67 M.N. PICCININI, 20 Bonavista Street, St. John's, Nfld., Canada. R-Automorphisms of Twisted Polynomial Rings, Preliminary report.

Let R be a commutative ring with a regular element, $\alpha$ an automorphism of R and T the total quotient ring of R. Then $\mu$ is an R-endomorphism of the twisted polynomial ring $R_\alpha[x]$ if and only if $\mu$ is a substitution map $g_t$ defined by $\sum r_i x^i \longrightarrow \sum r_i t^i$ where $r_i\epsilon R$ and $t= t_o+t'x$ is a polynomial in $T_\alpha[x]$ satisfying $t_i\epsilon\{s\epsilon T|\ s(\alpha^{i-1}(r)-r) = 0\ \forall r\epsilon R\}$ and $Rt_i\subseteq R$ for each $i\geq 0$. In this case, the following are equivalent: 1) $g_t$ is a monomorphism; 2) $t'$ is left regular in $T_\alpha[x]$; 3) $\bigcap_{i\geq 1}\{s\epsilon T|st_i= 0\} = \{0\}$. Also the following are equivalent: 1) $g_t$ is an epimorphism, $g_t$ is an automorphism; 3) $t'$ is a unit in $T_\alpha[x]$ and $Rt_1 = R$; 4) $t_1\epsilon T^*$, $t_i$ is nilpotent $\forall i\geq 2$ and $Rt_1 = R$. In the case of $\alpha$ being the identity on R, this result has been proved by R.W. Gilmer [MR 43, # 7453] ; it has also been proved in some special cases by J.B. Castillon [MR 43, #7453]. (Received December 18, 1975.)

*76T-A68 TIMOTHY P. DONOVAN, University of Colorado, Boulder, Colorado 80302. Quadratic residues for $3\times 3$ scalar matrices.

This paper demonstrates that, for p an odd prime, the $3\times 3$ scalar matrix $A\equiv\mathrm{diag}(k,k,k)\pmod p$ is a quadratic residue mod p if and only if k is itself a quadratic residue mod p. This is done by extracting from the matric congruence $(x_{ij})^2\equiv A\pmod p$ simultaneous congruences in four of the variables $x_{ij}$ and delineating into cases according to the rank of the coefficient matrix. The article further shows that every $n\times n$ scalar matrix with n even is a quadratic residue mod p with p again an odd prime. (Received December 19, 1975.) (Author introduced by John H. Hodges.)

76T-A69 **DAVID ZEITLIN, 1650 Vincent Ave. North, Minneapolis, Minnesota, 55411. Parametric solutions for two equal sums of 2n+2 cubes.**

For each n, let $P_i > 0$, $i = 1,2,\ldots,n$, be distinct integers such that $S = \sum_{i=1}^{n} P_i^3$ is an odd integer. For integers I, J, and $k=0,1,\ldots$, set $W_k = IU_{k+1} + JU_k$, where $U_0=0, U_1=1$, and $U_{k+2}=U_{k+1}+RU_k$ with $2R+1=S$. Then, for $k=0,1,\ldots$, the two equal sums of 2n+2 cubes are given by (*)

$$(4W_{k+4})^3+((S-1)^2W_k)^3+\sum_{i=1}^{n}((2S-2)P_iW_{k+1})^3+\sum_{i=1}^{n}(8P_iW_{k+2})^3 = \sum_{i=1}^{n}(4P_iW_{k+3})^3+\sum_{i=1}^{n}(4P_iW_{k+2})^3 +$$

$$((2S+6)W_{k+2})^3+((2S-6)W_{k+2})^3.$$

Moreover, the two sums of the base variables are equal for all n and k. Ex. 1. Since $2U_3=1+S$, $U_4=S$, $4U_5=S^2+4S-1$, we obtain from (*) for k = 0 the identity

$$(IS^2+4S(I+J)-I)^3+(I(S-1)^2)^3+\sum_{i=1}^{n}(P_i(I+J)(2S-2))^3+\sum_{i=1}^{n}(4P_i(IS+I+2J))^3 = \sum_{i=1}^{n}(2P_i(J+S(2I+J)))^3 +$$

$$\sum_{i=1}^{n}(2P_i(IS+I+2J))^3+(IS^2+(4I+2J)S+3I+6J)^3+(IS^2+(2J-2I)S-3I-6J)^3.$$

For $J=0, I\neq 0, n=1, S=P^3$, we obtain

$$(P^6+4P^3-1)^3+((P^3-1)^2)^3+(2P^4-2P)^3+(4P^4+4P)^3=(4P^4)^3+(2P^4+2P)^3+(P^6+4P^3+3)^3+(P^6-2P^3-3)^3.$$

For n=1,

$$(IP^6+4P^3(I+J)-I)^3+(I(P^3-1)^2)^3+((I+J)(2P^4-2P))^3+(4IP^4+(4I+8J)P)^3=((4I+2J)P^4+2JP)^3 +$$

$$(2IP^4+(2I+4J)P)^3+(IP^6+(4I+2J)P^3+3I+6J)^3+(IP^6+(2J-2I)P^3-3I-6J)^3,$$

which has three parameters. Each value of k in (*) gives a new family of identities. (Received December 22, 1975.)

*76T-A70 Michael Rich, Temple University, Philadelphia, Pa. 19121. The Levitzki radical in alternative rings.

Let A be an alternative ring and $A^q$ its attached quadratic Jordan ring. Then

Theorem: If A is finitely generated then $A^q$ is finitely generated.

We use the above result to prove the following theorem, where L denotes the Levitzki radical (the maximal locally nilpotent ideal).

Theorem: $L(A) = L(A^q)$ (Received January 2, 1976.)

*76T-A71 BRIAN A. DAVEY, La Trobe University, Bundoora, Victoria, Australia, 3083. Subdirectly irreducible distributive double p-algebras.

Let A be a distributive double p-algebra, let $\Phi$ be the congruence given by $a \equiv b\ (\Phi) \Leftrightarrow (a^* = b^* \ \&\ a^+ = b^+)$, let $K(A)$ be the lattice of congruences, let $D(A)$ be the dense set of A, and $\bar{D}(A)$ the dually dense set of A. An extrinsic characterization of the simple and the subdirectly irreducible (s.i.) algebras is given, which, in the finite case, yields the results below. Let $J(A)$ be the poset of nonzero join-irreducibles of A, and let Min(A) and Max(A) be respectively the minimal and maximal elements of $J(A)$. THEOREM 1. T.F.A.E. (i) A is simple; (ii) $J(A)$ is connected and $J(A) = \mathrm{Min}(A) \cup \mathrm{Max}(A)$; (iii) either $|A| = 2$ or A has trivial centre and the join of the atoms of A equals the meet of the dual atoms of A; (iv) either $|A| = 2$ or A has trivial centre and $|D(A) \cap \bar{D}(A)| = 1$; (v) A has trivial centre and $\Phi$ equals $\omega$; (vi) $|K(A)| = 2$. □ THEOREM 2. T.F.A.E. (i) A is s.i. but not simple; (ii) $J(A)$ is connected and there exists a unique element x such that $J(A) = (\mathrm{Min}(A) \cup \mathrm{Max}(A)) \cup \{x\}$; (iii) $|A| > 3$, A has trivial centre, and the join of the atoms of A is covered by the meet of the dual atoms of A; (iv) A has trivial centre and $|D(A) \cap \bar{D}(A)| = 2$; (v) A has trivial centre and $\Phi$ covers $\omega$; (vi) $|K(A)| = 3$. □ Counterexamples are given to show that these results do not lead to characterizations in the infinite case. Condition (iii) of both theorems is due to R. Freese and A. Romanowska. I would like to thank Professor Freese for providing counterexamples to the incorrect results which I announced earlier (Abstract 75T-A268, these *Notices* 22(1975), A-707). (Received January 2, 1976.)

*76T-A72 Henrik Bresinsky, University of Maine, Orono, Maine 04473 and Michael J. Fuller, University of Maine, Orono, Maine 04473. On minimal bases of polynomial ideals.

Let K be an infinite field, and let $R = K[x_1,\cdots,x_n]$ be the polynomial ring, in a finite number of variables, over K. Definition 1. Let A be an ideal of R, then the set $\{g_1,\cdots,g_m\} \subseteq R$ is a minimal basis of A if (i) $A = (g_1,\cdots,g_m)$, and (ii) for any i, $1 \leq i \leq m$, $(g_1,\cdots,g_{i-1},g_{i+1},\cdots,g_m) \subsetneq A$. Definition 2. Let A be an ideal of R, then the set $\{g_1,\cdots,g_m\} \subseteq R$ is a basis of minimal length of A if (i) $\{g_1,\cdots,g_m\}$ is a minimal basis of A, and (ii) if $\{f_1,\cdots,f_k\}$ is a minimal basis of A, then $m \leq k$. Theorem. Let A be a nonzero ideal of R, let $\{g_1,\cdots,g_m\}$ be a basis of minimal length of A. For every integer $k \geq m$ there exists a minimal basis $\{f_1,\cdots,f_k\}$ of A. (Received January 2, 1976.)

*76T-A73 DAVID BALLEW, South Dakota School of Mines and Technology, Rapid City, SD 57701. Pythagorean Triples and the Sum of Three Squares

We prove that an integer whose square is the sum of squares of two consecutive integers is itself the sum of squares of three integers of which at least two are consecutive. More formally.

Theorem Let $z^2 = x^2 + y^2$ with $|x-y| = 1$. Then there are integers t, u, v such that $z = t^2 + u^2 + v^2$ with $|u-v| = 1$. In fact, $t = zab$, $u = a^2 + 2ab$, $v = 2b^2 + 2ab$ for integers a and b. Conversely, if such t, u, v exist, then integers x and y exist such that $z^2 = x^2 + y^2$ with $|x-y| = 1$.

(Received January 5, 1976.)

# Analysis

*76T-B21 **Alexander G. Ramm, Institute of Fine Mechanics and Optics, Leningrad 197101. Boundary value problem of the Zaremba type.**

**Consider the problem $\Delta u = 0$ in D, $\partial u/\partial N|_{\Gamma_2} = f_2$, $u|_{\Gamma_1} = f_1$ (1), where D is a bounded domain in $R_3$ with the smooth boundary $\Gamma = \Gamma_1 \cup \Gamma_2$, the functions $f_j(x)$, $j = 1,2$ are supposed to be continuous. Consider also the problem $\Delta v = 0$ in D, $\partial v/\partial N + h(s) v|_{\Gamma} = F$ (2), where**

$$h(s) = \begin{cases} 0, & s \in \Gamma_2 \\ h, & s \in \Gamma_1 \end{cases}, \quad F = \begin{cases} f_2, & s \in \Gamma_2 \\ f_1, & s \in \Gamma_1 \end{cases}, \quad h = const > 0.$$

**Theorem. The following estimates hold: $\|u - v\|_{W_2^1(\mathcal{D})} \le C h^{-1}$, $h \to +\infty$, C = const does not depend on h; $\|u - v\|_{W_2^2(\tilde{\mathcal{D}})} \to 0$, $h \to +\infty$, $\tilde{\mathcal{D}}$ Being an arbitrary strict inner subdomain of D. /A.G. Ramm, Diff. Uravnenija, 9, (1973), 2075-2079/ an iterative process is given to calculate the solution of problem (2). The theorem shows this process is applicable to calculate the solution of problem (1) with the necessary accuracy. The results are of practical use in the heat transfer theory.** (Received May 30, 1975.)

76T-B22 S. ZAIDMAN, Université de Montréal, Montréal 101, Canada. Some inequalities for Kohn-Nirenberg pseudo-differential operators.

We consider nonhomogeneous symbols $a(x,\xi)$ as defined in Kohn-Nirenberg's well-known paper and the associated operator $\mathcal{A}(x,D)$ acting in $L^2$ or $H^s$ space. We prove that, at least in some special cases, the so-called Gohberg Lemma (as exposed in Andreotti's Lecture Notes, Pisa, 1967) can be extended from the usual pseudo-differential operators corresponding to regular homogeneous symbols to this more general setting.

(Received October 17, 1975.)

*76T-B23 RHONDA J. HUGHES, Tufts University, Medford, Massachusetts 02155. Semi-groups of unbounded linear operators in Banach space. II.

The theory of semi-groups of unbounded linear operators developed in part I (see these Notices, June 1975) is applied in the case of a one-parameter family $\{T_t\}_{t>0}$ of closed, densely-defined linear operators acting in a Banach space X. It is assumed that there exists a family of projections $\{P_N\}_{N\in Z^+}$ on X such that (i) for each $x \in X$, $\|P_N x - x\| \to 0$ as $N\to\infty$, and (ii) $P_N P_M = P_M$ if $M \le N$; moreover, (i') $\bigcup_{n\in Z^+} P_N X \subset D$, a suitable subspace of $\bigcap_{t>0}$ Domain$(T_t)$, and (ii') for each $t>0$, $N\in Z^+$, $T_t P_N x = P_N T_t x$, for $x \in$ Domain$(T_t)$. Theorem. The infinitesimal generator A of $\{T_t\}_{t>0}$ is a closable, densely-defined operator which uniquely determines the semi-group $\{T_t\}_{t>0}$. A Hille-Yosida type theorem is proved, and $\bar{A}$ (the closure of A) is characterized as a limit of certain closed operators in X. An application to semi-groups of unbounded scalar type operators with real spectrum is given, and it is shown that, under certain conditions, $T_t = e^{tB}$, where B is an unbounded scalar type operator with real spectrum; moreover, $B = \bar{A}$. (Received October 21, 1975.)

*76T-B24 ALBERT A. MULLIN, 6840 Todd, Patton Park, Ft. Hood, Texas 76544 Common fixed lattice points for families of mappings

Let B(n, r) be an origin-centered n-dimensional ball of radius $r \ge 1$ in real Euclidean space $E^n$, $n \ge 2$. Clearly, there exists a homeomorphism H of B(n, r) onto itself whose only fixed point is a highly visible lattice point of $E^n$; lattice point is used in the sense of Minkowski's Gitterpunkt. Lemma. Suppose S is any mapping of B(n, r) into itself which commutes with H; surely such

$S \neq H$ exists. Then H and S have a common fixed highly visible lattice point of $E^n$. Problem 1. Let C be a non-empty convex subset of a normed linear space N with origin $\Theta$. Let F be a non-empty commuting family of continuous mappings of C into C. What are necessary and sufficient conditions on F to guarantee the existence of a common fixed lattice point $p \neq \Theta$ for all members of F? Problem 2. Suppose N is restricted to be an inner product space. How must the conditions of problem 1 be changed to guarantee the existence of a common fixed lattice point $q \neq \Theta$ for all members of F? Applications to the problem of the existence of solutions of diophantine equations are discussed informally using the above techniques of functional analysis.

(Received October 29, 1975.)

*76T-B25 Leonard J. Gray, Union Carbide Corp., Nuclear Div., Computer Sciences Div. at Oak Ridge National Laboratory, Oak Ridge, TN 37830. On Bi-quasitriangular Operators. Preliminary report.

Let N denote the set of nilpotent operators on a separable Hilbert space, and let $N_c$ denote those $T \in N$ such that $T^k$ has closed range for all k. Independently, the author and Lawrence Williams have shown that every $T \in N_c$ is similar to a Jordan operator. Thus, $T \in N_c$ is bi-triangular (T and $T^*$ are triangular). We have shown:

Theorem 1: $N_c$ is norm dense in N.

Using a result of Voiculescu (Rev. Roum. Math. Pures et Appl., 19, 1974, pp. 371-378) and Theorem 1, we obtain:

Theorem 2: The norm closure of bi-triangular operators is equal to the set of bi-quasitriangular operators. (Received October 31, 1975.)

*76T-B26 ANDREAS BLASS, University of Michigan, Ann Arbor, Michigan 48104 and GARY WEISS, University of Cincinnati, Cincinnati, Ohio 45221. Sum Decomposition of Operator Ideals.

We develop a new characterization of operator ideals and use it to prove the following theorem. Theorem. Assume the Continuum Hypothesis. Let I be a (two-sided) ideal in the algebra of bounded linear operators on a separable, complex Hilbert space. If I properly contains the ideal of finite-rank operators, then I properly contains two ideals whose sum is I. The special case, I = the ideal of compact operators, solves, modulo the Continuum Hypothesis, a problem of Brown, Pearcy, and Salinas (Michigan Math. Journal, 18(1971)pp. 373-384). (Received October 31, 1975.)

76T-B27 Richard J. Easton, Indiana State University, Terre Haute, Indiana 47809
On Vector Measures I.

Let T be any set, A-ring of subsets of T, $\phi \in A$, E, F, l.c.t.v.s. with topologies $P=\{p\}$, $Q=\{q\}$ respectively, L(E,F) space of continuous linear maps from E to F with topology $R=\{r_{pq}\}$ where $r_{pq}(u)=\sup\{q(u(x)):p(x)\leq 1\}$. Let $m: A\to L(E,F)$, additive. Definitions: pq-semivariation of m; $\tilde{m}_{pq}(B)=\sup\{q(\sum_I m(A_i)x_i):I$ finite, $\{A_i\}$ partition of $B, A_i \in A$, $p(x_i)\leq 1\}$. pq-variation of m; $\bar{m}_{pq}(B)=\sup\{\sum_I r_{pq}(m(A_i)): I$ finite, $\{A_i\}$ partition B, $A_i \in A\}$. m is a pq-measure if for every $\{A_i\}\subset A$, $\{A_i\}\downarrow$, $A=\bigcup_1^\infty A_i \in A$, $r_{pq}(m(A)-\sum_1^n m(A_i))\to 0$ as $n\to\infty$. m is a vector measure if m is a pq-measure for every $p\in P$, $q\in Q$. m is pq-variational semiregular (pq-v.s.r.) if $\{A_n\}\subset A$; $\{A_n\}\searrow\phi$, then $\tilde{m}_{pq}(A_n)\to 0$. Lemma 1 $\tilde{m}_{pq}(B)=\sup\{r_{pq}(x):x\in$ balanced convex hull $m(A_B)\}=\sup\{\bar{m}_{x^*}(B):x^*\in U^Q_{pq}\}$. Lemma 2 If m is a pq-measure, then $m_1:A\to R^1$, $m_1(E)=\sup\{r_{pq}(x):x\in m(A_E)\}$ satisfies $m_1(E)\leq\tilde{m}_{pq}(E)\leq 2m_1(E)$. Both $m_1$ and $\tilde{m}_{pq}$ are bounded, positive, and $\sigma$-subadditive. Lemma 3 If m is a pq-measure, then m is pq-v.s.r. (Received November 6, 1975.)

76T-B28 V. Karunakaran, Ramanujan Institute, University of Madras, Madras-5. A certain generalization of functions with positive real part in the theory of univalent functions. Preliminary report.

Let p(z) be regular in the unit disc $E = \{z: |z| < 1\}$. Write $p(z) \in P(k, \alpha, \rho)$ iff $p(0) = 1$ and

$\int_0^{2\pi}|\mathrm{Re}\{[e^{i\alpha}p(re^{i\theta})-\rho]/[\cos\alpha-\rho]\}|\,d\theta \le k\pi$ where $|z| = r < 1$, $\rho$, $\alpha$ real and k an integer satisfying $|\alpha| < \pi/2$, $0 \le \rho < \cos\alpha$, $k \ge 4$. Besides certain properties of the class $P(k, \alpha, \rho)$, we obtain the exact lower bound on each $|z| = r$ of $\mathrm{Re}\{Cp(z) + zp'(z)/p(z)\}$ for $p(z) \in P(k, 0, \rho)$, $\rho \le 1/2$ and just a lower bound for the same in case $\rho > 1/2$. These estimates, obtained without appeal to variational techniques, are applied to solve certain interesting problems in the theory of schilcht functions. (Received November 11, 1975.) (Author introduced by Michael R. Ziegler.)

*76T-B29 M. R. Ziegler, Marquette University, Milwaukee, Wisconsin 53233, and V. Karunakaran, Ramanujan Institute, University of Madras, Madras-5. The radius of starlikeness for a class of functions regular in the unit disc.

Let $\mathcal{F}_1(\alpha, \gamma, c)$ denote the family of regular functions $F(z)$ which satisfy the equation $F(z) = [(c + 1)/g(z)^c] \int_0^z t^{c-1}f(t)dt$ where $g(z) = z + \cdots$ is starlike of order $\gamma$, $f(z) = z + \cdots$ is starlike of order $\alpha$, $c \ge 0$ and $|z| < 1$. Let $\mathcal{F}_2(\alpha, \gamma, c)$ denote the family of regular functions $f(z)$ which satisfy the equation $z^{c-1}(c + 1)f(z) = [F(z)g(z)^c]'$ where $g(z) = z + \cdots$ is starlike of order $\gamma$, $F(z) = z + \cdots$ is starlike of order $\alpha$, $c \ge 0$ and $|z| < 1$. In this paper the radius of $\beta$-starlikeness of $\mathcal{F}_2(\alpha, \gamma, c)$ and a lower bound on the radius of $\beta$-starlikeness of $\mathcal{F}_1(\alpha, \gamma, c)$ are determined. (Received November 12, 1975.)

76T-B30 Jeffrey P. Jones, Brown University, Providence, Rhode Island 02912 Generators of A(D). Preliminary Report.

Let D be the unit disc, A(D) the algebra of functions continuous on D, holomorphic on $D^{\circ}$. For F, G $\in$ A(D), denote by [F,G] the uniformly closed subalgebra of A(D) containing the constants which is generated by F and G. Assume F and G are smooth on D and separate points on D. It is known that if in addition for each $z \in D$ either $F'(z) \neq 0$ or $G'(z) \neq 0$, then $[F,G] = A(D)$. Theorem: There exists $H \in A(D)$ such that H is smooth on D, and $[(z-1)^3, H] \neq A(D)$. H is constructed so that $H(z) - H(z^*)$ has a singular inner factor on a subregion of D, where z and z* are points in D which are identified under $(z-1)^3$. (Received November 14, 1975.)

76T-B31 Leonard Sarason, University of Washington, Seattle, Washington 98195. Weak equals strong and second differentiability with corners. Preliminary report.

With $A_j$ symmetric, $j = 1,\cdots,n$, let $L = \Sigma A_j(x)\partial/\partial x_j + C(x)$ be a first order N by N system of partial differential operators acting in the quarter space $\{x:x_1>0,x_2>0\}$. Weak and strong extensions $L_w$ and $L_s$ of L are restricted to functions with $L_2$ boundary values. I. Theorem. If $n = 2$, if the $A_j$'s are in $C^N$, and if C is in $L_\infty$, then $L_w = L_s$. II. Conditions are given under which the solutions of dissipative problems together with their boundary values are in $H^2$ whenever the data are. If $n > 2$, these conditions are expressed by pseudo-differential operators. (Received November 17, 1975.)

*76T-B32 Jeng-Eng Lin, Brown University, Providence, Rhode Island 02912. Decay of Solutions of a Nonlinear Schrödinger Equation. Preliminary report.

Consider a $C^3$ solution $U(x,t)$ of $iU_t+\Delta U-h(|x|)|U|^2U=0$, $U(x,0)=A(x)$, $x\in R^3$. Assume $A\in C^3\cap H^3\cap L^1$, $h\in C^1$, $h\geq 0$, $h_r\leq 0$, and h and $h_r$ are bounded. If $U(t)\in H^3(R^3)$ and $D_x^\alpha U$ are bounded in x for each $t\geq 0, |\alpha|\leq 3$, then (1) $U(x,t)$ is uniformly bounded in all space-time. (2) If $\lim_{|x|\to\infty} h(|x|)=0$, then:

$$\sup_x |U|(x,t) \le \frac{\text{constant}}{(1+t)^{\frac{3}{2}}} \qquad \text{for all } t\geq 0.$$

(Received November 17, 1975.)

*76T-B33 ROBERT CARROLL, University of Illinois, Urbana, Illinois 61801. A uniqueness theorem for EPD type equations in general spaces.

Consider the EPD (Euler-Poisson-Darboux) equation $w^m_{tt} + ((2m+1)/t)\, w^m_t = A^2 w^m$ with $w^m(0) = e \in D(A^2)$ and $w^m_t(0) = 0$, where $E$ is a complete separated locally convex space and $A$ generates a locally equicontinuous group $T(t)$ in $E$. Existence of a solution is known for this problem, and other group theoretic analogues, by results of the author. One can now assert uniqueness as well for this type of problem. (Received November 17, 1975.)

76T-B34 WILLIAM D. L. APPLING, North Texas State University, Denton, Texas 76203. Mean Integrals and Continuity

All integrals considered are limits, for refinements of subdivisions, of the appropriate sums. For each interval $[a,b]$ and function $f$ from $[a,b]$ into $\mathbb{R}$, $f^{(R)}$ and $f^{(L)}$ denote, respectively, $\{([p,q],f(q)) : a \le p < q \le b\}$ and $\{([p,q],f(p)) : a \le p < q \le b\}$. Suppose $N$ is a positive integer, for $j = 1,2,\ldots,N$, $[s_j,t_j]$ is an interval, and $g$ is a function from $[s_1,t_1] \times \cdots \times [s_N,t_N]$ into $\mathbb{R}$. Then $g$ is continuous iff if $a < b$, $h$ is a function from $[a,b]$ into $\mathbb{R}$ having bounded variation and for $j = 1,2,\ldots,N$, $f_j$ is a function from $[a,b]$ into $\mathbb{R}$ and each of $r_j$ and $\ell_j$ is a non-zero number such that $\int_{[a,b]}[r_j f_j^{(R)}(I) + \ell_j f_j^{(L)}(I)]dh$ exists, then for each $r$ and $\ell$ in $\mathbb{R}$, $\int_{[a,b]}[rg(f_1^{(R)}(I),\ldots,f_N^{(R)}(I)) + \ell g(f_1^{(L)}(I),\ldots,f_N^{(L)}(I))]dh$ exists. (Received November 17, 1975.)

*76T-B35 F. BOMBAL GORDÓN and J. L. G. LLAVONA, University of Madrid, Madrid-3, Spain. Differentiable function spaces. Preliminary report.

Let $E$ be a real Banach space, $X$ a real locally convex space and $C^n_c(E,X)$ the space of $n$ times continuously differentiable functions in the sense of Hadamard ($\mathcal{L}^p(E,X)$, $0 \le p \le n$, with the compact topology). We consider in $C^n_c(E,X)$ the topology defined by the following base of neighborhoods of zero: $T(K,V) = \{f \in C^n_c(E,X) : D^p f(K)(K^p) \subset V,\ 0 \le p \le n\}$, where $K$ runs over the compact sets of $E$ and $V$ belongs to a base of neighborhoods of zero in $X$. Theorem 1. If $X$ is complete then $C^n_c(E,X)$ is complete and $C^n_c(E,X) = C^n_c(E)\epsilon X$. ($X\epsilon Y$ denotes the Schwartz $\epsilon$-product ("Théorie des distributions à valeurs vectorielles". I, Ann. Inst. Fourier (Grenoble) 7(1957), 1-139).) Theorem 2. The following sentences are equivalent: (i) $E$ verifies the approximation property. (ii) $C^n_c(E) = C^n_c(E,R)$ verifies the approximation property. (iii) $C^n_c(E,X)$ verifies the approximation property for each complete space $X$, which satisfies the approximation property. (Received November 17, 1975.) (Author introduced by Alfanso Casal.)

*76T-B36 Dennis D. Berkey, Boston University, Boston, Mass., 02215. A Method of Successive Approximations for the General Solution of a Linear Periodic Differential System.

Let $C$ and $D(t)$ denote $m \times m$ complex matrices and denote by $P(t)e^{Bt}$ the fundamental matrix solution of the differential equation

$$x'(t) = (C + D(t))x(t) \qquad D(t+\omega) = D(t),\ t\epsilon(-\infty,\infty)$$

whose existence is guaranteed by Floquet's Theorem. A method of successive approximations for computing $P(t)$ and $B$ is given which is shown to converge uniformly under the conditions $||D||$ small and $\lambda_j - \lambda_k \neq 2n\pi i\omega^{-1}$, $n = \pm 1, \pm 2, \ldots$ for any two eigenvalues $\lambda_j$ and $\lambda_k$ of $C$. The method is illustrated on a form of the Mathieu equation. (Received November 18, 1975.)

*76T-B37 Chung-Chun Yang, Naval Research Laboratory, Washington, D. C. 20375. On the functional equation $p(f(z)) = a(z) \sin \alpha(z) + b(z)$. Preliminary report.

Let $p(z)$ be a nonlinear polynomial, $a(z)$ and $b(z)$ be two nonconstant meromorphic functions and $\alpha(z)$

be a nonconstant entire function. Then it is shown that the functional equation $p(f) = a \sin\alpha + b$ has no transcendental meromorphic solution $f$ which satisfies $T(r, a) + T(r, b) = o\{T(r, f)\}$ as $r \to \infty$, where $T(r, f)$ is the Nevanlinna characteristic function of $f$. This also results when $a \sin\alpha + b$ is replaced by a linear combination of exponentials with slow-growing coefficients.

(Received November 20, 1975.) (Author introduced by Benjamin Lepson.)

*76T-B38 Jang-Mei G. Wu, University of Illinois, Urbana, Illinois 61801.
On the boundary properties of Green's potentials.

A Green's potential (GP) occurs in the Riesz decomposition theorem for subharmonic functions. Let $u$ be a GP on the unit disk $D$; it is known that the radial limit of $u$ is 0 a.e. on $\partial D$ but the nontangential limit need not exist at any point. We have proved the following results. (i) If $E$ is a closed set of measure 0 on $\partial D$, $f$ is a nonnegative continuous function on $E$, then there is a continuous GP $v$ such that $v(re^{i\theta}) \longrightarrow f(e^{i\theta})$ uniformly on $E$; the nontangential limit of $v$ is 0 on $\partial D \setminus E$ and $v(0) < 1$. (ii) Consider the level curves of a real-valued function $g$ on $\bar{D}$. If $g$ has certain differentiability conditions (e.g. $C^1$ and $g_\theta \neq 0$ on $\partial D$) then every GP has limit 0 along almost all the level curves. (iii) Let $\mu$ be the measure on $D$ representing the GP $u$ and $\ell_\phi$ be a segment in $D$ ending at 1 with an angle $\phi$ with x-axis for $-\frac{\pi}{2} < \phi < \frac{\pi}{2}$. If $\int_D \frac{1-|z|}{|1-z|}\, d\mu(z) < \infty$, then for all $\phi$ except a set of capacity 0, $u$ has finite variation on $\ell_\phi$. Several related results are proved also.

(Received October 14, 1975.)

76T-B39 Edwin M. Wolf, Brown University, Providence, Rhode Island 02912.
Approximate continuity at bounded point evaluations. Preliminary report.

Denote by $R^p(X)$, $p \geq 1$, the closure in the $L^p(X)$ norm of the rational functions with poles off the compact set $X$ in the complex plane. Let $\frac{1}{p} + \frac{1}{q} = 1$. In analogy with a theorem of James Wang ["An approximate Taylor's theorem for $R(X)$," Math. Scand. 33 (1973), 343-358] we prove the following result. Theorem: Let $\phi$ be an admissible function and $s$ a non-negative integer. Suppose that $p > 2$ and that $g \in L^q(X)$ is a representing function for $x$ such that $g(z)/|z - x|^s\phi(|z - x|) \in L^q(X)$. Then for every $\epsilon > 0$ there is a set $E$ having full area density at $x$, such that for every $f \in R^p(X)$ i) $f = \sum_{j=0}^{s} D_x^j(z - x)^j + R$ where $R \in R^p(X)$ satisfies ii) $|R(y)| \leq \epsilon|y - x|^s\phi(|y - x|)||f||_p$ for all $y \in E$ and iii) $\operatorname{app\,lim}_{y \to x} R(y)/|y - x|^s\phi(|y - x|) = 0$.

(Received November 25, 1975.)

*76T-B40 T.M.MILLS, Bendigo Institute of Technology, Bendigo, Vic., 3550, Australia.
Interpolation polynomials on equidistant nodes.

Let $R_n(f,x)$ denote the (0,1,2,3)-interpolation polynomial (in the sense of L.Fejér) corresponding to the function $f(x)$ based on the nodes $x_{k,n} = 1 - (2k-1)/n$, $k = 1(1)n$. The main result of this work is the following: THEOREM: *Let* $\alpha \in (0,1)$. *Then there is a function* $f(x)$ *which is continuous on the interval* $[-1,1]$ *such that* $R_n(f,x)$ *does not converge to* $f(x)$ *uniformly in the interval* $[-1+\alpha, 1-\alpha]$. This result is a marked contrast to one of H.N.Laden (1941) where the interpolation nodes are chosen to be the zeros of a Jacobi polynomial of degree n.

(Received December 1, 1975.)

*76T-B41 Robert Olin, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061 and James Thomson, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.
Limaçons, normal operators and polar factorizations.

Theorem one. Let $\varphi$ be a univalent function in $H^\infty$ with a zero in the open unit disic. The following are equivalent: (1) $\varphi/|\varphi| \in H^\infty$, (2) $\varphi = \chi \circ \lambda$ where $\lambda$ is a conformal automorphism of the disk and $\chi(z) = p + qz + pz^2$ with $q > 2|p|$.

Theorem two. Let N be a normal operator, $o \notin \sigma(N)$ and let $\mathfrak{W}(N)$ be the weakly closed algebra generated by N and 1. If N = UP is the polar factorization of N then the following are equivalent: (1) $U \in \mathfrak{W}(N)$ (2) $N = N_o \oplus N_1$, $\mathfrak{W}(N) = \mathfrak{W}(N_o) \oplus \mathfrak{W}(N_1)$ where $N_o$ is a reductive normal operator and $N_1$ is a normal operator whose spectrum is a limaçon and whose scalar spectral measure is harmonic measure for the polynomial convex hull of the linaçon. (Received November 26, 1975.)

*76T-B42 A.M. Krall and R.D. Morton, The Pennsylvania State University, University Park, PA 16802. A distributional solution to the Hamburger problem and the resulting orthogonal polynomials.

By using distributions a weight function is produced for any set of polynomials generated by moments which satisfy the Hamburger conditions. By using the Fourier transform, the connection between the weight function and the classical weight function is made in the case of the classical orthogonal polynomials. The procedures used extend to polynomials in more than one variable. (Received December 8, 1975.)

*76T-B43 Donald W. Hadwin, University of Hawaii, Honolulu, HI 96822. A Generalization of the Weyl-Von Neumann theorem.

