Diffusion, Cross-Diffusion, and Their Spike-Layer States

The Mathematics of Paul Erdős

1997 AMS-IMS-MAA Annual Survey (First Report)

Louisville Meeting
Manhattan Meeting
Philadelphia Meeting

The Singly Periodic Genus-One Helicoid (See page 8)
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**New Titles from the AMS**

**Conflations**
Yakov M. Eliashberg, Stanford University, CA, and William P. Thurston, University of California, Davis

This book presents the first steps of a theory of conflations designed to link geometry and topology of three-dimensional contact structures with the geometry and topology of codimension-one foliations on three-dimensional manifolds. Developing almost independently, these theories at first glance belonged to two different worlds: the theory of foliations is part of topology and dynamical systems, while contact geometry is the odd-dimensional "brother" of symplectic geometry. However, both theories have developed striking similarities. Conflations—which interpolate between contact structures and codimension-one foliations—should help us to understand better links between the two theories. These links provide tools for transporting results from one field to the other.

*University Lecture Series, Volume 18; 1997; 66 pages; Softcover; ISBN 0-8218-0776-5; List $16; All AMS members $13; Order code ULECT/18NT81*

**Elliptic Boundary Value Problems in Domains with Point Singularities**
V. A. Kozlov and V. G. Maz’ya, Linköping University, Sweden, and J. Rossmann, Rostock University, Germany

This monograph systematically treats a theory of elliptic boundary value problems in domains without singularities and in domains with conical or cuspidal points. This exposition is self-contained and a priori requires only basic knowledge of functional analysis. Restricting to boundary value problems formed by differential operators and avoiding the use of pseudo-differential operators makes the book accessible for a wider readership.

The authors concentrate on fundamental results of the theory: estimates for solutions in different function spaces, Fredholm property of the operator of the boundary value problem, regularity assertions and asymptotic formulas for the solutions near singular points. A special feature of the book is that the solutions of the boundary value problems are considered in Sobolev spaces of both positive and negative orders. Results of the general theory are illustrated by concrete examples. The book may be used for courses in partial differential equations.

*Mathematical Surveys and Monographs, Volume 52; 1997; 414 pages; Hardcover; ISBN 0-8218-0584-4; List $99; Individual member $59; Order code SURV/52NT81*

**Network Threats**
Rebecca N. Wright, AT&T Labs Research, Florham Park, NJ, and Peter G. Neumann, SRI International, Menlo Park, CA, Editors

The volume offers a timely assessment of avoiding or minimizing network threats. Presented here is an interdisciplinary, system-oriented approach that encompasses security requirements, specifications, protocols, and algorithms. The text includes implementation and development strategies using real-world applications that are reliable, fault-tolerant, and performance-oriented. The book would be suitable for a graduate seminar on computer security.

*DIMACS Series in Discrete Mathematics and Theoretical Computer Science, Volume 36; 1997; 180 pages; Hardcover; ISBN 0-8218-0632-3; List $99; All AMS members $63; Order code DIMACS/36NT81*

**Perspectives on Quantization**
Lewis A. Coburn, State University of New York at Buffalo, and Marc A. Rieffel, University of California, Berkeley, Editors

This book presents the proceedings of a 1996 joint summer Research Conference sponsored by AMS-IMS-SIAM on "Quantization" held at Mount Holyoke College (Northampton, MA). The purpose of the conference was to bring together researchers on various mathematical aspects of quantization. In the early work of Weyl and von Neumann at the beginning of the quantum era, the setting for this enterprise was operators on Hilbert space. This setting has been expanded, especially over the past decade, to involve $C^*$-algebras—noncommutative differential geometry and noncommutative harmonic analysis—as well as more general algebras and infinite-dimensional manifolds. The applications now include quantum field theory, notable conformal and topological field theories related to quantization of moduli spaces, and constructive quantum field theory of supersymmetric models and condensed matter physics (the fractional quantum Hall effect in particular).

The spectrum of research interests which significantly intersects the topic of quantization is unusually broad, including, for example, pseudodifferential analysis, the representation theory of Lie groups and algebras (including infinite-dimensional ones), operator algebras and algebraic deformation theory. The papers in this collection originated with talks by the authors at the conference and represent a strong cross-section of the interests described above.


**Recent Advances in Partial Differential Equations, Venice 1996**
Renato Spigler, University of Padova, Italy, and Stephanos Venakides, Duke University, Durham, NC, Editors

The work of Lax and Nirenberg on partial differential equations (PDEs) over the last half-century has dramatically advanced the subject and has profoundly influenced the course of mathematics. A large number of mathematicians honored these two exceptional scientists in a week-long conference in Venice (June, 1996) on the occasion of their 70th birthdays.

This volume contains the proceedings of the conference, which focused on the modern theory of nonlinear PDEs and their applications. Among the topics treated are turbulence, kinetic models of a rarefied gas, vortex filaments, dispersive waves, singular limits and blow-up of solutions, conservation laws, Hamiltonian systems and others. The conference served as a forum for the dissemination of new scientific ideas and discoveries and enhanced scientific communication by bringing together such a large number of scientists working in related fields. The event allowed the international mathematical community to honor two of its outstanding members.

*Proceedings of Symposia in Applied Mathematics, Volume 54; 1997; 335 pages; Hardcover; ISBN 0-8218-0657-7; List $99; Individual member $63; Order code PSAPM/54NT81*

**Topological Dynamics and Applications**
M. G. Nerurkar, Rutgers University, Camden, NJ, D. F. Dokken, St. Paul, MN, and D. B. Ellis, Beloit College, WI, Editors

This book is a very readable exposition of the modern theory of topological dynamics and presents diverse applications to such areas as ergodic theory, combinatorial number theory and differential equations. There are three parts: 1) The abstract framework of topological dynamics is discussed, including a comprehensive survey by Furstenberg and Glasner on the work and influence of R. Ellis. Presented in book form for the first time are new topics in the theory of dynamical systems, such as weak almost-periodicity, hidden eigenvalues, a natural family of factors and topological analogues of ergodic decomposition. 2) The power of abstract techniques is demonstrated by giving a wide range of applications to areas of ergodic theory, combinatorial number theory, random walks on groups and others. 3) Applications to non-autonomous linear differential equations are shown. Exposition on recent results about Floquet theory, synchronization theory and Lyapunov exponents is given.

*Contemporary Mathematics, Volume 215; 1998; 334 pages; Softcover; ISBN 0-8218-0608-8; List $99; Individual member $63; Order code CONM/215NT81*

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Here are some of the featured books that will be on display at the 1998 Joint Mathematics Meeting in Baltimore, MD. Stop by Booth #s 415 & 417 to receive a 20% discount!

**Representation Theory and Complex Geometry**
- N. Chriss, Harvard University & V. Ginzburg, University of Chicago
- 1997, 395 pp., Hardcover
- ISBN 0-8176-3992-3
- $64.50

**Numerical Analysis**
- An Introduction
- W. Gautschi, Purdue University, West Lafayette, IN
- 1997, 500 pp., Hardcover
- ISBN 0-8176-3895-4
- $64.50

**Representation Theory and Complex Geometry**
- N. Chriss, Harvard University & V. Ginzburg, University of Chicago
- 1997, 268 pp., 18 illus.
- Hardcover
- ISBN 0-8176-3806-7
- $79.50

**Foliations on Riemannian Manifolds and Submanifolds**
- V. Rovenskii, Pedagogical Institute, Russia
- 1997, 260 pp., 18 illus.
- Hardcover
- ISBN 3-7643-5776-2
- $99.50 (tent.)

**Geometry of Foliations**
- P. Tondeur, University of Illinois, Urbana
- 1997, 312 pp., Hardcover
- ISBN 3-7643-5741-X
- $98.00

**Non-vanishing of L-Functions and Applications**
- M.R. Murty, Queen's University, Ontario, Canada & V.K. Murty, University of Toronto, Ontario, Canada
- 1997, 121 pp., Hardcover
- ISBN 3-7643-5801-7
- $47.00 (tent.)

**An Introduction to the Mathematics of Biology**
- With Computer Algebra Models
- E.K. Yarborough, R.W. Shonehuis & J.V. Heeber, all, Georgia Institute of Technology, Atlanta
- 1996, 438 pp., 172 illus.
- Hardcover
- ISBN 0-8176-3809-1
- $64.50

**Fractals and Spectra**
- related to Fourier analysis and function spaces
- H. Triebel, Friedrich-Schiller-Universitat, Jena, Germany
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- ISBN 3-7643-5776-2
- $99.50 (tent.)

**Linear Algebra**
- J.H. Kwok & S. Hong, both, Pohang University of Science and Technology, Korea
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- $36.50

**An Introduction to the Mathematics of Biology**
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**Forthcoming 1998 Titles Will Be on Display at the 1998 Joint Mathematics Meeting**

**Due February 1998**
- **A Practical Guide to Heavytails**
- **Compartmentalization of Symmetric Spaces**
- **Lise Meitner and the Dawn of the Nuclear Age**
- **Mathematical Essays in Honor of Gian-Carlo Rota**

**Due March 1998**
- **Harmonic Analysis on the Heisenberg Group**
- **Complex Analysis**
- **Essays on the Future**
- **Metric Structures for Riemannian and Non-Riemannian Geometry**
- **Bernhard Riemann, 1826-1866**

**Due April 1998**
- **Riemann, Topology and Physics**

**Due May 1998**
- **Linear Algebraic Groups**

**Due September 1998**
- **Advances in Geometry and Mathematical Physics, Volume 1**
# Feature Articles

**Diffusion, Cross-Diffusion, and Their Spike-Layer Steady States**

Wei-Ming Ni

This article discusses the mathematics of diffusion when more than one reactant is involved. Surprising spikes can occur in models of the distribution of the reactants.

**The Mathematics of Paul Erdős**

László Babai, Carl Pomerance, and Péter Vértesi

When Paul Erdős passed away in September 1996, he left a mathematical legacy that includes more than 1,500 publications. In tribute to this prolific and beloved mathematician, Pomerance writes about number theory, Babai about combinatorics, and Vértesi about approximation theory.

**1997 AMS-IMS-MAA Annual Survey (First Report)**

Paul. W. Davis, James W. Maxwell, Kinda M. Remick


## Memorial Articles

- **Paul Erdős (1913–1996)**
  László Babai and Joel Spencer
  
  Niels Vigand Pedersen (1949–1996)
  V. S. Varadarajan

- **Chih-Han Sah (1934–1997)**
  Johan Dupont, Anthony Phillips, Vladimir Retakh, Judith Roitman, and Mark Saul

## Communications

- Experiences of AMS–AAAS Media Fellows
  *Liz Veomett and Ben Stein*

- Interview with Gail Burrill
  *Allyn Jackson*

- Senate Introduces Bill to Double Research Funding in Ten Years
  *Allyn Jackson*

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Editorial

A Look Back

Five years ago, out of the long, hard work of an AMS committee chaired by Hugo Rossi came a proposed transformation of the Notices. The creation of the new Notices was approved by the requisite AMS groups, Hugo reluctantly agreed to be the founding editor, and the first issue appeared in January 1995.

The Notices serves many purposes. It is the journal of record of the AMS, it alerts members to events and trends that seem important, and it is the only vehicle for members to express their opinions to the whole AMS membership. But Hugo saw an additional possibility—that the Notices could be a showplace for high-quality exposition in mathematics. This vision stemmed from his conviction that good exposition is far more important to the progress of research in mathematics than many mathematicians are ready to believe. In his October 1997 editorial he said, “The techniques and ideas of mathematical research have become so interrelated that to succeed in research it is now necessary to understand the themes and methods in many areas of mathematics.... Breakthroughs in one’s problems—often even the understanding of the problem—require the versatility that one acquires only by grasping and using techniques and programs in a wide range of subjects.” He saw expository mathematics articles in the Notices as a kind of “written colloquia” that would help in this process.

At this time of the changing of the guard, we salute Hugo Rossi for his vision and for his success at developing the Notices in this direction. He has been ably assisted by talented associate editors who have not been shy in helping him shape his vision. They all deserve our thanks.

Hugo ended his term as editor a few months early in order to become deputy director of the Mathematical Sciences Research Institute (MSRI). Happily, he has agreed to continue as a contributing editor. In this capacity he will still be able to solicit mathematics articles and to work his magic on the writing in them.