For each operator T on a separable Hilbert space H let $U(T) = \{U^*TU: U \text{ unitary}\}$. Theorem: If T is unitarily equivalent to a direct integral of compact operators, then there is an operator S that is a direct sum of compact operators such that T is unitarily equivalent to arbitrarily small compact perturbations of S. (Note that if T is normal, then S must be diagonal.) The proof uses only elementary properties of direct integrals and some classical theorems from measure theory. This theorem is used to show that if the image in the Calkin algebra of an operator T generates a CCR(liminal) C*-algebra, then (1) $U(T)^-$ is arcwise connected, and (2) every operator in $U(T)^-$ is unitarily equivalent to arbitrarily small compact perturbations of T. (Received November 7, 1975.)

*76T-B44 *ELEMER E. ROSINGER, Dept. Computer Science, Haifa Technion, Israel*
*Increasing the family of associative and commutative algebras containing the distributions in $D'(R^1)$.*

*In several previous papers (Notices, 1975, 75T-B39, B81, B98, B167, B228) the author constructed associative and commutative algebras with unit element and containing the distributions in $D'(R^1)$. In the present paper, the amount of those algebras is increased and a sufficient condition of purely algebraic nature is given in order to extend the construction of the mentioned algebras for the case of the distributions in $D'(R^n)$, with $n \geq 2$.* (Received December 9, 1975.) (Author introduced by Professor F. Treves)

76T-B45 ATHANASSIOS G. KARTSATOS, University of South Florida, Tampa, Fla. 33620. Nth order oscillations with middle terms of order n-2.

Consider the differential equation (*) $x^{(n)} + p(t)x^{(n-2)} + H(t,x) = 0$, where n is an even positive integer $\geq 2$, $p: R_T \to R$, $H: R_T \times R \to R$ are continuous, and H is increasing in its second veriable with $uH(t,u) > 0$ for every $(t,u) \in R_T \times R$ with $u \neq 0$. Here $R = (-\infty, \infty)$, $R_T = [T, \infty)$. Theorem 1. Let the equation $x'' + p(t)x = 0$ be nonoscillatory with p(t) nonnegative and $[t^m p(t)]$ decreasing where m is some integer with $0 \leq m \leq n-1$. Then if $\int_T^\infty t^m H(t, \pm k)dt = \pm\infty$ for every $k > 0$, all solutions of (*) are oscillatory. Theorem 2. Let $x'' + p(t)x = 0$ be nonoscillatory with p(t) nonnegative and decreasing. Then the condition $\int_T^\infty t^n p(t)dt < +\infty$ suffices for the oscillation of all solutions (all bounded solutions) of (*) if this is true for the equation with $p(t) \equiv 0$. Some more results are given, and the case of odd n is also covered. Sufficient conditions are given for the oscillation of any solution of (*) for n odd that

has at least one zero. Related are recent results of Waltman and Heidel.
(Received December 11, 1975.) (Author introduced by Professor M. N. Manougian)

*76T-B46 K. L. Singh, Texas A&M University, College Station, Texas 77843
A Fixed Point Theorem for Multivalued Densifying Mappings.

THEOREM Let $X$ be a real Banach space. Let $D$ be the neighborhood of the origin in $X$. Let $T:D \to K(X)$ be a $\Phi$-densifying mapping, where $\Phi = \chi_d$ or $\Phi = \gamma_d$ with $d = \| \ \|$, satisfying the following conditions: (1) $x$ in $T(x)$, $x$ in $D$ implies $x = 0$. Then for any $\Phi$-densifying mapping $F:X \to X$ the condition (2) $F(x) - F(y)$ in $T(x-y)$ for any $x-y$ in $D$ implies that the equation $x = F(x)$ has exactly one solution, whenever $F$ is continuous.
If the mapping $F$ satisfies the condition 2, then for any $a$ in $X$, so does the mapping $F_a(x) = F(x) - a$. Thus we may state above theorem as the mapping $I-F$ is homomorphism of $X$ onto itself. If the mapping $F$ is of the form $F(x) = H(x) + b$, where $b$ in $X$ and $H$ is linear, then we get a generalization of Fredholm Theorem. (Received December 15, 1975.)

76T-B47 Plastiras, Joan K., University of California at San Diego,
Quasitriangular Algebras.

Let $\mathcal{P} = \{P_n\}_{n=1}^{\infty}$ be a sequence of finite dimensional projections increasing to the identity on a Hilbert space. The associated quasitriangular algebra $\mathfrak{Q}(\mathcal{P})$ is defined to be the set of those operators $T$ for which $\|P_n^{\perp} T P_n\| \to 0$. It is easily verified that $\mathfrak{Q}(\mathcal{P})$ is an inseparable, non-self-adjoint Banach algebra.

In the following theorem, any map between two Banach algebras which preserves algebraic structure will be referred to as an algebraic isomorphism (i.e. no topological conditions are imposed):

Theorem: $\mathfrak{Q}(\mathcal{P})$ is algebraically isomorphic to $\mathfrak{Q}(\mathcal{S})$ if and only if there exist positive integers $m_0$ and $n_0$ such that $\dim(P_{m_0+k}) = \dim(S_{n_0+k})$ for all $k \in \mathbb{N}$. (Received December 15, 1975.)

76T-B48 GONG-HWAI CHEN and CHAO-KUANG PIAN, William Paterson College, Wayne, N.J. 07470. On approximation theorems of continuous functions.

Let $C(X)$ be the semigroup of all continuous self-maps of the topological space $X$ with composition as its operation, and $E(X)$ be the subset of $C$ whose elements are finitely idempotent generable. Theorem 1. If $X$ is a Euclidean n-space or an n-cube, then $E(X)$ is dense in the topological space $(C(X), \mathcal{T})$ where $\mathcal{T}$ is the compact open topology.

We have the following strengthened form of Weierstrass approximation theorem. Theorem 2. Let $f$ be a continuous self-map on $I$, a closed bounded interval of the set of all real numbers. Then $f$ can be uniformly approximated by a polynomial which is finitely idempotent generable on $I$. (December 17, 1976.)

*76T-B49 Stephen A. McGrath, U. S. Naval Academy, Annapolis, Maryland 21402. Abelian ergodic theorems for contraction semigroups.

Let $(X,\Sigma,\mu)$ be a $\sigma$-finite measure space and $L_p(\mu) = L_p(X,\Sigma,\mu)$, $1 \le p \le \infty$, the usual Banach spaces. Let $\Gamma = \{T_t : t \ge 0\}$ be a strongly continuous semigroup of $L_p(\mu)$ contractions for some

$1 \leq p < \infty$. Let $R_\lambda$ be the resolvent of $\{T_t\}$. If $p > 1$ and $\Gamma$ is a positive semigroup we show that $\lim_{\lambda\to\infty} \lambda R_\lambda f(x) = f(x)$ a.e. for $f \in L_p(\mu)$. In case $p = 1$, we show $\lambda R_\lambda f(x) \to f(x)$ a.e. for $f \in L_1(\mu)$ for an arbitrary semigroup of $L_1(\mu)$ contractions. These results extend a theorem of N. Dunford and J. T. Schwartz ["Convergence almost everywhere of operator averages," J. Math. and Mech. 5 (1956), 129-178]. (Received December 17, 1975.)

*76T-B50 PROFESSOR CHARLES BYRNE, CATHOLIC UNIVERSITY OF AMERICA, WASHINGTON, DC 20064. Sufficient conditions for weak compactness in $L^1(m,X)$ with applications to the integration of set-valued functions.

Let $(T,\Sigma,m)$ be a finite measure space, and $L^1(m,X)$, the Banach space of (equivalence classes of) strongly measurable Bochner integrable functions from T to Banach space X. Diestel has shown that if K is a bounded, uniformly integrable subset of $L^1(m,X)$, and if there is a weakly compact subset W of X with the property that for all f in K, f(t) is in W for almost all t in T, then K has weak compact weak closure in $L^1(m,X)$. This result admits the following extension: Theorem 1. Let F be a mapping from T into W(X), the non-empty weakly compact convex subsets of Banach space X, measurable, in the sense that F is the pointwise limit (in the Hausdorff metric) of a sequence of measurable W(X)-valued simple functions and integrably bounded (there is integrable $g:T \to$ reals with $||f(t)|| \leq g(t)$ for all f in $S(F) =$ f in $L^1(m,X) | f(t) \in F(t)$ a.e.$\}$ ). Then S(F), the selectors of F, is weakly compact in $L^1(m,X)$. Using this criterion for weak compactness we can answer some questions in the theory of integration of set-valued functions. Some examples: Theorem 2. The Debreu integral of measurable compact-convex valued mapping is equivalent to the Aumann integral, with no assumptions about the Banach space, X. Remark: This result was given by Debreu, but as has been pointed out by numerous authors, the proof is known to hold only if X is reflexive. Theorem 3. Let P be a measurable integrably bounded mapping from T into the relatively weakly compact subsets of Banach space X. Then if $F(t) = \overline{co}\, P(t)$, and $\int$ denotes the Aumann integral, then $\int F(t) =$ closure $(\int G(t))$. Remark: This includes known results of Datko and others, given for X reflexive. (Received December 22, 1975.)

*76T-B51 Chung Lin, Department of Mathematics, The University of British Columbia Vancouver, B.C., Canada V6T 1W5. Fourier Transforms of $\mathop{*}_{n=1}^{\infty}[(1-p_n)\delta_0 + p_n\delta_{x(n)}]$. Preliminary report.

We denote by G a nondiscrete metrizable locally compact abelian group, $\bar{\hat{G}}$ its dual group and $\hat{G}$ the closure of G in the structure space of the measure algebra M(G). We choose a local base $\{U_n\}$ of the identity of G for which $U_{n+1} + U_{n+1} \subset U_n$ for all n=1,2... . Let $K = \prod_{n=1}^{\infty} U_n$ and $X = \{p=(p_n) : 0 < p_n < 1$ for all $n\}$. For an element $x = (x(n))$ in K, we define, for each p in X, $\mu(x,p) = \mathop{*}_{n=1}^{\infty} [(1-p_n)\delta_0 + p_n\delta_{x(n)}]$. Theorem. If $x \in K$, then one of the following holds. (i) $\sup\{|(f,\mu(x,p))| : f \in \bar{\hat{G}} - \hat{G}\} \geq c$ for some positive constant c and all p in X; (ii) $\sup\{|(f,\mu(x,p))| : f \in \bar{\hat{G}} \setminus \hat{G}\} \leq 2\,\overline{\lim}\, |p_n - \frac{1}{2}|$ for all p in X. A consequence of this is that, for $x = (x(n)) \in K$, either $\mathop{*}_{n=1}^{\infty} (\frac{1}{2}\delta_0 + \frac{1}{2}\delta_{x(n)}) \in M_0(G)$ or $\mathop{*}_{n=1}^{\infty}[(1-p_n)\delta_0 + p_n\delta_{x(n)}] \notin M_0(G)$ for all p in X. (Received December 24, 1975.) (Author introduced by J. Coury.)

*76T-B52 P. Douglas Elosser, University of Kentucky, Lexington, Kentucky 40506. Least-First-Power (L-F-P) Approximation by Polynomials.

Let $n \in N$, $P_n$ be the set of polynomials of degree $\leq n$ and $I=[0,1]$. $f \in C(I)$ with $f \notin P_n$ is said to be adjoined to $P_n$ if f-p has at most n+1 zeros in I for each $p \in P_n$. Let $\hat{T}_{n+2}(x) = T_{2(n+2)}(\sqrt{x})$ where $T_{2(n+2)}(x)$ is the Chebychev polynomial of degree 2(n+2) and let $\hat{U}_{n+1}(x)$ and $\tilde{U}_{2n+3}(x)$ be the normalized derivatives of $\hat{T}_{n+2}(x)$ and $T_{2(n+2)}(x)$ respectively (leading coefficients are 1). We prove: i) $(2x)(\hat{U}_{n+1}(x^2)) = \tilde{U}_{2n+3}(x)$, ii) The zeros of $\hat{U}_{n+1}(x)$ in (0,1) are $\cos^2(\frac{1\pi}{2(n+2)}), \cos^2(\frac{2\pi}{2(n+2)}), \ldots, \cos^2(\frac{(n+1)\pi}{2(n+2)})$, iii) If $r_n^* \in P_n$ is the (L-F-P) approximation to $x^{n+1}$ on I, then $x^{n+1} - r_n^*(x) = \hat{U}_{n+1}(x)$ and iv) Let g be adjoined to $P_n$. If $r_n^* \in P_n$ is the (L-F-P) approximation to g on I, then

$g-r_n^*$ has zeros in (0,1) at $\cos^2(\frac{1\pi}{2(n+2)}),\ldots,\cos^2(\frac{(n+1)\pi}{2(n+2)})$ and for $j=1,2,\ldots,n+1$, $r_n^*(\cos^2(\frac{j\pi}{2(n+2)})) = g(\cos^2(\frac{j\pi}{2(n+2)}))$. (Received December 26, 1975.)

*76T-B53 Frederick Bloom, University of South Carolina, Columbia, S.C. 29208.
Growth Estimates for Solutions to Volterra Integro-differential Equations

For the abstract Volterra integro-differential equation in Hilbert space, $\underset{\sim}{u}_{tt} - \underset{\sim}{N}\underset{\sim}{u} + \int_{-\infty}^{t} \underset{\sim}{K}(t-\tau)\underset{\sim}{u}(\tau)d\tau = \underset{\sim}{0}$, with prescribed past history $\underset{\sim}{u}(\tau) = \underset{\sim}{U}(\tau)$, $-\infty < \tau < 0$ and associated initial data $\underset{\sim}{u}(0) = \underset{\sim}{f}$, $\underset{\sim}{u}_t(0) = \underset{\sim}{g}$, we establish conditions on $\underset{\sim}{K}(t)$, $-\infty < t < \infty$, which yield growth estimates for solutions $\underset{\sim}{u}(t)$, belonging to a certain uniformly bounded class, as well as lower bounds for the rate of decay of solutions. Our results are interpreted in terms of solutions to a class of initial-boundary value problems in isothermal linear viscoelasticity. (Received December 29, 1975.)
(Author introduced by Professor M. Slemrod.)

*76T-B54 Richard R. Goldberg, University of Iowa, Iowa City, Iowa 52242 and Stanley E. Seltzer, University of Iowa, Iowa City, Iowa 52242. Uniformly concentrated sequences and multipliers of Segal algebras.

A sequence $\{h_k\}$ in $L^1(R)$ is said to be uniformly concentrated if $\lim_{N\to\infty} \int_{|t|\geq N} |h_k(t)|dt=0$ uniformly for all k. THEOREM. Let S be a Segal algebra on the real line R. In order that a measure $\mu$ be a multiplier (via convolution) from $L^1$ to S it is necessary and sufficient that there exist a uniformly concentrated sequence $\{h_k\}$ in S such that $A = \sup_k \|h_k\|_S<\infty$, and such that (*) $\hat{h}_k\to\hat{\mu}$ uniformly on all compact subsets of R. If $\mu$ is a multiplier, and $\|\mu\|_\sim$ is defined to be the inf of the A for all uniformly concentrated $\{h_k\}$ satisfying (*), then $\|\mu\|_\sim$ is equal to the multiplier norm of $\mu$. The theorem extends to more general groups. (Received January 2, 1976.)

# Applied Mathematics

*76T-C11 Dr.H.K.VERMA, Assoc.Prof.of Math; P.A.U., Ludhiana. Title of Paper: Simultaneous diffusion and mass flow to plant roots-a theoretical solution.

Here we present a theoretical solution of the Mathematical model for simultaneous diffusion and mass flow to plant roots, given by P.H.Nye and J.A.Pspiers: 8th Inter.Cong.of Soil Sci.Bucharest, Romania, III (1964) p. 535. They have solved the problem for steady state as they could not find any general solution to unsteady state problem.

Movement of nutrients, pesticides, toxins and stimulants to plant roots surface is of great importance in 'Soil Science'. (Received November 12, 1975.)

*76T-C12 David D. Dobkin and Richard J. Lipton, Yale University, New Haven, Connecticut 06520.
A lower bound of $\frac{1}{2}n^2$ on linear search tree programs for the knapsack problem.
Preliminary report.

Linear tree programs use statements of the form

$L_i$: if $f(\underline{x})$ R 0 then go to $L_j$ else go to $L_k$

$L_m$: halt and accept

$L_n$: halt and reject

where $f(\underline{x})$ is an affine linear form in $\underline{x} = (x_1,\ldots,x_n)$ and R is >, = or <. We show that any such program for solving the knapsack problem (i.e. given $x_1,\ldots,x_n$ , does there exist a subset I of

$\{1,2,\ldots,n\}$ such that $\sum_{i\in I} x_i = 1$) must require at least $\frac{1}{2}n^2$ such statements for some input.

(Received November 18, 1975.) (Authors introduced by Martin H. Schultz.)

*76T-C13 R. P. BOAS, Northwestern University, Evanston, Illinois, 60201. Partial sums of divergent series.

Let $n_A$ be the integer such that the partial sums of the harmonic series $\Sigma\, 1/k$ exceed $A$ for the first time at index $n_A$. It has been conjectured that $n_A$ is the integer closest to $e^{A-\gamma}$, where $\gamma$ is Euler's constant, and it has been shown [Boas and Wrench, Amer. Math. Monthly 78(1971), 864-870] that this holds unless $e^{A-\gamma} + 1/2$ is very close to an integer. It is also known by computation that the conjecture holds for $A \leq 200$. Let $m = [e^{A-\gamma}]$. It is shown that $n_A = m$ or $m + 1$ according as $e^{A-\gamma} < m + 1/2 + 1/(24m) - 1/(45m^2)$ or $e^{A-\gamma} > m + 1/2 + 1/(24m)$. This does not of itself disprove the conjecture but does make it seem somewhat less plausible. Similar results hold for other divergent series $\Sigma\, 1/f(n)$.

(Received November 19, 1975.)

*76T-C14 Dr. George Robert Talbott, Pacific States University, 1516 So. Western Avenue, Los Angeles, California 90006. A classical derivation of fundamental quantities and of the key equations of modern atomic physics.

Using only classical equations and techniques with a new geometrical mapping, all of the basic equations of modern atomic physics are deduced. The following equation is obtained by an independent deduction, showing the power of the method:

$$b = \left[\frac{e}{2\omega_L\, m^{1/2}}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)\right]^{2/3}$$

Where b is the Bohr radius, e the unit electronic charge, m the electron mass, $\omega_L = 2\pi f_L$, $f_L$ is the frequency of light emitted in a transition characterized by principal quantum number $n_1$, $n_2$, the above equation allows a new computation and direct measurement of the Bohr radius in terms of emitted light. A new deduction of Planck's constant and of electron total energy are also given. Derivations appear in the author's textbook, Electronic Thermodynamics, (Pacific States University Press, Los Angeles, California, 1973), and in the now completed Philosophy and Unified Science.

(Received October 31, 1975.)

76T-C15 Gary Harrison, University of Georgia, Athens, Georgia 30602. Lotak-Volterra systems with time varying coefficients. Preliminary report.

Consider a general Lotka-Volterra system with time varying coefficients: $p_i' = p_i(r_i(t) + \sum_j a_{ij}(t)p_j)$, $i = 1,\ldots,n$. Let $A(t) = [a_{ij}(t)]$, $r^T(t)=(r_1(t),\ldots,r_n(t))$, $p^T = (p_1,\ldots,p_n)$, and define a time varying critical vector $c(t)$ by $r(t)+A(t)c(t)=0$. Assume that there is a positive diagonal matrix $D$ such that $Q(t) = -(A^T(t)D+DA(t))$ is positive definite and let $q(t)$ be the smallest eigenvalue of $Q(t)$. Then bounds B, L, and U are found, with $L < U$ and $L$ decreasing to $0$ as $\sup\|c'(t)\|$ decreases to $0$, such that if $\frac{\|c'(t)\|}{q(t)} \leq B$ for all $t$, then for any solution satisfying $\|p(0) - c(0)\| < U$, $\|p(t) - c(t)\|$ approaches or stays within the interval $[0,L]$ as $t$ approaches $\infty$. The proof uses the Lyapunov function $V(t) = \sum_i p_i(t)-c_i(t)-c_i(t)\ln\frac{p_i(t)}{c_i(t)}$. As a corollary, if the same conditions hold and the coefficients $r_i(t)$ and $a_{ij}(t)$ are all periodic, then there exists a periodic solution of the Lotka Volterra system.

(Received November 6, 1975.)

*76T-C16 Robert G. Jeroslow, Carnegie-Mellon University, Pittsburgh, Pa. 15213. Solving Nearby Integer Programs.

Fix vectors $c^1,\ldots,c^t \in R^n$. For a set $S \subseteq R^n$, $y^o$ is efficient for S if: (1) $y^o \in S$; (2) $y \in S$ and

$c^k y \leq c^k y^o, k = 1,\ldots,t$, implies $c^k y = c^k y^o$, $k = 1,\ldots,t$. (LP,b)-efficient refers to $S = \{y \mid Ay \geq b, y \geq 0\}$ and (IP,b)-efficient refers to $S = \{y \text{ integer} \mid Ay \geq b, y \geq 0\}$. Put $y^o = (y_1^o,\ldots,y_n^o) \geq 0$ and $y^* = (y_1^*,\ldots,y_n^*) \geq 0$. Thm. 1: If $y^o$ is (LP,b)-efficient and if $y_j^* > 0$ implies $y_j^o > 0$ for $j = 1,\ldots,n$, then $y^*$ is $(LP,b^*)$-efficient for $b^* = Ay^*$. Thm. 2: If $y^o$ is (IP,b)-efficient and if $y_j^* \leq y_j^o$ for $j = 1,\ldots,n$, then $y^*$ is $(IP,b^*)$-efficient for $b^* = Ay^*$. Remarks: (1) Proofs are easy; the case $t = 1$ is optimization. (2) Thm. 1 shows that solving the l.p. relaxation and then rounding-off fractional $y_j^o$, in any direction, gives an $(IP,b^*)$-efficient point; a suitable heuristic can be used to get $b^*$ "close" to b; (3) Both results are true when some inequalities are reversed or replaced by equality; (4) Both results supply sensitivity analysis for integer programs.

(Received December 3, 1975.)

76T-C17 Padam C.Jain and D.N.Holla, Indian Institute of Technology, Powai, Bombay 400076.

Finite Difference Approximations to Two Dimensional Wave Equation by using a Cubic Spline Technique.

By taking the wave equation in two space variables and using a cubic spline technique, a general finite difference implicit scheme has been derived and examined for its stability. Alternating Direction, Locally One Dimensional and Split Operator formulae are also obtained. By assigning particular values to the parameter of the general scheme, formulae due to Lee, Fairweather and Mitchell and Samarskii are deduced as special cases. For an optimum value of the parameter, LOD scheme turns out to be the 'best' scheme from the accuracy point of view. A numerical example is solved for comparing the results by these schemes. (Received October 31, 1975.)

76T-C18 Michel Eytan, U. E. R. Maths. , Université René-Descartes, 12 rue Cujas, 75005 Paris.

An algebraic Model for Z. S. Harris's Theory of Grammar. Preliminary report.

We give a model for "Theory of Grammar" (lectures by Z. S. Harris, given at Vincennes University in 1973-74, to appear), in terms of J. Bénabou's deduction-categories (unpublished lectures given at the Ecole Polytechnique in 1972-73). Harris's concatenational system is represented by a category C/A (of objects above a given object A), with C a cartesian closed category with pullbacks; therefore with all finite limits. His transformational system is represented by a functor $R$ from $C/A^*$ to the category *Pord* of preordered sets with finite infs (including that of the empty set). The set $R(\xi)$ is the set of all discourses of "category" $\xi$, the preordering being that of inequalities between discourses. A trnsformation is represented by $R(f)$, f an arrow in the category C/A; functoriality of $R$ means preservation of inequalities by transformations. The deduction-stucture, i.e. existence of an adjoint to $R(p)$, p aprojection in C/A, is simply the interpretation of zeroing. The paper is to appear in French, in T. A. Informations in 1976. (Received December 11, 1975.)

76T-C19 M. F. JANOWITZ, University of Massachusetts, Amherst, MA 01002,

An order theoretic model for numerical taxonomy.

Let P be a finite set ($|P| \geq 3$), Q the set of 2 element subsets of P, $\Sigma$ the lattice of all subsets of Q, L a join semilattice with 0 ($|L| \geq 2$), and LC(P) the set of all mappings of Q into L. Arguments are given to show how a clustering method may be regarded as a function $F: LC(P) \to LC(P)$. A 1-1 correspondence $d \mapsto Td$ is established between elements of LC(P) and residual mappings of L into $\Sigma$; here $Td(h) = \{X: X \in Q, d(X) \leq h\}$. A cluster method F is called flat if there is a mapping $\gamma: \Sigma \to \Sigma$ such that $TF(d) = \gamma \circ Td$ holds for all d in LC(P). Theorem 1. A cluster method F is flat iff $F(\theta d) = \theta F(d)$ for all d in LC(P) and all residuated mappings $\theta$ on L. Theorem 2. Let $\gamma: \Sigma \to \Sigma$. Then (1)$\Leftrightarrow$(2), (3)$\Leftrightarrow$(4), (5)$\Leftrightarrow$(6): (1) $\gamma$ determines a flat cluster method iff $\gamma(Q) = Q$. (2) $L = \{0,1\}$. (3) $\gamma$ determines a flat cluster method iff $\gamma$ is isotone and $\gamma(Q) = Q$. (4) L is a chain with more than 2 members. (5) $\gamma$ determines a flat cluster method iff $\gamma$ is residual. (6) L is not a chain. Corollary. Every flat cluster

**method is isotone. Other properties of a flat cluster method F are related to properties of the associated mapping $\gamma$.** (Received December 12, 1975.)

76T-C20 Thomas Jech, The Pennsylvania State University, University Park, Pennsylvania 16801.
An infinite game played with stationary sets. Preliminary report.

The following game was suggested by F. Galvin: White chooses a stationary subset $S_0$ of $\omega_1$, then Black chooses a stationary subset of $_\infty S_1$ of $S_0$, then White chooses a stationary $S_2 \subseteq S_1$ etc. White wins the game if and only if $\bigcap_{n=0} S_n$ is empty. M. Magidor has shown that Black does not have a winning strategy.

Theorem. White has a winning strategy if and only if the ideal I of nonstationary subsets is not precipitous. (By a result of the author and K. Prikry, I is not precipitous unless $\omega_1$ is measurable in L[I]. Moreover, it is not known whether it is consistent that I is precipitous.) (Received December 15, 1975.)

76T-C21 A. ISERLES, Ben Gurion University of the Negev, Beer-Sheva, Israel. Functional fitting—new family of schemes for integration of stiff O.D.E's.

Following the ideas of Liniger and Willoughby, although acting along different lines, a new family of numerical schemes, derived from the trapezoidal rule and suitable for stiff O.D.E.'s, is developed: Let $\mathcal{J} = \{\dot{z}_i = g_i(t, z_i),\ 1 \leq i \leq m\}$ be a set of scalar O.D.E.'s, the solutions of which are known and let $\underline{x}^{(j)}_{n+1}$ be the solution of the equation $\dot{\underline{x}} = \underline{f}(t,\underline{x}) \in E^N$, $\underline{x}(t_n) = \underline{x}_n$; applying the trapezoidal rule with $\ell_j$ substeps, $1 \leq j \leq k$, in the interval $[t_n, t_{n+1}]$. We define $\underline{x}_{n+1} = \underline{F}(\underline{x}^{(1)}_{n+1}, \underline{x}^{(2)}_{n+1}, \ldots, \underline{x}^{(k)}_{n+1})$ when $\underline{F}$ is order-preserving and is fitted to the equation of $\mathcal{J}$, i.e. $f(t,x) = g_i(t,x)$; then $\underline{x}_{n+1}$ is exact, $1 \leq i \leq m$. Various forms of the function $\underline{F}$ are established and their suitability and stability properties are considered. (Received January 2, 1976.) (Author introduced by Dr. Paul A. Fuhrmann.)

76T-C22 Mostafa A. Abdelkader, 25 Sh. Champollion, Alexandria, Egypt. Lotka-Volterra equations with time-varying coefficients.

The L-V nonlinear differential equations for two competing biological species are $dx/dt = x\,(r - ax - by)$, $dy/dt = y\,(s - cy - dx)$. When the coefficients are constants and two or more of them are interrelated, the author has given exact solutions of the equations (Math. Biosci. 20 (1974), 293-297). A much more realistic model, describing an unlimited variety of changing circumstances affecting the growth and mutual interaction of the two species, is obtained when the coefficients are assumed to be functions of time. The differential equations are then non-autonomous and their qualitative or numerical study for arbitrary coefficients is difficult. In this paper the exact solutions by quadratures are given when a, b, r, s are arbitrary functions of time, and c, d are given by :
$kc = a \exp \int_0^t (r - s)\,dt$, and $d = 2a - kb \exp \int_0^t (s - r)\,dt$, where k is any non-zero constant ( $\int$ denotes the integral sign). A generalization of the L-V equations is also given, with a similar case of exact integrability. (Received January 6, 1976.)

# Geometry

*76T-D4 PAUL E. EHRLICH, Bonn University, D5300 Bonn, West Germany. Elliptic isometries and the Dirichlet fundamental region.

Let M be a simply connected, complete Riemannian manifold without conjugate points of dimension $\geq 2$. Let $\Gamma$ be a discontinuous subgroup of isometries of M. Then E. Witt ("Ueber die Konstruktion von Fundamental Bereichen", Ann. Mat. Pura Appl. 36(1954), 215-221) has shown that the Dirichlet fundamental region based on $p \notin \mathrm{Fix}(\Gamma)$ defined by $\{q \in M;\ d(q,p) < d(f(p),q)\ \forall f \in \Gamma,\ f \neq \mathrm{Id}\}$ is a fundamental region for $\Gamma$ and is locally finite. We investigate further properties of this fundamental region with regard to elliptic elements in $\Gamma$, i.e., isometries with fixed points in M. We obtain many of the classical facts of automorphic function theory for the Dirichlet region. For instance, the walls are identified in pairs, every elliptic fixed point not of order 2 is a noninner point of some wall of the Dirichlet tesselation for any basepoint $p \notin \mathrm{Fix}(\Gamma)$, and for all basepoints $p \notin \mathrm{Fix}(\Gamma)$ except for a set of measure zero and discontinuous subgroups $\Gamma$ behaving like Fuchsian groups each elliptic cycle of vertices consists of a single point. (Received November 13, 1975.)

*76T-D5 MAURIZIO CHICCO, University of Genova, 16132 Genova, Italy. An elementary integral identity.

Let A be a bounded open set in $R^m$ $(m \geq 2)$ with boundary $\partial A$ of class $C^2$, let v be an m-dimensional vector field of class $C^1$ in a neighbourhood of $\partial A$, let N be the normal unit vector to $\partial A$ (defined also in a neighbourhood of $\partial A$ in a natural way), let H be the mean curvature of $\partial A$. Then the following identity is true:

$$\int_{\partial A} \left[\operatorname{div} v - \partial(v.N)/\partial N + (m-1)Hv.N\right] d\sigma = 0$$

(Received November 14, 1975.) (Author introduced by A. Figà-Talamanca.)

76T-D6 WLODIMIERZ S. WRONA, California State University, Hayward, California 94542. On some special symmetric spaces.

The m-directional curvature at a point of an n-dimensional Riemannian space $(1 < m < n)$ is the scalar curvature of an m-dimensional Riemannian subspace, which is tangent to the given m-direction and geodesic at the given point. Theorem. If at each point of a connected region of a Riemannian space with an absolutely parallel unit vector field $1^\lambda$ the m-directional curvature is an m-direction containing $1^\lambda$ with $m = 3 < n$ or $3 < m < n - 1$ does not depend on the special choice of this m-direction, then it does not vary from point to point, i.e., it is constant over that region. The space is then a reducible symmetric space over that region and its curvature tensor is given by (1) $K_{\lambda\mu\upsilon w} = (2\eta\varkappa/(n-2))\, g_{[\lambda[\upsilon}(g_{\mu]w]} - 2\, 1_{\mu]}1^{}_{w]})$, $\varkappa$ being the scalar curvature of the space. Conversely: If the curvature tensor of a Riemannian space has the form (1), then for every $1 < m < n - 1$ at each point the multisectional curvature is an m-direction containing $1^\lambda$ does not depend on the special choice of this m-direction and equals $\varkappa_{(m)} = n(m-2)\varkappa/m(n-2)$. Furthermore: (a) If for $n > 3$, $1^\lambda$ in (1) is a parallel vector field then the space is a reducible symmetric space. (b) Also if in a symmetric space the curvature tensor has the form (1), then $1^\lambda$ is a parallel vector field. (Received November 17, 1975.)

*76T-D7 George J. Minty, Indiana University, Bloomington, Indiana 47401. Topological versions of theorems of Kirszbraun-Valentine type. Preliminary report.

X is a finite-dimensional linear space over R, Y a topological space. Let $\varphi: X \times Y \times Y \to R$ be lower-semicontinuous and: for each sequence $(x_1,y_1),\ldots,(x_m,y_m) \in X \times Y$ and each $y \in Y$, and each $\vec{\lambda}$ with $\lambda_i \geq 0$, $\sum \lambda_i = 1$: $2\sum_i \lambda_i \varphi[x_i - \sum_j \lambda_j x_j, y_i, y] \leq \sum_{i,j} \lambda_i \lambda_j \varphi[x_i - x_j, y_i, y_j]$.

THEOREM. Let X, Y, $\varphi$ be as above. Given a sequence $x_1,\ldots,x_m \in X$ (let K be the convex hull of the x's) and continuous functions $f_1,\ldots,f_m, f$ mapping K into Y with

$$\varphi[x_i - x_j, f_i(x), f_j(x)] \leq 0 \quad (i,j=1,\ldots,m;\ \text{all } x \in K)$$

then: there exists an $x \in K$ such that

$$\varphi[x_i - x, f_i(x), f(x)] \leq 0 \quad (i=1,\ldots,m). \qquad (\alpha)$$

EXAMPLES. The special cases in which all the f's are constant functions contain some well known results. With X, Y inner-product spaces and $\varphi = \|x\|^2 - \|y_1 - y_2\|^2$, we get the Kirszbraun-Valentine Theorem. With X, Y linear spaces and $\varphi = B(x, y_1 - y_2)$, B a bilinear form, we get the Debrunner-Flor Lemma. (For background see the writer's paper "On the Extension... ", Bull. Amer. Math. Soc. 76 (1970), 334-339.)