Andy Magid has graciously served as acting editor for a few months, assisted by Allyn Jackson. No doubt Andy often received too much or too little advice from past and future editors. We are grateful for his bringing about a smooth transition.

—Anthony W. Knapp
Letters to the Editor

Electronic Communication Isolates Some Mathematicians
I turned recently to the pages of your Notices in order to seek information concerning the forthcoming International Congress of Mathematicians in Berlin. I have previously attended two such Congresses, but now find that because I have not kept up with the technology, I may never be able to attend another. Indeed, as an independent mathematician, I am not connected to the Internet and still rely mostly on the post to keep in touch. But, alas, nowhere in the information provided by the Notices is there any help for those of us not yet connected. I do not believe I am the sole backward mathematician in the world yet to go electronic, and I am very concerned that the enormous amount of emphasis that is being placed on advanced modes of communication, far from making it easier for all to have access to information, is widening the gap between those who have and those who have not the means, financial and otherwise, to keep in touch with the international mathematical community. I worry in particular for young mathematicians in many parts of the world—huddling Ramanujans who would like to be part of this community but cannot afford the hardware and software now required.

In the old days all that was required were a few rupees or pesos for stamps, a post office in the neighborhood, and a friendly and receptive Hardy at the other end. Are those days definitely gone?

Bernardo Recamán Santos
Bogotá, Colombia

(Received September 29, 1997)

Editor's Note: Dr. Recamán's letter refers to the September announcement in the Mathematics Calendar. The first announcement of ICM98, which appeared in the November Notices (page 1392), tells how to register using paper mail.

Reply to Bible Code Author
Having recently had the doubtful pleasure of hearing Bible Code author Michael Drosnin telling a litany of lies and half-truths to the media here in Australia, it is rather amusing to read his accusation (Notices, November) that I am the one perpetrating a hoax. Take for example his claim to have found one random pattern. Drosnin knows full well that he chose Moby Dick himself and that I found, not one, but many assassinations. In fact, I can find almost any I look for, including that of Rabin.

The bottom line is that the only thing Drosnin did that I have not repeated in Moby Dick is to predict an assassination before it happened. Even that prediction can be best described as a guess, as the words Drosnin claims as "assassin that will assassinate" are from a verse about accidental homicide and can be read in a variety of ways that include Rabin...
Letters to the Editor

being the killer or the killer being killed.

On the matter of Ilya Rips, I am sure that he sincerely believes in his "codes", but he has not presented clear evidence that requires a miraculous explanation. Until he does so we are entitled to withhold belief in his claims. Everyone who alleges scientific proof of a miracle should expect the same response.

Readers are invited to inspect a humorous reply to Drosnin and a serious reply to Rips at http://cs.anu.edu.au/~bdm/dilugim/torah.html.

Brendan McKay
Australian National University
(Received October 3, 1997)

Use Uniform Continuity to Teach Limits

In the May issue of these Notices, pp. 559-563, David Mumford argues passionately that when teaching calculus to "the millions", the basic concepts should be introduced in an intuitive fashion in terms familiar to the uninitiated. In this spirit Mumford accepts the Harvard Calculus definition of continuity of a function: "the closer \( x \) gets to \( a \), the closer \( f(x) \) gets to \( f(a) \)." In the September Notices, p. 893, Saunders Mac Lane objects to this definition, because it seems to imply that \( f(x) \) approaches \( f(a) \) monotonically and also because it fails to say that \( f(x) \) gets arbitrarily close to \( f(a) \). Therefore, he holds out for the \((\epsilon, \delta)\) definition of continuity, although he allows the substitution of Latin letters for Greek ones.

In my opinion neither Mumford nor Mac Lane nor Leonard Gillman in a note in the September Notices, pp. 932-934, has come up with a definition that is congenial to "the millions". As Gillman points out, the difficulty that students have with the notion of continuity is the number of quantifiers and their subtle placement in the definition: "For any \( a \) and for any \( \epsilon > 0 \), there is a \( \delta \) depending on \( a \) and \( \epsilon \) such that when \( x \) differs from \( a \) by less than \( \delta \), \( f(x) \) differs from \( f(a) \) by less than \( \epsilon \)."

For this reason, but not for this reason alone, I advocate the teaching of uniform continuity; one variable and one quantifier is thereby removed. But it is not enough to rename \( \epsilon \) and \( \delta \); their significance must be illustrated. Here is a natural way of doing this.

A function is a rule or algorithm that for each input of a real number \( x \) in the domain of the function produces a real number \( y \) as output. This concept is more abstract than it sounds, because the input \( x \) is an infinite decimal; it would take an algorithm an infinite amount of time to process it. To achieve finiteness, we observe that at no time are we interested in the exact value of the output \( y \); we only need to know it within a certain tolerance, dictated by the use to which it is put. The tolerance varies from occasion to occasion; sometimes we need to know \( y \) with 2-digit accuracy, sometimes with 6-digit accuracy, but we never need infinitely many digits.

Suppose now that our function has the following property: To compute the output \( y \) with 2-digit accuracy, we need to know the input \( x \) with, say, only 3-digit accuracy; to compute \( y \) with 6-digit accuracy, we may need to know \( x \) with, say, 9-digit accuracy. In general, in order to compute the output with \( k \)-digit accuracy, we need to know only a finite number, say \( n \), digits of \( x \). This property of a function is called uniform continuity.

Since a continuous function on a closed interval is uniformly continuous, our students encounter mostly uniformly continuous functions. There are other reasons for preferring uniform to pointwise continuity: it trains the mind to think of a function, not as the conglomeration of its values, but as a thing in itself. This is of great help even at the introductory calculus level—for instance, in grasping the idea of the definite integral, in discussing uniformly converging sequences of functions, and in many other contexts.

Peter D. Lax
Courant Institute,
New York University
(Received October 7, 1997)

Benefits of Electronic Journals

Despite the many benefits of electronic publishing of mathematical research journals, Steven Krantz's editorial (in the September 1997 Notices) chose to highlight and exaggerate some potential drawbacks without discussing the actions that are widely taken to address them. I wish to help inform Notices readers about those actions, so that we can all participate to help direct this inevitable change to our profession.

Most of the e-journals that currently exist (such as those published by the AMS) hold to the same editorial and ethical standards as mainstream paper journals—a paper is submitted to an editor and then anonymously refereed by one or two suitable peers. No big difference there from paper journals. Why should there be? It is a system that has worked well for a long time.

However, an enormous difference between paper and e-journals is the time lag between acceptance of a paper and publication. Paper journals often have backlogs of two years or more; no e-journal leaves a paper in final form waiting for more than a couple of months. Another big advantage of e-journals is that authors and readers can subsequently append (edited and refereed) notes to the paper so that future readers can follow later developments in the subject.

Krantz voices the popular fear that "deans" will not "count" papers in refereed, respected e-journals for promotion and tenure decisions. Why shouldn't they? Why would a poorly edited paper journal be worth more to a dean? On the contrary, most university administrators are keen to encourage electronic journals, since they appreciate the potential financial benefits.

Krantz worries about the archiving of mathematical material; he believes that as new media for storing data emerge, the technical world will not be willing to find a way to move current data to the new media. Why wouldn't businesses and governments want to find a way to restore their old data? Does Krantz think they won't share that technology? In fact, sev-
eral nonprofit corporations and leading academic libraries are currently engaged in making old, important (paper) science literature available online, despite the difficulties of doing that. They believe that this is a more accessible yet cheaper way to store important older work—check out http://www.jstor.org/ to find excellently scanned copies of the Annals, the Journal and Transactions of the AMS, and Math. Comp., every article from every issue up to five years ago. Moreover, most of the leading presses are making all of their current paper journals available in electronic form; they recognize the benefits of presenting academic work in this medium.

This all seems to suggest the exact opposite of Krantz’s fearful predictions!

Krantz makes the (correct) point that e-journals are not “free”. Indeed, the hours of editing, refereeing, typesetting, and the cost of buying computers all add up, though this is the case whether the journal is on paper or electronic. For years mathematics professors have been donating their time by serving on editorial boards, yet nobody previously included this time in the costs of producing a journal; indeed, most publishers have long exploited such contributed services yet valued them at next to nothing.

Krantz fears that e-journals will be of lower visual “quality”. However, I didn’t find this when comparing the most recent issues of the Electronic Research Announcements and the (on-paper) Bulletin. Indeed, after learning from some initial mistakes, e-journals look quite similar to paper journals, while allowing “search” and other advantageous electronic features.

Publishing is going to change in the next few years whether mathematicians like it or not. We are best off being in the vanguard of the revolution, helping to make these changes acceptable to our needs. We will surely benefit from the enormous financial savings (universities will probably pay about a tenth as much for e-journals as for paper journals), and we can also benefit academically from some of the added features. Indeed, anyone who has discovered how easy it is to research references on a given topic in the electronic MathSciNet will not be easily persuaded to go back to browsing through endless issues of Math Reviews. Moreover, the top researchers in certain areas of mathematics and physics (combinatorics and stellar modelling) now publish much of their most important work in electronic journals.

The main commercial publishers are eagerly changing with the new technology. The AMS has invested many of its resources into electronic publishing (after a slow start) and is now working through many of the trickier issues. Unfortunately, there are still a few loud voices in the mathematical community, such as Krantz, who cannot look forward and seem unable to embrace or even acknowledge the benefits of electronic publishing. Rather than fearing what is to come, we must shape these changes to support mathematics so that the inevitable transition to e-publication is valuable to everyone interested in mathematical research.

Andrew Granville
University of Georgia

(Received October 10, 1997)

Use of the Overhead Projector

At professional meetings the overhead projector is probably one of the most valuable aids for successful communication. For the most part, its use is ineffective and an embarrassment to the audience, an observation that spans invited addresses to presentation of 10-minute papers. It is absolutely thoughtless and a total disregard to the audience not to utilize the overhead to the fullest. This is especially true at international conferences. Recently an outstanding individual from a distinguished American university presented an invited hourly address by reading from the overlays before him while all but the very top of the screen was blocked by his body. In meeting rooms presenters read from the screen with their backs turned to the audience. The puzzling aspect is that today the overhead projector is considered to be an integral part of American classroom instruction. That experience should be transferable.

Examine the presentation of a “short” paper. Most of the contents can be condensed, organized, and prepared from the article itself on a word processor with font size at least 18 pt. The number of overlays required relates to the length and the style of presentation, under the assumption...
that time will be permitted to let the audience assimilate each overlay. This is particularly important for a descriptive portion. For the presenter to read an overlay is distracting to an audience that is capable of doing and will attempt to do the same if given sufficient time. Presenting need not imply speaking.

If there is a reason to either expand on or to highlight a point, place a pencil at the line in question on the overlay or use a pointer. Face the audience and speak clearly; some read lips. Glance at the screen occasionally to assure that the exposed part of the overlay and the lecture correlate. Being nonchalant, folksy, or "cute" diminishes the value of the investigation under discussion—it is an impedance to those who are impaired by either hearing or lack of fluency in English, the accepted professional language. In order not to block the view, examine the room prior to speaking; the rooms are usually open at an early hour. A small room may require one to sit beside the projector. The lecture is a communication, and presumably the topic and the contents are sufficiently important to engage the audience's time and to either challenge its intellect or be of value as a body of knowledge. In brief, if one's work is important enough to be accepted for presentation, this should be reflected in the delivery itself.

These same observations apply to an hourly presentation. Often in this case the overlay serves as an organized set of notes, each point of which will elicit more elaboration directed toward the audience by the speaker. Sometime prior to the delivery it is essential to walk through the auditorium or banquet hall in order to understand how best to either position oneself or to rearrange the stage setting in order to avoid blocking the screen. During the delivery have someone sit within the first few rows to signal adjustment of the overlay should that be necessary.

The local chairperson in charge of arrangements should keep all of the above in mind as the projectors are positioned in each room and auditorium. For example, is the lectern really needed, particularly if it blocks the view for those seated in the first few rows? These members of the audience may be there because of either the impairments noted above or an inarticulate speaker.

There is one other helpful suggestion. If it is possible to have screens pivot from the bottom as they move forward and down from the top, one eliminates the "v-ing" of the image whenever the screen is upright.