PROOF. Apply the Knaster-Kuratowski-Mazurkiewicz Lemma to the simplex of probability-vectors $(\lambda_1,\ldots,\lambda_m)$, letting the closed sets of the Lemma correspond to inequalities $(\alpha)$ above. (Received December 22, 1975.)

# Logic and Foundations

76T-E11 MARTIN K. SOLOMON, Stevens Institute of Technology, Hoboken, New Jersey 07030. Some results on measure independent Gödel speed-ups.

Definition. Let $s_1$ and $s_2$ be r.e. subsets of $\Sigma^*$. $s_2$ is a measure independent Gödel speed-up (M.I.G.S.U.) of s if any measure g with domain $s_2$ is a Gödel speed-up of any measure b with domain $s_1$ which has a recursive graph. The following are corollaries to the theorem in the preceding abstract. Corollary 1. (i) $s_2$ is a M.I.G.S.U. of $s_1 \Leftrightarrow s_2 - s_1$ is not r.e.; (ii) a theory T has a M.I.G.S.U. iff T is undecidable; (iii) if $s_2$ is a M.I.G.S.U. of $s_1$ and $s_3$ is an r.e. superset of $s_2$ then $s_3$ is a M.I.G.S.U. of $s_1$. Corollary 2. If domain(g) is a M.I.G.S.U. of domain(b) then $\forall_{\text{recursive } r:N\to N}$ [$\{\Sigma x \in \text{domain}(g) \cap \text{domain}(b) | r(g(x)) < b(x)\}$ is not recursive]. (Received October 9, 1975.) (Author introduced by Professor Stephen L. Bloom.)

*76T-E12 JAN MYCIELSKI, Department of Mathematics, University of Colorado, Boulder, Colorado 80302, A 01-law in a finite space.

$\mathbb{n} = \{0,1,\ldots,n-1\}$, $V_n$ is any set of $n$ points on the circumference of a circle, OR is the ternary relation of orientation of triples of points on a plane. For any $P \subseteq {}^r n$ and $Q \subseteq {}^r V_n$ we put $\mathfrak{A}_n(P) = \langle n,<,P\rangle$ and $\mathfrak{B}(Q) = \langle V_n, OR, Q\rangle$. For any first order sentence $\alpha$ with equality about the structure $\mathfrak{A}_n(P)$ or $\mathfrak{B}_n(Q)$ we put $a(\alpha,n) = \text{card}\{P \subseteq {}^r n: \mathfrak{A}_n(P) \models \alpha\}$ and $b(\alpha,n) = \text{card}\{Q \subseteq {}^r V_n: \mathfrak{B}_n(Q) \models \alpha\}$. Theorem 1. The limit $\lim_{n\to\infty} a(\alpha,n)/2^{n^r}$ exists and is a number of the form $s/2^t$, where $s,t \in \omega$. This improves a result of A. Ehrenfeucht (unpublished). Theorem 2. The set $\{\alpha: \lim_{n\to\infty} b(\alpha,n)/2^{n^r} = 1\}$ is a complete decidable theory. (This improves a result of R. Fagin, Model Theory of Finite Structures, Thesis, Berkeley, 1973.) The method of proof permits also to confirm both conjectures stated in 75T-E43 in the case when $\mathfrak{A} = \langle\{\ldots,-1,0,1,\ldots\},<\rangle$. The results generalise to the case when P or Q are replaced by finite sequences of relations. (Received November 13, 1975.)

*76T-E13 Volker Weispfenning, University of Heidelberg, 69 Heidelberg, Fed. Rep. Germany. A note on $\aleph_0$-categorical model completions. Preliminary report.

Let L denote a first-order language with at least one constant symbol. We say a universal theory T in L is locally finite ( uniformly locally finite ) if every finitely generated model of T is finite ( if there exists a function $f:\mathbb{N} \to \mathbb{N}$ such that every n-generated model of T has cardinality $\leq f(n)$ ).
THEOREM. Assume L has only finitely many constant, function, and relation symbols, T is a universal theory in L with at least one infinite model, and Mod(T) has the amalgamation property. Then the following are equivalent:
(i) T has a complete, $\aleph_0$-categorical model completion.
(ii) T is uniformly locally finite and has a prime model.
If, in addition, T is a universal Horn theory, then the above are equivalent to:
(iii) T is locally finite and has a prime model.

The theorem provides an easy proof of the existence of $\aleph_0$-categorical model completions e.g. for the following theories T: ordered sets, partially ordered sets, distributive lattices, Boolean algebras, Stone algebras, pseudocomplemented distributive lattices satisfying the Lee identity $L_2$. (Received November 7, 1975.)

76T-E14 Philip J. Scott, Dept. of Pure Math., University of Waterloo, Waterloo, Ontario N2L 3G1, Canada. The Dialectica Interpretation and Categories II. Preliminary Report.

We continue part I (these Notices, Oct. 1975, P.A-644). The category $C'$ of $\exists\forall$-formulae of $HA^\omega$ has as maps (equivalence classes of) pairs of terms $(Y,S)$, to which we give a "proof" interpretation similar to Kreisel, Bishop, et al.; e.g. if $f(x) = y$ is a provably functional relation, then Y computes (via D) the given function value and S is its "proof". The two analyses of the Dialectica Interpretation in part I are related; viz. Theorem 3: The category $C'$ is equivalent to the Joyal-Reyes regular category of $\exists\forall$-formulae and provably functional $\exists\forall$-relations. Thus thinking of D, $\mathcal{D}$ as functors: $C(HA^\omega) \to \text{Im}(D)$, we see they are identical up to category equivalence. □ Changing viewpoint: Let $H_{\exists\forall}$ be the Lindenbaum algebra of $\exists\forall$-formulae of $HA^\omega$. $H_{\exists\forall}$ forms a Heyting algebra under the operations $[A]\wedge[B] = [A\wedge B]$, $[A]\vee[B] \underset{\text{def}}{=} [(A\vee B)^D]$, $[A] \Rightarrow [B] \underset{\text{def}}{=} [(A \to B)^D]$. We assume known the structure of a hyperdoctrine (F.W. Lawvere, AMS Symposia in Pure Math, Vol. XVII). Theorem 4: $H$ and $H_{\exists\forall}$ form hyperdoctrines and the Dialectica Interpretation is a hyperdoctrine morphism $D: H \to H_{\exists\forall}$. □ This answers a question of Lawvere (loc.cit.,p.1). The above analyses generalize to versions of Kreisel's modified realizibility and to certain intensional theories. (Received November 17, 1975.)

*75T-E15 JOSEPH SGRO, Yale University, New Haven, Connecticut 06520
A maximal topological logic.

We prove that the logic, $L^{\text{Top}}$, on topological models studied by S. Garavaglia [these Notices 22(1975), A-473] is the strongest topological logic with a Łos ultraproducts

theorem and a generalized form of the Karp property. An $L_{\omega\omega}$ analogue is also noted.

(Received December 4, 1975.)

76T-E16 SAHARON SHELAH, Hebrew University, Jerusalem, Israel. Some remarks in model theory.

Theorem 1: Suppose $T \subseteq T_1$, $T$ is complete and not superstable, $T_1$ is consistent; and $\lambda > |T_1|$ is regular or $\lambda = \lambda^{\aleph_0}$. Then, e.g., there are models in $PC(T_1, T)$ which are in $\lambda$ $L_{\infty,\lambda}$ - equivalent but are not ismorphic. Theorem 2: For every $\kappa$, $1 \leq \kappa \leq \aleph_0$, there is a complete comptable theory with exactly $\kappa$ minimal models. Theorem 3: Let $T$ be a complete theory; we call the triples of predicates $(P, <, E)$ if $T$ "says" $(P^{\mu}, <)$ is a tree and $x E y$ "means" $x$ and $y$ are on the same level. Then for every regular $\lambda \geq |T|$, $T$ has a model of cardinality $\lambda^+$ in which no tree has any undefinable (by parameters) branch (= a totally ordered set of representatives from the $E$ - equivalence classes). Theorem 4: If $T$ is countable, $I(\aleph_\alpha, T) \leq |\alpha| + \aleph_0$ for every $\alpha$, $p$ a type, and $T$ has a model omitting $p$ in $\mathfrak{I}_\omega$. We can replace "$I(\aleph_\alpha, T) \leq |\alpha| + \aleph_0$" by "$T$ has $<|\alpha - \beta|^{\aleph_0}$ non isomorphic $\aleph_1$ - saturated models, $\aleph_\alpha \geq \aleph_\beta + 2^{\aleph_0}$".

Remark: In 2, even for $\kappa = 1$ the theory has no prime model. (Received December 10, 1975.)

76T-E17 FORREST, WILLIAMS, Simon Fraser University, Burnaby, B. C. Canada V5A 1S6
Two Theorems in the Theory of Universal Classes with the Amalgamation Property

Let $\Sigma$ be a universal class with AP. A structure $A \in \Sigma$ is $L_A$-saturated if for every substructure $A_0 \leq A$ with $< |A|$ generators if $\Gamma(v_0)$ is an open type over $A_0$ then $\Gamma$ is realized in $A$. Theorem 1 A countable structure $B \in \Sigma$ is $L_A$-saturated iff $B$ is existentially universal. An uncountable $L_A$-saturated structure is existentially universal. Corollary 1 If $A \leq B \in \Sigma$ and $A,B$ are $L_A$ saturated then $A \preceq_{\infty,\omega} B$. Theorem 2 Suppose $B \in \Sigma$ and $\psi$ is an $L(B)$ sentence. Tbere is a finitely generated extension $B_1$ of $B$ in $\Sigma$ such that $B_1 \Vdash \psi$ or $B_1 \Vdash \neg\psi$. Here the symbol $\Vdash$ denotes infinite forcing. Corollary 2 If $B \in \Sigma$ is $L_A$-saturated then $B$ is infinite generic. (Received December 30, 1975.)

*76T-E18 Judith Roitman, Wellesley College, Wellesley, Mass. 02181. Cohen reals and Martin's Axiom. Preliminary report.

Let M be a transitive model of set theory, B the Boolean algebra adding one Cohen real. Then Martin's axiom + not-CH is false in $M^B$. (This follows from the existence of a certain topological space in $M^B$ which Kunen has shown inconsistent with MA + not-CH.) (Received December 31, 1975.)

*76T-E19 Alexander ABIAN, Iowa State University, Ames, Iowa 50011.
Inducive Boolean Rings.

Let $(B,\leq)$ be a Boolean ring and $k$ a cardinal number. Definition. $B$ is called $k$-inducive if and only if every inversely well ordered (w.r.t. $\leq$) subset $S$ of nonzero elements of $B$ with $\overline{\overline{S}} < k$ has a nonzero lower bound. Theorem. Let $p$ be a nonzero element of a $k$-inducive Boolean ring $B$ and $(H_i)_{i\in k}$ a family of subsets $H_i$ of $B$ such that $h_i = \text{glb } H_i$ for every $i \in k$. Then $B$ has an ultrafilter $U$ such that $p \in U$ and if $H_i \subseteq U$ then $h_i \in U$ for every $i \in k$. For $k = \aleph_0$ the Theorem implies a well-known result of Rasiowa-Sikorski. The Definition of a $k$-inducive Boolean ring is extended to a partially ordered set $P$ without a minimum element and an analogous theorem is proved for the existence of an appropriate generic subset $G$ of $P$ (where $G$ intersects $k$-many dense subsets of $P$). (Received January 6, 1976.)

76T-E20 KEITH HARROW, Brooklyn College, CUNY, Brooklyn, New York 11210. Equivalence of some predicate hierarchies.

Various hierarchies of primitive recursive functions have been proposed. The most striking fact about these hierarchies is that above a certain point the corresponding classes are identical. Here, this is extended to several predicate hierarchies. For each $n \geqq 0$, let $\mathcal{E}^n$ be the class of functions definable by limited recursion from a group of initial functions (including $f_n$, the nth Grzegorczyk function). $G^n$ is defined as $\mathcal{E}^n$, except that limited minimum is used rather than limited recursion. BA is the class of bounded arithmetic predicates, which is identical to the constructive arithmetic and the rudimentary classes. Let $BA(f_n)_*$ be the smallest class of predicates which includes BA and is closed under quantification bounded by $f_n$. Let $(H^n)_*$ be the smallest class which contains certain initial predicates and is closed under Boolean operations and quantification bounded by a function in $\mathcal{E}^n$. Given any class of functions F, let $(F)_*$ be the 0-1 functions (or predicates) of F. Extending a theorem of Grzegorczyk, it is shown that: $BA(f_n)_* = (G^n)_* = (H^n)_* = (\mathcal{E}^n)_*$ for each $n \geqq 3$. This characterization does not extend completely for $n < 3$, although parts do still remain true. (Received January 5, 1976.)

# Statistics and Probability

*76T-F2 BENJAMIN KEDEM, University of Maryland, College Park, Maryland 20742. A remark about the central limit theorem for stationary processes.

Let $\{x_t, t = 0, \pm 1, \cdots\}$ be a $2^{\underline{nd}}$-order *stationary* process with spectral density $f(\lambda)$ continuous at $\lambda = 0$ and such that $f(0) > 0$. Let $S_n = x_1 + \cdots + x_n$, and let $S_n^*$ be the normalized corresponding sum with mean 0 and variance 1 and characteristic function $\varphi_n$. There exists a two-valued random variable $Y_n$ with mean 0, variance 1, and characteristic function $\varphi_{Y_n}$ such that $\varphi_n(\theta) = \left[\varphi_{Y_n}(\theta/\sqrt{n})\right]^n \to e^{-\theta^2/2}$, as $n \to \infty$. (Received October 31,1975.)
(Author introduced by Jerome Dancis.)

*76T-F3 A. KUMAR, and B.M. SCHREIBER, Wayne State University, Detroit, Michigan 48202. Characterization of subclasses of class L probability distributions.

**We characterize the subclasses of class L probability distribution recently studied by K. Urbanik by requiring certain functions be convex and have derivatives of some fixed order. We then obtain the extreme points of certain compact convex sets which are then used to obtain the Levy-Khinchine representation of these probability distributions in the same fashion as Urbanik has obtained for class L probability measures.** (Received November 1975.)

*76T-F4 Mark J. Christensen, Georgia Institute of Technology, Atlanta, Georgia. Gleason Measures on Infinite Tensor Products of Hilbert Spaces. 30332

Nowak (Bull. Acad. Polon. Sci. Ser. Sci. Math. Astronom. Phys. 22 (1974), 393-395) has given an example of a consistent (in the sense of Kolmogorov) family of Gleason measures (A. M. Gleason, J. Math. Mech. 6 (1957), 885-894) $\{m_n\}$ defined over $\bigotimes_{i=1}^{n} H_i$ which do not extend to a Gleason measure on $\bigotimes_{i=1}^{\infty}{}^{\Phi} H_i$ for a given construction of the infinite tensor product. In this paper we show: (1) In the example of Nowak it is not necessary to assume, as is done, that the $H_i$ are infinite dimensional. (2) That every consistent family developed from pure states, which is the type considered by Nowak, extends over the complete infinite tensor product of von Neumann (Compositio Math. 6 (1938), 1-77). (3) Even if each $H_i$ is two-dimensional and the complete infinite tensor product of von Neumann is used it is possible to give a simple counter-example to the conjecture that every consistent family of Gleason measures extends by the use of non-pure states. (Received December 19, 1975.)

*76T-F5 Habib Salehi, Michigan State University, East Lansing, Michigan 48824. On square root of a positive $B(\mathcal{X},\mathcal{X}^*)$-valued function.

Let $(\Omega,\mathcal{B},\mu)$ be a measure space, $X$ a separable Banach space, $X^*$ its dual. Let $f$ be a weakly

summable positive $B(X,X^*)$ valued function defined on $\Omega$. The existence of a separable Hilbert space $K$, a weakly measurable $B(X,K)$ valued function $Q$ satisfying the relation $Q^*(\omega)Q(\omega) = f(\omega)$ is proved. This result is used to define the Hilbert space $L_{2,f}$ of square integrable operator-valued functions with respect to $f$. (Received December 22, 1975.)

# Topology

*76T-G15 CHANDAN S. VORA, The Free University of Iran, A Simplicial homology theory on the category of simplicial complexes and weighted maps - Preliminary.

Professor G. Darbo introduced the category of Hausdorff topological spaces and weighted maps and constructed a singular homology theory satisfying the axioms similar to Eilenberg-Steenrod which agrees with the singular homology theory for single valued maps. But, he was unsuccessful in constructing a simplicial homology theory.

In this paper the author constructs a simplicial homology theory on the category of simplicial complexes and weighted maps. (Received July 28, 1975.)

*76T-G16 Y. H. Wan State University of New York at Buffalo, Amherst, New York, 14226. On the Uniqueness of invariant manifolds. Preliminary report.

Let F be a $C^r$ mapping from a neighborhood of zero in $R^n$ into $R^n$ with $F(0)=0$. Denote by $\lambda_1, \cdots \lambda_n$ eigenvalues of $DF(0)$. Suppose $L_0$ is a c-dimensional invariant subspace and the restriction $DF|L_0$ of $DF(0)$ on $L_0$ has eigenvalues $\lambda_1, \cdots, \lambda_c$. In this situation, we have the following weak uniqueness result for invariant submanifolds of this mapping F. Theorem If $\lambda_j \neq \lambda_1^{n_1} \cdots \lambda_c^{n_c}$ for any $j>c$ and nonnegative integers $n_1, \cdots, n_c$ with $n_1 + \cdots + n_c \leq s$ then any two $C^s$ invariant submanifolds of F ($s \leq r$) with the same tangent space $L_0$ at zero are in contact at zero to order s. Analogous result for invariant submanifolds of a vector field X on $R^n$ with $X(0)=0$ is also valid. Combining with the Poincaré normal form, the proof can be used to derive formulas in Hopf bifurcation theorem. (Received October 5, 1975.) (Author introduced by Professor S. Hastings.)

*76T-G17 Robert Warren Button, Southern Illinois University, Carbondale, Illinois, 62901. A Non-Standard Characterization of Perfect Mappings.

In this paper a conjecture by I. Juhász characterizing perfect mappings is proven and several examples of its applications are given.

Theorem. Let X be a regular space and let $f: X \to Y$ be a closed surjection. Then f is perfect iff:

(i) For each $x \in X$, $f(\mu(x)) \subseteq \mu(f(x))$.

(ii) For each remote $z \in {}^*X$, $f(z)$ is remote in ${}^*Y$.

Theorem. Let X and Y be any topological spaces and let $f: X \to Y$ be perfect. Then for each $x \in {}^*X$, x is remote iff $f(x)$ is remote in ${}^*Y$. (Received November 3, 1975.)

*76T-G18 ROBERT A. HERRMANN, Math. Dept. U. S. Naval Academy, Annapolis, MD 21402. Nearly-compact Hausdorff extensions.

In this paper, it is shown that each almost completely regular space $(X,T)$ can be densely embedded into a nearly-compact Hausdorff space $(\alpha(X),\alpha(T))$ with the following properties. (1) For each nearly-compact Hausdorff space $(Y,\tau)$ and each continuous open [resp. almost-continuous] $f:X \to Y$ there exists a unique continuous [resp. almost-continuous] $F:\alpha(X) \to Y$ which extends f. (2) Any nearly-compact Hausdorff space in which X can be densely embedded and which possesses property (1) is homeomorphic [resp. $\theta$-homeomorphic] to $\alpha(X)$. (3) $(\alpha(X),\alpha(T))$ is the projective maximum in the class of all nearly-compact Hausdorff spaces in which X can be densely embedded. (4) X is C*-embedded in $\alpha(X)$. An application to P-closed spaces is given. ( Received November 13, 1975.)

*76T-G19 D.R.MCMILLAN,JR.,Univ.of Wis.,Madison,Wis.53706 and N. SHRIKHANDE Pahlavi Univ.,Shiraz,Iran. Simple connectivity of a quotient space.

Theorem. If X is a continuum in the connected compact absolute neighborhood retract S, then the quotient space Y="S mod X" is locally simply connected if and only if the projection $P:S\to Y$ induces a surjection on fundamental groups. It is then quite easy to decide whether an n-cell mod X is simply connected in many interesting cases. For example, an n-cell mod a solenoid or the Case-Chamberlin continuum, is not simply connected. (The reason these cases are easy to settle using the above result is that Shrikhande has shown that local simple connectivity of the quotient space is equivalent to McMillan's shape property of X called "nearly 1-movable", which is usually not hard to check.) Since the Case-Chamberlin continuum embeds in $S^3$ with contractible complement, there is a contractible, open set in $S^3$ whose one-point compactification is not simply connected. (The Whitehead example has simply connected compactification.) Considering $S^3\subset S^n$ in the usual way and taking the complement in $S^n$ of the same embedding of this continuum, one obtains a similar example for each $n \geq 3$. (Received November 19, 1975.)

*76T-G20 Jeong S. Yang, University of South Carolina, Columbia, S. C. 29208. The space of normal subgroups of C(X,G).

If X is a topological space and G a topological group, let $\Gamma$ be the topological group of all continuous functions from X into G endowed with the compact-open topology and the pointwise multiplication. Let $\Delta(X) = \{M_x: x\in X\}$, where $M_x = \{f\in\Gamma: f(x) = e\}$. For a collection $\Xi$ of normal subgroups of $\Gamma$, we define "*" as follows: If $U\subset\Xi$, and $U \neq \phi$, let $U^* = \{M\in\Xi: M\supset\cap U\}$; let $\phi^* = \phi$. The following are some of the results obtained. Theorem 1 "*" is a closure operator on $\Xi$ if and only if whenever $M\in\Xi$ and $M\supset M_1\cap M_2$, where $M_1, M_2 \lhd \Gamma$, then either $M\supset M_1$ or $M\supset M_2$. If "*" is a closure operator on $\Xi$, we shall say that $\Xi$ admits the S-topology. Theorem 2 If (X,G) is an S-pair (Proc. Amer. Math. Soc. 39 (1973), 619-624), then $\Delta(X)$ admits the S-topology and the S-topology is Hausdorff. Theorem 3 If (X,G) is an S-pair, the mapping $\psi: X \to \Delta(X)$ defined by $\psi(x) = M_x$ is a homeomorphism. (Received November 3, 1975.)

76T-G21 KENNETH S. BROWN, Cornell University, Ithaca, N.Y. 14853 and PETER J. KAHN, Cornell University, Ithaca, N.Y. 14853. Homotopy-dimension and simple-homological-dimension of nilpotent spaces. Preliminary report.

The homotopy-dimension of a CW complex X, written hdim X, is defined to be inf{dim Y }, where Y ranges over all CW complexes homotopy equivalent to X. The simple-homological-dimension of X, written Hdim X, is defined to be $\sup\{i \mid H^i(X;A) \neq 0\}$, where A ranges over all abelian groups. The value $\infty$ is allowed in both cases. It is well known that Hdim X = hdim X for 1-connected X. Theorem: If X is nilpotent and $\pi_1 X$ is finitely-generated, then Hdim X = hdim X. This verifies a conjecture of G. Mislin and strengthens previously announced results of the second author. Equality is also proved for many classes of non-nilpotent spaces. (Received November 21, 1975.)

*76T-G22 Rodolofo Talamo, Carnegie-Mellon University, Pittsburgh, PA 15213. Lifting Problems in Structures. Preliminary Report.

Let T be the forgetful functor that associates with every uniform space its underlying topological space. We characterize those sources which are lifted to an initial space by T. This answers a question appearing in W. N. Hunsaker and P. Sharma, "Proximity Spaces and Topological Functors", Proc. AMS 45(1974), 419-425. Analogous results for nearness spaces are given. (Received November 24, 1975.)

76T-G23 VINOD KUMAR, Indian Institute of Technology, Hauz Khas, New Delhi-110029. An extension of convergence spaces.

Let p be a property of subsets of a set X possessed by $\phi$ and X and closed under finite intersection. Let $pX = \{A \subset X | A \text{ has } p\}$. p-filters, p principal filters, p-ultrafilters p-convergence and p-compactness etc. have obvious meaning. For p-convergence spaces $(X,q_X)$ and $(Y,q_Y)$ call $f: X \to Y$ p-continuous iff $f^{-1}\, pY \subset pX$ and $(f\phi, fx) \in q_Y$ whenever $(\phi, x) \in q_X$. Call f weakly p-perfect iff f is p-continuous and takes non-convergent p-ultrafilters to either non-convergent p-ultrafilters or p-principal filters. p-convergence Hausdorff spaces with weakly p-perfect maps form a category C. Let D be the subcategory of p-compact spaces. Theorem. If X* is X union all non-convergent p-ultrafilters on X then there exists a p-compact convergence structure $q_{X*}$ on X* which is Hausdorff iff $q_X$ is and gives a functor from C to D. Moreover, if the inclusion $X \subset X^*$ is weakly p-perfect and epi in C then this functor is an epireflection. As particular cases we obtain Richardson's compactification, Formin's H-closed extension, zero-dimensional compactification and Banaschewski's minimal $T_2$-extension (the last mentioned as an epireflection thus settling a question of Herrlich and Strecker, Math. Ann. 177(1968) 302-309). (Received November 24, 1975.) (Author introduced by Stanley P. Franklin.)

76T-G24 JOGENDRA K. KOHLI, Hindu College, University of Delhi, Delhi-110007, India. On Monotone Extensions of Maps

Let f be a function, not necessarily continuous, from a topological space X into a topological space Y. We say that f is monotone if for each $y \in Y$ the fibre $f^{-1}(y)$ is either connected or empty.

Proposition A. There is a superspace X* of X and a monotone function $f^* : X^* \to Y$ whose restriction to X is f. If the function f is continous (or closed), so is f*.

We say that X* preserves property P if X* possesses property P whenever X possesses P.

Proposition B. The space X* preserves the property of being a (1) $t_0$-space, (2) connected or a locally connected space, (3) compact or a locally compact space, (4) space of local weight m. (Received November 24, 1975.) (Author introduced by Stanley P. Franklin.)

*76T-G25 Teodor C. Przymusiński, Instytut Matematyczny PAN, Warsaw and University of Pittsburgh, Pittsburgh, PA 15260. A note on locally finite coverings.

It is known, that every locally finite open covering of a normal space has a $\sigma$-discrete open refinement. Example 1. (answering a question of G. M. Reed) There exists a completely regular metacompact Moore space and its open locally finite covering which does not have a $\sigma$-discrete open refinement.

A covering $\mathcal{U}$ is uniformly locally finite (M. Katětov) if there exists a locally finite open covering $\mathcal{V}$ such that each $V \in \mathcal{V}$ intersects finitely many elements of $\mathcal{U}$. It is known, that every locally finite covering of a countably paracompact collectionwise normal space is uniformly locally finite. Example 2. There exists a collectionwise normal space X and its countable, locally finite, cozero cover, which is not uniformly locally finite. This example also shows, that there exists a collectionwise normal space, which is not weakly $c\mathfrak{b}$ -space. (Received November 28, 1975.)

*76T-G26 Donald Marxen, Marquette University, Milwaukee, Wisconsin 53233. Uniform Quotients of Metric Spaces.

A surjection f of a uniform space $[X, \mathcal{U}]$ onto a uniform space $[Y, \mathcal{V}]$ is called a uniform quotient map if $\mathcal{V}$ is the quotient uniformity determined by f and $[X, \mathcal{U}]$. In this paper we

investigate the preservation of pseudometrizability (of uniform spaces) under uniform quotient maps. Most important, it is shown that a uniform quotient of a metric space need not be pseudometrizable, thus answering in the negative a question posed by Himmelberg [Bull. Inst. Math. Acad. Sinica 2(1974), 357-369]. (Received December 1, 1975.)

76T-G27 Jun-iti Nagata, Math. Inst., Universiteit van Amsterdam, Roetersstr. 15, Amsterdam, Holland. A characterization of paracompact M-spaces.

Let $C^*(X)$ be the ring of the bounded, real-valued continuous functions on a Tychonoff space $X$. We consider $\bigvee_\alpha f_\alpha$ and $\bigwedge_\alpha f_\alpha$ for an infinite subset $\{f_\alpha | \alpha \in A\}$ of $C^*(X)$ when they sup. and inf. are bounded and continuous.

Definition. A subset $L$ of $C^*(X)$ is $\sigma$-normally generated by its subset $\bigcup_{m=1}^{\infty} L_m$ if (1) for every subset $\{f_\alpha | \alpha \in A\}$ of $L_m$, $\bigvee_\alpha f_\alpha$ and $\bigwedge_\alpha f_\alpha$ exist, (2) $L = \{f \in C^*(X) \mid$ For every $\epsilon > 0$ there are subsets $\{g_\beta | \beta \in B\}$ and $\{h_\gamma | \gamma \in \Gamma\}$ of $\bigcup_{m=1}^{\infty} L_m$ such that $\|f - \bigvee_\beta g_\beta\| < \epsilon$, $\|f - \bigwedge_\gamma h_\gamma\| < \epsilon\}$.

A subset $J$ of $C^*(X)$ is fixed iff it is contained in a maximal ideal $J'$ of $C^*(X)$ such that $\bigvee_\alpha f_\alpha \in J'$ whenever $\{f_\alpha | \alpha \in A\} \subset J'$ and $\bigvee_\alpha f_\alpha$ exists; otherwise $J$ is free.

Theorem. A Tychonoff space $X$ is paracompact and M (K. Morita, General Topology and its Applications 1 (1971) 49-55) iff there is a $\sigma$-normally generated subset $L$ of $C^*(X)$ such that for every maximal free ideal $J$ of $C^*(X)$, $J \cap L$ is free. (Received December 1, 1975.)

76T-G28 GLORIA TASHJIAN, University of Rhode Island, Kingston, R.I. 02881. Cartesian-closed coreflective hulls in Tychonoff spaces. Preliminary report.

Let $\mathcal{S} \subset$ Tych be map-invariant and let $\phi(\mathcal{S})$ be the coreflective hull of $\mathcal{S}$ in Tych. For $X,Y \in \phi(\mathcal{S})$ let $X^Y$ be the morphism set $\mathcal{C}(Y,X)$ with the $\phi(\mathcal{S})$-coreflection of the topology of uniform convergence on $\mathcal{S}$-sets, and let $X \otimes Y$ be the coreflected product.

Theorem: $(X^Y)^Z = X^{Y \otimes Z}$ for all $X,Y,Z \in \phi(\mathcal{S})$ if and only if the projections $\pi: X \otimes Y \to X$ are z-closed for all $X,Y \in \mathcal{S}$. It follows that, in this case, $X \times Y$ is pseudocompact for all $X,Y \in \mathcal{S}$, using a theorem of Comfort and Hager. In particular, the coreflective hull of $\mathcal{T} = \{X \in$ Tych: $X \times Y$ is pseudocompact for every pseudocompact $Y\}$ is cartesian-closed. Also, if $\mathcal{S} \subset \mathcal{T}$, then $(X^Y)^Z = X^{Y \otimes Z}$ for all $X,Y,Z \in \phi(\mathcal{S})$ if and only if $X \times Y \in \phi(\mathcal{S})$ whenever $X,Y \in \mathcal{S}$. Finally, an example is given of a cartesian-closed $\phi(\mathcal{S})$ where $\mathcal{S} \not\subset \mathcal{T}$. (Received December 3, 1975.)

76T-G29 P. Th. Lambrinos, Kansas State University, Manhattan, Kansas, 66506. A bicoreflective subcategory of top broader than the category of K-spaces. Preliminary report.

For any arbitrary topological space $(X,\mathcal{T})$ define the B-extension $\mathcal{T}_B$ of $\mathcal{T}$ as follows: $X \supset A \in \mathcal{T}_B$ iff for any bounded subset $S$ of $(X,\mathcal{T})$ (i.e. such that $S$ is contained in a finite union of members of any open cover of the whole space $(X,\mathcal{T})$ (see also abstract *729-G18, these "Notices" 22 (November 1975) p. A-733)), $A \cap \mathrm{cl}S$ is open in $\mathrm{cl}S$. The topological spaces $(X,\mathcal{T})$, $(X,\mathcal{T}_B)$ have exactly the same bounded subsets and they agree on their closures. Call $(X,\mathcal{T})$ a BG-space ("boundedly generated space") if $\mathcal{T}_B = \mathcal{T}$. Any (Hausdorff) K-space and any locally bounded space is a BG-space but there are Hausdorff non regular BG-spaces wich are not K-spaces. The B-extension of any space is a BG-space. The category of BG-spaces is a full bicoreflective subcategory of top containing the "convenient" category of K-spaces as a full bicoreflective subcategory. (Received December 4, 1975.)

76T-G30 J.M. van Wouwe, Free University, Amsterdam, The Netherlands.
On ordered p-spaces. Preliminary report

A. Every (generalized) ordered space can be decomposed into maximal convex subsets without (pseudo-) gaps. We prove the following theorem: A generalized ordered space is a p-space (in the sense of Ar'hangelskii)iff this decomposition-space is metrizable.

B. It is well-known that in general a strict p-space is a wΔ-space. We prove that a generalized ordered p-space is a wΔ-space. In contrast with this, we have an example of an ordered M-space which is not a p-space. (Received November 11, 1975.)

76T-G31 GERALD A. ANDERSON, Massachusetts Institute of Technology, Cambridge, Mass. 02139. Higher Whitehead Torsion.

Let $\pi$ be a multiplicative group, $R$ a ring with 1 and $F:\pi \longrightarrow R^{\cdot}$ a homomorphism. For each $i=0,1,2,\ldots$, we define a group $Wh_i(\pi;F)$, called the i-th Whitehead group of $\pi$ with coefficients $F$. We have $Wh_0(\pi;F) = \tilde{K}_0(R)$, $Wh_1(\pi;F) = Wh(\pi;F)$ (classical) and $Wh_2(\pi)$ is the group defined by Hatcher and Wagoner. Given any "stably free" geometric problem on a space $X$, e.g. homotopy equivalence, Poincare duality, etc., we define a sequence of obstructions in $H^i(X;Wh_i(\pi;F))$, extending known constructions. If $K$ is a finite complex, then we also define $Wh_i^+(\pi_1K;Z_2\times\pi_2K)$ and a homomorphism $Wh_i(\pi_1K) \oplus Wh_{i-1}^+(\pi_1K;Z_2\times\pi_2K) \longrightarrow \pi_{i-1}Wh(K)$, where $Wh(K)$ is Hatcher's Whitehead space. (Received December 12, 1975.)