So with forethought and prior planning a presentation accompanied by an overhead projector can reflect a professional maturity compatible with the occasion.

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Diffusion, Cross-Diffusion, and Their Spike-Layer Steady States

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Introduction

Many mathematicians, myself included, were brought up to believe that diffusion is a smoothing and trivializing process. Indeed, this is the case for single diffusion equations. Consider the heat equation

\[
\begin{cases}
  u_t = \Delta u & \text{in } \Omega \times (0, \infty), \\
  u(x, 0) = u_0(x) \geq 0 & \text{in } \Omega, \\
  \frac{\partial u}{\partial n} = 0 & \text{on } \partial \Omega \times (0, \infty),
\end{cases}
\]

where \( u_t = \frac{\partial u}{\partial t} \) and \( \Delta = \sum_{i=1}^{n} \frac{\partial^2}{\partial x_i^2} \) is the usual Laplace operator, \( \Omega \) is a bounded smooth domain in \( \mathbb{R}^n \), \( u \) is the unit outer normal to \( \partial \Omega \), and \( u_0 \) is a real-valued continuous function (not identically zero) representing the initial heat distribution. Here the boundary condition implies that (1) is an isolated system. It is well known that the solution \( u(x, t) \) of (1) becomes smooth as soon as \( t \) becomes positive and eventually converges to the constant \( \frac{1}{|\Omega|} \int_{\Omega} u_0(x) \, dx \) as \( t \) tends to \( \infty \). In other words, in an isolated system, no matter what the initial heat distribution is, eventually the heat distribution becomes homogeneous. A similar result holds when a source/sink term (or a reaction term) is present. That is, if we replace the linear heat equation in (1) by

\[
u_t = \Delta u + f(u),
\]

where \( f \) is a smooth function (linear or nonlinear), then Matano and Casten-Holland in 1978–79 proved that stable steady states must be constants provided that the domain \( \Omega \) is convex. Interesting results for nonconvex \( \Omega \) have been obtained by Matano, Hale-Vegas, Jimbo-Morita, and others.

On the other hand, it is important to be able to use diffusion (and reaction) to model pattern formation in various branches of science (e.g., biology and chemistry). Therefore, it is rather significant that the situation becomes drastically different when we come to systems of diffusion equations. In fact, even as early as 1952 Alan Turing argued, in an important paper [28], that in a system of equations modeling two interactive substances, different diffusion rates could lead to nonhomogeneous distributions of such reactants. Since then several models in morphogenesis have developed Turing’s idea. One distinctive characteristic of many of those models is that at least one of the reactants is often highly concentrated in small areas and thereby exhibits strikingly different patterns. In this expository paper we shall first briefly introduce the current mathematical research on those highly concentrated solutions, i.e., solutions whose graphs display narrow peaks or spikes, also known as point-condensation solutions, or spike-layers. Using an activator-inhibitor system below, with slowly diffusing activator and rapidly diffusing inhibitor, not only will we discuss the existence of such spike-layer steady states, but we will also determine the profile of those spikes and the locations of their peaks, as well as their stability and instability properties.

In contrast to those models developed from Turing’s idea, in which different diffusion rates combined with suitable reaction terms produce
nonhomogeneous patterns or spike-layers, we shall include below a classical Lotka-Volterra competition-diffusion system in population dynamics for which no nonconstant steady state could exist no matter what the diffusion rates are. However, it is not entirely reasonable to add just 

diffusions to models in population dynamics, since individuals do not move around randomly. In particular, while modeling segregation phenomena for two competing species, one must take into account the population pressures created by the competitors. This leads us to a “cross-diffusion” system proposed by Shigesada, Kawasaki, and Teramoto [27] in 1979 that improves the Lotka-Volterra system. Putting this in a slightly larger context, we see that “taxis,” i.e., oriented movements by individuals under the influence of environmental factors, should be included in modeling population dynamics. In this framework the model in [27] turns out to be a “negative taxis” system. (Here the “negativity” refers to the “directions” of individual movements.) We will also include a chemotaxis model, due to Keller and Segel [13], that is a “positive taxis” system and, of course, also a “cross-diffusion” system. It is interesting to note that spike-layers appear in each of those two systems under appropriate conditions. In addition to discussing spike-layers in those two cross-diffusion systems, we shall focus on the effect of cross-diffusion versus that of diffusion. Roughly speaking, our results for the Shigesada-Kawasaki-Teramoto system indicate that, in contrast to diffusions, the gap between the two cross-diffusions alone suffices to create nontrivial patterns.

In the last section of this paper some open questions or conjectures and possible future directions of research are discussed.

**Spike-Layers in Diffusion Systems**

A far-reaching example beginning with Turing’s idea, “diffusion-driven instability”, is the following system (already suitably rescaled), due to Gierer and Meinhardt [11] in 1972:

\[
\begin{align*}
U_t &= d_1 \Delta U - U + UP / V^q \quad \text{in } \Omega \times \mathbb{R}^+, \\
\tau V_t &= d_2 \Delta V - V + U^r / V^s \quad \text{in } \Omega \times \mathbb{R}^+, \\
\frac{\partial U}{\partial \nu} &= 0 = \frac{\partial V}{\partial \nu} \quad \text{on } \partial \Omega \times \mathbb{R}^+,
\end{align*}
\]

where \(d_1, d_2, p, q, r, \tau, s \geq 0\), and

\[0 < \frac{p-1}{q} < \frac{r}{s+1}.
\]

(The original choices in [11] of the exponents are \(p = 2, q = 1, r = 2, \) and \(s = 0\).) This system was motivated by biological experiments on *Hydra* in morphogenesis. *Hydra*, an animal of a few millimeters in length, is made up of approximately 100,000 cells of about fifteen different types. It consists of a “head” region located at one end along its length. Typical experiments on *Hydra* involve removing part of the “head” region and transplanting it to other parts of the body column. Then, a new “head” will form if and only if the transplanted area is sufficiently far from the (old) head. These observations have led to the assumption of the existence of two chemical substances—a slowly diffusing (short-range) activator and a rapidly diffusing (long-range) inhibitor. Here \(U\) represents the density of the activator and \(V\) represents that of the inhibitor. To understand the dynamics of (2), it is helpful to consider first its corresponding “kinetic system”

\[
\begin{align*}
\frac{U_t}{\tau U'} &= -U + \frac{U^p}{V^q}, \\
\tau V_t &= -V + \frac{U^r}{V^s}.
\end{align*}
\]

This system has a unique constant steady state \(U = 1, V = 1\). For \(0 < \tau < \frac{s+1}{p-1}\) it is easy to see that the constant solution \(U = 1, V = 1\) is stable as a steady state of (4). However, if \(d_1\) is small and \(d_2\) is large, it is not hard to see that the constant steady state \(U = 1, V = 1\) of (2) becomes unstable and bifurcations occur. (Heuristically, this may be seen by linearizing (2) at \(U = 1 = V\) and replacing the Laplace operator \(\Delta\) by one of its eigenvalues.)

This phenomenon is generally referred to as Turing’s “diffusion-driven instability”, as was mentioned in the introduction.

The fact that \(U\) diffuses slowly and \(V\) diffuses rapidly may be reflected by the assumption that \(d_1 = \epsilon^2\) is small and \(d_2 = \epsilon^2\) is large. If we divide the second equation in (2) by \(d_2\) and let \(d_2\) tend to \(\infty\), it seems reasonable to expect that, for each fixed \(t\), \(V\) tends to a (spatially) harmonic function that must be a constant by the boundary condition. That is, as \(d_2 \to \infty\), \(V\) tends to a spatially homogeneous function \(\zeta(t)\). Thus, integrating the second equation in (2) over \(\Omega\), we reduce (2) to the “shadow system”

\[
\begin{align*}
U_t &= \epsilon^2 \Delta U - U + \frac{U^p}{\zeta^q} \quad \text{in } \Omega \times \mathbb{R}^+, \\
\tau \zeta_t &= -\zeta + \frac{1}{\zeta} \int_\Omega U'(x,t) \, dx \quad \text{in } \mathbb{R}^+, \\
\frac{\partial U}{\partial \nu} &= 0 = \frac{\partial V}{\partial \nu} \quad \text{on } \partial \Omega \times \mathbb{R}^+.
\end{align*}
\]

It turns out that the steady states of (5) and their stability properties are closely related to that of the original system (2) and that the study of the steady states of (5) essentially reduces to that of the following single equation:
\begin{align*}
\begin{cases}
\epsilon^2 \Delta u - u + u^p = 0 & \text{in } \Omega, \\
u > 0 & \text{in } \Omega, \\
\frac{\partial u}{\partial n} = 0 & \text{on } \partial \Omega.
\end{cases}
\end{align*}

(6)

Since \( \epsilon \) is small, (6) is a singular perturbation problem. However, the traditional method, using inner and outer expansions, simply does not apply here, because a spike-layer solution of (6) is exponentially small away from its peak. To solve (6), it is important to note that although the corresponding elliptic system for (2) does not admit a variational structure, there is a natural "energy" functional for (6) in \( H^1(\Omega) \)

\[ J_\epsilon(u) = \frac{1}{2} \int_\Omega (\epsilon^2 |\nabla u|^2 + u^2) - \frac{1}{p+1} \int_\Omega u^{p+1}, \]

where \( u_\epsilon = \max\{u, 0\} \). Thus, to solve (6) we need only to find nontrivial critical points of \( J_\epsilon \). This energy consideration of solutions turns out to be the new key ingredient. Since this functional \( J_\epsilon \) is neither bounded from above nor bounded from below, instead of looking for (local) maxima or minima, we search for a saddle point of \( J_\epsilon \) via a variational approach. This approach, due to Ding and the author [19], unifies the "mountain-pass" lemma of Ambrosetti and Rabinowitz and a constrained minimization principle of Nehari in 1960, and allows us to obtain a "least-energy" solution. The existence of a single-peaked spike-layer solution of (6), its profile, and the location of the peak are all derived from this variational approach in a series of papers [15] and [20, 21] during 1986–93.

**Theorem 1** [15, 20, 21]. Suppose that \( 1 < p < \frac{n+2}{n-2} \) (\( \infty \) if \( n = 1 \) or 2). Then for every \( \epsilon \) sufficiently small \( (6) \) possesses a least-energy solution \( u_\epsilon \) that has exactly one (local, thus global) maximum point \( P_\epsilon \) in \( \Omega \). Moreover, the following properties hold.

(i) \( P_\epsilon \in \partial \Omega \) and \( H(P_\epsilon) = \max_{\partial \Omega} H \) as \( \epsilon \to 0 \), where \( H \) is the mean curvature of \( \partial \Omega \).

(ii) \( u_\epsilon \to 0 \) everywhere in \( \Omega \) and \( u_\epsilon (\varphi_\epsilon (e)) - w(y) \) as \( \epsilon \to 0 \) where \( \varphi_\epsilon^{-1} \) is a diffeomorphism straightening \( \partial \Omega \) near \( P_\epsilon \) and \( w \) is the unique positive solution of

\[ \Delta w - w + w^p = 0 \text{ in } \mathbb{R}^n, \]

\[ w \to 0 \text{ at } \infty, \]

\[ w(0) = \max_{\mathbb{R}^n} w. \]

In other words, although \( J_\epsilon \) is not bounded from below, it does have a minimum when restricted to the set of all solutions of (6), and we call this solution a "least-energy solution." Moreover, the least-energy solution \( u_\epsilon \) has exactly one peak, which must be situated on the boundary \( \partial \Omega \) and near the "most curved" part of the boundary.

Heuristically speaking, the energy of a spike-layer solution concentrates on a small neighborhood of each of its peaks. Thus, a least-energy solution \( u_\epsilon \) should have only one peak. Moreover, since a "boundary-peak" has roughly half the energy an "interior-peak" does, the least-energy solution \( u_\epsilon \) ought to have its peak on the boundary. To determine where on the boundary this peak should be is quite delicate; we need the following energy expansion of \( u_\epsilon \), for \( \epsilon \) small:

\[ J_\epsilon(u_\epsilon) = \epsilon^n \left( \frac{1}{2} I(w) - C \epsilon H(P_\epsilon) + o(\epsilon) \right), \]

where \( C \) is a positive constant depending on \( n \) and \( w \) and

\[ I(w) = \int_{\mathbb{R}^n} \left[ \frac{1}{2} |\nabla w|^2 + w^2 \right] - \frac{1}{p+1} \int_{\mathbb{R}^n} w^p \]

is the energy of the entire solution \( w \). It is now intuitively clear that in order to "minimize" \( J_\epsilon(u_\epsilon) \) one needs to maximize \( H(P_\epsilon) \).