*76T-G32 SAMUEL BROVERMAN, University of Manitoba, Winnipeg, Manitoba, Canada. R3T 2N2.
N-Compact Spaces, Preliminary Report.

All spaces are assumed to be completely regular and Hausdorff. Let $\beta X$ denote the Stone-Čech compactification of $X$. We call a space weakly homogeneous if for any $p \in \beta X - X$, the set $\{q \in \beta X - X: q = \beta(f)(p)$ for some $f: X \to X\}$ is dense in $\beta X - X$. If $E$ is a space the a space $X$ is E-compact if $X$ can be embedded as a closed subset of $E^m$ for some cardinal number m (see "Further Results on E-compact Spaces I," by Mrowka, Acta. Math. 120, 161 - 185(1968)). Theorem 1. Let $E = I \times N$ where $I$ is the closed unit interval and $N$ is the natural numbers. Then any E-compact space is weakly homogeneous. Theorem 2. Let $X$ be locally compact. Then $X$ is N-compact if and only if $X$ is realcompact, weakly homogeneous and 0-dimensional (a space is 0-dimensional if it has a base of open-and-closed sets). (Received December 15, 1975.)

76T-G33 Daniel Baker, S.U.N.Y., Stony Brook, N.Y. 11794. Characteristic Classes for Foliations. Preliminary Report.

Let $B\Gamma_n^r$ be the classifying space for $C^r$ codim. n Haefliger structures ($r\geq 2$). There is a map $\pi: B\Gamma_n^r \longrightarrow BGl(n)$ obtained by associating a Haefliger structure to its normal bundle. Let $F\Gamma_n^r$ be the homotopy theoretic fibre of this map. Let $W_n = \Lambda^*(u_1,\ldots,u_n) \otimes P_n(c_1,\ldots,c_n)$ with $du_i=c_i$, $dc_i=0$. There is a map $H^*(W_n) \longrightarrow H^*(F\Gamma_n^r)$. We give information about the image of this map obtained by constructing specific foliations and evaluating these classes on them. Our results extend facts already known (Yamato,K. Examples of Foliations with Non-trivial Char. Classes, Osaka Jour. of Math., August 1975,Vol. 12, #2), and intersect a part of work done independently by Kamber and Tondeur (Non-trivial Char. Invariants of Homogeneous Foliated Bundles, sec. 7, preprint). Sample results are: 1) The classes $c_1^n u_1 u_{i_1} \ldots u_{i_k}$, $1<i_1<\ldots<i_k\leq n$, are all non zero and satisfy no linear relations. 2) In (1) we can replace $c_1^n$ with any other monomial $q(c_1,\ldots,c_n)$ of dim. 2n and (1) is still true. 3) If $q(c_1,\ldots,c_n)$ has dim. $2(n-j+1)$ then the classes $q(c_1,\ldots,c_n)u_j u_{i_1}\ldots u_{i_k}$, $j<i_1<\ldots<i_k\leq n$, are non zero. The impossibility of certain relations existing between classes of types (1), (2), and (3) is also shown. (Received December 16, 1975.)

*76T-G34 R.PAUL BEEM, University of Indiana at South Bend, South Bend, Ind., 46615, Generators of G Bordism.

Let $G$ be a finite abelian group whose order is not divisible by four. Let $f_i$ be the collection of distinct homomorphisms into the circle group. Each $f_i$ induces a $G$ action on the total space of the real projective bundle of the Whitney sum of $E(n)$ with a trivial real line bundle, where $E(n)$ is the canonical complex line bundle over n-dimensional complex projective space. Call this action, $E(n,i)$.

Let H be a subgroup of odd index in G. There is a natural G action on the factor group, G/H.

THEOREM: a. For G with odd order, the above actions algebraically generate the bordism ring of all unoriented unrestricted G manifolds.
b. If the order of G is congruent to two (Mod 4), the above actions algebraically generate G bordism modulo the ideal of extensions of involutions.
(Received December 19, 1975.)

76T-G35 JUN TERASAWA, State University of New York at Buffalo, Amherst, New York 14226. $N \cup R$ need not be strongly 0-dimensional. Preliminary report.

According to S.Mrówka/Bull. Acad.Polon.Sci. 18(1970),443-448/, $N \cup R$ is the union of the set $N$ of integers and an almost-disjoint collection $R$ of subsets of $N$ endowed with the following topology: each point of $N$ is isolated and each point $p \in R$ has a neighborhood basis $\{\{p\} \cup p \setminus F \mid F$ is a finite subset of $N\}$. The author has constructed a maximal almost-disjoint collection $R$ of subsets of $N$ such that $N \cup R$ is not strongly 0-dimensional. (Received December 22, 1975.)

*76T-G36 Czes Kosniowski, University of Newcastle upon Tyne, Newcastle upon Tyne, NE1 7RU.
Characteristic Numbers of $\mathbb{Z}/p$ manifolds.

Let p be a prime number and let $\mathbb{Z}/p$ denote the cyclic group of order p. By a manifold we shall mean either a unitary manifold or an oriented manifold - in the latter case p is assumed to be an odd prime.

Suppose that M is a $\mathbb{Z}/p$ manifold of dimension 2n such that

(i) $n = 0 \bmod (p-1)$,

(ii) either $n = -1 \bmod p$ or else each component of the fixed point set has trivial normal bundle in M,

(iii) no component of the fixed point set is of dimension 2n, and

(iv) $n \neq p^k - 1$ for any $k \geq 0$,

then M is decomposable mod p, i.e. decomposable as an element of $\mathfrak{U}_*/p\mathfrak{U}_*$ or $\Omega_*/p\Omega_*$.
(Received December 29, 1975.)

76T-G37 Dennis Burke, Miami University, Oxford, Ohio 45056. On K-semi-metric spaces. Preliminary report.

A semi-metric d for a space X is called a K-semi-metric if $d(H,K) > 0$ for any pair H,K of disjoint compact subsets of X. Arhangel'skiĭ has conjectured that every semi-metrizable space has a compatible K-semi-metric; the following result provides a counterexample. Example. There is a separable Moore space which does not possess a compatible K-semi-metric. (Received December 29, 1975.)

*76T-G38 ULRICH KOSCHORKE, Mathematics Institute, Bonn University
Geometric Interpretations of Generalized Hopf Invariants

Assume $r \leq 2n-2$. Identify the homotopy group $\pi_{r+n+m}(S^{n+m})$ with the bordism group of framed r-dimensional submanifolds of $\mathbb{R}^{r+n+m}$. Theorem 1. This group can already be described by embeddings which project to framed immersions into $\mathbb{R}^{r+n}$.-Selfintersections of the resulting immersions lead to a "double point invariant". Theorem 2. Under canonical identifications, this invariant corresponds to the generalized Hopf invariant of Whitehead and James.- Theorem 3. The group $\pi_{r+n+m}(S^{n+m})$ can already be described by submanifolds of $\mathbb{R}^{r+n}$ (but framed only in $\mathbb{R}^{r+n+m}$).- An invariant is obtained which measures to what extend such a submanifold fails to be already framed in $\mathbb{R}^{r+n}$. Theorem 4. Under canonical identifications, this "singularity invariant" also corresponds to the generalized Hopf invariant.- More generally, we obtain two distinct geometric interpretations of James' EHP-sequence, and also two filtrations

for every homotopy group of spheres. Moreover, homotopy computations translate into interesting differential topology. (Received December 29, 1975.)

## Miscellaneous Fields

76T-H2 Henryk J. Dwornik, 44-100 Gliwice, ul. Kościuszki 32, Poland. A $2^n$ number system in the arithmetics of prehistoric cultures.

Irregularities in numeral systems, some methods of Babylonian and Egyptian arithmetics, and the calendrical system of the Maya are interpreted by accepting a hypothetical binary-contracted-to-$2^8$ number system functioning in several prehistoric cultures. This system identified with the archaic solar symbol is considerably shorter in script compared with the decimal system in Arabic notation. It seems confirmed by the Babylonian signs for 1 𒁹 and 10 𒌋, the Greek sign for 5 Γ, and indirectly by the Babylonian sign for 100 𒁹𒌋, if 100 is to be understood as $1 \cdot 60 + 4 \cdot 10$. Several transition systems are described: a (16-1) system preserved in many languages with a special term for the number 15, the Babylonian sexagesimal system (64-4), the duodecimal-decimal system preserved in the ancient concept of "hundred", later "long hundred" (128-8), a (256+4) system used by the Maya in chronological and astronomical calculations and preserved in the sacred year "tzolkin". The principles of a prehistoric arithmetics are reproduced and its performance on a $8^2$ squares board as used in board games known to be very ancient is given. Measures and weights originating from the $2^n$ number system are quoted. (Received December 12, 1975.)

# The November Meeting in Los Angeles, California
# November 15, 1975

*730-B14 Stephen Simons, University of California, Santa Barbara, California 93106. Vector lattices, generalized L-spaces, weak compactness in spaces of Radon Measures and vector measures. Preliminary report.

Various generalizations to vector lattices of Grothendieck's criterion for a set of Radon Measures to be weakly relatively compact are discussed. An application is given to the theory of vector measures. (Received November 28, 1975.)

# The March Meeting in Tallahassee, Florida
# March 4 – 5, 1976

## Algebra & Theory of Numbers

732-A1 Stephen McAdam, The University of Texas, Austin, Texas 78712. The Upper Conjecture: A Melodrama in one Indeterminate. Preliminary report.

Let $(R,M)$ be a local domain and let $x$ be an indeterminate. Let $S(M) = \{n \mid$ there is a saturated chain of primes from $0$ to $M$ of length $n\}$. Define $S(M,x)$ analogously with respect to $(M,x)$ in $R[x]$. There are diverse characterizations of $S(M,x)$. One is in terms of the completion of $R$, another in terms of integral extensions of $R$, a third in terms of certain D.V.R. overrings of $R$. One would prefer characterizations of $S(M)$. None are known. Thus it is valuable to study the relationship between $S(M)$ and $S(M,x)$. Clearly $\{n+1 \mid n \in S(M)\} \subset S(M,x)$. Nagata's famous example shows this inclusion can be proper. The upper conjecture says $\{n+1 \mid n \in S(M)\} \subset S(M,x) \subset \{n+1 \mid n \in S(M)\} \cup \{2\}$. (Received December 11, 1975.)

*732-A2 Peter Hoefsmit, University of Virginia, Charlottesville, Virginia 22903 Representations of generic Algebras corresponding to Classical Weyl Groups

Let $(W,R)$ be a Coxeter system, where $W$ is a Weyl group of classical type, and let $A(W)$ denote the generic algebra corresponding to $W$, defined over $Q(u_r : r \quad R)$, $u_r$ indeterminates over $Q$. We will discuss the construction of all the irreducible representations of $A(W)$. This is accomplished by generalizing an explicit matrix construction of A. Young of the irreducible representations of the symmetric group (Proc. London Math. Soc., 34 (1932)) Results on character values for these

representations will also be discussed. As one application we derive explicit formulas, in terms of hook lengths in appropriate Young diagrams for the degrees of the irreducible constituents of the permutation character $1_B^G$, where G is a Chevalley group whose Weyl group is of classical type, and B is a Borel subgroup of G. As these degrees are given genericly, they yield the degrees of these characters for the classical simple groups $A_n(q)$, $A_n^2(q^2)$, $B_n(q)$, $D_n(q)$, and $D_n^2(q^2)$. (Received December 12, 1975.)

732-A3 MATTHEW J. O'MALLEY, University of Houston, Houston, Texas 77004.
Homomorphisms of power series rings, Preliminary report.

Let R be a commutative ring with identity, let $\{X_i\}_{i=1}^n$ and $\{Y_i\}_{i=1}^m$ be sets of indeterminates over R, and let $R^{((n))}$ and $R^{((m))}$ denote the formal power series rings in $\{X_i\}_{i=1}^n$ and $\{Y_i\}_{i=1}^m$, respectively. Questions concerning existence and uniqueness of R-homomorphisms and R-isomorphisms of $R^{((n))}$ into $R^{((m))}$ are discussed. For example, if $\phi_1$ and $\phi_2$ are R-homomorphisms of $R^{((n))}$ into $R^{((m))}$ such that $\phi_1(X_i) = \phi_2(X_i)$ for each i, then $\phi_1 = \phi_2$. Of prime importance is a result of P. Eakin and A. Sathaye [R-endomorphisms of R[[X]] are essentially continuous, preprint], which states that if $\phi$ is an R-homomorphism of $R^{((n))}$ into $R^{((m))}$ such that for each i $\phi(X_i) = c_i + g_i$, where $c_i \in R$ and $g_i \in (\{Y_i\}_{i=1}^m)$, then there exists an R-automorphism $\psi$ of $R^{((n))}$ such that $\psi(X_i) = c_i + X_i$ for each i. (Received December 12, 1975.)

732-A4 Wayne R. Jones, University of Virginia, Charlottesville, Virginia 22903.
On the 1-cohomology of finite groups of Lie type. Preliminary report.

Let G be a finite Chevalley group over $k = GF(p^n)$ and let V be an irreducible kG-module of dominant weight $\lambda$. When $\lambda$ is "minimal', $H^1(G,V)$ has been completely determined for $p^n \leq 3$ by this author and for $p^n > 3$ by Cline, Parshall, and Scott (Publ. Math. I.H.E.S., no.45). Here we consider some cases when $\lambda$ is not "minimal" and in particular prove the following - Theorem: Let $\psi$ be the maximal short root in the root system $\Sigma$ defining G. If $\lambda \notin \mathbb{Z}\Sigma$ and if $2(\lambda,\psi)/(\psi,\psi) < p - 3$, then $H^1(G,V) = 0$. (Received December 15, 1975.)

732-A5 Mark Benard, Tulane University, New Orleans, Louisiana 70118. Schur indices and defect groups. Preliminary report.

Let p be a prime and let $k = \mathbb{Q}_p$, the p-adic completion of the rationals. The author has shown that if $\chi$ is an irreducible character of a finite group belonging to a p-block with cyclic defect group and $\phi$ is an irreducible p-modular constituent of $\chi$, then the Schur index $m_k(\chi)$ of $\chi$ over k equals $|k(\chi,\phi) : k(\chi)|$. Continuing work along these lines, the author has begun investigating the case when p = 2 and the defect group is dihedral. Preliminary results show that in this case, it appears that the Schur indices over $\mathbb{Q}_2$ are always 1. (Received December 15, 1975.)

732-A6 Harold N. Ward, University of Virginia, Charlottesville, Virginia 22903.
Multilinear invariants for the Weil representation.

The Weil representation of the finite symplectic group Sp(2n,q), q a power of an odd prime, is a reducible representation of degree $q^n$. This paper concerns multilinear invariants for the representation and some of their uses. When n=1 and the field of the representation is the complex field, a complete list of multilinear invariants has been determined. Some of these, with their underlying representation, can be read into small finite fields to yield interesting situations. For example, q=11 produces a symmetric trilinear form over GF(3) in 5 dimensions whose group is $M_{11}$,

and a symmetric four-linear form (over GF(3)) in 6 dimensions whose group is the covering group of $M_{12}$. These two forms have been the subject of a recent study. When q=13 one obtains an alternating trilinear form in 7 dimensions that can be used to embed PSL(2,13) into the Chevalley group of type $G_2$ over any number of fields. Further examples with combinatorial applications will be presented. (Received December 15, 1975.)

732-A7 Arnold D. Feldman, Louisiana State University, Baton Rouge, Louisiana 70803. Fitting height of certain solvable groups admitting $\mathbb{Z}_p$. Preliminary report.

Let $F(G)$ be the Fitting subgroup of the finite solvable group $G$. Suppose $G$ admits $P$ of prime order, $p$, and $q$ is a prime different from $p$. Theorem 1. If $C_G(P)$ is an abelian q-group, then $G/F(G)$ is nilpotent, i.e., the Fitting height of $G$ is at most 2. Theorem 1 is used to eliminate conditions on $p$ and $q$ from a result of Rickman. We obtain: Theorem 2. If $C_G(P)$ is a cyclic q-group, then $G$ is q-closed or q-nilpotent. (Received December 15, 1975.)

732-A8 BRIAN PARSHALL, University of Virginia, Charlottesville, Virginia 22903. Cohomology of finite forms of semisimple algebraic groups.

We will discuss some recent results (mostly due to Cline, Scott, and the author) concerning the relationship between the Hochschild cohomology of a semisimple algebraic group $G$ over $GF(p)$ and the cohomology of its finite forms $G(q)$, $q = p^n$. This represents efforts to determine the "sporadic" cohomology of $G(q)$ (a cohomology class is sporadic if it does not arise as the restriction to $G(q)$ of a cohomology class for $G(q')$, $q'$ a large power of $q$). A possible application (first pointed out by Griess) is that for $H^1$ such sporadic cohomology may lead to interesting sporadic embeddings of subgroups.
(Received December 19, 1975.)

*732-A9 J. T. Arnold and D. W. Boyd, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061. Transcendence degree in power series rings. Preliminary report.

Let D be an integral domain with quotient field K and let J be an overring of D; that is, $D \subseteq J \subseteq K$. This paper considers the relation between the power series rings $D[[X]]$ and $J[[X]]$. The main result of the paper shows that if D is integrally closed, then the quotient field of $J[[X]]$ has finite transcendence degree over the quotient field of $D[[X]]$ if and only if $J[[X]] \subseteq (D[[X]])_{D-(0)}$.
(Received December 18, 1975.)

*732-A10 Louis Dale, University of Alabama in Birmingham, Birmingham, Alabama 35294. Monic Free Ideals in a Polynomial Semiring in Several Variables.

Let S be a semiring and B an ideal in $S[x_1, x_2, \ldots, x_n]$ with basis $\mathcal{U}$. If $X = \{x_1, x_2, \ldots, x_n\}$ and $P = \{x_{\alpha_1}, \ldots, x_{\alpha_r}\}$ is a subset of X, define $X_P = \{g(x_{\alpha_1}, \ldots x_{\alpha_r}) \mid g(x_{\alpha_1}, \ldots, x_{\alpha_r}) \in \mathcal{U}\}$ for $P \neq \emptyset$ and $X_P = \{c \in B \mid c \in \mathcal{U}\}$ for $P = \emptyset$. Let $B_P = (X_P)$ be the ideal generated by $X_P$. Then $B = \sum_{P \subset X} B_P$ is a decomposition of B into at most $2^n$ ideals with non-intersecting bases. It is shown that an ideal B is monic free if and only if each non-empty $B_P$ is monic free. Also if B is a monic free k-ideal, then each $B_P$ is monic free and $B_P = \bigcup E_\alpha$, $\{E_\alpha\}$ being a proper ascending chain of ideals each generated by polynomials in the same variables. (Received December 19, 1975.)

*732-A11 Antonio M. Lopez, Jr. and John K. Luedeman, Clemson University, Clemson, South Carolina 29631. Quasi-injective S-systems and their S-endomorphism semigroup.

Quasi-injective ring modules have been studied by R.E. Johnson and E.T. Wong (J. Lond. Math. Soc. 36(1961),260-268), C. Faith and Y. Utumi (Archiv Math. 15(1964),166-174), and B. Osofsky (Canad. J. Math. 20(1968),895-903) among others. It has not been

until recently that M. Satyanarayana (to appear Math. Nachr.) studied their semigroup counterpart, quasi- and weakly-injective S-systems. Our paper is a study of quasi-injective S-systems and their S-endomorphism semigroups along the lines of the above named ring theorists. We characterize the smallest quasi-injective essential extension of certain S-systems $M_S$ contained in the injective hull of $M_S$. Further, we give conditions for $\mathrm{Hom}_S(M,M)$ to be (von Neuman) regular and get as corollaries a result of M. Botero de Meza (Thesis (1975), Technischen Universitat Clausthal) dealing with the regularity of Q(S), the maximal right quotient semigroup of a semigroup S, and a result analogous to that of Faith and Utumi. (Received December 19, 1975.)

*732-A12 PAMELA A. FERGUSON, University of Miami, P.O. Box 249085, Coral Gables, Florida 33124. On 3-Closure of 3'-Homogeneous Finite Groups.

A finite group G is said to be 3'-homogeneous if $\frac{N_G(H)}{C_G(H)}$ is a 3' group for every 3' subgroup H of G. A group G is 3-closed if the subset consisting of 3-elements is a subgroup of G.

Let G denote a 3'-homogeneous finite group such that $3 \mid |G|$.

Since PSL $(2, 2^{2n+1})$, $n \geq 1$, is a 3' homogeneous group which is not 3-closed: it is not true that 3'-homogeneous groups are 3-closed. Thus some extra conditions are necessary to guarantee that G is 3-closed.

Let $G_3$ denote a Sylow 3-subgroup of G. If G is 3-closed, then clearly $C_G(x) \subseteq N_G(G_3)$ for all $x \in G_3^{\#}$. Theorem A below shows this is also a sufficient condition for G to be 3-closed if $G_3$ is not cyclic. Again G = PSL $(2, 2^{2n+1})$, $n \geq 1$, shows that $G_3$ non-cyclic is necessary.

<u>Theorem A.</u> Let G be a finite 3' homogeneous group. If $G_3$ is a Sylow 3 subgroup of G, assume $G_3$ is non-cyclic. Then G is 3-closed. if $C_G(x)$ $N_G(G_3)$ for all $x \in G_3^{\#}$. (Received December 19, 1975.)

*732-A13 D. D. Anderson, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, 24061. Multiplication ideals, multiplication rings and the ring R(X).

It is shown that a multiplication ideal in a quasi-local ring is principal. This result is used to study multiplication ideals outside the quasi-local case and to simplify several known results about multiplication rings and almost multiplication rings. Several special classes of multiplication rings and almost multiplication rings are studied. We show that the rings R and R(X) have isomorphic lattices of ideals if and only if R is arithmetical. In this case R(X) must be Bezont. Several applications are given of this result and the results concerning R(X) are extended to modules. (Received November 17, 1975.)

*732-A14 DAVID E. DOBBS, University of Tennessee, Knoxville, Tennessee 37916. Divided rings and going down.

Let R be an integral domain. R is said to be divided in case $P=PR_P$ for each $P \in \mathrm{Spec}(R)$. Theorem. For quasilocal R, the following are equivalent: (1) R is GD (in the sense of the author, Comm. in Algebra 1(1974), 439-458); (2) there exists divided T such that $R \subset T$ is integral and unibranched; (3)=(2) with T further restricted to be an overring of R. Corollary. For root-closed R, R is GD iff $R_M$ is divided for each maximal ideal M of R. The above results generalize work of Akiba (Theorem 1 in Bull. Kyoto Univ. Ser. B 31(1967), 1-3) and McAdam (Corollary 11 in "Simple going-down," J. London Math. Soc., to appear). As the theorem implies that factor domains inherit GD, some results of Papick, Bull. Amer. Math. Soc. 81(1975), 718-721, are also extended. Another approach to factor domains (and the fact that divided => GD) is by the Proposition. R is not GD iff there exist $P \in \mathrm{Spec}(R)$ and a valuation over-

ring V of R so that: (1) for all nonzero $v \in V$, $v^{-1} \notin P$, and (2) for some $v \in V$, $v^{-1} \in PR_P$. Finally, the extensions T in the theorem figure in conditions guaranteeing that certain quasilocal GD rings are divided; delimiting such conditions is a pertinent 2-dimensional quasilocal nondivided GD ring appearing in Example 1.6 of Boisen and Sheldon, Pac. J. Math. 58(1975), 331-344. (Received November 17, 1975.)

732-A15 Johnette Hassell, Department of Computer Science, Xavier University, New Orleans, Louisiana 70125. The torsion product of valued vector spaces and abelian p-groups.

Let A and B be valued vector spaces over $\Phi$ in the sense of L. Fuchs (J. Algebra, to appear). The torsion product TOR(A,B) of A and B is the valued vector space quotient F/K where F is the free valued vector space generated by $\{[a,b] : a \in A, b \in B\}$ with $v([a,b]) = \min\{v(a), v(b)\}$ and K is the subspace generated by $\{[a,b] + [a',b] - [a+a',b], [a,b] + [a,b'] - [a,b+b'], \alpha[a,b] - [\alpha a,b], \alpha[a,b] - [a,\alpha b] : a \in A, b \in B, \alpha \in \Phi\}$. Theorem: For abelian groups G and H, Tor(G,H)[p] is isometric to TOR(G[p], H[p]), where valuations are given by heights in the respective groups. (Received December 22, 1975.)

*732-A16 RONALD C. LINTON, University of South Alabama, Mobile, Alabama 36688 and CHARLES MEGIBBEN, Vanderbilt University, Nashville, Tennessee 37235. Fully invariant subgroups of totally projective groups.

It is known that if F is a fully invariant subgroup of the totally projective group G, then F and G/F are also totally projective groups. We prove the following Theorem. Suppose that F is an unbounded, fully invariant subgroup of the reduced, p-primary group G having the form F = G(u), where u denotes an increasing sequence of ordinals less than the length of G. If F and G/F are totally projective groups, then G is also a totally projective group. We also consider the case where $F \neq G(u)$. (Received January 2, 1976.) (Author introduced by Richard Vinson.)

732-A17 James K. Deveney, Virginia Commonwealth University, Richmond, Virginia 23284. Splitting of Inseparable Field Extensions, Preliminary Report.

Let L be a finitely generated extension of a field K of characteristic $p \neq 0$ and let J be an intermediate field of L/K which is purely inseparable over K. J is said to split from L/K when there exists a field D, $L \supset D \supset K$ such that $L = J \otimes_K D$. Let n be the inseparability exponent of L/K. Theorem 1. J splits from L/K if and only if $K(L^{p^n})(J)$ splits from $L/K(L^{p^n})$. Theorem 2. Assume $L/K(L^{p^n})$ is modular. Then J splits from L/K if and only if $J(L^{p^n})$ and $K(L^{p^i})$ are linearly disjoint over $K(L^{p^n})(J^{p^i})$ for $i = 1,2,\ldots,n$. Conjecture: Let $J = K^{p^{-\infty}} \cap L$ and assume $L/K(L^{p^n})$ is modular. Then J splits from L/K. (Received December 23, 1975.)

*732-A18 W. E. DESKINS and E. A. IDOWU, University of Pittsburgh, Pittsburgh, Pennsylvania 15260. F-hypercentral automorphisms.

The concept of F-hypercenter, $Z_F(G)$, of a finite group G, where F is a saturated formation locally defined by an integrated system $\{F(p)\}$, was introduced by B. Huppert (J. Algebra 19(1968), 561-579). He proved that $[G_F, Z_F(G)] = 1$ where $G_F$ is the F-residual of G; hence an inner automorphism of G induced by an element of $Z_F(G)$ is trivial on the F-residual. In this paper we extend that result by showing that if $\alpha$ is any automorphism of G such that the induced automorphism $\bar{\alpha}$ is trivial on $G/Z_F(G)$ (i.e., $\alpha$ is F-hypercentral), then $\alpha$ is trivial on $G_F$. Although the converse is not true in general, we show that each automorphism of G which is trivial on $G_F$ and fixes a maximal F-supplement of $G_F$ is in fact F-hypercentral. Moreover, the F-hypercentral automorphisms of G are characterized by these two properties. We also show that if the group G is assumed to be solvable, the F-hypercentral automorphisms are precisely those which fix every element of each F-system of G as defined by Carter and Hawkes (J. Algebra 5(1967), 175-202). (Received December 30, 1975.)

732-A19 H. F. KREIMER, Florida State University, Tallahassee, Florida 32306. Cyclic extensions of rings. Preliminary report.

Let R be a commutative ring with identity element 1, let n be a positive integer such that $n \cdot 1$ is a unit in R, and let G be a cyclic group of order n. For each positive integer p, a functor from the category of commutative R-algebras to the category of abelian groups is obtained by assigning to an R-algebra S, the Harrison cohomology group $H^p(S,G)$; and the elements of $H^2(S,G)$ correspond to G-isomorphism classes of Galois extensions of S with group G which have normal bases. Let $T=R[x]/(f(x))$, where f(x) is the polynomial $1+x+\ldots+x^{n-1}$. Theorem: Setting $E_2^{p,q}$ equal to the Amitsur cohomology group $H^p(T/R, H^{q+1}(\cdot, G))$, one obtains a spectral sequence which converges to H(R,G). If n is a prime, then from the sequence of terms of low degree an isomorphism of $H^2(R,G)$ onto $H^0(T/R,H^2(\cdot,G))$ is obtained, and $H^0(T/R,H^2(\cdot,G))$ is calculated to be $U(R)/U(R)^n$, where U(R) denotes the multiplicative group of units in R. (Received January 2, 1976.)

*732-A20 F. T. Boesch, Bell Telephone Lab., Holmdel, N.J., C. Suffel and R. Tindell, Stevens Inst. of Tech., Hoboken, N.J. 07030. The spanning subgraphs of Eulerian graphs.

We consider here the following question: for which graphs G is it possible to obtain an eulerian graph by the addition of lines only. The answer is provided by the Theorem A graph G spans an eulerian graph if and only if G is not spanned by any bipartite graph $K_{m,n}$ with both m and n odd. We also develop a formula for the minimum number of new lines required to produce an eulerian spanning supergraph , calculable by a polynomial time algorithm. (Received January 2, 1976.)

732-A21 TAE-IL SUH, East Tennessee State University, Johnson City, Tenn. 37601. On the hypercommutative nucleus of an alternative ring. Prelim. report.

Let A be an alternative ring, that is, a nonassociative ring satisfying $(x,y,y) = (y,y,x) = 0$ for all x and y of A, $(x,y,z) = (xy)z - x(yz)$. The set of el'ts a of A such that $ax^n = x^na$, $n = n(x, a) \geq 1$, for all x of A is called the hypercommutative nucleus T(A) of A. It is shown that if A is alternative with no nil ideals, then T(A) coincides with the center of A, the set of el'ts c of A such that $cx = xc$ and $(c,x,y) = 0$ for all x and y of A. In the key part of the proof we use M. Slater's result (J. Algebra 21(1972), 394-409): A prime alternative ring without nil ideals is a Cayley-Dickson ring. I. N. Herstein has proved that if A is an associative ring with no nil ideals, then T(A) coincides with the center of A (On the hypercenter of a ring, J. Algebra 36(1975), 151-157). (Received January 7, 1976.)

732-A22 ELOISE HAMANN, North Central College, Naperville, Illinois 60540. The Cancellation Problem, Preliminary report.

Let R and S be commutative rings such that R[X] = S[Y] with X, Y indeterminate over R and S respectively then in general R and S need not be isomorphic. Similarly, if R[[X]] = S[[Y]] with X, Y analytic indeterminates over R and S respectively, then R and S need not be isomorphic in this case either. Counter-examples, however, are not easily found, and those known are

relatively recent. A natural question arises, namely, what properties of R would force S to be isomorphic to R in either of the cases above. Such a ring R is called invariant in the first case, and power-invariant in the second.
The talk will discuss those properties which imply invariance or power-invariance. (Received January 7, 1976.)

*732-A23 JUDITH D. SALLY, Northwestern University, Evanston, Illinois 60201
Luröth's Problem for Rings.

This is joint work with S. GLAZ and W. V. VASCONCELOS. Let $A[T]$ be the polynomial ring in one indeterminate over the commutative ring $A$. We deal with the problem of describing the $A$-subalgebras $B$ of $A[T]$ over which $A[T]$ is flat. Under mild regularity conditions, $B$ is an augmented $A$-algebra with invertible augmentation ideal but may fail to be finitely generated even when $A = Z$. If $A[T]$ is faithfully flat over $B$, then there is a finite extension $A_1$ of $A$ such that $B \otimes A_1$ is the symmetric algebra of a projective $A_1$-module. (Received January 7, 1976.)

*732-A24 PAUL M. EAKIN, University of Kentucky, Lexington, Kentucky 40506.
Reduced symmetric powers and projectivity.

Let $R$ be a finite dimensional, noetherian integral domain with quotient field $K$ and integral closure $\bar{R}$. Let $M$ be a finitely generated torsion free $R$-module of rank $r$ with injective envelope $E(M)$. Let $M\bar{R}$ denote the $\bar{R}$ submodule of $E(M)$ generated by $M$ and $S(M)$ the symmetric algebra of $M$. Denote by $\bar{S}(M)$ the image of $S(M)$ under the natural mapping $S(M) \to S(M) \otimes_R K$, and let $h$ denote the Hilbert polynomial of this graded algebra. These are equivalent (i) $\deg h = r - 1$, (ii) there exist $n$ such that $h(n) < \binom{n+r}{r}$, (iii) $M\bar{R}$ is projective. (Received January 8, 1976.)

*732-A25 Douglas L. Costa, University of Virginia, Charlottesville, Virginia 22903, & Jon L. Johnson, University of Kentucky, Lexington, Kentucky 40506.
Inert Extensions of Krull Domains.

Let A B be Krull domains with B an inert extension of A. Let $P(A)$ be the set of height one primes of A. If $T=\bigcap_{p\varepsilon P(A)} B\otimes A_p$ is a Krull domain and each $B_p=B\otimes A_p$ is a unique factorization domain, then the divisor class groups of A and T are isomorphic under the natural homorphism. This result is applied when B is a symmetric algebra and when B is locally a polynomial ring over A.

If C is an integral domains, $S=\bigcap_{p\varepsilon P(A)} C\otimes A_p$ and C is an inert extension of A then a sufficient condition for S to be a Krull domain is obtained. (Received January 8, 1976.)

732-A26 Donald R. Peeples, Emory University, Atlanta, Georgia 30322. Algebras with modular subalgebra lattices.

Let an M-algebra (ring) be an algebra over a field F with a modular subalgebra (subring) lattice. The main theorem in the paper gives necessary and sufficient conditions for an algebra to be an M-algebra in terms of nil M-algebras and M-algebras that are division rings. Nil M-algebras are fully characterized when char $F \neq 2$ and partially characterized when char $F = 2$. The characterization of division M-algebras is given only in the case when F is finite; therefore, M-rings R satisfying $pR = 0$ are characterized for an odd prime $p$. Torsion-free nil M-rings are also described. (Received January 8, 1976.)

732-A27 L. Carlitz, Duke University, Durham, North Carolina 27706. Functions and correspondences in a finite field. Invited Lecture (1 hour).