From this solution \( u_\epsilon \) it is straightforward to construct a steady-state solution \( (U_\infty, \zeta_\infty) \) for the shadow system (5) as follows:

\[ U_\infty = \zeta_\alpha^{\frac{q}{p-1}} u_\epsilon \] and \( \zeta^{-\alpha} = \frac{1}{|\Omega|} \int_\Omega u_\epsilon' \),

where \( \alpha = \frac{q r}{p-1} - (s+1) > 0 \) by (3). Returning from \( (U_\infty, \zeta_\infty) \) to a steady-state solution \( (U_{d_2}, V_{d_2}) \), for large \( d_2 \), of the original system (2) is, however, highly nontrivial and requires very detailed knowledge of the spike-layer solution \( u_\epsilon \). This is accomplished in [22] for the special case when \( \Omega \) is axially symmetric or \( n = 1 \). (It should be noted that in case \( n = 1 \), the system (2) was solved earlier by Takagi.)

To complete our discussion of the system (2), we include a paragraph on the stability and instability properties of the spike-layer steady-state solution obtained above for \( n = 1 \).

Again, the first step is to study the shadow system. Setting \( \beta = \frac{q r}{p-1} - \frac{1}{2} \) and recalling \( \alpha = \frac{q r}{p-1} - (s+1) \), we have the following:

**Theorem 2** [23]. Assume that \( n = 1 \) and \( \alpha > 0 \).

(i) Suppose that \( \tau > \beta \). If \( \alpha \) and \( \epsilon \) are sufficiently small, then the steady-state solution \( (U_\infty, \zeta_\infty) \) of (5) is unstable.

(ii) Suppose that \( r = 2 \) and \( \beta > \tau > 0 \). If \( \alpha \) and \( \epsilon \) are sufficiently small, then the steady-state solution \( (U_\infty, \zeta_\infty) \) of (5) is stable.

(iii) Suppose that \( r = p+1 \) and \( 1 < p < 5 \). Then there exists \( T_0 > 0 \) such that if \( \beta > \tau > T_0 \) and \( \alpha, \epsilon \) are sufficiently small, then the steady-state solution \( (U_\infty, \zeta_\infty) \) of (5) is stable.
Figure 1. The numerical solution for the activator $U$ in system (2) with $d_1 = 0.001$, $d_2 = 10$, $p = 2$, $q = 1$, $r = 2$, $s = 0$, $t = 0.7$, and $\Omega = (0, 1)$ and initial data

\[ U(x, 0) = \begin{cases} 
1.1 - x, & 0 \leq x \leq 0.1, \\
1, & 0.1 \leq x \leq 1, 
\end{cases} \quad \text{and} \quad V(x, 0) \equiv 1, \quad 0 \leq x \leq 1 \]

Figure 2. The graph for the peak $U(0, t)$, $0 \leq t \leq 200$, of the solution in Figure 1.
Figure 3. The numerical solution for the activator $U$ in system (2) with the same initial value and parameters as in Figure 1 except that $\tau = 0.83$ here.

Figure 4. The graph for the peak $U(0, t)$, $0 \leq t \leq 200$, of the solution in Figure 3.
Theorem 2 shows that in order for the spike-layer steady state to be stable, the inhibitor needs to react fast (i.e., \( \tau \) must be reasonably small) in response to the change of the activator. The proof contains detailed analysis of the characteristic equation

\[
\alpha + \lambda \left[ \frac{q_r \int_\Omega u_{r-1} (L_x - \lambda)^{-1} u_x - \tau}{(p-1) \int_\Omega u_x} \right] = 0,
\]

where \( L_x = \epsilon^2 \Delta + p u_x \), and is quite involved.

It turns out that exactly the same conclusions for the shadow system (5) in Theorem 2 hold for the steady-state solution \((U_{d1}, V_{d1})\) of the original system (2) provided that \( d_2 \) is sufficiently large.

To illustrate further the role of the parameters in the dynamics of the system (2), we present some numerical simulations here done by E. Yanagida and M. Fukushima at the University of Tokyo. First, in (2) we fix the domain \( \Omega = (0,1) \); the diffusion rates \( d_1 = 0.001 \), \( d_2 = 10.0 \); the exponents \( p = 2 \), \( q = 1 \), \( r = 2 \), \( s = 0 \); and the initial data

\[
U(x,0) = \begin{cases} 
1.1 - x, & x \in [0,0.1] \\
1, & x \in [0.1,1]
\end{cases}
\]

and

\[
V(x,0) = 1, \quad x \in [0,1].
\]

Note that the initial value here represents a small perturbation of the constant steady state \( U = 1 \) and \( V = 1 \). In Figures 1 and 2 the numerical solution for the activator \( U \) in (2) with \( \tau = 0.7 \) is illustrated. Note further that when \( \tau \) is reasonably large, say, \( \tau = 0.83 \), the numerical solution seems to stabilize to a periodic motion instead, as indicated in Figures 3 and 4. The rigorous mathematical analysis for this phenomenon is currently under investigation.

Many interesting and important questions remain open, even in the case \( n = 1 \).

The biological experiments on hydra described in [11] indicate that the system (2), in the case \( n = 1 \), should have many stable spike-layer steady states—some with single peak, others with multiple peaks—and perhaps the spike-layer steady state with a single boundary peak should be the "most" stable one. Mathematically, with what we have done it is easy to construct, in case \( n = 1 \), spike-layer steady states to (2) with single peak or multiple peaks, and with interior peaks, boundary peaks, or their combinations. What can we say about their stability or instability? We have already proved in Theorem 2 that under suitable conditions the single-boundary-peak solution \((U_{d2}, V_{d2})\) (corresponding to the "least-energy" solution \( u_c \) of (6)) is stable if \( d_2 \) is sufficiently large.

It is conjectured that as \( d_2 \) decreases, more and more multipeak spike-layer steady states become stable. Heuristically, since the rapidly diffusing inhibitor suppresses the formation of new spikes close to the existing ones, the larger \( d_2 \) becomes, the fewer stable spikes are expected. The stability question for multidimensional spike-layer steady states is even more fascinating, because the geometry of domain also comes into play.

**A Cross-Diffusion System with Competition**

We begin our discussion with the classical Lotka-Volterra competition-diffusion system:

\[
\begin{align*}
U_t &= d_1 \Delta u + u(a_1 - b_1 u - c_1 v) & \text{in } \Omega \times (0,\infty), \\
V_t &= d_2 \Delta v + v(a_2 - b_2 u - c_2 v) & \text{in } \Omega \times (0,\infty), \\
\frac{\partial U}{\partial n} &= \frac{\partial v}{\partial n} & \text{on } \partial \Omega \times (0,\infty),
\end{align*}
\]

where all the constants \( a_i, b_i, c_i, d_i, i = 1,2 \) are positive and \( u, v \) are nonnegative. Here, as is explained in [29], \( u \) and \( v \) represent the population densities of two competing species. For convenience we set \( A = \frac{a_1}{a_2}, B = \frac{b_2}{b_1}, \) and \( C = \frac{a_2}{a_1} \). It is known that in the "weak competition" case, i.e.,

\[
B > A > C, 
\]

the constant steady state

\[
(U_\ast, V_\ast) = \left( \frac{a_1 c_2 - a_2 c_1}{b_1 c_2 - b_2 c_1}, \frac{b_1 c_2 - b_2 c_1}{b_1 c_2 - b_2 c_1} \right)
\]

is globally asymptotically stable regardless of the diffusion rates \( d_1 \) and \( d_2 \). This implies, in particular, that no nonconstant steady state can exist for any diffusion rates \( d_1, d_2 \).

On the other hand, as was also remarked before, the pressures created by mutually competing species should be taken into account. In an attempt to model segregation phenomena between two competing species, Shigesada, Kawasaki, and Teramoto [27] proposed in 1979 the following cross-diffusion model:

\[
\begin{align*}
U_t &= D[(d_1 + \rho_{12} v)u] + u(a_1 - b_1 u - c_1 v) & \text{in } \Omega \times (0, T), \\
V_t &= D[(d_2 + \rho_{21} u)v] + v(a_2 - b_2 u - c_2 v) & \text{in } \Omega \times (0, T), \\
\frac{\partial u}{\partial n} &= \frac{\partial v}{\partial n} & \text{on } \partial \Omega \times (0, T),
\end{align*}
\]

where \( \rho_{12} \) and \( \rho_{21} \) represent the cross-diffusion pressures and are nonnegative. In fact, the model in [27] also includes "self-diffusion" pressures that turn out to be not so different from the usual dif-
fusion, as is shown in [16]. Here, for simplicity, we shall discuss only (9). Considerable work has been done concerning the global existence of solutions to the system (9) under various hypotheses. However, it is worth noting that even the local existence question for (9) is highly nontrivial and was only recently resolved in a series of papers by H. Amann [1, 2].

We first focus on the effect of cross-diffusions on steady states. To illustrate the significance of cross-diffusions, we again go to the weak competition case (i.e., $B > A > C$), since in this case (9) has no nonconstant steady states if both $ho_{12} = ho_{21} = 0$.

Let $0 = \lambda_0 < \lambda_1 < \lambda_2 < \ldots$ denote the eigenvalues of $-\Delta$ subject to the same boundary condition as in (1), and let $m_k$ be the multiplicity of $\lambda_k$.

**Theorem 3** [16]. Suppose that $B > A > (B + C)/2$ and $m_k$ is odd for some $k \geq 1$. Then there exist positive constants $K_1 = K_1(a_1, b_1, c_1) < K_2 = K_2(a_1, b_1, c_1)$ such that for any $d_1 > 0$, $\rho_{21} \geq 0$, and $d_2 \in (K_1, K_2)$ the system (9) has at least a nonconstant steady state if $\rho_{12} \geq K_3$ for some positive constant $K_3 = K_3(a_1, b_1, c_1, d_1, \rho_{21})$.

Thus, for every fixed $d_1 > 0$, $\rho_{21} \geq 0$, and $d_2$ belonging to a proper range, if we keep increasing the cross-diffusion $\rho_{12}$, eventually we will have a nonconstant steady state of (9). On the other hand, increasing the diffusion coefficients $d_1$ or $d_2$ while other parameters are fixed tends to eliminate any existing patterns.

**Theorem 4** [16]. Suppose that $B > A > C$. Then there exists a positive constant $K_4 = K_4(a_1, b_1, c_1)$ such that $(u_0, v_0)$ is the only positive steady state of (9) provided that one of the following holds:

(i) \[ \max \left\{ \frac{\rho_{12}}{d_1}, \frac{\rho_{12}}{d_2} \right\} \leq K_4 \]

(ii) \[ \max \left\{ \frac{\rho_{12}}{d_1}, \frac{\rho_{12}}{d_2}, \frac{\rho_{21}}{d_1}, \frac{\rho_{12} \rho_{21}}{d_1 d_2}, \frac{\rho_{12} \rho_{21}}{d_1 d_2}, \frac{\rho_{12} \rho_{21}}{d_1 d_2} \right\} \leq K_4 \]

(iii) \[ \max \left\{ \frac{\rho_{12}}{\sqrt{d_1 d_2}}, \frac{\rho_{21}}{\sqrt{d_1 d_2}}, \frac{\rho_{12} \rho_{21}}{d_1 \sqrt{d_1 d_2}}, \frac{\rho_{12} \rho_{21}}{d_2 \sqrt{d_1 d_2}}, \frac{\rho_{12} \rho_{21}}{d_1 \sqrt{d_1 d_2}} \right\} \leq K_4 \]

Note that when $\rho_{21} = 0$, Theorem 4 implies that if any one of the three quantities

\[ \frac{\rho_{12}}{d_1}, \frac{\rho_{12}}{d_2}, \frac{\rho_{12}}{d_1 d_2} \]

is small, then nonconstant steady states of (9) do not exist.

In the "strong competition" case, i.e., $B < A < C$, the situation of steady-state solutions of (7) becomes more interesting and complicated and is not completely understood. Nonetheless, cross-diffusions still have similar effects in helping create nontrivial patterns of (9). We refer interested readers to [16] for the details.

So far in this section we have only touched upon the existence and nonexistence of nonconstant steady states. It seems a natural and important question to ask if we can derive any qualitative properties (such as the spike-layers in the previous section) of those steady states. Our first step in this direction is to classify all the possible (limiting) steady states when one of the cross-diffusions pressures tends to infinity.

**Theorem 5** [17]. Suppose for simplicity that $\rho_{21} = 0$. Suppose further that $B \neq A \neq C$, $n \geq 3$, and $\frac{d_2}{d_1} \neq \lambda_k$ for all $k$. Let $(u_j, v_j)$ be a nonconstant steady-state solution of (9) with $\rho_{12} = \rho_{12,j}$. Then, by passing to a subsequence if necessary, either (i) or (ii) holds as $\rho_{12,j} \to \infty$, where

(i) \[ (u_j, v_j) \to (u, v) \text{ uniformly, } u > 0, v > 0, \]

and

(ii) \[ (u_j, v_j) \to (\xi, w) \text{ uniformly, } \xi \text{ is a constant, } w > 0, \]

\[ \begin{align*}
    d_2 \Delta w + w(a_2 - c_2 w) - b_2 \xi &= 0 \quad \text{in } \Omega, \\
    \frac{\partial w}{\partial \nu} &= 0 \quad \text{on } \partial \Omega ;
\end{align*} \]

The proof is quite lengthy. The most important step in the proof is to obtain a priori bounds on steady states of (9) that are independent of $\rho_{12}$.

Incidentally, both alternatives (i) and (ii) above do occur under suitable conditions. Moreover, it turns out that both systems possess spike-layer solutions. For instance, using a suitable change of variables, the equation in (ii) may be transformed into (6) with $p = 2$. Thus, spike-layer solutions exist. Perhaps we ought to remark that in fact what is important is the ratio of cross-diffusion versus diffusion $\rho_{12}/d_1$ in which $d_1$ also varies. A deeper classification result is obtained in [17] as $\rho_{12} \to \infty$ in (9) in terms of various possibilities of $\rho_{12}/d_1$ and $d_1$.

**Another Cross-Diffusion System: Chemotaxis**

A basic equation in population dynamics (without the reaction term for the time being) is

\[ u_t = \nabla \cdot (d \nabla u + u \nabla \psi(E(x, t))), \]

where $d > 0$, $\psi$ is increasing, and $E$ represents environmental influences that could also depend on $u$. The first term on the right-hand side of (10) is dif-
fusion, while the second term there represents the “directed movement”, or the “taxis”. Examples for \( \psi \) include \( \psi(E) = kE, k \log E, \) or \( kE^m/(1 + aE^n) \), where \( k > 0 \) and \( m \in N \). When the negative sign in (10) is used, we refer to the movement as “positive taxis”. When the positive sign in (10) is adopted, we have “negative taxis”, as in the system (9) already discussed before.

To illustrate “positive taxis”, we turn to a chemotaxis model due to Keller and Segel [13]. Chemotaxis is the orientation movement of cells in response to chemicals in their environment. Cellular slime molds (amoebae) release a certain chemical, cAMP, move toward its higher concentration, and eventually form aggregates. Letting \( u(x, t) \) be the population of amoebae at place \( x \) and at time \( t \) and \( v(x, t) \) be the concentration of this chemical, Keller and Segel proposed the following model to describe the chemotactic aggregation stage of amoebae:

\[
\begin{align*}
\frac{du}{dt} &= d_1 \Delta u - \eta \nabla \cdot [u \nabla \psi(v)] \quad \text{in } \Omega \times (0, T), \\
\frac{dv}{dt} &= d_2 \Delta v - av + bu \quad \text{in } \Omega \times (0, T), \\
\frac{\partial u}{\partial \nu} &= 0 = \frac{\partial v}{\partial \nu} \quad \text{on } \partial \Omega \times (0, T), \\
u(x, 0) &= u_0(x), \quad v(x, 0) = v_0(x) \quad \text{in } \Omega.
\end{align*}
\]

where the constants \( \eta, a, \) and \( b \) are positive. Comparing the first equation in (11) to (10), we see that (11) is indeed an example for “positive taxis”. Popular examples for the “sensitivity function” \( \psi \) include \( \psi(v) = kv, k \log v, \) or \( kv^2/(1 + v^2) \), where \( k > 0 \) is a constant. Much work has focused on the case \( \psi(v) = v \). For the case \( \psi(v) = k \log v \), Nagai and Senba [18] recently proved global existence for a modified parabolic-elliptic system in case \( n = 2 \). Observe that in (11) the total population is always conserved; that is, for all \( t > 0 \) we have

\[
\int_{\Omega} u(x, t)dx \equiv \int_{\Omega} u_0(x)dx.
\]

Therefore, to study the steady states of (11) for the case \( \psi(v) = \log v \), we consider the following elliptic system:

\[
\begin{align*}
d_1 \Delta u - \eta \nabla \cdot (u \nabla \log v) &= 0 \quad \text{in } \Omega, \\
d_2 \Delta v - av + bu &= 0 \quad \text{in } \Omega, \\
\frac{\partial u}{\partial \nu} &= 0 = \frac{\partial v}{\partial \nu} \quad \text{on } \partial \Omega, \\
\frac{1}{|\Omega|} \int_{\Omega} u(x)dx &= \bar{u} \quad \text{(prescribed)}.
\end{align*}
\]

With \( p = \eta/d_1 \) it is not hard to show that \( u = \lambda v^p \) for some constant \( \lambda > 0 \). Thus, setting \( \epsilon^2 = d_2/a, \mu = (b \lambda/a)^{\epsilon^{-1}}, \) and \( w = \mu v \), we see that \( w \) satisfies (6); i.e.,

\[
\begin{align*}
\epsilon^2 \Delta w - w + w^p &= 0 \quad \text{in } \Omega, \\
\frac{\partial w}{\partial \nu} &= 0 \quad \text{on } \partial \Omega,
\end{align*}
\]

and our previous results for (6) apply. To obtain a solution pair for (12) from a solution of (13), simply set

\[
\begin{align*}
u &= \frac{\bar{u}|\Omega|}{\int_{\Omega} w^p}, \\
v &= \frac{\bar{v}|\Omega|}{\int_{\Omega} w}
\end{align*}
\]

with \( \bar{v} = b\bar{u}/a \). In this way we obtain a spike-layer steady state for the chemotaxis system when \( d_2/a \) is small and \( 1 < \eta/d_1 < \frac{\eta^2}{2} \) \((\approx \text{if } n = 1, 2)\). Although many believe that this particular steady state (corresponding to the “least-energy” solution of (6)) is stable, its proof has thus far eluded us.

**Concluding Remarks**

In this expository paper, through several examples, we have considered mathematically the notions and mechanisms of diffusion and cross-diffusion from the point of view of pattern formation. In particular, we have considered only one type of pattern, namely, the spike-layers. Thus, it would be helpful to include a few remarks to put spike-layers in perspective.

1. We start with equation (6). First, note that (6) always has a constant solution \( u \equiv 1 \). In fact, it was proved in [15] that if \( \epsilon \) is large, then \( u \equiv 1 \) is the only solution of (6). More interestingly, as \( \epsilon \) tends to 0, pushing the “energy” method developed in [15] and [19, 20, 21] further, Gui and Wei [12] showed that the number of spike-layer solutions of (6) tends to infinity. Furthermore, for particular domains, it can be verified that, when \( \epsilon \) is small, (6) has layer solutions of various dimensions. More precisely, if we view spike-layers as \( 0 \)-dimensional (since the set where a spike-layer does
not tend to 0 as $\epsilon \to 0$ consists of isolated points), then for every integer $k$ between 0 and $n - 1$, (6) has a $k$-dimensional layer provided that $\epsilon$ is sufficiently small. The rich structure of solutions to (6) makes it extremely interesting and challenging to understand the entire dynamics of these related nonlinear diffusion systems. It should be remarked that the results included in this paper concerning the spike-layer solutions of (6) do generalize to more general nonlinearities than $u^p$. This kind of extension seems important both from a mathematical point of view as well as for its potential applications, as models in applied mathematics or other branches of science often involve a certain degree of uncertainty or arbitrariness and thus require some flexibility. In this connection we mention that when $p = \frac{n^2}{n^2 - 2}$, $n \geq 3$, in (6), the situation is not nearly as clear as that of the subcritical case $p < \frac{n^2}{n^2 - 2}$, and it does not seem to allow much flexibility at all. That is, the exact nonlinearity $u^{n^2}$ is required, and therefore the model in this case is not robust. We refer to [10] for some more recent developments and a brief description of previous work in this direction. For the supercritical case $p > \frac{n^2}{n^2 - 2}$ (6) remains largely open.

II.) Mathematically, it seems interesting to replace the homogeneous Neumann boundary condition in (6) by the homogeneous Dirichlet boundary condition $u = 0$ on $\partial \Omega$. First of all, it was established in [24] that the least-energy solution survives this change and it also has a unique (local) maximum point (i.e., the peak) $Q_\epsilon$ in $\Omega$. Moreover, the profile of the spike is a rescaled version of $w$ also. However, the peak $Q_\epsilon$ now “converges” to the “most-centered” part of $\Omega$; i.e., dist$(Q_\epsilon, \partial \Omega) - \max_{\xi \in \Omega} \text{dist}(\xi, \partial \Omega)$ as $\epsilon \to 0$. In addition, since the Dirichlet boundary condition is far more rigid than the Neumann boundary condition, it allows much fewer solutions to exist. It would be very interesting to understand how solutions change while the Dirichlet boundary condition $u = 0$ is continuously deformed to the Neumann condition $\frac{\partial u}{\partial \nu} = 0$ on $\partial \Omega$, say, via

$$(1 - \gamma)u + \gamma \frac{\partial u}{\partial \nu} = 0 \text{ on } \partial \Omega,$$

where $\gamma$ varies from 0 to 1. When $\gamma$ is close to 1, Ward [31] studied this problem by using formal asymptotic analysis.

III.) Comparing the chemotaxis model (12) to the competition model of (9), we find that the $u$ and $v$ in (12) must peak together, while our results in [17] on the systems (i), (ii) in Theorem 5 show that the system (9) does have steady states that form segregates. This is consistent with our intuition on “positive taxis” as well as “negative taxis”.

IV.) Spike-layer solutions also appear in nonlinear Schrödinger equations. Beginning with the work of Floer and Weinstein [9], there has been much research on this topic. See, for instance, [25, 30, 5, 6]. Some of the recent work was stimulated by the development of research on the Neumann problem (6). The Ginzburg-Landau equation is yet another such example; it also exhibits concentration phenomena. Interested readers are referred to [4] and [14].

V.) Transition-layers are clearly very much related to our interest here. The studies of transition-layers began much earlier, and it seems that they are better understood. In particular, a powerful technique—the singular limit eigenvalue problem method—has been developed by several Japanese mathematicians, including Nishiura, Mimura, Fujii, and others. There is, of course, a vast literature on transition-layers; we shall only refer interested readers to Paul Fife’s monograph [7] and the references therein. However, it should be mentioned that for Cahn-Hilliard equations in phase transitions (in material science), transition-layers have been studied extensively by Alakisos, Bates, Chen, Fife, Fusco, Hale, and others. Moreover, recent research [3] shows that spike-layers also appear in Cahn-Hilliard equations and are related to the “nucleation” phenomena. Although spike-layers there perhaps are unstable, they seem to have profound implications on the dynamics involved.

Finally, we would like to include some brief comments on the models used in this paper. As was pointed out by Okubo in his book [26], most, if not all, mathematical models in biology are not “realistic”, but “educational”. Nevertheless, there are good reasons for formulating them and for studying them. We refer to a very interesting discussion by Fife [8] on the rationale of using reaction and diffusion in modeling biological phenomena. We hope the mathematical progress in understanding diffusion, cross-diffusion, and their spike-layer solutions not only produces interesting mathematics but also enhances our ability in modeling real-world phenomena in various other branches of science.