It is well known that every function from a finite field into itself can be represented by a polynomial with coefficients in the field. Moreover with every function in $F_q = GF(q)$ one may associate a set of numbers $a_1,\ldots,a_k \in F_q$ and a partition $F_q = A_1 \cup \ldots \cup A_k$, where the $A_i$ are non-vacuous and $f(b_i) = a_i$ for all $b_i \in A_i$. This is

generalized in the following way. Let (*) $A_0, A_1, \ldots, A_k$; $B_0, B_1, \ldots B_k$ denote partitions of $F_q$ such that $A_1, \ldots, A_k$, $B_1, \ldots, B_k$ are non-vacuous but $A_0, B_0$ are unrestricted. Then there exists a polynomial $f(x,y) \in F_q[x,y]$ such that $f(a,b) = 0$ for $a \in A_j$, $b \in B_j$, $1 \leq j \leq k$ and $= 1$ otherwise. The polynomial $f(x,y)$ is said to characterize the correspondence defined by the partitions (*). A polynomial $h(x,y)$ satisfying these conditions except that the non-zero values are arbitrary is said to be admissible. The present paper is intended as an introduction to the study of correspondences.
(Received January 8, 1976.)

# Analysis

*732-B1 Joseph A. Cima, University of North Carolina, Chapel Hill, North Carolina 27514. Hadamard Products of Convex Functions.

Let $A$ denote the metric space of functions holomorphic on the unit disk and let $K_\alpha(z) \equiv (\frac{1+z}{1-z})^\alpha$ for $\alpha \in (0,1)$.

Theorem. For each $\alpha \in (0,1)$ the linear operator $\Lambda_\alpha$ induced on $A$ by convolution with $K_\alpha$ is a one to one, onto, continuous linear operators on $A$.

Corollary. There are a countable number of $\{\alpha_j\}_{j=1}^\infty$, with $\alpha_1 = \frac{1}{2} < \alpha_2 < \ldots$ and $\lim_{n\to\infty} \alpha_n = 1$ such that $\Lambda_\alpha$ has non-trivial (e.g. $f(z) \not\equiv$ constant) fixed points. If $\alpha_j$ is such a number there exists an integer $n_j$ such that all fixed points of $\Lambda_{\alpha_j}$ are of the form $a + bz^{n_j}$.

Theorem. Let $\alpha$ and $\beta$ be given in $(0,1)$ with $\alpha + \beta < 1$, then $K_\alpha * K_\beta(z) = h(z)$ is in $H^\infty$.

Theorem. Let $h$ be a function in $A$ and assume $h$ is subordinate to $f(z) = \frac{1}{2}\log(\frac{1+z}{1-z})$. Then the operator $\lambda(g) = g*h$ is a mapping of $H'$ into $H^\infty$. (Received November 17, 1975.)

732-B2 ROBERT F. WHEELER, Northern Illinois University, DeKalb, Illinois 60115. Weak compactness in the space of continuous functions. Preliminary report.

Let $X$ be a completely regular Hausdorff space, $C^*(X)$ the space of bounded continuous real-valued functions on $X$, $M(X)$ the Banach space dual of $C^*(X)$. Let $\mathcal{A}$ denote the family of subsets of $C^*(X)$ which are uniformly bounded and relatively compact for the topology of pointwise convergence. The basic question considered here is: for what subspaces $L$ of $M(X)$ is it true that every member of $\mathcal{A}$ is relatively $\sigma(C^*, L)$-compact? If (and only if) $X$ is pseudocompact, $L = M$ will do (Grothendieck-Ptak-Tomasek). $L = M_t$ is acceptable for any $X$; any suitable $L$ must be a subspace of $M_S$, the "separable measures" on $X$. Conjecture: for any $X$, the largest acceptable $L$ is $M_S(X)$. Some partial results in this direction are given. (Received December 4, 1975.)

732-B3 STEVEN F. BELLENOT, Florida State University, Tallahassee, Florida 32306. Mazur spaces and completeness. Preliminary report.

A locally convex space $(E,\xi)$ is a Mazur space if each $\xi$-sequentially continuous linear functional on $E$ is $\xi$-continuous. Let $\tau[\sigma]$ be the Mackey [weak] topology. Let $\nu(E,E')$ $[\tau_a(E,E')]$ be the topology of uniform convergence on $(E',E)$-null sequences $[\tau(E',E)$-absolutely convex compact sets]. Theorem 1. $(E',\sigma(E'.E))$ is Mazur iff $(E,\nu(E,E'))$ is complete. Theorem 2. If $(E,\xi)$ is a separable barreled space, then $(E',\tau(E',E))$ is Mazur iff $(E,\tau_a(E,E'))$ is complete.

Let $\ell_1(\Gamma)$ be the Banach space of absolutely summable functions on $\Gamma$. It is shown that $\ell_1(\Gamma)$ satisfies Theorem 1 iff the only real-valued measure on $P(\Gamma)$ which assigns zero to all singletons is the zero measure. Let $C(X)$ be the space of real-valued continuous functions on the completely regular space $X$ with the compact-open topology. Theorem 3. $C(X)$ is Mazur iff $C(X)$ is bornological iff $X$ is real compact. Hence there maybe counterexamples to a nonseparable version of Theorem 2 among the spaces $C(X)$. These results were obtained jointly with Ed Ostling.
(Received December 15, 1975.)

*732-B4 Dennis Sentilles, University of Missouri, Columbia, Mo. 65201. Boolean algebras and $L^1$ and $L^\infty$ spaces. Preliminary report.

The purpose of this talk is to indicate how a rather naive knowledge of Boolean algebras and their Stone space representation can be used to study both the duality of bounded measures and bounded measurable functions and of $L^1$ and $L^\infty$ spaces, through the use of strict-like topologies

defined relative to the Stone space of the Boolean algebra of measurable sets. In the case of $\sigma$-finite measure spaces, this strict topology (on $L^\infty$) is the strongest locally convex topology agreeing with convergence in measure on norm bounded sets and is the Mackey topology of the dual pair $(L^\infty, L^1)$. (Received December 22, 1975.)

732-B5 W.H. Summers, University of Arkansas, Fayetteville, Arkansas 72701. The strict topology, weighted spaces, and weighted approximation.

The strict topology as introduced by R. C. Buck [Michigan Math. J. 5 (1958), 95-104] can be considered in the context of a larger scheme; namely, the theory which L. Nachbin [Ann. of Math. 81 (1965), 289-302] has formalized around the concept of a weighted space of continuous functions. In this talk, we will discuss the part taken by the strict topology in advancing the general theory with particular emphasis on the development of a Bishop-Stone-Weierstrass theorem for weighted spaces.
(Received December 29, 1975.)

732-B6 William H. Graves, University of North Carolina, Chapel Hill, N.C. 27514. Strict Topologies and Abstract Measures: A Universal Measure

Let $M(R)$ be the space of scalar-valued simple functions for a ring $R$ of subsets of a set $X$. Let $\chi : R \to M(R)$ be the map which associates to each $A \in R$ the characteristic function $\chi_A$. There is a locally convex topology $\tau$ on $M(R)$ such that $\chi : R \to (M(R),\tau)$ is a universal measure in the sense that for any locally convex space $W$ and any measure $\mu : R \to W$, $\mu = \tilde{\mu} \circ \chi$ for a unique continuous linear map $\tilde{\mu} : (M(R),\tau) \to W$. This universal measure is a device for translating questions and results concerning vector measures to questions and results concerning $(M(R),\tau)$ and continuous linear maps on $(M(R),\tau)$. Among the classical results which admit proof in this linearized setting are Bartle-Dunford-Schwartz-type results on weakly compact sets of scalar measures and on weak compactness of the range of a vector measure, Orlicz-Pettis-type theorems, and extension theorems for vector measures. The completion $(\hat{M}(R),\hat{\tau})$ plays a major role in this development as does the fact that $\tau$ is a strict topology. This approach to vector measures will be discussed.
(Received December 29, 1975.)

732-B7 BRUCE LUND, University of New Brunswick, Fredericton, N. B., Canada Function algebras isomorphic to subalgebras of A(D). Preliminary report.

Let $T = \{z \in \mathbb{C} : |z| = 1\}$ and let $X$ be a compact Hausdorff space. Let $A$ be a function algebra on $X$ with maximal ideal space $M(A)$. Give $M(A)$ the weak-star topology (inherited from $A^*$). For $f \in A$, let $\#\hat{f}^{-1}(x)$ denote the cardinality of $\{\hat{f}^{-1}(x)\}$. Let $A(D)$ be the disk algebra.

Theorem: Let $A$ be as above. Suppose $P$ is a Gleason part in $M(A)$ with $\overline{P} \setminus P = X$ so that $x \in P$ has a unique representing measure on $X$. Suppose there is $f \in A$ with $|f| = 1$ on $X$ such that $E = \{x \in T : 0 < \#\hat{f}^{-1}(x) < \infty\}$ has positive measure and assume that $S = \{g \in A : |g| = 1 \text{ on } X\}$ separates points of $X$. Then there is a finite set $K$ contained in $T \times T \setminus \{(t,t) : t \in T\}$ such that $A$ is isomorphic to $A_K = \{f \in A(D) : f(a) = f(b) \text{ for } (a,b) \in K\}$. Moreover, $A$ is Dirichlet on $X$. (Received December 29, 1975.)

*732-B8 Donald C. Taylor, Montana State University, Bozeman, Montana 59715. The strong bidual of $\Gamma(K)$. Preliminary report.

Let $A$ be a C*-algebra with a $\sigma$-compact spectrum and let $K_A$ deonote the Pedersen ideal of $A$. Let $\Gamma(K_A)$ be the two sided multipliers of $K_A$, $\Gamma(K_A)'$ the strong dual of $\Gamma(K)$, and $\Gamma(K_A)''$ the strong bidual. Theorem. Arens multiplication in $\Gamma(K_A)''$ is well defined and regular; consequently, $\Gamma(K_A)''$ is an algebra with involution. Moreover, it is a b*-algebra. Theorem. The b*-algebra $\Gamma(K_A)''$ is *-isomorphic to a b*-algebra of not necessarily bounded operators on an inner product space which is

closed in the weak operator topology. This isomorphism is bicontinuous with respect to the b*-topologies and the weak topologies. Other results are proved. (Received January 5, 1976.)

732-B9 Richard A. Gayler, Florida State University, Tallahassee, Florida 32306. Some Topologies on $UL_p$. Preliminary report.

Let $L_p$ denote $L_p[0,1]$. In this paper the space $(\underset{0<p<1}{UL_p}, \tau)$ is studied where $\tau$ is the strongest vector topology on $UL_p$ for which each injection from $L_p$ into $UL_p$ is continuous.

Theorem 1: A set $B \subset UL_p$ is $\tau$-bounded iff $B \subset L_p$ for some p and B is $L_p$-bounded.

Theorem 2: A sequence $(f_n) \subset UL_p$ $\tau$-converges iff $(f_n) \subset L_p$ for some p and $(f_n)$ $L_p$-converges.

Theorem 3: A subspace $X \subset UL_p$ is $\tau$-metrizable iff $X \subset L_p$ for some p and the $L_p$ topology and the topology of convergence in measure agree on X.

Also the topology $\mathcal{T}$ generated by translates of sets of the form $\bigcup_{k=1}^{n} S_{p_k, \epsilon_k}$, where $S_{p_k, \epsilon_k}$ is the $\epsilon_k$-ball in $L_{p_k}$, is studied. It is shown that the subspaces of $UL_p$ on which $\mathcal{T}$ is linear are precisely the $\tau$-metrizable subspaces. (Received January 8, 1976.)

732-B10 CARLOS A. INFANTOZZI, Universidad de la República, Atlántico 1514, Montevideo, Uruguay. "Generalized Logarithmic Tests for Series".

Let $\sum d_n$ be a divergent series of positive terms and $\sum_{i=1}^{i=n} d_i = D_n$. We assume that $\lim_{n\to\infty} \frac{d_n}{D_n} = 0$. If $L_0 x = x$, $L_m x = L L_{m-1} x$ (L natural logarithm) and $P_0(x) = L_0 x$, $P_m(x) = P_{m-1}(x) L_m x$, then the following criteria of convergence for a series of positive terms are valid:

$$E_m = \frac{P_m(D_n)}{d_{n+1}} \left\{ \frac{d_{n+1}}{d_n} \left[ 1 - d_n \left( \frac{1}{P_0(D_n)} + \cdots + \frac{1}{P_m(D_n)} \right) \right] - \frac{u_{n+1}}{u_n} \right\} \begin{cases} \geq h > 0 & \underline{C} \\ \leq 0 & \underline{D} \end{cases}$$

$$F_m = \frac{P_m(D_n)}{d_{n+1}} \left[ \frac{d_{n+1}}{d_n} \cdot \frac{P_{m-1}(D_{n-1})}{P_{m-1}(D_n)} - \frac{u_{n+1}}{u_n} \right] \begin{cases} \geq k > 1 & \underline{C} \\ \leq 1 & \underline{D} \end{cases}$$

(notations of K. Knopp "Theorie und Anwendung der Unendlichen Reihen").

There are some expressions analogous to $E_m$ and $F_m$ but containing the ratio $\frac{u_n}{u_{n+1}}$.

If the upper and lower limits of $E_m$ are $\Lambda$ and $\lambda$ respectively, then the upper and lower limits of $F_m$ are $\Lambda+1$ and $\lambda+1$.

The first criterion can be presented thus: $E_m = E_{m-1} L_m n - 1 \begin{cases} \geq h > 0 & \underline{C} \\ \leq 0 & \underline{D} \end{cases}$ with $E_0 = \frac{D_n}{d_{n+1}} \left[ \frac{d_{n+1}}{d_n} \left( 1 - \frac{d_n}{D_n} \right) - \frac{u_{n+1}}{u_n} \right]$ (Similar presentation is valid for the second criterion).

The logarithmic test of first kind becomes

$$B_m = \frac{L\{d_n [u_n P_{m-1}(D_n)]^{-1}\}}{L_{m+1} D_n} \begin{cases} \geq k > 1 & \underline{C} \\ \leq 1 & \underline{D} \end{cases}$$

and $\lambda+1 \leq \overline{\lim}\, B_m \leq \Lambda+1$. (Received January 7, 1976.)

# Applied Mathematics

*732-C1 SUBHA SENGUPTA, Centre of Advanced Study in Appl. Math., Univ. of Calcutta, India; LOKENATH DEBNATH, Math. Dept., East Carolina Univ., Greenville, N. C. 27834. On Boundary Layer Flow Past a Porous Plate with Variable Suction or Blowing.

A study is made of the nontorsionally generated hydrodynamic and hydromagnetic boundary layer flow in a semi-infinite expanse of rotating viscous fluid bounded by an infinite porous plate with variable suction or blowing. The main feature of the flow field and the structure of the associated boundary layers are investigated. It is shown that the solution consists of the modified Ekman-Hartmann layer, and the secondary boundary layer which arises solely due to the fluctuation of suction or blowing at the plate. Several special cases of interest are obtained from this analysis. (Received December 15, 1975.)

*732-C2 Michiel Hazewinkel, Erasmus Univ. Rotterdam, Rotterdam, The Netherlands. On the nonexistence of continuous canonical forms for real linear dynamical systems.

A real linear dynamical system $\dot{x} = Fx + Gu$, $y = Hu$ is defined by the triple of real matrices $(F,G,H)$. Base change in state space changes this triple into the triple $(SFS^{-1}, SG, HS^{-1})$, $S \in GL_n(\mathbb{R})$.

Let $\underline{DS}^{cr,co}_{n,m,p}$ denote the space of all triples of matrices $(F,G,H)$ of sizes $n \times n$, $n \times m$, $p \times n$ respectively such that the associated dynamical system is completely reachable and completely observable. A continuous canonical form for the action of $GL_n(\mathbb{R})$ on $\underline{DS}^{cr,co}_{n,m,p}$ would be a continuous

map $\alpha$: $\underline{DS}^{cr,co}_{n,m,p} \to \underline{DS}^{cr,co}_{n,m,p}$ such that 1°) $\alpha(F,G,H) = (SFS^{-1},SG,HS^{-1})$ for some $S \in GL_n(\mathbb{R})$ (which may depend on $(F,G,H)$, 2°) $\alpha(F,G,H) = \alpha(F',G',H')$ if and only if $\exists S \in GL_n(\mathbb{R})$ such that $(F',G',H') = (SFS^{-1},SG,HS^{-1})$.

We show that for certain $(n,m,p)$ such a continuous canonical form cannot exist. (Received December 29, 1975.)

732-C3 R. E. KALMAN, Center for Mathematical System Theory, University of Florida, Gainesville, Florida 32611. On the global theory of the Riccati equation.

• This address will be concerned with the global theory of the matrix Riccati equation arising in the theory of optimal control. An almost completely explicit picture of the global behavior of solutions will be given, using primarily algebraic and variational methods. This is believed to be the only class of nonlinear ordinary differential equations for which a global theory is available irrespective of the dimension. (Received January 8, 1976.)

# Geometry

732-D1 MARK P. HALE JR., University of Florida, Gainesville, Florida 32601.
Synthetic Theory of Dual Affine Spaces. Preliminary report.

The problems of an adequate synthetic theory for geometries in which each plane is dual affine or projective is discussed. The chief difficulties arise from the presence of non-collinear points, and the consequent possibility of plane intersections which do not behave like lines. (Received December 15, 1975.)

732-D2 Robert E. Goad, University of Georgia, Athens, Georgia 30602. Approximating Approximate Fibrations. Preliminary report.

The fruitful concept of cell-like maps has recently been generalized by D. Coram and P. Duvall and independently by L. Mand. In the current work, the concept of hereditary homotopy equivalence is generalized and it is observed that the new classes of maps defined by Coram, Duvall and Mand satisfy this generalized local homotopy property. It is shown that if a map of high dimensional manifolds has this property and fibres with the shape of a circle or proper shape of a line, then it can be approximated by a circle or line bundle projection. This generalizes a theorem of L. Siebenmann on approximating cell-like maps by homeomorphisms. (Received December 22, 1976.)

# Statistics and Probability

*732-F1 *Mou-Hsiung Chang, University of Alabama, Huntsville, Alabama 35807.* *On Compactness of Infinitely Divisible Measures on An Orlicz Space. Preliminary report.*

*Let $E_\alpha$ be the Orlicz space considered by Kuelbs and Mandrekar in Trans. AMS, Vol. 169, 1972, pp. 113-152, we have*

*Theorem Let $\mu_n = [x_n, T_n, F_n]$ be a sequence of infinitely divisible measures on $E_\alpha$ with $F_n$ an increasing sequence of finite measures on $E_\alpha$. Then $\{\mu_n\}$ is conditionally compact if and only if (i) $\{x_n\}$ is compact, (ii) $F_n$ restricted to the complement of a neighborhood of zero is weakly conditionally compact, (iii) the sequence of bilinear forms on $E_\alpha^* \times E_\alpha^*$*

$$R_n(y,y) = \int_U (x,y)^2 dF_n(x) + T_n(y,y) \text{ is compact, where}$$

$$U = \{x \in E_\alpha : \sum_{i=1}^{\infty} \alpha(x_i^2) \le 1\},$$ *(iv) $\{\mu_n\}$ is a $\lambda$ - family with respect to the fixed $\lambda$ yielding the representations $\mu_n = [x_n, T_n, F_n]$.*

*The above result is a generalization of a theorem of Kuelbs and Mandrekar.* (Received January 8, 1976.)

# Topology

*732-G1 J. L. Bryant and R. C. Lacher, Florida State University, Tallahassee, Florida 32306.
A Hopf-like invariant for mappings between odd-dimensional manifolds.

We seek local criteria for determining when a mapping $f$ between $(2k+1)$-dimensional manifolds is $\varepsilon$-homotopic to a spine map (i.e., a map which shrinks finitely many spines of connected summands

to points). Assuming each point-inverse of $f$ is $(k-1)$-connected (or more generally, has property $UV^{k-1}$), we define an invariant $d(f)$ in terms of local data; $d(f)$ can take on non-negative integer values (or $+\infty$). $d(f) = 0$ is necessary and sufficient that $f$ be the composition of a spine map and a cellular map.

When $d(f) \geq 2$, little can be deduced of a global nature, as examples of R. H. Bing show.

The most interesting case is when $d(f) = 1$. Under this assumption, we show that there exist k-spheres in the domain manifold whose normal bundles have non-zero Stiefel-Whitney class $w_k$; it follows from a theorem of J. F. Adams that $k = 1,2,4$, or $8$. Conversely, the Hopf fibration $S^{2k-1} \to S^k$ can be used to construct examples with $d(f) = 1$.

The proof hinges on symmetry of a linking invariant defined for disjoint k-cycles in the total space of a $(k+1)$-plane bundle $\xi$ over a closed k-manifold. This linking is symmetric if and only if $w_k(\xi) = 0$. (Received October 23, 1975.)

732-G2 Fredric D. Ancel, University of Wisconsin, Madison, WI 53706, and J. W. Cannon, Utah State University, Logan, UT 84322. Any embedding of $S^{n-1}$ in $S^n$ $(n \geq 5)$ can be approximated by locally flat embeddings.

We apply the method of M. A. Stanko [Soviet Math. Dokl. 12 (1971), 906-909] in the context of cell-like embedding relations as expounded by J. W. Cannon in "Taming Cell-Like Embedding Relations" [in Geometric Topology, Lecture Notes in Math., Vol. 438, Springer Verlag, 1975]. The well-known difficulties of applying Stanko's method in codimension one are overcome by "blowing up points" at the appropriate juncture in the proof to obtain a cell-like embedding relation, and then exploiting the flexibility inherent in cell-like relations to carry out Stanko's program. At the end of the proof, the transformation from an embedding relation back to an embedding is made via the 1-LC Taming Theorem For Cell-Like Relations [Cannon; op. cit.] and the Cellular Approximation Theorem [Siebenmann, Topology 11 (1972), 271-294].

The theorem of the title can be generalized in two directions: the first occurrence of "embedding" can be replaced by "cell-like embedding relation"; and $S^{n-1}$ and $S^n$ can be replaced by boundaryless connected PL manifolds of dimensions n-1 and n, respectively. The techniques used here give another proof of the One-Sided Taming Theorem of Cernavski and Seebeck [Notices AMS 22 (1975), A-655]. (Received November 24, 1975.)

*732-G3 R.B. SHER, University of North Carolina at Greensboro, Greensboro, N.C. 27412.
Some bad embeddings of Q in Q.

Letting Q denote the Hilbert cube, we show that there exists a space $X$ such that $X = Q_1 \cup Q_2$, where $Q_1 \cong Q_2 \cong Q_1 \cap Q_2 \cong Q \not\cong X$. We further show how to construct such an example where $Q_1 \cap Q_2$ contains (does not contain) an fd cap set which is a $\sigma$-Z-set in both $Q_1$ and $Q_2$. Some other consequences of the construction of $X$ are discussed.
(Received December 15, 1975.)

*732-G4 John R. Quine, Florida State University, Tallahassee, Florida 32306.
Homotopies and intersection sequences.

Consider a closed curve as a smooth map $\gamma: S^1 \to \mathbb{C}$ and let $\gamma_t$ for $t \in I$ be a smooth homotopy. A vertex of $\gamma_t$ is a point $w$ such that $w = \gamma_t(z) = \gamma_t(\zeta)$ for $z \neq \zeta$. Let $X = I \times S^1 \times S^1$; for $x = (t,z,\zeta) \in X$, define $G(x) = [\gamma_t(z) - \gamma_t(\zeta)]/(z-\zeta)$. We study the changing configuration of vertices and cusps by studying $Z = \{x \in X \mid G(x) = 0\}$. For suitable homotopies, $Z$ is an oriented 1-submanifold of $X$. The oriented intersection of $Z$ with the $t$ cross-sections of $X$ gives the Titus intersection sequence of $\gamma_t$ if $\gamma_t$ is a normal immersion. We show how $Z$ describes the changes in the intersection sequence and in the tangent winding number of $\gamma_t$. In particular, we show that the change in the tangent winding number is the number of oriented intersections of $Z$ with $I \times \Delta \subseteq X$, where $\Delta = \{(z,z) \mid z \in S^1\}$. (Received December 11, 1975.)

*732-G5 D. S. CORAM and P. F. DUVALL, JR., Oklahoma State University, Stillwater, OK 74074. Approximate Fibrations and a Movability Condition for Maps.

In a previous paper, the authors defined the approximate homotopy lifting property and

studied its implications. This property generalizes the homotopy lifting property of classical fiber space theory. This paper gives a condition on point-inverses, generalizing complete regularity, for a map to have the approximate homotopy lifting property for n-cells. Furthermore, it is shown that if a map has the approximate homotopy lifting property for n-cells, then it has this property for all spaces. These results are applied to show that any two point inverses of a weak (Serre) fibration have the same shape, to give some conditions for a map between manifolds to be approximable by locally trivial fibrations, and to generalize the Reeb-Milnor theorem. (Received December 15, 1975.)

*732-G6 Robert J. Daverman, University of Tennessee, Knoxville, Tennessee 37916.
Side Approximations of Codimension One Spheres.

Let $\Sigma$ denote an (n-1)-sphere topologically embedded in the n-sphere $S^n$, and let $W$ denote a component of $S^n - \Sigma$, to be referred to as a side of $\Sigma$. One says that $\Sigma$ can be almost approximated from $W$ if for each $\varepsilon > 0$ there exists an $\varepsilon$-embedding $e$ of $\Sigma$ in $S^n$ such that the diameter of each component of $e(\Sigma) - W$ is less than $\varepsilon$. The main result extends Bing's 3-dimensional Side Approximation Theorem to higher dimensions, as follows. Theorem: Each (n-1)-sphere $\Sigma$ in $S^n$ can be almost approximated from either side; moreover, $\Sigma$ can be almost approximated from either side by locally flat embeddings iff its inclusion in $S^n$ can be approximated by locally flat embeddings. Tapping a more technical vein, one says that $\Sigma$ can be carefully almost approximated from $W$ if there exist such $\varepsilon$-embeddings $e$ for which $e(\Sigma) \cap \Sigma$ is covered by the interiors of pairwise disjoint (n-1)-cells in $e(\Sigma)$ of diameter less than $\varepsilon$. Theorem: If $\Sigma$ can be carefully almost approximated from $W$ and $n \geq 5$, then the sewing of $\Sigma \cup W$ to itself by the identity on $\Sigma$ yields $S^n$. Examples are given to illustrate the sharpness of the latter theorem and the falsity of its converse.
(Received December 22, 1975.)

*732-G7 Julian R. Eisner, Columbia University, New York, New York 10027.
A Characterization of Non-Fibered Knots.

Using the free product with amalgamation structure of the fundamental group of the infinite cyclic covering space of a knot, we show that if F is a minimal spanning surface of a knot k and U is the image of $\pi_1(S^3-F)$ in $\pi_1(S^3-k)$ under the map induced by the inclusion of $(S^3-F)$ in $(S^3-k)$, then $\mathrm{Norm}(U) = U$ if k is non-fibered, while, if k is fibered, then U is the commutator subgroup of $\pi_1(S^3-k)$, which is normal. (Received December 24, 1975.)

*732-G8 JOAN S.BIRMAN, Columbia University, New York, N.Y.10027 and R.CRAGGS, University of Illinois, Urbana, Ill.61801.
Some connections between 2, 3 and 4-manifold topology.

Let $U$ be a handlebody of genus $n$, and let $\mathcal{H}(n)$ be the group of all orientation-preserving homeomorphisms of $\mathrm{Bd}U \to \mathrm{Bd}U$. If $h \in \mathcal{H}(n)$, then one may define a closed orientable 3-manifold $M(h)$ as the disjoint union of $U$ and $-U$, identified along $\mathrm{Bd}U$ by the homeomorphism $h$. Let $\mathcal{K}(n) \subset \mathcal{H}(n)$ be the group of homeomorphisms in $\mathcal{H}(n)$ which induce the identity automorphism of $H_1(\mathrm{Bd}U;Z)$. Then, for each $h_1 \in \mathcal{H}(n)$, $h_2 \in \mathcal{H}(n)$ such that $H_1(M(h_1h_2);Z/2Z) = 0$ there exists a well-defined homomorphism from $\mathcal{K}(n)$ onto $Z/2Z$, with kernel $\mathcal{K}_{h_1,h_2}(n)$, such that $k \in \mathcal{K}_{h_1,h_2}(n)$ if and only if the $\mu$-invariants of the manifolds $M(h_1kh_2)$ and $M(h_1h_2)$ coincide. These homomorphisms are studied with two goals in mind: first, to gain a better understanding of the meaning of the $\mu$-invariant, and second to deduce various group-theoretical properties of $\mathcal{K}(n)$. (Received January 5, 1976.)

*732-G9 Martin Scharlemann, University of Georgia, Athens, Georgia 30602. Non-PL imbeddings of 3-manifolds.

For $M^m$, $N^n$ closed PL manifolds, consider locally flat topological imbeddings $M \hookrightarrow N$. For $n-m \geq 3$, Morlet, Rourke-Sanderson, and Kirby-Siebenmann show that the space of such imbeddings is homotopy equivalent to the space of locally flat PL imbeddings. For $n-m \leq 2$, $m \geq 5$, such TOP imbeddings may again be studied in the PL category, possibly by altering the PL structure of M. Here we study the case $m = 3$, $n = 5$, and prove a similar theorem: Isotopy classes of non-PL imbeddings of M in N are canonically equivalent to isotopy classes of PL imbeddings (with an appropriate condition on fundamental group) of a manifold M', homology equivalent to M. This further yields a new interpretation of non-PL knots and their Seifert surfaces. (Received January 5, 1976.)

*732-G10 D. W. Summers, Florida State University, Tallahassee, Florida 32306 and J. M. Woods, Oklahoma Baptist University, Shawnee, Oklahoma 74801. On the monodromy of reducible plane curves.

The algebraic link associated with a plane algebraic curve of $r$ branches is a link with $r$ components, each component being an iterated torus knot. An iterative calculation of the integral homology and the integral homology invariants of the universal abelian covering of such a link is made, reproving and extending the classical results of Burau $(r = 1,2)$ to $r \geq 3$, and sharpening the results of Burau in that in addition to a calculation for $\Delta_1$, the Alexander Polynomial of the universal abelian cover, we calculate $\lambda_1$, the minimal polynomial of the universal abelian cover. The calculation of $\Delta_1$ for the universal abelian cover provides a complete calculation for $\Delta_1$ of the infinite cyclic cover, and the calculation of $\lambda_1$ of the universal abelian cover yields a partial calculation for $\lambda_1$ of the infinite cyclic cover. Since $\Delta_1$ and $\lambda_1$ of the infinite cyclic cover are respectively the characteristic and minimal polynomial of the monodromy, we then extract criteria which force either finite or infinite monodromy. This method provides a very nice proof of finite monodromy for analytically irreducible plane curves $(r = 1)$. (Received January 6, 1976.)

*732-G11 B. J. BALL, University of Georgia, Athens, Georgia 30602. Geometric topology and shape theory.

• The theory of shape, introduced by K. Borsuk in 1968, has developed extremely rapidly in the intervening years. Much of the recent work has concentrated on the pro-homotopy, categorical aspect of the theory; this may well prove ultimately to be the most important part of the subject, but there remain many interesting problems of a more geometric nature. The purpose of this talk is to give a survey of shape theory results which may be classified (broadly) as "geometric topology" and to call attention to a number of unsolved problems of this kind. (Received January 8, 1976.)

732-G12 S. A. Stricklen Jr. Southern Technical Institute, Marietta, GA 30060 Cross Products and Closed Mappings preliminary report

If Each of A and B is a non-discrete Frechet space, and A is the image of a metric space under a closed mapping, then A is metrizable if $A \times B$ is a Frechet space. (Received January 8, 1976.)

732-G13 MARVIN ISRAEL, St. Mary's College of Maryland, St. Mary's City, Maryland 20686. PL isotopy of balls by linear moves. Preliminary report.

Let B be a PL ball and let f and g be p.l. homeomorphisms of B. We say f and g are isotopic by linear moves if there is a triangulation K with respect to which f and g are both simplicial and there are homeomorphisms $h_1, h_2, \ldots, h_n$, where $h_i$, $i = 1, \ldots, n$, moves one vertex and is linear on simplices such that $h_n \cdots h_1 f = g$. If f keeps Bd(B) fixed, it is, in general, an open question whether or not f is isotopic by linear moves which also keep Bd(B) fixed, to the identity. We review and extend some recent results relating to this problem and its parameterized versions. (Received January 8, 1976.)

*732-G14 D.E.Galewski and John G. Hollingsworth, University of Georgia, Athens, Georgia 30602. Acyclic Homotopy Equivalences.

In 1969 M. M. Cohen showed that a contractible simplicial map $h: M^n \to N^n$

between closed simplicial homotopy manifolds of dimension $n \geq 5$ is $\epsilon$-homotopic to a homeomorphism. Siebenmann generalized the theorem to contractible maps between topological manifolds. We generalize Cohen's theorem to the following: If $h: M^n \to N^n$ is an acyclic homotopy equivalence between closed triangulated topological manifolds of dimension $n \geq 5$, then $h'$ is homotopic to a homeomorphism. Obviously $h$ need not be $\epsilon$-homotopic to a homeomorphism.

(Received January 8, 1976.)

*732-G15 Robert Craggs, University of Illinois, Urbana, Illinois 61801.
4-manifolds and their Heegaard diagrams. Preliminary report.

Manifolds are pwl, compact, oriented. Let N be a 4-manifold with three boundary components $(M_{12}, M_{23}, M_{31})$. A Heegaard diagram for N is a triple $(U_1, U_2, U_3)$ of oriented handlebodies in IntN with the same boundaries and disjoint interiors so that (a) $\cup U_i$ is a spine of N and (b) each $U_i \cup (-U_{i+1})$ $(i=1)$ is a parallel copy of $M_{i,i+1}$ in N. Two Heegaard diagrams are equivalent if there is an ordered equivalence of the triples. The sum $(U_1,\ldots)\#(U_1',\ldots)$ of two diagrams is defined to be $(U_1\#U_1',\ldots)$ where the latter sums are boundary sums defined consistently. We define a diagram $\xi$ for $S^2\times S^2$ minus three open 4-balls. If D is a diagram for N, then $D\#\xi$ is a diagram for $N\#S^2\times S^2$ (interior connected sums). Theorem. For any simply connected 4-manifold N, some $N\#q(S^2\times S^2)$ has a Heegaard diagram. If D and D' are Heegaard diagrams for N and N', if BdN contains a 3-sphere, then $\exists(p,p')\ni D\#p\xi\approx D'\#p'\xi' \Longleftrightarrow \exists(q,q')\ni N\#q(S^2\times S^2)\approx N'\#q'(S^2\times S^2)$ (latter equivalence to preserve order of boundary components).