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References


Paul Erdős died September 20, 1996, and a memorial article appears elsewhere in this issue. This feature article gives a cross section of his monumental oeuvre. Most of Erdős's work falls roughly into the following categories:

- number theory
- finite combinatorics (including graph theory)
- combinatorial geometry
- set theory, set-theoretical topology
- constructive theory of functions (approximation theory)
- other areas of classical analysis (polynomials, theory of series, functions of a complex variable)
- probability theory, ergodic theory

The first two areas are represented in Erdős's work by more than 600 articles each, the next three by more than 100 articles each. There are some overlaps in this rough count. A large number of articles fall into a "miscellaneous" category.

In what follows, Pomerance gives a glimpse into the variety of topics Erdős worked on in number theory. Babai discusses (infinite) set theory, finite combinatorics, combinatorial geometry, combinatorial number theory, and probability theory. Vértesi treats approximation theory, with a hint of related work on polynomials.

—László Babai, Organizer

Paul Erdős, Number Theorist Extraordinaire

Carl Pomerance

Nearly half of Paul Erdős's 1,500 papers were in number theory. He was a giant of this century, showing the power of elementary and combinatorial methods in analytic number theory, pioneering the field of probabilistic number theory, making key advances in diophantine approximation and arithmetic functions, and until his death leading the field of combinatorial number theory. Paul Erdős was also a kind and generous man, one who would seek out young mathematicians, work with them, give them ideas, teach them, and in the process make a lifelong friend and colleague. I was one of these lucky ones, but more on that later.

Perhaps the single most famous paper of Erdős is [3], wherein he described an elementary proof of the prime number theorem.

The history of the prime number theorem seems to be punctuated by major developments at half-century intervals and often in two's. At the end of the eighteenth century Gauss and Legendre independently conjectured that the number of primes up to x, denoted π(x), is asymptotically x/log x as x → ∞. (This came some fifty years after Euler had proved that the sum of the reciprocals of the primes is infinite.) In the mid-nineteenth century Chebyshev showed by an elementary method that there are positive constants c₁, c₂ with c₁x/log x < π(x) < c₂x/log x for all large x, and

Note: Except where otherwise noted, all photographs in this article are from the collection of Vera T. Sós.
Riemann laid down a plan to prove the prime number conjecture of Gauss and Legendre via analytic methods. It is in this paper that Riemann stated what came to be known as the "Riemann hypothesis," one of the most famous and important unsolved problems in mathematics.

At the close of the nineteenth century, de la Vallée Poussin and Hadamard independently succeeded in giving complete proofs of the prime number theorem. (Though roughly following Riemann's plan, they avoided an outright assault on the Riemann hypothesis.) A tour de force for analytic methods in number theory, it was thought by many that an elementary proof of the prime number theorem was impossible. It was thus quite a sensation when Erdős and Atle Selberg actually did come up with elementary proofs in 1948.

Another fifty years have passed. Will there soon be another great advance?

In response to the theory of quantum mechanics, Einstein exclaimed, "God does not play dice with the universe." Though this never happened, I would like to think that Paul Erdős and the great probabilist, Mark Kac, replied, "Maybe so, but something is going on with the primes." In 1939 Erdős and Kac [10] proved one of the most beautiful and unexpected results in mathematics. Their theorem states that the number of prime factors in a number is distributed, as the number varies, according to a Gaussian distribution, a bell curve.

Let \( \omega(n) \) denote the number of distinct prime factors of \( n \). In 1917 Hardy and Ramanujan proved that \( \omega(n) \) is normally \( \log \log n \). What this means is that for each \( \varepsilon > 0 \), the density of the set of natural numbers \( n \) with \( (1 - \varepsilon) \log \log n < \omega(n) < (1 + \varepsilon) \log \log n \) is 1. (A set \( S \) of natural numbers has density \( d \) if the number of members of \( S \) up to \( x \), when divided by \( x \), tends to \( d \) as \( x \to \infty \). So, for example, the odd numbers have density 1/2, the prime numbers have density 0, and the set of numbers with an even number of decimal digits does not have a density.) Later, Paul Turán, a close friend of Erdős, came up with a greatly simplified proof of the Hardy-Ramanujan theorem by showing that the sum of \( (\omega(n) - \log \log n)^2 \) for \( n \) up to \( x \) is of order of magnitude \( x \log \log x \). This would later come to be thought of as a variance calculation in probability theory, but it was not conceived of in this way.

Mark Kac viewed the number theoretic function \( \omega(n) \) probabilistically. He reasoned that being divisible by 2, 3, 5, etc., should be thought of as "independent events," and so \( \omega(n) \) could be viewed as a sum of independent random variables. Since the sum of \( 1/p \) for \( p \) prime, \( p \leq x \), is about \( \log \log x \), Kac reasoned that this is what is behind the Hardy-Ramanujan-Turán theorem and that in fact a Gaussian distribution should be involved, with standard deviation \( \sqrt{\log \log x} \). That is, Kac conjectured that for each real number \( u \), the density of the set of \( n \) with \( \omega(n) \leq \log \log n + u \sqrt{\log \log n} \) exists and is equal to

\[
\frac{1}{\sqrt{2\pi}} \int_{-\infty}^{u} e^{-t^2/2} dt,
\]

the area under the bell curve from \( -\infty \) to \( u \).

How the collaboration of Erdős and Kac came about is best left to Kac's own words, as quoted by Peter Elliott in [2]:

"If I remember correctly, I first stated (as a conjecture) the theorem on the normal distribution of the number of prime divisors during a lecture in Princeton in March 1939. Fortunately for me and possibly for Mathematics, Erdős was in the audience, and he immediately perked up. Before the lecture was over he had completed the proof, which I could not have done, not having been versed in the number theoretic methods, especially those related to the sieve."

What Erdős knew quite well was that via the methods of sieves, as developed by Brun early in this century, it could be shown that the primes up to \( x^\varepsilon \) actually do distribute themselves "independently" among the numbers up to \( x \), and of course no number \( n \leq x \) can have more than \( 1/\varepsilon \) prime factors that exceed \( x^\varepsilon \).

This result opened the book on probabilistic number theory, the branch of mathematics that studies number theoretic functions, such as \( \omega(n) \), via probabilistic methods.
Paul Erdős is equally well known for his remarkable problems. Here are a few in number theory:

1. Among the integers up to \( x \), the set of powers of 2 have the property that the various subset sums are all different, and of course there are \( \log_2 x + O(1) \) powers of 2 up to \( x \). Is it true that if \( S \) is a set of integers in \([1, x]\) with all subset sums different, then \( S \) has at most \( \log_2 x + O(1) \) members?

2. Suppose \( A \) is a subset of the nonnegative integers such that every nonnegative integer \( n \) can be written as \( a_1 + a_2 \), where \( a_1, a_2 \) are in \( A \). Let \( r(n) \) be the number of such representations of \( n \). Must the sequence \( r(n) \) be unbounded?

3. Suppose \( B \) is a subset of the positive integers with the sum of the reciprocals of the members of \( B \) being infinite. Must \( B \) contain arbitrarily long arithmetic progressions?

4. The set \( \{2, 3, 4, 6, 12\} \) is a "covering set", since there are residue classes with these moduli that cover the integers: in particular, \( 0 \mod 2, 0 \mod 3, 1 \mod 4, 1 \mod 6, 11 \mod 12 \) will do. For each \( k \) is there a (finite) covering set with distinct moduli, each \( > k \)?

Each of these problems has its own interesting story, as do hundreds of other Erdős problems. They are often tips of icebergs. For example, problem 2, which is joint with Turán, is related to the famous theorem of Erdős and W. Fuchs [8], which asserts that no matter what sequence is chosen for \( A \), the sum of \( r(n) \) for \( n \) up to \( x \) cannot be of the form \( cx + o(x^{1/4}/(\log x)^{1/2}) \). (Erdős was justifiably proud of this beautiful result. A few years ago he wrote (in [7]) that the Erdős-Fuchs theorem "certainly will survive the authors by centuries."

Problem 4 is related to an old problem of Euler, who considered whether an odd number \( n > 1 \) can be expressed as a sum of a prime and a power of 2. Euler noticed that 127 and 959 cannot be represented, though de Polignac conjectured in 1849 that every odd number \( n > 1 \) can be represented! The problem was revived by Romanoff in 1934 and solved independently by Erdős [4] and van der Corput [1] in 1950. In fact, Erdős showed that there is an infinite arithmetic progression of odd numbers that cannot be represented as a sum of a prime and a power of 2. The proof used the covering set \( \{2, 3, 4, 8, 12, 24\} \). If problem 4 were to hold, then there would be, for each positive integer \( k \), an infinite arithmetic progression containing no numbers that are a sum of a power of 2 and a number with at most \( k \) different prime factors. Erdős was fond of repeating Selfridge's covering set problem: is there a covering set with odd moduli \( > 1 \)? This is still unsolved.

While he was alive, Erdős offered money for each of problems 1-4 and many others. For example, problem 3 (which would have the sensational corollary that there are arbitrarily long arithmetic progressions consisting of primes) was worth $3,000. Erdős liked to joke that his prize money violated the minimum wage law.

Paul Erdős, often through his prizes, inspired many other mathematicians. Endre Szemerédi, for example, earned $1,000 when he showed a slightly weaker result than problem 3: he showed that if \( B \) does not have density 0, then it contains arbitrarily long arithmetic progressions. And Helmut Maier and Gérald Tenenbaum earned money from Erdős when they showed that the density of those numbers \( n \) with two divisors \( a, b \) with \( a < b < 2a \) is 1.

I too owe much to Paul Erdős. At the end of an article in 1956 Erdős gave a brief heuristic argument on why he thought there should be infinitely many Carmichael numbers and, in fact, why they should be plentiful among all numbers. (A composite number \( n \) for which \( a^n \equiv a \mod n \) for all \( a \) is called a Carmichael number. In 1910 Carmichael conjectured there should be infinitely many.) Erdős and I discussed his heuristic argument several times over the years, and he was very
pleased when Red Alford, Andrew Granville, and I succeeded recently in making it the backbone of a proof of the infinitude of Carmichael numbers. We were happy to dedicate our paper to Erdős on the occasion of his eightieth birthday.

I like to tell the story of how I first met Paul Erdős, since it is not only a good story, but shows a fundamental quality of Erdős as a man and a mathematician. I was home on April 8, 1974, watching a baseball game on television. I was then an assistant professor at the University of Georgia, less than a couple of years from graduate school, with few theorems but a love of numbers. This was not an ordinary baseball game, but the one in which Hank Aaron of the Atlanta Braves hit his 715th major league home run, thus surpassing the supposedly unbeatable record of 714 that had been set by Babe Ruth some four decades earlier.

I noticed that 714 and 715 have a peculiar property, namely, that their product is also the product of the first 7 primes. The next morning I challenged my colleague David Penney to find an interesting property of 714 and 715. He soon found the same thing I had, but he also posed the problem to his numerical analysis class, where a student came up with another interesting property: the sum of the prime factors of 714 is equal to the sum of the prime factors of 715. Working with another student, Carol Nelson, Penney and I found many other examples of consecutive pairs of numbers with this latter property and were able to come up with a strong heuristic for why there ought to be infinitely many. We wrote up our observations in a light-hearted article that was published several months later in the Journal of Recreational Mathematics. Calling 714 and 715 a "Ruth-Aaron pair," we conjectured that such pairs have density 0: that is, the set of \( n \) such that the sum of the prime factors of \( n \) is equal to the sum of the prime factors of \( n+1 \), has density 0.

Paul Erdős, the giant of twentieth-century number theory, was also a reader of the Journal of Recreational Mathematics. He did not know me, nor should he have, but he wrote me a letter saying he thought of the work that Ruth-Aaron pairs have density 0 and he would like to visit Georgia and discuss it with me. Much of what I now know in mathematics I learned from Erdős working on this and subsequent joint papers. It is fair to say that I owe my career to this serendipitous collaboration.

I am very grateful to have this chance to write these words in tribute to Paul Erdős. But I am cognizant of the vast amount of his work that did not get mentioned. In fact, I cannot close without giving four more delightful results.