(Received January 8, 1976.)

# The March Meeting in Urbana, Illinois
# March 15 – 20, 1976
## Algebra & Theory of Numbers

*733-A1 David L. Reiner, Trinity College, Hartford, CT 06106. Sequences of polynomials of fractional binomial type.

A sequence of polynomials $p_{n/m}(x)$, $p_0(x) = 1$, with subscripts multiples of $1/m$ for an integer $m \geq 1$, is of 1/m binomial type iff $p_{n/m}(x+y) = \sum \binom{n/m}{k/m} p_{k/m}(x)\, p_{(n-k)/m}(y)$. If $m = 1$ and $p_1 \neq 0$, the sequence is of the familiar binomial type of Rota, et al.; however, if $p_1 = 0$, the sequence is singular and has no umbral inverse. We show that if a singular sequence has $p_1 = \cdots = p_{r-1} = 0$, but $p_r \neq 0$, then it has an umbral left inverse of $1/r$ binomial type. We characterize all sequences of $1/m$ binomial type in terms of their umbral inverses. Generating functions, explicit formulas, and delta operator equations are derived. (Received November 3, 1975.)

733-A2 URI FIXMAN and FRANK OKOH, Queen's University, Kingston, Canada K7L 3N6. Extensions of pairs of linear transformations between infinite-dimensional vector spaces. Preliminary report.

An object of the category of $\mathbb{C}^2$-systems is a pair $S = (V,W)$ of $\mathbb{C}$-vector spaces with a bilinear transformation $\mathbb{C}^2 \times V \to W$. Further definitions in Studia Math. 30, 273-338; Trans. A.M.S. 113, 424-453. $\mathrm{Ext}^1(S^2,S^1)$ is a $\mathbb{C}$-vector space. Fixman and Sankaran computed its dimension for $S^1$, $S^2$ finite-dimensional (to appear). We extend the computation to include systems of types $\Pi_\theta^\infty$ and torsion-free systems of rank 1 and type $\overline{H}$ specified by a height function $H$. Theorem. $\dim \mathrm{Ext}^1(\Pi_\theta^\infty, \Pi_\theta^n) = n = \dim \mathrm{Ext}^1(\Pi_\theta^n, \overline{H})$ if $H_\theta < \infty$. $\mathrm{Ext}^1(S^2,S^1)$ is infinite-dimensional in each of the cases: (i) type $(S^2) = \Pi_\theta^\infty$, type$(S^1) = \overline{H}$ with $H_\theta < \infty$; (ii) $S^1$ is infinite-dimensional of type $\overline{H}$ or $\Pi_\theta^\infty$, type$(S^2) = I^n$, (iii) type$(S^j) = H^j$, $j = 1,2$ and for some $\theta \in \mathbb{C} \cup \{\infty\}$ $H_\theta^1 < \infty$, $H_\theta^2 = \infty$; (iv) type$(S^j) = \overline{H^j}$,

$j = 1,2$ and $\{\theta\in\mathbb{C}: H^1_\theta<\infty$ and $H^2_\theta\neq 0\}$ is infinite. In all other new cases considered here $\mathrm{Ext}^1(S^2,S^1) = 0$. We also express $\mathrm{Ext}^1$ in terms of factor sets which are themselves $\mathbb{C}^2$-systems. (Received December 1, 1975.)

*733-A3 Richard P. Stanley, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139. Symmetric magic squares and commutative algebra.

Commutative algebra is a valuable tool for proving certain results in enumerative combinatorics. The proof of the following theorem involves heights of ideals, systems of parameters, Cohen-Macaulay rings, and also Tutte's one-factor theorem.

Theorem. Let $n\geq 1$ and let $S_n(r)$ be the number of nxn symmetric matrices of non-negative integers such that every row sums to $r$. Let $d = \binom{n}{2} + 1$ and $f = \binom{n-1}{2}$ if $n$ is odd, while $f = \binom{n-2}{2}$ if $n$ is even. Define $V_n(\lambda) = \left(\sum_{r=0}^{\infty} S_n(r)\lambda^r\right)(1-\lambda)^d(1+\lambda)^f$. Then $V_n(\lambda)$ is a monic polynomial of degree $d+f-n$ with non-negative integer coefficients satisfying $\lambda^{d+f-n}\, V_n(1/\lambda) = V_n(\lambda)$. (Received December 22, 1975.)

733-A4 Herbert S. Wilf, University of Pennsylvania, Philadelphia, PA 19174. Algorithms for a problem of Frobenius.

If $0 < a_1 < a_2 < \cdots < a_k$ are relatively prime integers than there is a minimal $n_0 > 0$ such that $n \geq n_0$ implies $n = x_1a_1 + \ldots + x_ka_k$ for some nonnegative integers $x_i$. Algorithms are given for determining $n_0$ and $\omega$, the number of values omitted by the form, for finding if a given $n$ is representable, and for finding a representation of a given $n$. $n_0$ and $\omega$ can be found with $O(ka_k^2)$ operations and just $a_k$ bits of array storage. Comparison is made with earlier methods, due to Heap and Lynn, and to A. Brauer. (Received December 22, 1975.)

*733-A5 ALBERT NIJENHUIS, University of Pennsylvania, Philadelphia, Pennsylvania 19174. On the zeros of rook polynomials. Preliminary report.

Following an idea of H.S. Wilf, the rook polynomial of an arbitrary $m\times n$ matrix is defined as $r(x,A) = \sum_{k\geq 0} r_k(A)(-x)^k$, where $r_k(A)$ is the sum of the permanents of all $k\times k$ submatrices of $A$; he has also conjectured that if all entries of $A$ are nonnegative, then all zeros of $r(x,A)$ are real. This generalizes the definition of rook polynomial of a chessboard [cf. Riordan, An introduction to combinatorial analysis, Wiley, New York] and a conjecture by Goldman, Joichi and White [Rook theory V, to appear]. This abstract announces a proof of the general conjecture. Furthermore, if the entries of $A$ are positive, then the zeros of $r(x,A)$ and $r(x,A')$ interlace, where $A'$ is obtained from $A$ by the deletion of any one row or column. Corollaries include inequalities for the $r_k(A)$ of a chessboard; in particular, the sequence $r_0(A), r_1(A), \ldots$ is unimodal. (Received December 22, 1975.)

*733-A6 Jay R. Goldman, University of Minnesota, Minneapolis, Minnesota 55455; J.T. Joichi, University of Minnesota, Minneapolis, Minnesota 55455, and Dennis E. White, University of Minnesota, Minneapolis, Minnesota 55455. Rook theory and the chromatic structure of graphs.

The relationship between the rook vector of a general board and the chromatic structure of an associated set of graphs is studied. We prove that every rook vector is a chromatic vector. We give algebraic relationships between the factorial polynomials of boards and the chromatic polynomials of graphs. General expressions for rook and factorial polynomials will be discussed. (Received December 22, 1975.)

733-A7 Richard Askey, University of Wisconsin, Madison and Mourad Ismail, University of Toronto. Inequalities between rearrangements with side conditions. Preliminary report.

N distinct objects are put in $j$ boxes, $k_i$ in the i'th box. A rearrangement is a movement of some of the objects to other boxes so that each box has as many objects after the move as before. If $j=2$ each

rearrangement of the original pattern has an even number of objects that move. This is not true for more than two boxes, but substitute results can be found which are more interesting. If $j=3$ there are more rearrangements with an even number of objects that move than rearrangements with an odd number of objects that move. This is false for $j \geqq 5$, but there are two substitute results that are incompletely understood at present. The results used include MacMahon's master theorem and various aspects of special functions, including transformation formulas for generalized hypergeometric functions, generating functions for Laguerre polynomials, and the connection between spherical harmonics associated to unitary and orthogonal groups. The case $j=4$ is probably false but the appropriate example has not been found as yet. It would be very interesting if true in this case. (Received December 29, 1975.)

733-A8 E.F. ASSMUS, Jr., Lehigh University, Bethlehem, Pa. 18015 and H.F. MATTSON, Jr., Syracuse University, Syracuse, N.Y. 13210. Block Designs

The incidence matrix of a combinatorial design is a $b \times v$ matrix of 0's and 1's where $b$ is the number of blocks and $v$ the number of points of the design. For each prime $p$ we consider the row space of this matrix modulo $p$, a linear $(v,\ell)$-code over $GF(p)$, where $\ell$ is the rank of the matrix viewed as a matrix over $GF(p)$. The only primes of interest are those dividing $rk(r-\lambda)$ where $r$, $k$ and $\lambda$ have their usual combinatorial meanings.

For expository purposes we restrict ourselves to symmetric designs and give a rather complete discussion of the cases $\lambda = 1$ (projective planes) and $\lambda = 2$ (so-called biplanes).

Time permitting we discuss Hamada's conjecture concerning the classical symmetric designs arising from projective spaces and also a new connection between biplanes and planes with emphasis on the putative planes of orders 10 and 12. In particular we show that the known symmetric designs with parameters $(56,11,2)$ and $(79,13,2)$ cannot be used to construct projective planes of orders 10 and 12. (Received December 29, 1975.)

*733-A9 L. Carlitz and Richard Scoville, Duke University, Durham, North Carolina 27706. Some permutation problems.

Let $\pi$ denote a permutation of $Z_n = \{1,2,\ldots,n\}$, $\pi$ has an up, down, or fixed point at a according as $a < \pi(a)$, $a > \pi(a)$, $a = \pi(a)$, $1 \leq a \leq n$. Problem I. Evaluate $\bar{A}(r,s,t)$, the number of $\pi \in Z_n$ with r ups, s downs and t fixed points. Problem II. Let $1 \leq a \leq n$ and consider the triple $\pi^{-1}(a)$, $a$, $\pi(a)$. Let R denote an up and F a down. Evaluate $B(n,r,s)$, the number of $\pi$ with r occurrences of $\pi^{-1}(a)\,RaR\,\pi(a)$ and s occurrences of $\pi^{-1}(a)\,FaF\,\pi(a)$. In both problems the cycle structure of permutations is used. The solution of I is given in terms of associated Eulerian numbers, the solution of II is shown to depend on the number of permutations with a given number of rises, falls and maxima. (Received December 29, 1975.)

*733-A10 GENE A. BERG, Virginia Commonwealth University, Richmond, Virginia 23284, An Application of n-Partitions to Coding Theory. Preliminary Report.

This paper is concerned with finding the number, $F_m(N,K,s)$, of K-flats in $PG(N,s)$ which have minimum weight $\geq m + 2$, that is, which have the property that each point has at least $m + 2$ nonzero coordinates. Each such K-flat corresponds to an $(N+1,K+1,m+2)$ linear code.

For $0 \leq i \leq N$, let $X_i$ denote the point in $PG(N,s)$ whose vector consists of all zeros except for a "1" in the $(i+1)$-th coordinate. Define the fundamental simplex, $\Delta$, as the simplex formed by the points $X_0,X_1,\ldots,X_N$. Call the i-flat spanned by any $i + 1$ of these points an i-cell of $\Delta$.

Let $H = \{X_0,\ldots,X_N\}$. An n-partition of H is a family $A = \{A_1,\ldots,A_a\}$ of subsets $A_i$ of H such that $|A_i| \geq n$, $\cup A_i = H$, and every n-element subset of H is contained in a unique member of

$A$. We say $A \leq B$ if each member of $A$ is contained in some member of $B$. Let $L_n$ denote the lattice of n-partitions of H. Let $L_0$ denote the lattice of subsets of H.

For $A = \{A_1,\ldots,A_a\} \in L_m$, define

$$\left.\begin{matrix} M(A) \\ N(A) \end{matrix}\right\} = \text{The number of K-flats which intersect no (m-1)-cell of } \Delta\text{, but do intersect every m-cell of } \Delta \text{ in } A_1\text{, in } A_2,\ldots\text{, in } A_a\text{, and } \left\{\begin{matrix}\text{perhaps}\\ \text{no}\end{matrix}\right\} \text{ other m-cells of } \Delta.$$

Then by Möbius inversion we have the following:

Theorem. $F_m(N,K,s) = N(\phi) = \sum_{B\in L_m} M(B)\mu(\phi,B)$ (Received December 11, 1975.)

733-A11 George E. Andrews, University of Wisconsin, Madison, Wisconsin 53705.
Computer searches for Rogers-Ramanujan type identities. Preliminary report.

Theoretical methods have established that certain classes of partition functions related to so-called "linked partition ideals" contain many of the partition functions occurring in classical partition identities of the Rogers-Ramanujan type (Bull. Amer. Math. Soc., 80(1974), 1033-1052). Since linked partition ideals are each characterized by certain finite sets of parameters, it has been propposed that one systematically investigate which occur in Rogers-Ramanujan type partition identities (Bull. Amer. Math. Soc., 80(1974), 1049). Here we describe a method for expanding each relevant generating function in an infinite product. We also discuss the fruits of a computer search organized on these ideas. (Received January 2, 1976.)

733-A12 J. Peter Stonitsch, University of Notre Dame, Notre Dame, Indiana, 46556
The local integral representation of symmetric bilinear forms. Preliminary report.

Let F be a local field of characteristic 2with ring of integers D. An n-ary F-space V furnished with a symmetric bilinear form B is called a bilinear space. If L'(respL) is a D-lattice in the bilinear space V' (resp. V), L represents L'(denoted $L' \rightarrow L$)if there is a D-homomorphism f from L' into L such that $B(fx,fy)=B'(x,y,)$ for all x,y in L'. A sufficient condition for $L' \rightarrow L$ is given in terms of the Jordan invariants of L' and L. In particular, those lattices L' which can be represented by an arbitrary modular L are completely characterized. The method employed is similar to that of Riehm for quadratic lattices (American Journal of Mathematics 86(1964),32-64) (Received January 5, 1976.)

*733-A13 RICHARD J. DUFFIN, Carnegie-Mellon University, Pittsburgh, PA 15213.
Newton's Recursion Formulae and Powerful Algebraic Numbers. Preliminary report.

A number greater than one is termed "powerful" if its nth power is nearly an integer in the sense that the discrepancy vanishes as n becomes infinite. For example, one plus square root two is powerful. It is shown that an algebraic number is powerful if and only if it is an algebraic integer whose conjugate roots each have absolute value less than one. The analysis is based on Newton's sequence (the nth term being the sum of the nth powers of the roots of a polynomial). The computational aspect of the problem is treated by an algorithm which determines whether or not a polynomical has a powerful root. If m is the degree of the polynomial this algorithm requires only m rational steps. (Received January 6, 1976.)

*733-A14 T. Lockman Greenough, Dartmouth College, Hanover, New Hampshire 03755.
Enumeration of Interval Orders Without Duplicated Holdings.

A partially ordered set (X,<) without duplicated holdings, (w.o.d.h.), is one

in which no two elements of X are greater than and less than the same elements of X. An interval order $(X,<)$ is a partially ordered set satisfying the condition: If a,b,c,d are distinct elements of X with $a<b$ and $c<d$, then $c<b$ or $a<d$ or both. The length of an interval order (w.o.d.h.) is the cardinality of the smallest linearly ordered set $(L,<_\ell)$ upon which the interval order can be represented as a collection of intervals of $(L,<_\ell)$. In this paper we show that the number of interval orders (w.o.d.h.) of length n is given by:

$$I(n) = 1 + \sum_{k=2}^{n} \{ \binom{n}{k} [ \sum_{i=2}^{k} (-1)^i \{ \prod_{j=i+1}^{k} (2^j - 1) \} ] \}.$$

(Received January 8, 1976.)

*733-A15 Kenneth P. Bogart, Dartmouth College, Hanover, New Hampshire, 03755.
The number of indecomposable error correcting codes.

An (n,k) code over a field with q elements is a k dimensional subspace of the space of all n-tuples over the field. The weight of an n-tuple is the number of nonzero entries. Two vector spaces are equivalent if there is a weight preserving linear isomorphism between them. A code is indecomposable if it is not equivalent to an external direct sum of two nontrivial codes. A class of codes is closed under projection and sum (a CUPS class) if 1) whenever an (n,k) code equivalent to a direct sum of an $(n_1,k_1)$ code and an $(n_2,k_2)$ code with $n_1 + n_2 = n$ is in the class, then the two summands are in the class, and 2) whenever an $(n_1,k_1)$ code and an $(n_2,k_2)$ code with $n_1 + n_2 = n$ are in the class, then any (n,k) code equivalent to their direct sum is in the class. This paper gives formulas for the number of indecomposable codes of length n in a CUPS class in terms of the number of codes of length $m \leq n$ in the class and for the number of indecomposable (n,k) codes in the class in terms of the number of (m,j) codes in the class with $m \leq n$ and $j \leq k$. The paper gives explicit expressions for the number of indecomposable codes of length n and the number of indecomposable (n,k) codes in each of the following CUPS classes: 1)All codes 2)Codes with full support 3)Error correcting codes.
(Received January 8, 1976.)

733-A16 Daniel J. Kleitman, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139.
Asymptotic Enumeration of Linear Extensions of Boolean Algebras.

In this paper we investigate the question: in how many ways $(F_n)$, can we extend the ordering of the elements of a Boolean algebra on n generators to a complete or chain ordering? A lower bound of $\prod_{j=0}^{n} \binom{n}{j}!$ is immediate and an upper bound of $\prod_{j=0}^{\frac{n-1}{2}} \binom{n}{j}^2 \binom{n}{j+1}$ for odd n (and similar for even n) is easy. The problem addressed here is: which of these is closer for large n? The two bounds differ by a factor of roughly $e^{(2^n)}$ we show that the former bound is closer to this accuracy; that is, that $\lim_{n\to\infty} 2^{-n}\log F_n = \lim_{n\to\infty} 2^{-n}\log \prod_{j=0}^{n} \binom{n}{j}!$
(Received January 8, 1976.)

733-A17 S.G. Williamson, University of Minnesota, Minneapolis, Minnesota 55455
Lexicographic Order Isomorphism For Partitions

Several basic order isomorphisms for classes of set partitions are discussed. In particular we consider lexicographic order isomorphisms for lists of all ordered partitions, ordered partitions corresponding to a given multinomial index, all unordered partitions, unordered partitions with a bounded number of blocks, unordered partitions with a fixed number of blocks, unordered partitions with blocks of equal size, unordered partitions corresponding to a fixed ordered partition, and unordered partitions of specified block type. These order isomorphisms are frequently useful for organizing computations associated with the above lists and provide a general method for the random selection of elements from any of these lists. (Received January 8, 1976.) (Author introduced by Professor J. R. Goldman.)

*733-A18 F. B. Drane and D. P. Roselle, Department of Defense, Fort Meade, MD 20755 and Virginia Polytechnic Institute and State University, Blacksburg VA 24061. The Extended Simon Newcomb Problem.

A matrix formulation of the problem is given and this is utilized to obtain simpler proofs of several previously published results. (Received January 8, 1976.)

733-A19 PETER ROLLAND, Pima College, West Campus, Tucson, Arizona 85726. On the uniqueness of the tetrahedral association scheme. Preliminary report.

The tetrahedral association scheme $\mathcal{T}_n$ of order n is defined on the set of unordered triples of an n-set by the rule: two distinct triples are ith associates (i = 0, 1, or 2) iff their intersection has cardinality i. The parameters of the scheme are n, $n_i$ (number of triples which are ith associates of a given triple), and $p^i_{jk}$ (number of triples which are jth associates of a given triple and kth associates of a given second triple, the two given triples being ith associates of each other; $i, j, k \in \{0, 1, 2\}$). Let $\mathcal{A}_n$ be an association scheme with parameters identical to those of $\mathcal{T}_n$. We prove that $\mathcal{A}_n$ is isomorphically equivalent to $\mathcal{T}_n$, $\forall\, n \geqq 6$. Let $a \in \mathcal{A}_n$ and define $G_a$ to be the graph whose vertices are the 2nd associates of a, two vertices being adjacent iff they are 2nd associates of each other. We show that $G_a$ is the disjoint union of three cliques of order n - 3; furthermore, each vertex lies in exactly one clique of order 3, the elements of which lie in distinct (n - 3)-cliques. These 3 (n - 3)-cliques associated with a correspond to the edges of a triangle, whose vertices correspond to a triple from an n-set. Primary tools are counting techniques and eigenvalue arguments derived from the Cauchy interlacing theorem. The question resolved here is a natural extension of work by Connor, Shrikhande, Chang, and Hoffman on the triangular association scheme and Bose, Laskar and Aigner on the tetrahedral graph. (Received January 8, 1976.) (Author introduced by Professor Richard Sacksteder.)

*733-A20 Dr. H. R. P. FERGUSON, Brigham Young University, Provo, Utah 84602 Selberg trace formula applied to Ramanujan's tau function.

From the Selberg trace formula applied to Hecke operators we prove the concise expression

$$\tau(p) = 42p^6 - 90p^4 - 75p^3 - 35p^2 - 9p - 1 - \sum_{0 < m < 2\sqrt{p}} H(4p - m^2)m^{10}$$

where p is a prime, $\tau(p)$ is the coefficient of the first nontrivial cusp form for $SL_2(\mathbb{Z})$, H(n) is a class number of binary quadratic forms defineable by a linear recurrence of order $\sqrt{n}$.

More generally, the philosophy of trace formulas is sketched, the trace formula for Hecke operators is materially simplified and inverted for sums of powers of integers convolved with class numbers, some combinatorial features of these class numbers are discussed and an analytic continuation of the above expression is developed with corresponding Ramanujan-Petersson conjectures. (Received January 8, 1976.)

*733-A21 Hariharan K. Iyer, University of Utah, Salt Lake City, Utah 84112. Odd order extensions of orthogonal simple groups.

Let R be a finite group such that it has a subgroup H isomorphic to O(U) where U is a quadratic space over $F_q$ of dimension $\geq 10$ (q odd), the subgroup M of H that is isomorphic to $\Omega(U)$ is normal in R and [R:H] is odd.

We investigate all finite groups G with no subgroups of index 2 that have an involution t with $C(t) \simeq R$. We obtain the following results.

(A) When U is even dimensional with square discriminant, G is isomorphic to an odd order extension of $\Omega(V)$ by field automorphisms, where V is a quadratic space over $F_q$ (q odd) with nonsquare discriminant and dim V = dim U + 2.

(B) When U is odd-dimensional or if it is even dimensional with nonsquare discriminant, t is a non-central involution in G. (Further investigation under progress in this case.)

In particular, we obtain the following non-simplicity result:

(C) If G is a finite group with a central involution t such that $C(t) = \langle t \rangle \times H$ where $H \simeq O^+(U)$ with U a quadratic space over $F_q$ of odd dimension or of even dimension and nonsquare discriminant, then G has a subgroup of index 2. In particular, G is not simple. (Received January 8, 1976.)

*733-A22 CURTIS GREENE, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139. Acyclic orientations of graphs.

A survey of results obtained by enumerating acyclic orientations of the edges of a graph. Among the results are new interpretations of the $\mu$ and $\beta$ invariants and the coefficients of chromatic polynomials. (Received January 8, 1976.)

733-A23 HUGH MONTGOMERY, University of Michigan, Ann Arbor, Michigan 48104. The large sieve for the mathematician in the street.

• Bombieri's monograph has emphasized the far reaching consequences of the large sieve in the theory of numbers. In this talk we dwell on the analytic principle involved, with a view toward making the presentation as self-contained as possible. (Received January 8, 1976.)

733-A24 WITHDRAWN

733-A25 DAVID A. KLARNER, State University of New York, Center at Binghamton, Binghamton, New York 13901. Enumeration of plane trees with certain forbidden subtrees.

We obtain asymptotic formulas for the number of trees described in the title with n edges. (Received January 8, 1976.)

733-A26 ADRIANO M. GARSIA, University of California, San Diego, La Jolla, California 92037. Binary search trees.

A new algorithm for the construction of the optimal binary search tree will be presented. (Received January 8, 1976.)

733-A27 WILLIAM T. TUTTE, University of Waterloo, Waterloo, Ontario, Canada. The rotor effect in the theory of chromatic polynomials.

A rotor is a piece of a network with rotational, but not reflectional, symmetry. We replace a rotor by its mirror image and study the invariance of the network. Conjecture. The chromatic polynomial is an invariant. This is proved in some special cases. (Received January 8, 1976.)

733-A28 PAUL R. STEIN, Los Alamos Scientific Laboratory, Los Alamos, New Mexico 87544. A brief history of enumeration. Preliminary report.

The main themes and techniques of enumeration are traced from the 18th century to the present, using a large number of concrete problems as illustrations. Earlier efforts to develop a unified treatment of the subject are assessed in the light of current knowledge, and an attempt is made to evaluate the aims and attitudes of our predecessors in this field. (Received January 8, 1976.)

*733-A29 L. H. HARPER, University of California, Riverside, California 92502. An $n \times \log n$ lower bound on synchronous combinational complexity.

It is shown that if a Boolean function of n variables satisfies certain subfunction conditions (which are satisfied by "almost all" such functions), then its synchronous combinational complexity must be at least $n \times \log n$. (Received January 8, 1976.)

# Analysis

*733-B1 Peter B. Worland, Gustavus Adolphus College, St. Peter, Minnesota 56082. Parallel Methods for the Numerical Solution of Ordinary Differential Equations.

This paper studies various classes of methods, collectively known as block implicit methods, for the purpose of solving initial value problems in ordinary differential equations on a parallel processor. Modifications of the sequential procedures are discussed which enable them to be used in a parallel mode. Both one-step and predictor-corrector type algorithms are examined. The parallel schemes are compared in each case with the corresponding sequential algorithms, the results indicating that the algorithms are well-suited to parallel processing. Methods for the general first order equation and special second order equations are considered. (Received December 8, 1975.) (Author introduced by Professor Rolf Jeltsch.)

*733-B2 Zeev Schuss, Rensselaer Polytechnic Institute, Troy, N.Y. 12181. Backward and Degenerate Parabolic Equations. Preliminary report.

Let $L_t$ be a second order strongly uniformly elliptic operator with time depndent coefficients. Set $r(x) = \text{dist.}(x,S)$ near the boundary S of a compact domain D in $R^n$. Backward parabolic equations of the type $u_t + r(x)L_t u = g(x,t)$ in $D \times (0,\infty)$, and degenerate forward equations of the type $tu_t - r(x)L_t u = g(x,t)$ in $D \times (0,1)$ arise

in mathematical genetics and, via Ito's formula, in the theory of stochastic differential equations. In this paper existence, uniqueness and expansions of solutions for appropriate boundary value problems and their dependence on the parameters of the problem are investigated. Estimates of the rate of convergence of the expansions is given. Some applications and derivations are discussed. (Received December 4, 1975.)

733-B3 Paul L. Davis, Manhattanville College, Purchase, New York, 10577. Higher order and related hyperbolic equations. Preliminary report.

Equations of the form $Mu_t = Fu$ when M is a parabolic operator are considered. Equations with special choices of M and F, F being quasilinear and elliptic, are examined and solutions are compared to solutions of related quasilinear hyperbolic equations before shocks occurs. Other higher order equations related to hyperbolic ones are also considered. (Received December 19, 1975.)

*733-B4 Jerry L. Bona, The University of Chicago, Chicago, Illinois 60637. Model equations for the two-way propagation of waves.

Systems of equations are examined which can serve as models for the two-way propagation of nonlinear waves in dispersive media. The prototype is the pair of equations derived by Boussinesq to approximate the evolution of small-amplitude plane waves in water of finite depth in which nonlinear steepening effects are balanced by the effects of dispersion. The systems considered can take account of more general nonlinearities and more general dispersion relations. The latter ingredient leads to equations of Sobolev type which may involve non-local operators.
Global existence, uniqueness and continuous dependence results are established for a class of such models. Regularity theory and the propagation of singularities are also considered. (Received December 22, 1975.)

*733-B5 Peter A. Loeb, University of Illinois, Urbana, Illinois 61801. An Almost Everywhere Regular Boundary Supporting the Maximal Representing Measure for Bounded and Quasibounded Harmonic Functions.

Let W be a connected, locally compact but not compact Hausdorff space and $\mathcal{H}$ a family of real-valued functions with open domains in W. We assume that $\mathcal{H}$ satisfies M. Brelot's three axioms, that 1 is $\mathcal{H}$-superharmonic on W, and that there is a bounded, nonzero $\mathcal{H}$-harmonic function and a positive $\mathcal{H}$-potential defined on W. It is shown that there is an ideal boundary $\Delta$ for W such that points of $\Delta$ correspond to non-negative $\mathcal{H}$-harmonic functions, $\Delta$ supports the maximal representing measures for positive bounded and quasibounded $\mathcal{H}$-harmonic functions, and almost all points (with respect to harmonic measure) of $\Delta$ are regular for the Dirichlet problem. M. G. Shur [A Martin compact with a non-negligible irregular boundary point, Theory of Probability and its Applications, Vol. 17, No. 2 (1972), pp. 351-355] has shown that the latter property need not hold for the Martin boundary. (Received December 26, 1975.)

*733-B6 Howard A. Levine, University of Rhode Island 02881. An Equipartition of Energy Theorem for Weak Solutions of Evolutionary Equations in Hilbert Space.

Let H be a Hilbert Space and $D \subset H$ a dense linear subspace. Let (,) denote the scalar product on H and let M,N be symmetric linear operators from D into H with $(x,Mx)>0$ for $x\varepsilon D$, $x\neq 0$ and $(x,Nx)\geq 0$ for $x\varepsilon D$. Let $K = \{x\varepsilon D | Nx=0\}$ and $K_M = \{y\varepsilon D | (y,Mx) = 0 \forall x\varepsilon K\}$. Let $u = [0,\infty)\to D$ be a weak solution of the Cauchy problem

$$(1) \qquad M\ddot{u}(t)+Nu(t) = 0;\ u(0) = \dot{u}_0,\ u(0) = v_0;\ (\dot{u} \equiv du/dt).$$

If the range of N is dense in the image of $K_M$ under M, then

$$(a) \qquad \lim_{t\to\infty} \frac{1}{2t}\int_0^t [(Mu(\eta),u(\eta)) - (Nu(\eta),u(\eta))]d\eta = \frac{1}{2}(x,Mx)$$

and

(b) $\lim_{t\to\infty} (u(t)/t-x,\ M(u(t)/t-x)) = 0$

where $x \in K$ is the M orthogonal projection of $v_0$ onto K. From (a) we infer that the Cesaro means of the kinetic and potential energies approach $\frac{1}{2}E(0) + \frac{1}{4}(x,Mx)$ and $\frac{1}{2}E(0) - \frac{1}{4}(x,Mx)$ respectively. Here $E(0) = \frac{1}{2}(v_0,Mv_0) + \frac{1}{2}(u_0,Nu_0)$ is the initial energy associated with (1). The proof avoids spectral theory. As a side result it is shown that weak solutions to (1) are unique even if N is only assumed to be symmetric and without recourse to a conservation of energy hypothesis even in the weak form $E(t) \leq E(0)$ for $t>0$. (Received December 29, 1975.)

*733-B7 Alexander ABIAN, Iowa State University, Ames, Iowa 50011. On a useful economy in the formation of Riemann sums.

In this paper it is shown that in order to ascertain that a function f is Riemann integrable it is sufficient to follow Riemann's procedure, however, by restricting the formation of Riemann sums to the sum of the product of the length of a typical subdivision $[x_k,x_{k+1}]$ by the value of f evaluated only at $z \in [x_k,x_{k+1}]$ where z is selected from $[x_k,x_{k+1}]$ by a function S belonging to a class of functions called "selection functions". A function S from the set of all non-empty real closed intervals $[x,y]$ is called a selection function if $S([x,y]) = z$ with $x \leq z \leq y$ where x is a function of $y-x$ and z, continuous in z. Functions picking up the left endpoint or the right endpoint or the middle point of a closed interval are examples of selection functions; so are also functions which pick up a point z from a closed interval such that z is located at a given ratio with respect to the endpoints of that interval. (Received December 29, 1975.)

*733-B8 CORNELIUS O. HORGAN, University of Houston, Houston, Texas 77004.
Korn's inequalities in continuum mechanics.

The integral inequalities known as Korn's inequalities play a crucial role in continuum mechanics. In the field of elasticity, for example, the applications range from fundamental existence theory to estimation of elastic vibration frequencies. For sufficiently smooth vector fields $u_i$ defined on a bounded domain R in $E^n$, consider the functionals defined by the volume integrals

$$D(\underset{\sim}{u}) = \int u_{i,j}u_{i,j}\ ,\ S(\underset{\sim}{u}) = \frac{1}{4}\int (u_{i,j} + u_{j,i})(u_{i,j} + u_{j,i}).$$

A Korn inequality asserts the existence of a positive number K, depending only on R, such that $D(\underset{\sim}{u}) \leq KS(\underset{\sim}{u})$ for all $\underset{\sim}{u}$ satisfying certain side conditions. The optimal constant in this inequality, called Korn's constant, is denoted by $K_R$. In this paper we present some techniques for estimating $K_R$ for various domains. The analysis is based on examination of spectral properties of associated eigenvalue problems as described in work of the author and J. K. Knowles (Arch. Rat. Mech. Anal. 40 (1971) 384-402) and of the author (SIAM J. Appl. Math. 28(1975) 419-430; ZAMP 26(1975), 155-164.) (Received November 28, 1975.)

*733-B9 John R. Cannon, The University of Texas at Austin, Texas, 78712. Some questions concerning quasi-linear parabolic systems of equations.

The flow of several fluids in a porous medium can be described by the system $U^i = (C^{\ell m}_{ij}, U^j_{,m} + B^{\ell}_i)_{,\ell} + F_i$ along with appropriate boundary and initial conditions. Some results of J.R. Cannon, Wayne T. Ford and Alan Lair will be reviewed and various open questions related to the system will be raised. (Received December 31, 1975.)

733-B10 Thomas Armstrong, University of Minnesota, Minneapolis, Minnesota 55455. Multiply Harmonic Presheaves and Product Sweeping Systems. Preliminary report.