Amicable numbers have been studied since Pythagoras: a pair \( m, n \) is amicable if the sum of the proper divisors of \( m \) is \( n \), and vice versa. The first amicable pair with \( m \neq n \) is 220, 284. Paul Erdős [5] was the first to prove that the set of amicable numbers has density 0. It is still not known if there are infinitely many.

Can the product of consecutive integers be a power? This problem, with roots in the eighteenth century, was settled in the negative by Erdős and Selfridge [11] in 1975. It is still not known whether the Erdős-Selfridge theorem can be generalized to arithmetic progressions—the conjecture is that a product of four or more consecutive terms of a coprime arithmetic progression cannot be a power.

An additive function \( f(n) \) is a real-valued function defined on the natural numbers with the property that \( f(mn) = f(m) + f(n) \) whenever \( m \) and \( n \) are coprime. For example, the number-of-prime-factors function \( \omega(n) \), mentioned above in connection with the Erdős-Kac theorem, is additive, as is the function \( \log n \). In 1944 Erdős proved that if \( f(n) \) is additive and \( f(n+1) \geq f(n) \) for all large \( n \), then \( f(n) = c \log n \) for some number \( c \). This also holds if one replaces the monotonicity assumption with \( f(n+1) - f(n) \to 0 \). Others, including Feller, Wirsing, Kátai, and Kovács, have added more to this theory of characterizing the logarithm as an additive function. For example, Wirsing [14] proved in 1970 the long-standing conjecture of Erdős that if \( f(n) \) is additive and \( f(n+1) - f(n) \) is bounded, then there is a number \( c \) such that \( f(n) - c \log n \) is bounded.

Finally, I cannot resist describing the Erdős "multiplication table theorem." Let \( M(n) \) be the number of distinct numbers in the \( n \times n \) multiplication table. For example, in the familiar \( 10 \times 10 \) multiplication table (at least familiar to those of us who did not grow up with calculators), there are 43 distinct numbers among the 100 entries, and so \( M(10) = 43 \). Erdős asked about the behavior of \( M(n)/n^2 \) as \( n \to \infty \). What do you think it is? Clearly, since the multiplication matrix is symmetric, we have \( \lim \sup M(n)/n^2 \leq 1/2 \). Is \( 1/2 \) the limit? Erdős showed [6] in 1960 that \( M(n)/n^2 \to 0 \) as \( n \to \infty \), a theorem that I find as surprising as it is delightful. (Once one sees the proof, the surprise factor diminishes, though not the delight. As we saw before, most numbers up to \( n \) have about \( \log \log n \) prime factors, and thus most products in the table have about \( 2 \log \log n \) prime factors. This is an abnormal number of primes for a number up to \( n^2 \), so there are not very many products.) We still do not have an asymptotic formula for \( M(n) \) as \( n \to \infty \), though from the work of Tenenbaum we have some good estimates.

This last result illustrates a most important point. At first glance one might think of the work of Erdős as a collection of unconnected and ad hoc results. Upon deeper inspection, especially of the proofs, one finds a glorious theory, with many interrelations of ideas and tools. It is this edifice of "Erdős-theory" that Paul Erdős leaves for us, and number theory is much the richer for it.
Nothing serves as a better illustration of this point than the excitement his questions brought to the simplest concepts of Euclidean plane geometry: points, lines, triangles.

Consider a set of \( k \) points and \( t \) lines in the plane. What would Erdős ask about them? Many things, but perhaps the simplest question is this: what is the maximum number \( f(k, t) \) of incidences between the points and the lines? After many years Szemerédi and Trotter (1983) confirmed Erdős’s conjecture that the points of a square grid together with a certain set of lines give the optimal order of magnitude. The proof from The Book appeared in 1997 (L. Székely).

Another, even simpler, problem of Erdős asks the maximum number \( g(n) \) of unit distances that can occur among \( n \) points in the plane. In 1946 Erdős proved that \( n^{1+\varepsilon}/\log n < g(n) < cn^{3/2} \). The upper bound was improved by Beck, Spencer, Szermerédi, and Trotter to \( n^{3/2} \). Erdős conjectured that the lower bound, obtained from the square grid, has the correct order of magnitude. The problem remains wide open; the large gap between the upper and lower bounds offers a continuing challenge.

Let me quote a related open problem Erdős volunteered for the “Math Investigations” column of George Bézsenyi in the student journal Quantum: “Let \( f(n) \) be the largest integer for which there is a set of \( n \) distinct points \( x_1, x_2, \ldots, x_n \) in the plane for which for every \( x_i \) there are \( \geq f(n) \) points \( x_j \) equidistant from \( x_i \). Determine \( f(n) \) as accurately as possible. Is it true that \( f(n) = o(n^3) \) for every \( c > 0 \)?” Erdős offered $500 for a proof and “much less” for a counterexample. The estimate \( f(n) < cn^{2/3} \) follows from a result of Clarkson et al. (1990).

As these questions indicate, Erdős’s combinatorics, as long as finite sets are concerned, is about asymptotic orders of magnitude. Asymptotic thinking has been common in number theory (especially in the study of the distribution of prime numbers), which was Erdős’s first love. But it seems to be without precedent in combinatorics and in geometry. And even within number theory, Erdős’s style brought about a new field, combinatorial number theory, an area expounded in hundreds of papers by Erdős (57 of them joint with A. Sárközy).

Combinatorial ideas appear already in Erdős’s earliest work on number theory. Erdős was greatly influenced by a question he heard in 1934 from Fourier analyst Simon Sidon on sequences of integers with pairwise different sums. In a paper published in Tomsk (Siberia) in 1938 Erdős considers a multiplicative version of Sidon’s problem: what is the maximum number \( f(n) \) of positive in-

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Master of Patterns

Elementary geometry and Ramsey theory met in one of Erdős's earliest papers (1935), written with fellow undergraduate and lifelong friend, George Szekeres, then a student of chemical engineering. They proved that sufficiently many points in the plane necessarily include $k$ points that form a convex $k$-gon. Later Erdős dubbed the question the "Happy Ending Problem": proposed by Eszter Klein and Erdős, the problem was first solved by Szekeres, who subsequently married Klein. "The wedding took place just a day after I learned that Vinogradov had proved the odd Goldbach conjecture," Erdős recalled in 1995.

Szekeres, in a remarkable tour de force, even rediscovered Ramsey's theorem, which was then only three years old, for his solution. This work represented a milestone in Erdős's combinatorial thinking. Erdős recognized the vast domain opened up by Ramsey's theorem, this "generalized pigeon hole principle." In the cited 1935 paper with Szekeres, Erdős studied Ramsey numbers for graphs, the first step in building what at the hands of Erdős would become Ramsey theory, a large area in finite and transfinite combinatorics. Transfinite Ramsey theory became a fundamental part of modern set theory.

One of Erdős's heroes was Georg Cantor; Erdős learned the basics of Cantor's set theory from his father. Erdős loved infinite cardinals and contributed to the birth of very large ones. (We use the term "transfinite" to emphasize that the focus is beyond $\omega$, usually far beyond.)

Although the methods of the finite and the transfinite are almost disjoint (counting is fundamental in the former, well-ordering in the latter), it was Erdős's axiom that if a question makes sense both for finite and for infinite sets, it must be investigated in both domains. This view is especially prominent in his fifty-four (often massive) joint papers with A. Hajnal.

The chromatic number of a graph is the smallest number of colors that can be assigned to the vertices of the graph such that adjacent vertices receive different colors. Until the mid-1950s this concept was mostly discussed in the limited context of the 4-color conjecture. Erdős's work, which includes dozens of papers entitled "Chromatic graph theory," played a major role in establishing the true depth of the concept. Together with Haj-
nal, Erdős also pioneered the extension of this notion to set systems (no member of the set system should be monochromatic), creating one of the powerful unifying concepts of modern combinatorics.

One of the great early successes of Erdős's probabilistic method in finite combinatorics was his proof in 1957 that for any \( k, m \) there exists a graph of chromatic number \( k \) without cycles of length \( \leq m \), putting an end to a long quest by the best combinatorial minds.

While it was relatively easy to get rid of short odd cycles, the short even cycles proved to be much harder to eliminate. A surprising explanation of this phenomenon came in a milestone paper by Erdős and Hajnal, "Chromatic number of graphs and set systems" (1966). Corollary 5.6, one of the paper's five dozen results, asserts: If the chromatic number of a graph is \( \geq \aleph_1 \), then the graph must contain a 4-cycle! Buried in this paper, which is alephs all over, is an important result of finite combinatorics: Erdős's cited result on large chromatic finite graphs without short cycles is generalized to set systems.

Erdős was fascinated by the global nature of the chromatic number. A striking expression of this is his 1962 result that to every \( k \) there is an \( \epsilon > 0 \) such that for all \( n > k \) there exist \( k \)-chromatic graphs on \( n \) vertices such that all of their subgraphs on \( \leq \epsilon n \) vertices are 3-colorable. As usual, he pursued the idea for infinite graphs as well and found that it led to a wealth of questions and surprising answers. With Hajnal, Erdős showed (1968) that there exist graphs of uncountable chromatic number on \( (2^{\aleph_0})^+ \) vertices such that all subgraphs on \( \leq 2^{\aleph_0} \) vertices are countably colorable. (Here \( \alpha^+ \) denotes the successor cardinal of \( \alpha \).) In the nicely shaping landscape, however, as in virtually all areas of Erdős's inquiry into the transfinite, "independence raised its ugly head" after Cohen's seminal work: a number of related questions turned out to be independent of ZFC (Zermelo-Fraenkel set theory with the axiom of choice), even under the Generalized Continuum Hypothesis. Among these is the question of the existence of an \( \aleph_2 \)-chromatic graph with \( \aleph_1 \) vertices such that all subgraphs with \( \leq \aleph_1 \) vertices are \( \aleph_0 \)-colorable (Baumgartner, 1984; Foreman and Laver, 1988).

If combinatorics is the art of finding patterns under virtually no assumption, Erdős was the master of this art. Here is a simple example. A set system \( \{A_1, \ldots, A_k\} \) is called a sunflower with \( k \) petals (or a \( k \)-system in the original terminology of Erdős and Rado) if all pairwise intersections \( A_i \cap A_j \) are equal to \( \bigcap_{i=1}^k A_i \). Erdős and Rado recognized the significance of this simple pattern in 1960 and showed that for any \( k \) and \( r \), any sufficiently large family of sets of size \( r \) contains a sunflower with \( k \) petals. Erdős offered $1,000 for deciding whether \( C^r \) is sufficiently large to guarantee \( k = 3 \) petals for some (large) \( C \). The problem remains wide open to date. At the hands of Frankl and others, sunflowers have become a powerful tool in the structural theory of set systems; Razborov used them in a profound lower-bound proof in the theory of Boolean circuits.

Ramsey theory provides the ultimate in the quest for simple patterns. Assume we color each \( r \)-subset of a set \( S \) of cardinality \( \kappa \) red or blue. We say that a subset \( H \subseteq S \) is homogeneous if all \( r \)-subsets of \( H \) have the same color. The Erdős-Rado symbol \( \kappa \rightarrow (\alpha, \beta)^r \) means that regardless of the coloring, there must be either a red-homogeneous subset of size \( \alpha \) or a blue-homogeneous subset of size \( \beta \). We omit \( \beta \) if \( \beta = \alpha \). Ramsey's theorem states that \( \kappa \rightarrow (\kappa)^r \) for every finite \( r \). Its finite version says that \( N \rightarrow (k)^r \) for sufficiently large finite \( N = N(k, r) \). The estimation of the quantities \( N(k, r) \) is a major problem area. Here is an example of a tantalizing gap: it is known that \( n - (c_1 \log \log n)^3 \) (Erdős-Rado, 1952) and \( n + (c_2 \sqrt{\log n})^3 \) (from the 100-page "giant triple paper" by Erdős, Hajnal, and Rado (1965)).

Partition calculus, the term Erdős and Rado (1956) used for transfinite Ramsey theory, started with a result of Erdős that \( \kappa \rightarrow (\kappa, \kappa)^2 \), included in a 1941 paper by Dushnik and Miller. Shortly afterwards, Erdős proved the basic result that \( (2^\kappa)^+ \rightarrow (\lambda)^2 \) (1942) and noted that by a result of Sierpiński this bound is tight: \( (2^\kappa)^+ \neq (\lambda)^2 \).