Let $X_1$ and $X_2$ be locally compacts fitted with harmonic presheaves $\mathcal{H}^1$ and $\mathcal{H}^2$ respectively. Let $\mathcal{M}$ be the harmonic presheaf of multiply harmonic functions on the space $X_1 \times X_2$. If both $\mathcal{H}^1$ and $\mathcal{H}^2$ satisfy any of the following so does $\mathcal{M}$ : topological completeness, nondegeneracy, Montelness, nuclearity, ellipticity or quasi-analyticity. If either $\mathcal{H}^1$ or $\mathcal{H}^2$ is Montel any locally bounded separately harmonic function is multiply harmonic. If $X_1$ possesses an $\mathcal{H}^1$-sweeping system and $X_2$ posseses an $\mathcal{H}^2$-sweeping system a product sweeping system is defined on

$X_1 \times X_2$ which is shown to be an $\mathcal{M}$-sweeping system. If such sweeping systems exist $\mathcal{M}$ inherits either of the convergence axioms of Bauer or Brelot from its factor presheaves. Finally, a characterization of ellipticity of a harmonic presheaf $\mathcal{H}$ is given in terms of $\mathcal{H}$-sweeping systems. (Received December 31, 1975.)

733-B11 Richard E. Ewing, Oakland University, Rochester, Michigan 48063. A coupled non-linear hyperbolic-Sobolev system. Preliminary report.

A boundary-initial value problem for a quasilinear hyperbolic system in one space variable is coupled to a boundary-initial value problem for a linear equation of Sobolev type in two space variables of the form $u_t(x,t) + \gamma M u_t(x,t) + Lu(x,t) = f(x,t)$ where $M$ and $L$ are second order elliptic operators. The coupling occurs through one of the boundary conditions for the hyperbolic system and the source term in the equation of Sobolev type. Such a coupling can arise in the consideration of oil flowing in a fissured medium and out of that medium via a pipe. Barrenblatt, Zheltov and Kochina (J. Appl. Math. Mech., 24 (1960)) have modeled flow in a fissured medium via a special case of the above equation. A local existence and uniqueness theorem is demonstrated. The proof involves the method of characteristics, some applications of results of R. Showalter and the contracting mapping theorem. (Received January 2, 1976.)

*733-B12 David W. Fox, The Johns Hopkins University Applied Physics Laboratory, Laurel, Maryland 20810. An initial value problem for slow flow in stratified fluids.

The linear theory of inviscid incompressible stratified fluids in which the buoyancy frequency and initial density are treated as constant is governed by the system of equations (1) $w_{tt} + w + \partial\varphi/\partial x_3 = 0$ and $\Delta\varphi - \partial w/\partial x_3 = \nu$ in which $\varphi$ and $w$ are scalars from which the velocity field $u$, the pressure distribution, and the density can be determined, and $\nu$ is a prescribed function. A solution of the general "slow flow" initial value problem for arbitrary small initial velocities, initial density, and source distribution is obtained in $R^3 \times (0,T)$ under appropriate conditions of smoothness on the prescribed functions and of compatibility between the initial value of the source distribution and the prescribed initial velocities. The solution is expressed in terms of the data of the problem and an explicitly known fundamental solution. (Received January 2, 1976.)

*733-B13 Robert P. Kertz, Georgia Institute of Technology, Atlanta, Georgia 30332. Semigroup Perturbation Theorems with Application to a Singular Perturbation Problem in Non-linear o.d.e.'s.

Let B denote the infinitesimal generator of a strongly continuous contraction semigroup $S(t)$, with resolvent $R_\lambda$, defined on Banach space L. Operators P and V are defined so that $\lambda R_\lambda f = Pf + \lambda Vf + o(\lambda)$ as $\lambda \to 0^+$. For $\alpha, \eta > 0$ and A a possibly unbounded linear operator, we assume $\alpha A + \eta B$ generates the strongly continuous contraction semigroup $U_{\alpha,\eta}(t)$. Under appropriate simultaneous convergence of the parameters $\alpha$ and $\eta$, we obtain theorems for the strong convergence of $U_{\alpha,\eta}(t)$ to a semigroup $U(t)$, having generator characterized by $\lim_{\alpha,\eta} \alpha \Sigma_{j=0}^{n} (\alpha/\eta)^j PA(VA)^j f$. For the case in which this limiting generator is $PA(VA)^r f$ for r a non-negative integer, we give an application of our abstract theorem to a singluar perturbation initial value problem for a non-linear system of ordinary differential equations. (Received January 5, 1976.)

*733-B14 MOSES GLASNER, The Pennsylvania State University, University Park, Pennsylvania 16802 and MITSURU NAKAI, Nagoya Institute of Technology, Gokiso, Shôwa, Nagoya 466, Japan. The roles of nondensity points.

Consider a density P on a hyperbolic Riemann surface R. The Green energy nondensity points $\Delta_P$ of P and the nondensity points $\Delta^P$ of P (cf. M. Nakai, Bull. Amer. Math. Soc. 77(1971), 381-385) are especially significant for the study of the spaces PBD(R) of bounded Dirichlet finite solutions of $\Delta u = Pu$ on R and PBE(R) of bounded energy finite solutions of $\Delta u = Pu$ on R. The main result of this paper is that $\Delta_P$ and $\Delta^P$ do not characterize the spaces PBD(R)

and PBE(R). Specifically, there exists an infinite regular covering surface $T^\infty$ of the Tôki surface such that $T^\infty \in O^\infty_{HD} \setminus \bigcup_{n=1}^{\infty} O^n_{HD}$ and densities P, Q on $T^\infty$ such that $\Delta^P = \Delta_P = \Delta^Q = \Delta_Q$ nevertheless $PBE(T^\infty) = PBD(T^\infty)$ is not canonically isomorphic to $QBE(T^\infty) = QBD(T^\infty)$. (Received January 5, 1976.)

733-B15 V.R. Gopala Rao, Lehigh University, Bethlehem, Pa. 18015. A Cauchy problem for pseudo-parabolic systems. Preliminary Report.

Let A and B be two operators defined by $Av_r = \sum_{s=1}^{M} \sum_{k=0}^{m} \sum_{|q|=k} a^q_{rs}(x)\, D^q v_s(x,t) + \lambda^m a_0 v_r(x,t)$ and $Bv_r = \sum_{s=1}^{M} \sum_{k=0}^{m} \sum_{|q|=k} b^q_{rs}(x)\, D^q v_s(x,t)$, $r=1,\ldots,M$, where the coefficients $a^q_{rs}$ and $b^q_{rs}$ are defined in $R^\nu, \nu \geq 1$ and $a_0$ is a nonzero constant. The functions $v_r(x,t)$ are defined in $R^\nu \times R$. Definition: An $M \times M$ - pseudo-parabolic system of equations is of the form $LV \equiv A(\partial V/\partial t) + BV = F$ where $F(x,t) = (f_1(x,t),\ldots,f_M(x,t))^T$ and $V(x,t) = (v_1(x,t),\ldots,v_M(x,t))^T$. In this article we establish the existence and regularity of solutions to the Cauchy problem $LV=F$, $\lim_{t\to 0} V(x,t) = V_0(x)$, where $V_0(x) = (v_{1,0}(x),\ldots,v_{M,0}(x))^T$ in the function space $W^{M,m,P}(R^\nu)$ (the M-fold product of $W^{M,P}(R^\nu)$ with itself) under suitable conditions on A and B such as ellipticity of A. The method employs the principal fundamental matrix of A as constructed by A. Avantaggiati. (Received January 5, 1976.)

*733-B16 Margaret C. Waid, University of Delaware, Newark, Delaware 19711. Differential inequalities for systems of degenerate parabolic operators. Preliminary report.

The Prodi-Westphal theorem is generalized to systems of differential inequalities for nonlinear nonuniformly parabolic operators of the form

$0 < F_s(x,t,z_1,\ldots,z_m,\frac{\partial z_s}{\partial x_i},\frac{\partial^2 z_s}{\partial x_i \partial x_k},\frac{\partial z_s}{\partial t})$, $s = 1,\ldots,m$. The operator $F_s$ is defined for $(x, t)$ in a hypercylinder $B = G \times (0, T) \subset R^{m+1}$, where G is a bounded open domain in $R^m$. Suppose that $F_s(x,t,u,q_i,p_{ik},d)$ is elliptic with respect to $p_{ik}$ and that $\frac{\partial F_s}{\partial d} \leq 0$, $s = 1,\ldots,m$. Since it is admissible that $\frac{\partial F_s}{\partial d} = 0$ at some points of B, $F_s$ may be nonuniformly parabolic. Two additional theorems on differential inequalities for systems are proved and the results are applied to the problem of investigating stability of solutions of certain systems of degenerate parabolic equations, e.g.

$$c_s(x,t,z_1,\ldots,z_m)\frac{\partial z_s}{\partial t} = \Delta z_s + f_s(x,t,z_1,\ldots,z_m),$$

$s = 1,\ldots,m$, where $c_s(x,t,z_1,\ldots,z_m) \geq 0$. (Received January 5, 1976.)

*733-B17 J. M. Anderson, University College, London, England and Lee A. Rubel, University of Illinois, Urbana, Illinois 61801. Hypernormal meromorphic functions. Preliminary report.

Two new classes of meromorphic functions are introduced--the hypernormal and the absolutely hypernormal functions. These notions sharpen the well-known notion of normal functions. A normal function in the unit disc is one whose orbit, under the group of Möbius transformations, forms a normal family. For hypernormal functions, the convex hull of the orbit is supposed to be normal. For absolutely hypernormal functions, the absolute convex hull is taken instead. The most striking result is that the absolutely hypernormal functions f are just the (analytic) Bloch functions, i.e. $|f'(z)| \leq K(1-|z|^2)$. By contrast, the hypernormal functions don't even form a linear space. Analogous studies are made in the plane, where the relevant group is the group of all translations. The absolutely hypernormal meromorphic functions there are just $az+b$ and $A \exp \lambda z + B$. (Received January 7, 1976.)

733-B18 Maynard Arsove, University of Washington, Seattle, Washington 98195, and Heinz Leutwiler, University of Erlangen, D852 Erlangen, West Germany. Lattice-theoretic methods in axiomatic potential theory.

A purely algebraic approach to axiomatic potential theory is developed, using ideas related to Riesz space theory. Let $(\mathcal{U}, +, \leq)$ be a partially ordered abelian semigroup with identity 0, such that (i) $u \geq 0$ and (ii) $u \leq v \Longleftrightarrow u+w \leq v+w$ (all $u,v,w \in \mathcal{U}$). Mixed lower and upper envelopes, $u \wedge v$ and $u \vee v$, are defined in terms of specific order on $u$ and (the given) initial order on $v$. If the mixed envelopes exist and satisfy $u \wedge v + v \vee u = u + v$ for all $u,v,w \in \mathcal{U}$, we call $(\mathcal{U}, +, \leq)$ a mixed lattice semigroup. Topics discussed in this setting include harmonic and potential bands, orthogonality and projection properties, Riesz decompositions, increasing additive operators and duals, pseudo projection and balayage operators, generators and quasi-units, and quasibounded and singular elements.

(Received January 7, 1976.)

*733-B19 STEPHEN WAINGER, University of Wisconsin, Madison, Wisconsin and Institute for Advanced Study, Princeton, New Jersey 08540. Some problems in harmonic analysis related to curves.

• Let $f \in C_0^\infty(R^n)$, and let $r(t)$ be a curve in $R^n$. Define $H_r f = \text{P.V.} \int_{-\infty}^{\infty} f(x - r(t))\, dt/t$ and $M_r f = \sup_{h>0} (2h)^{-1} \int_{-h}^{h} |f(x - r(t))|\, dt$. At the Nice International Conference, E.M. Stein posed the problem of finding values of $p$ and curves $r$ such that $\|H_r f\|_p \leq A_p \|f\|_p$ and $\|M_r f\|_p \leq \|f\|_p$. Nagel, Riviere, and Wainger have shown $H_r$ is bounded in $L^p$ if $r(t) = (|t|^{\alpha_1} \operatorname{sgn} t, \ldots, |t|^{\alpha_n} \operatorname{sgn} t)$ with $\alpha_i > 0$ for $1 < p < \infty$. Nagel and Wainger have shown that for a large class of plane curves $(t, r(t))$, $H_r$ is bounded for $5/3 < p < 5/2$. $r(t)$ can be for example $(e^{|t|} - 1)\operatorname{sgn} t$ or $(e^{|t|} - e)\operatorname{sgn} t$. In the case $r(t) = (t, t^2)$ Nagel, Riviere, and Wainger have shown $M_r$ is bounded for $p > 3/2$. (Received January 7, 1976.)

733-B20 John Lagnese, Georgetown University, Washington, D.C. 20057. Perturbations in degenerate variational inequalities.

Let $V$ be a real reflexive Banach space with dual $V'$. Suppose $\{X_\varepsilon : 0 < \varepsilon < \varepsilon_0\}$ is a family of closed, convex subsets of $V$ and, for each $\varepsilon \in (0, \varepsilon_0)$, $A_\varepsilon$ is a pseudomonotone operator from $X_\varepsilon$ into $V'$. Let $E_\varepsilon \in L(V, V')$ be nonnegative and suppose $-\Lambda$ is a linear operator in $V$ which generates a continuous semigroup of bounded linear operators on $V$. Let $f_\varepsilon \in V'$ and consider the variational inequality (1) $u_\varepsilon \in X_\varepsilon, (f_\varepsilon - A_\varepsilon u_\varepsilon - E_\varepsilon \Lambda v, v - u_\varepsilon) \leq 0$, $\forall v \in X_\varepsilon \cap D(\Lambda, V)$. It is shown that $u_\varepsilon$ converges in a certain sense to a solution of the variational inequality (2) $u \in X$, $(f - Au - E\Lambda v, v - u)$, $\forall v \in X \cap D(\Lambda, V)$, provided the data in (1) converge to the data in (2) in an appropriate manner. A number of examples and applications are considered, including degenerate partial differential equations with nonlinear (convex) boundary conditions. (Received January 7, 1976.)

733-B21 CHARLES L. BELNA, MICHAEL J. EVANS, AND PAUL D. HUMKE, Western Illinois University, Macomb, Illinois 61455, A directional cluster set example. Preliminary report.

Let $f$ be a mapping from the open upper half plane $H$ into the Riemann sphere $W$, let $x$ be a point on the real line $R$, and let $C(f,x)$ and $C(f,x,\theta)$ denote respectively the cluster set of $f$ at $x$ and the cluster set of $f$ at $x$ in the direction $\theta (0<\theta<\pi)$. E. F. Collingwood [Ann. Acad. Fenn. Ser. AI, no. 250/6 (1958), Theorem 2 together with Theorem 3] proved: If $f: H \to W$ is continuous, then for a residual set $S$ of points $x \in R$ the set $\Theta(x) = \{\theta : C(f,x,\theta) = C(f,x)\}$ forms a residual subset of $(0,\pi)$. A. M. Bruckner and Casper Goffman raised the question as to whether or not the residual set of directions can be taken to be the same for each $x \in S$. The authors prove: There exists a continuous

$f:H\to W$ such that for any second category set $A\subseteq R$, $\bigcap_{x\in A}\Theta(x)$ is a non-residual subset of $(0,\pi)$; in fact, for any residual set $A\subseteq R$, $\bigcap_{x\in A}\Theta(x)$ is of the first category.

(Received January 8, 1976.)

*733-B22 CHARLES L. BELNA, MICHAEL J. EVANS, AND PAUL D. HUMKE, Western Illinois University, Macomb, Illinois 61455, Most directional cluster sets have common values. Preliminary report.

Let f be a measurable function from the open upper half plane H into the Riemann sphere W, let x be a point on the real line R, and let $C(f,x,\theta)$ denote the cluster set of f at x in the direction $\theta(0<\theta<\pi)$. The authors prove: For almost every and nearly every x in R, there exists a full measure set of directions $\Theta(x)$ such that $\bigcap_{\theta\in\Theta(x)} C(f,x,\theta)\neq\emptyset$.

(Received January 8, 1976.)

733-B23 Jang-Mei G. Wu, University of Illinois, Urbana, Illinois 61801. Green's Potentials on Lipschitz Domains. Preliminary report.

Let D be a Lipschitz domain in $R^n$ $(n\geq 2)$, $\mu$ be a positive mass distribution on D and u be the Green's potential of $\mu$ on D. We shall discuss i) conditions on $\mu$ so that $u\not\equiv+\infty$, ii) boundary properties of u and iii) special results obtained from conformal mappings when $n=2$. (Received January 8, 1976.)

*733-B24 H. A. Watts and M. R. Scott, Sandia Laboratories, Albuquerque, New Mexico 87115. The Solution of Two-Point Boundary-Value Problems by Initial-Value Methods. Preliminary report.

An algorithm, based on using superposition principles, will be discussed for the numerical solution of general two-point boundary-value problems. An orthonormalization procedure is applied to solutions of certain linear initial-value problems. When solving non-linear problems, the method proceeds by first linearizing the problem; that is, quasilinearization or Newton's scheme is applied. The implementation of these techniques into a general purpose computer code will be described. Some results showing the performance of the code will be given. (Received January 8, 1976.) (Authors introduced by Rolf Jeltsch.)

733-B25 Lawrence E. Payne, Cornell University, Ithaca, New York 14853. Some remarks on isoperimetric inequalities and their applications.

Isoperimetric inequalities are frequently used to estimate physically interesting quantities in terms of geometrical properties of the region of interest. They are also useful in the derivation of explicit a priori inequalities, estimates of decay rates for solutions of evolutionary processes and not infrequently to give best possible uniqueness criteria. A few of the most interesting isoperimetric inequalities for eigenvalues in linear and nonlinear problems will be discussed and recent results will be indicated. (Received January 8, 1976.)

733-B26 Daniel H. Luecking, University of Illinois, Urbana, Illinois 61801. Function algebras and badly approximable functions. Preliminary report

Let A be a complex function algebra on a compact Hausdorff space X. A continuous function g on X is said to be badly approximable (w.r.t. A) if the distance from g to A in the sup norm is equal to the norm of g. We give necessary and sufficient conditions that the set of badly approximable functions be nonempty, as well as descriptions— for certain algebras A— of the badly approximable functions. In particular, when X is the boundary of a finitely connected compact subset Y of the complex plane and A is R(Y) restricted to X, we give a necessary condition and a sufficient condition that a function g be badly approximable. When Y has connected complement this becomes a complete description of the badly approximable functions. These results extend work of Poreda(Trans.A.M.S. 169) and Gamelin, Garnett, Rubel, and Shields(J. Approx. Theory, to appear.) (Received January 8, 1976.)

*733-B27 Thomas A. W. Dwyer, III, Northern Illinois University, DeKalb, IL 60115. Vector-valued variational equations of infinite order.

Let M be a measure space with a positive measure m and F a Banach space. Let g be a mapping from

$L^\infty(M)$ into F satisfying the following condition: g has integrable variational derivatives of all orders at some x' in $L^\infty(M)$, such that (*): $\lim_n (n!^{-1/p}\int\ldots\int\|\delta^n g/x'^n\, dm^{\otimes n}\|)^{1/n} = 0$. Let $(x'_n)_n$ be a sequence of symmetric kernels in $L^\infty(M^n)$ such that (#): $\lim\sup_n (n!^{-1/p'}\text{ess sup}\{|x'_n| : M^n\})^{1/n} < \infty$, where $p \geq 1$ and $1/p+1/p' = 1$. Let A be a surjective bounded linear operator on F. We consider the following equation : (1): $\Sigma_{n=0}^\infty n!^{-1}\int\ldots\int A\delta^n f/\delta x'^n x'_n dm^{\otimes n} = g(x')$. Theorem: (a): The F-valued function f on $L^\infty(M)$ of the form (2): $f(x') = \{(\int vx'dm)^n \exp\int ux'dm\}y$ is a solution of (1) with g = 0 iff either y is in KerA or u is a zero with order > n, along v, of the scalar-valued fucntion $x \to \Sigma_{n=0}^\infty \int\ldots\int x'_n x^{\otimes n} dn^{\otimes n}$ on $L^1(M)$ ("symbol" of (1)). (b): All solutions of (1), with g = 0 and satisfying (*), are limits of linear combinations of solutions of form (2) for the norms $\|f\|_{\rho,p} = (\Sigma_{n=0}^\infty n!^{-1}\rho^n\{\int\ldots\int\|\delta^n f/x'^n\|dm^{\otimes n}\}^p)^{1/p}$. (c): (1) is solvable by f satisfying (*) for all g satisfying (*) Similar results hold when (*) and (#) are interchanged if $p > 1$. Forier-Borel duality and the Dunford-Pettis theorem underlie the proof. (Received January 8, 1976.)

733-B28 Myron Goldstein, Arizona State University, Tempe, Arizona 85281. LIG domains.

A bounded domain D in $R^n$ is said to be an LIG domain if it has the property that every subharmonic function in D which possesses a harmonic majorant near each boundary point of D possesses a globally defined harmonic majorant in D. Gauthier and Hengartner in 1973 showed that the unit disk is an LIG domain. Later on, Gauthier and the author proved that a bounded domain D in $R^n$ whose Martin, minimal Martin, and topological boundaries coincide is an LIG domain and thus every bounded Lipschitz domain in $R^n$ is an LIG domain. Finally, we have found necessary and sufficient conditions for a bounded domain in $R^n$ to be an LIG domain. It should be mentioned that the term LIG domain is due to Hueber who also studied the properties of such domains. (Received January 8, 1976.)

733-B29 Bertram Walsh, Rutgers University, New Brunswick, New Jersey 08903. Properties of harmonic spaces preserved under perturbation.

Let $(X,\mathcal{H})$ be a harmonic space possessing a priori only those properties needed to establish the perturbation theory developed in the author's paper [Ann. Inst. Fourier (Grenoble) 20 (1970), 317-359]. A survey will be given of old and new results on the inheritance by perturbed sheaves of special properties of $\mathcal{H}$ (particularly convergence axioms), and on intrinsic characterization of perturbed sheaves. (Received January 8, 1976.)

*733-B30 R.V.M. Zahar, Pennsylvania State University, University Park, PA. 16802. Recurrence algorithms for series solutions of differential equations.

Recurrence techniques for Chebyshev and Taylor series solutions to ordinary differential equations are discussed. Methods are presented for formulating the recurrences so that they can be solved in a stable manner. The results are applied to an iterative algorithm for the numerical solution of eigenvalue problems. (Received January 8, 1976.) (Author introduced by Rolf Jeltsch.)

733-B31 James E. Daly, University of Oregon, Eugene, Oregon 97403. Multipliers and singular integrals over local fields. Preliminary report.

Let K denote a local field and $K^d$ the d-dimensional vector space over K.
Theorem 1: If $m \in L^\infty(K^d)$, m is homogeneous of degree zero, and m satisfies $\int_{|y|<1}\int_{|x|=1} |m(x+y) - m(x)|^r dx|y|^{-(sd+\epsilon)}dy = B_{r,s}^r < \infty$ for some $\epsilon > 0$, $1 < r,s < \infty$, then there is a singular integral T such that $(Tf)^\wedge = m\hat{f}$ for all $f \in L^2 \cap L^p$, $1 < p < \infty$. The kernel w of T satisfies $\sup_{|y|\leq 1}\int_{|x|>1} |w(x+y) - w(x)|\,|x|^{-d}dx \leq C(\|m\|_\infty + B_{r,s})$.
Let $A(r,s)$ denote the collection of singular integrals T whose multiplier m satisfies the conditions of Theorem 1 and define $|||T||| = \|m\|_\infty + B_{r,s}$.

Theorem 2: $A(r,s)$ is a semi-simple, commutative Banach algebra that is inverse and adjoint closed. (Received January 8, 1976.)

733-B32 JOHN C. TAYLOR, McGill University, Montreal, Quebec, Canada. The Martin compactification of a bounded Lipschitz domain in a Riemannian maxifold X.

Hunt and Wheeden (1970) showed that for $X = \mathbb{R}^n$ and the Laplacian $\Delta$ the Martin compactification of a bounded Lipschitz domain $D$ is $\overline{D}$. This result is extended to arbitrary open Riemannian manifolds with $\Delta$ denoting the Laplace-Beltrami operator. The basic idea is to localize the problem and then to verify the result in $\mathbb{R}^n$ for any sufficiently "nice" 2nd -order elliptic operator. (Received January 8, 1976.)

*733-B33 William Rundell, Texas A&M University, College Station, Texas 77843. A maximum principle for equations of Sobolev type.

Let $D$ be a bounded, simply connected and open subset of $R^n$. Let $M$ and $L$ be linear, elliptic partial differential operators of second order.

Theorem. Let $u$ satisfy $(\varepsilon M-I)\frac{\partial u}{\partial t} + \eta M u \leq 0$ in $D\times[0,\tau]$ with $u(x,0) \geq 0$ and $u(x,t) \geq 0$ for $(x,t) \in \partial D\times[0,\tau]$ where $\varepsilon$ and $\eta$ are positive constants. Then $u \geq 0$ in $D\times[0,\tau]$.

Examples are given to show that the above result is in general false for the more general Sobolev inequality $(\varepsilon M-I)\frac{\partial u}{\partial t} + Lu \leq 0$. (Received January 8, 1976.)

733-B34 KOHUR N. GOWRISANKARAN, McGill University, Montreal, Quebec, Canada. Multiply superharmonic functions.

Some recent results concerning integral representations of multiply superharmonic functions and applications are given. (Received January 8, 1976.)

# Applied Mathematics

733-C1 WITHDRAWN

733-C2 Lars B. Wahlbin, Cornell University, Ithaca, N.Y. 14853
On finite element methods for numerical solution of some Sobolev equations. Preliminary report.

In recent years, highly accurate finite element methods have been devised for the numerical solution of a second order elliptic problem $Lu = f$ in $\Omega \subset\subset R^N$, $u = 0$ on $\partial\Omega$. We have in mind for example methods given by Babuška and Nitsche, and also the ordinary Ritz-Galerkin method.

For time-discretization (in parabolic problems) Calahan, Zlámal, and Baker and Bramble have constructed computationally convenient high order one step methods.

In this talk we shall consider the application of the methods mentioned above to approximating the solution of the model Sobolev type problem

$$Ldu/dt + Pu = f \text{ in } \Omega \times [0,T],\ u = 0 \text{ on } \partial\Omega \times [0,T],\ u = u_0 \text{ at } t = 0,$$

where $P$ is a partial differential operator of first or second order.
(Received November 26, 1975.)

*733-C3 Rolf Jeltsch, University of Kentucky, Lexington, Kentucky 40506. Necessary condition for A-stability of Multistep Multiderivative Methods.

The region of absolute stability of multistep multiderivative methods is investigated in a neighborhood of the origin. This leads to a necessary con-

dition for A-stability. For example one finds that a convergent, strongly stable multistep multiderivative method can not be A-stable if the error order p is odd and $c(-1)^{(p+1)/2} < 0$, c error constant of the method. Furthermore it is found that Hermite interpolatory and Adams type methods with nonnegative damping order can not be A-stable if $p = 2\ell + 1 \bmod 4$, where $y^{(\ell)}(x)$ is the derivative of highest order used in the formulas. (Received December 11, 1975.)

733-C4 Julio Cesar Diaz, University of Kentucky, Lexington, Kentucky 40506.
Collocation-Galerkin solutions of the two point boundary value problem.

Consider the problem $Lu \equiv -u'' + au' + bu = f$ on $I = (0,1)$ with boundary conditions $u(0) = u(1) = 0$. Given a partition $\Delta : 0 = x_0 < x_1 < \ldots < x_n = 1$ of I, let M and N be two finite dimensional spaces of piecewise polynomial functions over $\Delta$ such that dim M = dim N.

If N can be decomposed as $N = N_1 \oplus N_2$ where dim $N_1$ = kn, for k an integer, then the collocation-Galerkin approximation to u is defined to be the function $U \in M$ that satisfies k collocation conditions on each subinterval and the Galerkin equations with $N_2$ as the space of test functions.

For specific choices of M and N optimal global error estimates and superconvergence estimates are given. (Received December 18, 1975.)

733-C5 Richard A. Holley and Daniel W. Stroock, University of Colorado, Boulder, Colorado 80302.
A Strong Cluster Property for Lattice Systems at High Temperatures or Low Densities.

A Gibbs state on $\{0,1\}^{Z^d}$ has the strong cluster property if the probabilities of configurations on a finite set, $\Lambda$, conditioned on the configuration in $\Gamma^c$, where $\Lambda \subset \Gamma$, converge to the total probabilities of configuartions on $\Lambda$ exponentially fast as a function of the distance from $\Lambda$ to $\Gamma^c$. It is well known that in one dimension all Gibbs states with finite range potentials have the strong cluster property. By using the stochastic Ising model as a tool we show that this is also true in higher dimensions, provided that the temperature is sufficiently high or the density is sufficiently low. (Received December 18, 1975.)

733-C6 Robert D. Skeel, University of Illinois, Urbana, Illinois 61801 and L. Wayne Jackson, University of Alberta, Edmonton, Alberta T6G 2E1.
Stability of variable step linear multistep methods. Preliminary report.

There are numerous ways of converting fixed step linear multistep formulas into variable step formulas. Three possibilities are the constant-$\rho$ technique, the constant-$\sigma$ technique, and Nordsieck's interpolation technique. Theoretical results are presented on the storage requirements and the stability of these three techniques. (Received December 19, 1975.) (Author introduced by Rolf Jeltsch.)

733-C7 V. PEREYRA, University of Southern California, Los Angeles, California 90007.
A one-step 4k order method for nonlinear two-point boundary value problems.

We consider the first order system $y' = f(t,y)$ subject to $g(y(a),y(b)) = 0$, where $y,f,g \in R^m$. We assume that this problem has an isolated smooth solution $y^*(t)$. Consider a nonuniform mesh $\{t_i\}$, and the finite difference discretization $y_{i+1}-y_i-\frac{1}{2}h_i(f_{i+1}+f_i)+h_i^2/12 \cdot (f'_{i+1} - f'_i) = 0$, $i=0,\ldots,N-1$, $g(y(0),y(N)) = 0$, where $f_i=f(t_i,y_i)$, $f'_i=(f_y f+f_t)_i$, $h_i=t_{i+1}-t_i$. For this discretization $\max\left|y^*(t_i)-y_i\right| = O(h^4)$ ($h=\max h_i$), and k-1 deferred correction steps will produce the order indicated in the title. A quasi-Newton technique is used to solve the nonlinear systems. The Jacobian matrix is approximated by a block diagonal matrix J whose ith block row has nonzero elements $\left[-I-\frac{1}{2}h_i f_{y_i} - h_i^2/12\, f_{y_i} f_{y_i}\right]$; $\left[I-\frac{1}{2}h_i f_{y_{i+1}} + \right.$

$h_i^2/12\, f_{y_{i+1}} f_{y_{i+1}}$ ] i.e. no second order derivatives are employed. A first approximation is obtained by using full Newton's method on the trapezoidal rule. With this accurate predictor the quasi-Newton method converges linearly but with a very high rate for all the subsequent systems to be solved. Asymptotic error estimates and mesh selection are provided as a part of a complete adaptive algorithm. (Received December 23, 1975.) (Author introduced by Rolf Jeltsch.)

733-C8 R. G. GALLAGER, Massachusetts Institute of Technology, Cambridge, Massachusetts. Overview of Information Theory.

Information theory is primarily a mathematical discipline motivated by, and providing insight into, the problems of communication engineering. We first define the mathematical concept of information, then briefly describe the major theorems of information theory, and then discuss the implications of these theorems to communication systems. We conclude with a brief description of current research problems in the field. (Received December 29, 1975.) (Author introduced by J. Wolfowitz.)

733-C9 JACOB WOLFOWITZ, University of Illinois, The classical channel.

This is an invited expository paper on the classical channel, intelligible to any mathematician. No prior knowledge of information theory is required, and the stress will be on ideas and intuitive understanding rather than on details. The notions of coding theorems and weak and strong converses will be explained. Among discrete channels discussed will be the memoryless channel, a channel with memory, and a channel with feedback. Continuous channels will be discussed in the context of Gaussian channels with an energy constraint, and without and with feedback. It will be shown that such channels with feedback do not require coding. (Received December 29, 1975.)

733-C10 Toby Berger, Cornell University, Ithaca, New York 14853. Rate-distortion theory and ε-entropy.

This tutorial presentation treats rate-distortion theory, the branch of information theory devoted to data compression problems. Some investigators, particularly those in the Soviet Union, refer to this discipline as ε-entropy. From the pure mathematician's viewpoint rate-distortion theory amounts to covering theory on sequence space or function space extended to cases in which there is a probability measure on the space. From the applied mathematician's viewpoint it also encompasses questions about the complexity of the encoding algorithms needed to produce the index of the cover element to which a given point in the space belongs. Recent work focuses on

(i) "Universal" encoding algorithms for cases in which the probability measure is partially or totally unknown

(ii) Situations in which several encoders working in isolation must simultaneously compress data from correlated information sources

(iii) Connections with the ergodic theorems of Kolmogorov and Ornstein. (Received December 29, 1975.) (Author introduced by J. Wolfowitz.)

*733-C11 AARON D. WYNER, Bell Laboratories, Murray Hill, N. J. 07974 Multiple-User Shannon Theory

In this introductory talk we discuss several multiple-user communication situations. This class of problem is charactarized by a multiplicity of users (e.g., senders or receivers) and by various restrictions and the amount of allowable collaboration between them. One of these situations called the "wire-tap channel" will be discussed in some detail. Here the first "user" transmits information over a classical channel, and the

second "user" is a noisy wire-tapper. We show how the first user can transmit information in perfect secrecy, even though the "code-book" is known to the wire-tapper. (Received December 29, 1975.) (Author introduced by J. Wolfowitz.)

733-C12 JAMES L. MASSEY, University of Notre Dame, Notre Dame, Indiana 46556.
Overview of Coding Theory. Preliminary Report.

Coding theory, or the theory of error-correcting codes, has proved to be an unusually fertile area for the application of combinatorics and abstract algebra, disproving (as N. Levinson has noted) G. H. Hardy's "conjecture" on the non-utility of beautiful mathematics. The field of coding theory will be sketched in this presentation so as to point out the main mathematical problems which it poses and the current states of progress thereon. Linear block codes, i.e., vector spaces of n-tuples over a finite field, will be discussed with respect to: 1) the bounding problem, 2) the construction problem both for specific codes and for ensembles of codes, 3) the descriptive problem for specific codes, particularly, their weight distributions, and 4) the decoding problem for both hard- and soft-decisioned data. Convolutional codes; i.e., vector spaces of n-tuples over a field of rational functions derived from a finite field, will be similarly discussed to an extent which should make apparent the much less satisfactory mathematical understanding, vis-a-vis linear block codes, of these highly practical non-block codes. (Received December 29, 1975.) (Author introduced by J. Wolfowitz.)

733-C13 N. J. A. SLOANE, Bell Laboratories, Murray Hill, New Jersey 07974
Error-Correcting Codes and Invariant Theory: New Applications of a Nineteenth-Century Technique.

An unfashionable nineteenth-century technique has recently been used to solve problems in coding theory. This technique is potentially of much wider application, is very powerful, often produces startling results, and (not least) is fun to use. (Received December 29, 1975.)

733-C14 Ian F. Blake, IBM Thomas J. Watson Research Center, Yorktown Heights, N. Y. 10598.
Group characters and representations in coding theory.

Two applications of group characters and representations to coding theory are considered in this tutorial presentation. In the first, a linear code for a discrete channel is defined as an ideal in the group algebra of a finite group over a finite field. Many properties of the code can be developed with the use of characters and as an illustration a sketch of the proof of the MacWilliams weight enumeration formula will be given. The second application involves the generation of equal energy codes for a continuous channel using group representations. Specifically, if $\rho:G \to GL(V)$ is a representation of the finite group G in the general linear group of the real vector space V then, for some $x \in V$ a group code is defined as the set $C = \langle \rho(g)x, g \in G \rangle$. The distance and structure properties of such codes will be discussed. (Received December 29, 1975.) (Author introduced by J. Wolfowitz.)

*733-C15 MARTIN H. GUTKNECHT, University of British Columbia, Vancouver, B.C., V6T 1W5.
Solving Theodorsen's integral equation for conformal maps with the fast Fourier transform. Preliminary report.

The iterative solution of Theodorsen's integral equation requires at every step the evaluation of a conjugate function. The classical method using Wittich's matrix demands for $O(N^2)$ operations. It is shown that by applying the fast Fourier transform only $O(N \log N)$ operations are needed. Underrelaxation permits further economization and allows to treat boundaries with $|\rho'/\rho| > 1$ (if $\tau$, $\rho(\tau)$ denote the polar coordinates of the boundary). Under special assumptions a simple formula for the asymptotically optimal underrelaxation factor holds. Numerical examples are given. (Received December 29, 1975.) (Author introduced by Rolf Jeltsch.)

*733-C16 CHARLES P. DOWNEY and J. K. KARLOF, University of Nebraska at Omaha, Omaha, Nebraska 68101. On the Existence of [M,n] Group Codes for the Gaussian Channel with M and n odd.

Biglieri and Elia (IEEE Trans. of Info T. Vol. IT-18, No 3, p.399) have settled the question of the existence of nonplaner [M,n] group codes for the Gaussian Channel except in the case of n odd and M odd and composite. We show that the existence of such codes is equivalent to the existence of a group G with the following properties: $|G|$ is even, G has an irreducible faithful representation, T, of the first kind of odd dimension, and T restricted to P, the 2-Sylow subgroup of G, contains the one-representation of P. In particular, we prove that for

each odd n not of the form $2^m-1$ there exists a nonplaner [M,n] group code with M odd and composite. The irreducible representation of $S_{n+1}$ corresponding to the partition {n,1} is used to generate such codes with M of the form $\binom{n+1}{n_1,n_2,\ldots,n_k}$ where $n+1 = \sum_{i=1}^{k} n_i$ and each $n_i$ is a sum of powers of 2, no power of 2 occurring more than once. (Received December 16, 1975.)

733-C17 WITHDRAWN

*733-C18 F. Odeh, IBM Thomas J. Watson Research Center, Yorktown Heights, New York 10598. Non-linear fixed-h stability of linear multistep formulae.

Stability properties similar to A-stability are established for implicit linear multistep formulae, LMF, when applied to nonlinear stable systems. Sufficient criteria are given which guarantee the fixed-h stability of the global numerical error for various classes of non-linearities. These criteria relate the behaviour of the root-locus curve defined by the LMF to the dissipative properties of the system. A simple criterion for the stability of a composite system is also given. (Received January 2, 1976.)

733-C19 Alan Di Cenzo, Case Western Reserve University, Cleveland, Ohio 44106. A study of perturbation effect on spectra of operators. Preliminary report.

We consider a linear selfadjoint differential operator A and a perturbed operator $A_h$. Both operators are of order m, and defined on the Sobolev space $H_m(\Omega)$, where $\Omega$ is a domain in $E_n$. We show that if the perturbation is slight, the spectrum and spectral functions of $A_h$ resemble those of A. In case A is elliptic, we obtain special results on the counting function $N(\lambda)$ of the eigenvalues. The special case where A is the Sturm-Liouville operator is treated in Steven Pruess, Numerische Mathematik 24, (1975), 241-247. (Received January 5, 1976.) (Author introduced by Gerald Hedstrom.)

733-C20 Mr. Martin Rooney, The University of Texas, Austin, Texas 78712. Galerkin approximation of Sobolev equations for nonlinear waves.

The Galerkin semidiscrete approximation of the conservative nonlinear problem

$$\begin{cases} u_t - u_{xxt} = G(u)u_x , & a < x < b , \quad -\infty < t < \infty \\ u(x,0) = u_o(x) , & u_o \in H^1(a,b) , \quad u_o(a) = u_o(b) \\ u(a,t) = u(b,t) \end{cases}$$

with $G(\cdot) \in C^1(\mathbb{R})$ has *a priori* error bounds that grow linearly -- not exponentially -- in time. Implicit (nonlinear) differencing preserves the linear dependence of the bound. Similar results hold for a conservative abstract evolution equation generalizing the above. (Received January 5,1976.)

733-C21 Fred Chipman, Acadia University, Wolfville, N.S., Canada. A family of one-parameter, B-stable, R-K methods. Preliminary report.

A family of one-parameter, implicit Runge-Kutta methods is defined. The methods appear to be B-stable (Butcher), i.e. adjacent numerical solutions of the system $y' = f(y)$ approach one another in a region $D \subseteq R^n$ in which $\langle f(u)-f(v), u-v\rangle < 0$ $\forall\, u,v \in D$. Here $\langle\cdot\rangle$ denotes an inner product on $R^n$. These methods permit one degree of exponential fitting. (Received January 5, 1976.) (Author introduced by Rolf Jeltsch.)

*733-C22 Bengt Lindberg, University of Illinois, Urbana, Illinois 61801. Estimation of errors for discretization algorithms for nonlinear functional equations. Preliminary report.

A simple technique for estimating the error in the numerical solution of functional equations will be

discussed. The error estimate is obtained as the difference between the solution of the original discretized problem and the solution of a slightly perturbed problem. The perturbation can be wieved as the residual (on the gridpoints), which is obtained when the numerical solution of the original problem is substituted for the unknown function in the functional equation. Function values for points not on the grid and derivatives of the unknown function are approximated by sufficiently accurate linear combinations of values from the grid.

The approach will be illustrated on a nonlinear two-point boundary value problem, with nonlinear boundary conditions. Numerical results for two-dimensional linear and nonlinear elliptic boundary value problems with Dirichlet and von Neuman boundary conditions will be given if time permits. (Received January 5, 1976.) (Author introduced by Rolf Jeltsch.)

733-C23 Robert D. Russell and Jan C. Christiansen, Simon Fraser University, Burnaby, British Columbia, Canada V5A 1S6. Adaptive mesh selection strategies for solving boundary value problems. Preliminary report

A number of mesh selection strategies are brought together and compared for solving two-point boundary value problems. While the strategies are applied to collocation methods, most of the observations and conclusions are valid for other types of methods and for general boundary value problems. Much of the comparison done and suggestions made is on the basis of numerical results for a group of test problems. (Received January 5, 1976.) (Author introduced by Rolf Jeltsch.)

733-C24 Daniel S. Watanabe, University of Illinois, Urbana, Illinois 61801 and Bruce D. Link, University of Illinois, Urbana, Illinois 61801. Block implicit formulas for stiff equations. Preliminary report.

A new class of block implicit formulas for stiff ordinary differential equations is presented. The formulas are based on collocation or quadrature and use function values at nonmesh points obtained through Hermite interpolation. The order and stability properties of special subclasses of block one-step formulas are analyzed, and sufficient conditions for the stability of variable formula methods based on special subclasses of multistep formulas are described. Numerical results demonstrating the efficiency and effectiveness of several representative one-step formulas and variable formula methods are also presented. (Received January 5, 1976.) (Author introduced by Rolf Jeltsch.)

*733-C25 D.A.ARCHER, University of North Carolina, Charlotte, North Carolina 28213 and J.C.DIAZ, University of Kentucky, Lexington, Kentucky 40506. Modified collocation methods for two point boundary value problems.

The numerical approximation of two point boundary value problems by collocation with Hermite cubic splines usually requires that the differential equation be collocated at two points per subinterval. If these points are chosen arbitrarily only $O(h^2)$ rates of convergence may be expected; however, collocation at the two Gauss quadrature points in each subinterval yields $O(h^4)$ estimates--the optimal rate for Hermite cubics. Here we develop and analyse a class of Hermite cubic methods that obtain $O(h^4)$ accuracy by collocating a modified differential equation at the images in each subinterval of the points $(1 \pm t)/2$ $[0 < t \leq 1]$. In case $t = 1/\sqrt{3}$ our method reduces to the usual Gauss point method. Superconvergence results for derivatives are obtained at selected points. (Received January 6, 1976.) (Authors introduced by Rolf Jeltsch.)

*733-C26 Daniel D. Warner, Bell Laboratories, Murray Hill, N.J. 07974. An Exponentially Fitted Trapezoidal Rule.

In this talk we will analyze some aspects of an exponentially fitted trapezoidal rule proposed by W. B. Gragg for the solution of stiff systems of ordinary differential equations. In particular, we will show that the method is strongly A-stable and that it possesses an asymptotic expansion in powers of $h^2$. The key computational difficulty with this method is the evaluation of a matrix-valued entire function. The implementation of this will be addressed in some detail. (Received January 6, 1976.)

733-C27 Jerrold S. Rosenbaum, Virginia Commonwealth University, Richmond, VA 23284
Numerical Integration of Differential Equations for Real Time Simulation

Numerical integration of ordinary differential equations for real time simulation presents many unusual constraints on allowable techniques. For example, often only one derivative evaluation per step is allowable, step size is determined a priori, and output has an inherent time delay. Also, most systems are stiff. The capability of implementing (semi) implicit methods for real time simulation is discussed. One approach to an allowable integration technique is to use exponential linear multistep methods based on the exponential of an approximation to the Jacobian and approximations to a convolution term. (Received January 6, 1976.)

*733-C28 WERNER LINIGER, IBM Thomas J. Watson Research Center, Yorktown Heights, New York 10598.
On Liapunov stability of nonlinear multistep difference equations.

The recently introduced concept of $(G,\mu)$-stability [Germund G. Dahlquist, "On stability and error analysis for stiff nonlinear problems," Part I, Report TRITA-NA-7508, Department of Information Processing, Royal Institute Tech., Stockholm, Sweden, 1975] is useful for discussing Liapunov stability of solutions of nonlinear difference equations, generated by applying linear multistep formulas to dissipative, monotone systems of ordinary differential equations $\dot{y} = f(t,y)$ of dissipation $\mu$, $\mu \leqq 0$; i.e., to systems for which, in some scalar product $\langle\ ,\ \rangle$, we have $\mathrm{Re}\,\langle z, f(t,y+z) - f(t,y)\rangle \leqq \mu\|u\|^2$ for all (or an appropriate subset of) values of $y, z$, and $t$. $(G,\mu)$-stability for $\mu = 0$ is referred to as G-stability, a nonlinear concept analogous to the linear concept of A-stability. The theory of G-stability and $(G,\mu)$-stability will be summarized and a construction will be presented which facilitates the investigation of these properties. By this construction it has been proved, for example, that for the four-parameter family of all three-step formulas which are second-order accurate, A-stability is necessary and sufficient for G-stability. (Received January 6, 1976.) (Author introduced by Rolf Jeltsch.)

733-C29 G. D. BYRNE, Department of Mathematics & Statistics, University of Pittsburgh, Pittsburgh, PA 15260; A. C. HINDMARSH, Numerical Mathematics Group, Lawrence Livermore Laboratory, Livermore, CA 94550; K. R. JACKSON, Department of Computer Science, University of Toronto, Toronto, Canada M5S 1A7; H. G. BROWN, Department of Computer Science, Northeast Louisiana University, Monroe, LA 71201. Testing computer codes for ordinary differential equations. Preliminary report.

We discuss several aspects of some software testing which we carried out at Argonne National Laboratory under the auspices of USERDA. These aspects include problem selection, timing execution at various levels and the related difficulties, the statistics gathered, etc. This is accomplished by examining some of the results obtained for the two ordinary differential equations packages studied -- EPISODE and GEAR. (Received January 8, 1976.)

733-C30 R. Leonard Brown, University of Virginia, DAMACS, Thornton Hall, Charlottesville, Va. 22901. Numerical Integration Techniques for Real Time Simulation-Part II

Criteria for evaluation of numerical integration techniques for real time simulation must take into account the constraints of the problem. Some criteria that can be considered are the region of absolute stability, accuracy of the solution to systems with perturbed eigenvalues, and the time response to input functions which take into account the time delays that are inherent in the real time simulation problem. Linear multistep methods fitted to system characteristics are considered with respect to the constraints of the problem and the evaluation criteria. Certain of these methods are presented. (Received January 8, 1976.) (Author introduced by Rolf Jeltsch.)

733-C31 Mary Fanett Wheeler, Rice University, Houston, Texas 77001. Some collocation-finite element methods for 2m-th order boundary value problems. Preliminary report.

Families of collocation-finite element methods corresponding to the $L_2$-Galerkin and $H^{-m}$-Galerkin methods respectively are defined for 2m-th order boundary value problems. $L_p$ estimates, optimal in rate and norm on solution, are obtained. Superconvergence results and local quadratures giving accuracy of higher order are developed. (Received January 8, 1976.)

*733-C32 Paul S. Jensen, Lockheed Research Laboratory, Palo Alto, California 94304. Special Purpose Linear Multi-Step Formulas. Preliminary report.

For some classes of ODE's it is beneficial to tailor a linear multi-step formula to the problem. For example, in the stiff-oscillatory systems associated with structural vibration, one seeks an integration formula which exhibits negligible numerical damping over a broad band of low frequency components but damps out high frequency components.

A number of considerations involved in expressing special objectives for a multi-step formula as a non-linear, constrained optimization problem will be discussed. Some results for a stiff-oscillatory system will also be presented. (Received January 8, 1976.) (Author introduced by Rolf Jeltsch.)

733-C33 R. BRUCE SIMPSON, Department of Computer Science, University of Waterloo, Waterloo, Ontario, Canada. Adaptive mesh modification for the box scheme.

Aspects of adaptive modifications to a mesh for the box finite difference scheme for two-point boundary-value problems will be considered. In particular, we will discuss algorithms for generating meshes and measures of performance for these algorithms. (Received January 8, 1976.) (Author introduced by Professor Rolf Jeltsch.)

733-C34 BYRON L. EHLE, University of Victoria, Victoria, B.C., Canada. A comparison of the effectiveness of various methods for solving stiff equations.

Research into systems of stiff ordinary differential equations has produced at least nine broad classes of methods which might be used in generating numerical solutions. In this paper we compare codes for eight different numerical methods which are representative of six of these different classes. Comparisons are based on how well each method solves a carefully selected collection of 72 stiff initial value problems. Methods are rated using several different combinations of comparison criteria so that a user may pick a satisfactory method based on his particular standards. (Received January 8, 1976.) (Author introduced by Professor Rolf Jeltsch.)

733-C35 J. D. Lawson, University of Waterloo, Waterloo, Ontario, Canada. Padé-Walsh arrays for $\exp(-z)$ on $[0,\infty)$ with applications to the numerical solution of heat conduction problems.

The Padé-Walsh array for $f(z)$ on $[a,b]$ is the set of best uniform rational approximations $R_{i,j,k}(z)$ with numerator of degree $i$, denominator of degree $j$ and constrained to have agreement through $k$ terms of the Taylor expansions of $R(z)$ and $f(z)$ about $a$. The use of these approximations to $\exp(-z)$ on $[0,\infty)$ permits derivation of methods extending the results of Cody, Meinardus and Varga [J. Approximation Theory 2(1969), 50-65] to problems with time-dependent boundary conditions. (Received January 8, 1976.) (Author introduced by Professor Rolf Jeltsch.)

733-C36 SEYMOUR SHERMAN, Indiana University, Bloomington, Indiana 47401. Cluster-star inversion and Möbius formula.

The cluster-star equations are inverted by using the general Möbius inversion formula. (Received January 8, 1976.)

# Statistics and Probability

*733-F1 Loren D. Pitt, University of Virginia, Charlottesville, Virginia 22903. A Gaussian Correlation inequality for even convex sets. Preliminary report.

Let $\{X(t);\ t \in R'\}$ be the stationary Ornstein Uhlenbeck velocity process on $R^d$. Let $A_i = -A_i$, $i = 0,\ldots,n$ be convex subsets of $R^d$ and for positive times $t_o, t_1,\ldots t_n$ set $p(t_o, t_1,\ldots, t_n) = P\{X(t_i) \in A_i:\ i = 0,\ldots,n\}$. Theorem. When $d \leq 2$, $p(t_o,t_1,\ldots,t_n)$ is a decreasing function of $t_1,\ldots,t_n$. The report will describe this theorem and other results obtained so far in our efforts to remove the condition $d \leq 2$. (Received December 11, 1975.)

*733-F2 Allan Gut, Duke University, Durham, North Carolina 27706. Convergence of reversed martingales with multidimensional indices.

Let $d \geq 2$ be an integer and $Z_+^d$ the positive integer d-dimensional lattice points. Convergence of reversed martingales with indices in $Z_+^d$ is established. The main results are that, if the probability space is of product type, $L(\log L)^{d-1}$-boundedness implies a.s. convergence and $L^1$-boundedness implies convergence in probability and in $L^1$. Some results for reversed submartingales and for martingales and submartingales, which partly extend earlier results due to Cairoli, are also obtained and an application to laws of large numbers is given. (Received January 5, 1976.) (Author introduced by Morris Weisfeld.)

*733-F3 Richard S. Ellis, University of Massachusetts, Amherst, Massachusetts 01002, and Charles M. Newman, Technion, Haifa, Israel. Necessary and sufficient conditions for the GHS inequality with applications to differential equations.

Let $p_j$, $1 \le j \le N$, be even probability measures on $\mathbb{R}$ with suitably bounded tails. We give necessary and sufficient conditions on the $p_j$ such that the GHS inequality holds (see J. Math. Phys. 11 (1970), 790-795):

$$(*) \quad \frac{\partial^3}{\partial h_{j_1} \partial h_{j_2} \partial h_{j_3}} \log \int_{\mathbb{R}^N} \exp[\Sigma J_{jk} x_j x_k + \Sigma h_j x_j] \, \pi_j dp_j(x_j) \le 0$$

for any $1 \le j_1, j_2, j_3 \le N$, $h_j \ge 0$, $J_{jj}$ real $(1 \le j \le N)$, $J_{jk} \ge 0$ $(1 \le j \ne k \le N)$. The main result is that (*) holds if and only if for each j, $p_j(x) = [\delta(x-y) + \delta(x+y)]/2$, some $y \ge 0$, or $p_j \ll dx$ and there exists $0 < K \le \infty$ and $V \in C^1((-K,K)\setminus\{0\})$, $V'$ convex on $(0,K)$, so that $\mathrm{supp}(p_j) = [-K,K]$, $dp_j/dx = \exp(-V(x))$, $x \in (-K,K)$. Applications to special positivity-preserving properties of certain parabolic partial differential equations are also given. (Received January 5, 1976.)

*733-F4 PHILIP E. PROTTER, Duke University, Durham, North Carolina 27706. Stability of the Classification of Stopping Times. Preliminary Report

Stopping Times may be classified into previsible (or predictable), accessible, or totally inaccessible stopping times. Some deterministic operations (e.g., $\wedge, \vee, +$) preserve stopping times, and which of these preserve the classifications are determined. Theorem: If $\varphi(t_1, \ldots, t_n)$ maps stopping times to stopping times, it maps previsible ones into previsible ones, and accessible ones into accessible ones. The situation of total inaccessibility is more complicated: $\varphi$ must be lattice operations on a partition of the space (except for a "small" set) in order for $\varphi$ to map the totally inaccessible times into themselves. (Received January 8, 1976.)

*733-F5 PAUL ERDŐS, Hungarian Academy of Sciences, Budapest, Hungary. Applications of probability methods to combinatorial analysis and number theory.

• Applications of probability methods will be discussed to the theory of additive arithmetical functions and to additive number theory, also the limitations of the method will be pointed out and many unsolved problems will be stated. In general few if any deep results on probability will be used. I also state many applications of probability methods to combinatorial and graph theoretic problems. Here we only use very elementary probability but nevertheless several problems are solved which have not been done up to the present by any other method. Here also the limitations and many unsolved problems will be discussed. (Received January 8, 1976.)

# Topology

733-G1 Joseph N. Simone, University of Missouri at Kansas City, Kansas City, Missouri 64110. Hereditarily Locally Connected Continua and the Hahn-Mazurkiewicz Problem. Preliminary report.

In this paper we study properties of nonmetric hereditarily locally connected (hlc) continua and continuous images of ordered compacta (IOK's). It is shown that a continuum is hlc iff it contains no nondegenerate continuum which is the limit of a suitably defined net of continua. This characterization is then used to show that if X is a connected IOK with no nondegenerate metric subcontinuum, then X is hlc. A continuum X is paraseparable iff each collection of disjoint open sets in X is countable. A netlike continuum is one in which each two points are separated by some finite set. B.J. Pearson and L.E. Ward, Jr. have shown that every netlike continuum is a continuous image of an arc. This theorem is used to establish that a paraseparable continuum with no nondegenerate metric subcontinuum is an IOK iff it is netlike. (Received January 8, 1976.)

# Short Course On Introduction To Computer Science For Mathematicians
# Biltmore Hotel, New York
# April 12, 1976

SC 76-9 NICHOLAS PIPPENGER, IBM T.J. Watson Research Center, Yorktown Heights, New York 10541. The complexity of algebraic and order-theoretic computations.

The goal of the talk is to illustrate the results obtained by considering the complexity of various computational

tasks relative to restricted computational models. The theoretically most important models are those (such as the Turing machine) that allow unrestricted symbol manipulation, and results in terms of these models possess a certain natural significance. Restricted computational models sacrifice some of this natural significance in exchange for a more faithful representation of the way in which computations are actually performed in practice and for the privilege of working with familiar mathematical structures. We shall study algebraic computations, in which the answers can be obtained from the input data by means of a finite number of rational operations (additions, subtractions, multiplications, and divisions). Most prominent among these are computations of linear algebra (such as multiplication and inversion of matrices) and evaluation and interpolation of polynomials; excluded are analytic processes such as the iterative solution of nonlinear equations. The restricted computational model of interest here is variously known as the straight-line program, chain, or network. A contrasting family of problems will be provided by the study of order-theoretic computations, in which two-way comparisons are used to answer questions about the relative order of the input data, which are assumed to take values in a totally ordered set. Typical of such problems are sorting, merging, and finding the median, and the relevant model is the decision tree. (Received January 12, 1976.)

Reading List

A.V. Aho, J.E. Hopcroft, and J.D. Ullman, The design and analysis of computer algorithms. Addison-Wesley, Reading, Mass., 1974, Chaps. 1, 3, 6, 12.

A. Borodin and I. Munro, The computational complexity of algebraic and numeric problems, American Elsevier, New York, 1975, Chaps. I, II, III, V.

D.E. Knuth, The art of computer programming. Vol. 3: Sorting and searching, Addison-Wesley, Reading, Mass., 1973, Section 5.3.

SC 76-10 ROBERT L. CONSTABLE, Cornell University, Ithaca, New York 14850. Proving the correctness of programs.

There are many applications of computers that require absolute reliability (as in air traffic control, automated banking, defense networks, etc.). Physical hardware reliability can be achieved by conventional engineering methods such as redundancy and overspecification, but program or "software" reliability means correct rigorous reasoning, not redundancy; it is a mathematical concept more than an engineering concept. In this course we will be concerned with methods of reasoning about computer programs. We will begin with examples close to traditional mathematical proofs about discrete structures and then consider systematically the concerns which lead to formalisms for proofs that are different than the existing formal logics based on the classical first order predicate calculus. We will proceed by considering a few examples of proofs about programs (both FORTRAN and PL/C examples will be used but no specific programming language or programming experience is required). We will then consider axioms for various programming language features including recursion and develop the examples more deeply using these axioms. The course will conclude with a discussion of the metamathematics of the logics for reasoning about programs. The course should be of interest to those who want to see a systematic mathematical approach to programming. Such an approach can help people produce better programs or can help teachers enrich programming instruction or can help researchers appreciate problems in computing theory. The reading list is small because the subject is new and the best literature is still in press. The book by Z. Manna is the most comprehensive source, but the course will be less theoretical, more like the book of Dahl et al. The list is in approximately an order of relevance. Reference [7] is a source for the programming language PL/C and reference [8] marks one origin of the subject. (Received January 12, 1976.)

Reading List

1. Z. Manna, Mathematical theory of computation, McGraw-Hill, N.Y., 1974, 448 pp.

2. O.J. Dahl, E.W. Dijkstra and C.A.R. Hoare, Structured programming, Academic Press, N.Y., 1972.

3. C.A.R. Hoare, An axiomatic basis for computer programming, Comm. ACM (1969), 576-581.

4. _____, Procedures and parameters: An axiomatic approach, Symposium on Semantics of Algorithmic Languages (E. Engeler, ed.), Lecture Notes in Math., No. 188, Springer, Berlin, 1971, pp. 102-116.

5. Z. Manna, S. Ness and J. Vuillemin, Inductive methods for proving properties of programs, Comm. ACM 8(1972), 491-502.

6. N. Wirth, Systematic programming, an introduction, Prentice-Hall, Englewood Cliffs, N.J., 1973, 169pp.

7. R. Conway and D. Gries, An introduction to programming, a structured approach using PL/I and

PL/C-7, 2nd ed., Winthrop, Cambridge, Mass., 1975, 509 pp.

8. R.W. Floyd, Assigning meaning to programs, Proc. Sympos. Appl. Math., vol. 19, Amer. Math. Soc., Providence, R.I., 1967, pp. 19-32.

SC 76-11 MICHAEL O. RABIN, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139.

Exponential explosions in computations.

About forty years ago the notion of a computable function was assigned a mathematically precise meaning through definitions proposed by Church, Gödel, Post, and Turing. This made it possible to show that certain problems are not computationally solvable. A. Church proved that the decision problem for arithmetic, i.e. the problem of deciding for every given sentence whether it is a theorem of arithmetic, is (computationally) unsolvable. A similar result was established by Church for the decision problem of the first-order predicate calculus. This was followed by such celebrated results as the unsolvability of the word-problem of semigroups (Post and Markov), the unsolvability of the word-problem of groups (Novikov and Boone), and many others. On the other hand, many important problems were shown to be computationally solvable, or decidable, by exhibiting algorithms for their solution. Thus, for example, Presburger has shown that the theory of addition of natural numbers is decidable, and Tarski has proved that the theory of the field of real numbers is decidable. This last result implies that so-called elementary geometry is decidable. In some instances a problem is immediately seen to be decidable due to the fact that it is of finite size and consequently can be solved by a process of enumeration. The question whether a formula of the propositional calculus involving $n$ propositional variables is satisfiable can be answered by enumerating $2^n$ truth-value assignments. The problem whether two graphs on $n$ vertices are isomorphic can be solved by checking the $n!$ possible mappings between the sets of vertices. Such problems were deemed to be trivially solvable. In the last decade attention started to focus on the computational effort involved in the solution of a problem. In a paper [1] in 1966, the present author raised the question whether certain solvable decision problems, including somewhich are "trivially solvable", are in fact practically unsolvable because any algorithm for their solution would entail an impossibly large number of computational steps. Meyer and Stockmeyer have shown that certain problems concerning automata, while solvable, require a much worse than exponential number of computational steps. Fischer and Rabin proved that any algorithm for deciding the theory of any field is of exponential complexity, and any algorithm for Presburger's theory of addition of natural numbers is of double exponential complexity. The question whether problems such as satisfiability of propositional formulas or graph isomorphism are exponentially complex is as yet open. S. Cook, however, has developed a theory which strongly suggests that these problems are impossibly hard. These new results have practical implications because some of the computational problems proven or suspected of being ruinously complex do appear in practical contexts. The interested reader will find further information in the books [2] (especially Karp's paper) and [3]. (Received January 12, 1976.)

Reading List

1. M.O. Rabin, Mathematical theory of automata, Proc. Sympos. Appl. Math., vol. 19, Amer. Math. Soc., Providence, R.I., 1967, pp. 153-175.

2. R.E. Miller and J. W. Thatcher (Editors), Complexity of computer computations, Proc. Sympos. (Yorktown Heights, New York, 1972), Plenum Press, New York, 1972.

3. Complexity of computation, SIAM-AMS Proc., vol. 7, Amer. Math. Soc., Providence, R.I., 1974.

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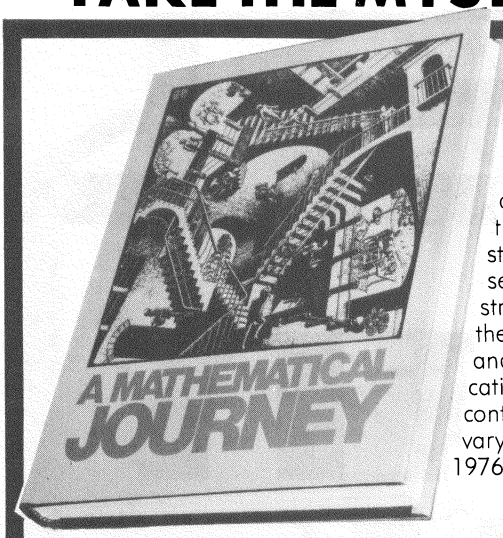


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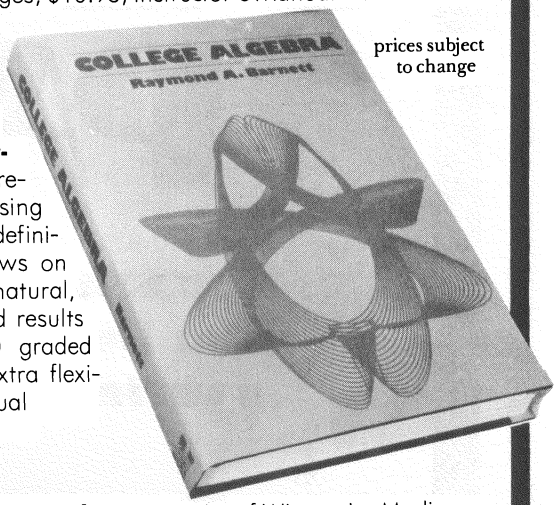


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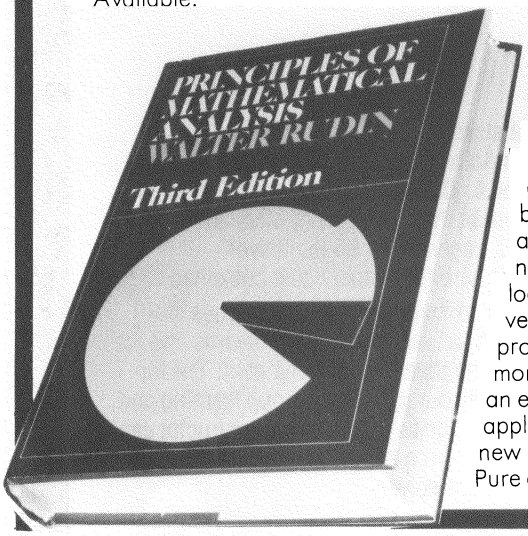


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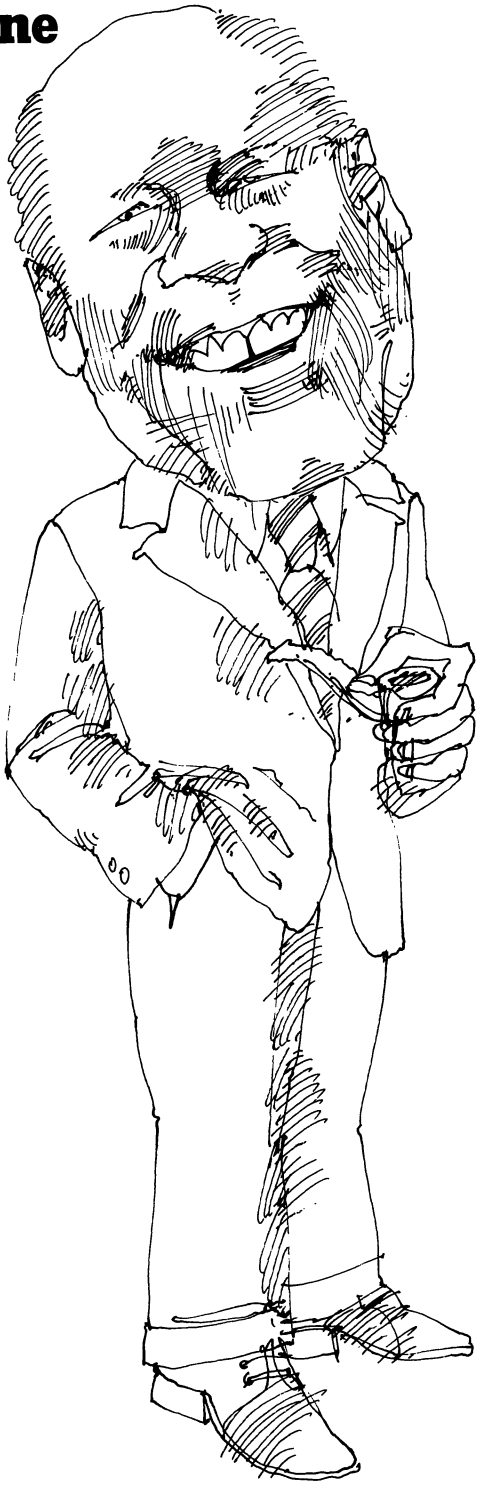

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