The fact that innocuous problems of transfinite combinatorics lead to inaccessible cardinals was a stunning discovery made in a 1943 paper by Erdős and Tarski, especially famous for its footnotes. Regarding the simplest of partition relations, \( \kappa \rightarrow (\kappa)^2 \), they recognized that it cannot hold unless \( \kappa \) is strongly inaccessible (\( \kappa \) is not the sum of

Ronald L. Graham (left), Erdős, Peter Frankl finishing a paper on “anti-Ramsey graphs” at a conference in Hakone, Japan, 1990. The interests shared by Graham and Frankl include solving problems of Erdős, helping Erdős’s influence spread in the Orient, and juggling (both are world-class jugglers).
fewer, smaller cardinals, and $\alpha < \kappa$ implies $2^\alpha < \kappa$, and it does hold if $\kappa$ is measurable (admits a nontrivial $< \kappa$-additive $(0,1)$-measure defined on all subsets of $\kappa$). Out of these observations, the theory of large cardinals, a vital component of modern set theory, was born. Cardinals satisfying $\kappa < (\kappa)^2$ are called weakly compact cardinals.

Another important class of large cardinals grew out of Erdős's first joint paper with then graduate student András Hajnal (1958). Erdős and Hajnal proved that measurable cardinals satisfy the partition relation $\kappa \rightarrow (\kappa)^2_\alpha$ (all finite sets are colored). This relation defines what are called Ramsey cardinals. Amazing consequences of the weaker relation $\kappa \rightarrow (\omega_1)^2_\alpha$ to descriptive set theory were found in the mid-1960s by F. Rowbottom, J. H. Silver, R. Solovay, and others. In recognition of Erdős's pioneering role in defining large cardinals via partition relations, the cardinals satisfying the relation $\kappa \rightarrow (\omega_1)^2_\alpha$ are commonly referred to as Erdős cardinals.

We stated Ramsey's theorem for two colors; the generalization to a finite number of colors is immediate. It is clear, however, that no homogeneous subset is to be expected unless the set is "large" compared to the number of colors. Nevertheless, one of a short list of canonical structures exists regardless of the number of colors! In the simplest case ($r = 2$) there are only three types of canonical structure: a homogeneous set (all pairs have the same color), a multicolored set (each pair has a different color), and the min-coloring: the color of $\{i,j\}$ is $\min(i,j)$ (assuming the set is well ordered).

This very useful fact is the Canonical Ramsey Theorem of Erdős and Rado (1950).

In a series of papers starting in 1973 Erdős, Graham, Montgomery, Rothschild, Spencer, and Straus laid the foundations of Euclidean Ramsey Theory, melding Ramsey theory to the geometry of real $n$-space. The typical question is this: given a geometric configuration $K$, is it true for all $r$ that any $r$-coloring of $n$-space contains a monochromatic copy of $K$, assuming $n \geq n_0(r)$? If $K$ has this property, we say that $K$ is a Ramsey configuration. Erdős et al. have shown that the bricks are Ramsey and sets that cannot be inscribed in a sphere are not Ramsey. A major problem left open in their work was settled by Frankl and Rödl in 1986: all triangles are Ramsey.

Much of Erdős's work concerns the paradigm that "density implies pattern." The most famous of Erdős's solved prize problems ($\$1,000$) asserts that a sequence of integers of positive upper density contains arbitrarily long arithmetic progressions. Proposed by Erdős and Turán in 1936, this conjecture was confirmed in 1975 in "a masterpiece of combinatorial thinking" [4] by Endre Szemerédi, a disciple of Erdős and one of the most formidable problem solvers of our time. Subsequently H. Furstenberg gave an ergodic proof. Szemerédi's proof builds on his Regularity Lemma, which has far-reaching consequences in graph theory; the method of Furstenberg's proof gave a new direction to ergodic theory. This is but one of the long list of examples demonstrating the profound relevance of the problems championed by Erdős.

A great many problems in combinatorial number theory have a flavor similar to the problem of arithmetic progressions. Young Erdős was captivated by Sidon's 1934 problem, which asks how dense a set of integers can be if all pairwise sums are different\footnote{One can hardly overestimate the influence of Sidon's problems on Erdős's career. It is remarkable how the twenty-year-old Erdős's irresistible insistence on mathematical communication virtually compelled Sidon, a reclusive man employed by an insurance company, to reveal his remarkable thoughts to the eager youth. A classic anecdote: One afternoon, when Erdős and Turán showed up at Sidon's doorstep, Sidon opened the door a crack and greeted the two with these words: "Please visit another time and especially another person."}. If we denote by $A(n)$ the number of elements $\leq n$ in such a sequence, it is clear that $A(n) \leq c_1 n^{1/2}$, and "greedy" choice results in a sequence with $A(n) \geq c_2 n^{1/3}$. Only very recently (1997) did Erdős protegé Imre Ruzsa succeed in substantially reducing this sixty-year-old gap. Ruzsa has shown the existence of a Sidon sequence such that $A(n) \geq n^{\alpha - \epsilon}$ with $\alpha = \sqrt{2} - 1 \approx .41$.

In extremal graph theory the fundamental Erdős-Stone-Simonovits theorem (1946, 1966) considers the minimum edge density of graphs that will
force the appearance of a fixed "pattern" subgraph \( H \). It turns out that asymptotically, the density depends solely on the chromatic number of \( H \)! This in particular implies that the set of critical limiting densities is well ordered. Erdős asked whether this fact generalizes from graphs to systems of \( r \)-sets ("\( r \)-hypergraphs") for \( r \geq 3 \); his second (and last) $1,000 award went to Frankl and Rodl for their negative answer, "Hypergraphs don't jump" (1984).

**Combinatorics and Probability**

Erdős was not versed in probability theory at the time he arrived in Princeton in 1938. He was not even familiar with the central limit theorem. Yet he deeply understood it in a flash when he first heard about it in a lecture by Mark Kac; by the end of the talk he had completed the proof of Kac's conjecture on the normal (Gaussian) distribution of the number of prime divisors of integers. While this result gave birth to probabilistic number theory, Erdős went on and made major contributions to probability theory itself, especially the theory of random walks and Brownian motion. He worked with Kac, K. L. Chung, Dvoretzky, Kabutani, among others, in these areas. Erdős's best-known result in probability theory is a full asymptotic expansion of the law of the iterated logarithm (1942).

A "statistical view" of mathematical objects was one of Erdős's key innovations in many areas of mathematics. Following work by Goncharov in the 1940s, Erdős and Turán developed statistical group theory, a study of the distribution of various sets of parameters associated with a group, in a series of seven highly technical papers between 1965 and 1976. They showed, for instance, that the logarithms of the orders of elements in the symmetric group \( S_n \) are asymptotically normally distributed.

The foundations of a beautiful statistical theory of combinatorial structures were laid in the landmark study by Erdős and Rényi of the "evolution of random graphs" in a series of seven papers between 1959 and 1968.

Let us construct a "random" graph with \( n \) vertices and \( m \) edges by picking the edge set uniformly at random from the set of \( \binom{n}{2} \) possibilities. Erdős and Rényi observed the typical behavior of these graphs as a function of \( m = mn \) and determined very sharp thresholds for various monotone properties to become "typical." For instance, connectedness occurs around \( mn = n \log n / 2 \); in fact, they proved that if \( (m_n/n) - (\log n / 2) \to c \), then the probability of connectedness approaches \( e^{-e^{-c}} \).

The most striking discovery of Erdős and Rényi was a phase transition which occurs around \( m_n = n/2 \): suddenly, a giant component appears. If \( m_n < (1 - \epsilon)n / 2 \), then typically all connected components of the graph are of size \( O(\log n) \) and have very simple structure. But when \( m_n > (1 + \epsilon)n/2 \), the largest component has size \( > c(\epsilon)n \), while all other components remain of logarithmic size and are absorbed into the giant component as \( m_n \) increases. Béla Bollobás took the lead in a 1984 paper in uncovering the fine structure of this phase transition, the study of which has yielded a series of remarkable insights and is continuing to this day.

Much of Erdős's work had an impact on the theory of computing, a field in which Erdős never took an interest [2]. Richard M. Karp writes: "The Erdős-Rényi papers on random graphs exerted major influence on my work. The beautiful scenario of the successive stages in the evolution of random graphs, progressing in an essentially inevitable way, has stimulated me to find other stochastic processes, associated with algorithms, which unfold in the same kind of inevitability. Researchers have exhibited such processes in connection with many problems related to graphs, Boolean formulas and other structures. Specific results related to random graphs have been applied to hashing, storage allocation, load balancing and other problems relevant to algorithms and computer systems."

**Probabilistic Proof of Existence**

Among the numerous techniques Paul Erdős taught us, perhaps the probabilistic method has been the most influential. This method establishes the existence of certain objects by selecting an object at random from a certain probability space and proving that the object has the desired properties with positive (usually overwhelming) probability. While Erdős was not the first to employ an idea of this type, it was he who recognized its vast scope and developed it into a powerful technique.

Erdős first demonstrated the power of this method in 1947 by proving that his Ramsey bound with Szekeres, \( n - (c \log n)^2 \), is tight apart from the constant \( c \); i.e., there exists a graph on \( n \) vertices without homogeneous subsets (clique or independent set) of size \( c_1 \log n \). The probability bound is obtained by generously overestimating, via simple counting, the number of graphs which do not have the desired property.

This non-constructive proof of existence immediately raised the challenge of an explicit construction. Frankl (1977) was the first, via the sunflower technique, to construct explicit graphs without homogeneous subsets of size \( n^c \); an elegant alternative proof was given by Frankl and Wilson using the linear algebra method (1981). Their bounds on homogeneous subsets are, however, still far from logarithmic.

Another great success of the probabilistic method was Erdős's cited result on the existence of graphs with large chromatic number and without short cycles (1959). In this case a mere random choice alone will not suffice; the random graph ob-
tained from a carefully chosen distribution needs to be modified in order to satisfy the conditions.

The derandomization of this result required major effort and was eventually successful in simultaneous work by Margulis and Lubotzky-Phillips-Sarnak (1988). A key ingredient is the theory of diophantine equations of the form \( x^2 + 4q^2(y^2 + Z^2 + w^2) = n \) (Ramanujan conjecture, solved for this case by Eichler (1954) and Igusa (1959)).

Erdős applied the probabilistic method in many other contexts, in combinatorics as well as in number theory, geometry, and analysis. Let me state a beautiful example from analysis: In a 1959 paper with A. Dvoretzky, Erdős demonstrated the existence of a power series of the form \( \sum \alpha_n n^{-1/2} z^n \) with real \( \alpha_n \) that diverges on the whole unit circle.

To derandomize another probabilistic proof of Erdős in graph theory, Graham and Spencer (1971) invoked André Weil's character sum estimates, which imply, that, in some sense, "quadratic residues are random." Recently (1996) Kollár, Rónyai, and Szabó employed the elements of commutative algebra to derandomize, for infinitely many values of the parameters, a result of Erdős in extremal graph theory.

Our limited experience thus indicates that algebraic tools of considerable depth may hold the key to replacing probabilistic proofs of existence by explicit construction. In most cases, however, the Erdős-style proofs of existence cannot currently be matched by explicit constructions, a challenge that continues to grow with the increasing number of applications of the probabilistic method [1].

Why should we care about derandomizing probabilistic proofs of existence? The combinatorist may find the challenge and the beauty of the question inspiring. The reasons, however, run considerably deeper in the theory of computing. The central objective of that area is to show the intrinsic computational difficulty of explicit functions (the difficulty of computing a random function being evident).

The probabilistic method is most often used to demonstrate the existence of objects that are actually present in abundance. For instance, a random graph is very likely to have the right Ramsey parameter. Is the method doomed to fail when searching for rare objects? A coloring problem for set systems led Erdős and Lovász to the discovery of the Local Lemma (1974), a powerful tool to detect events of low but nonzero probability. Informally the lemma asserts that the intersection of a set of events, none of which correlates with more than a small number of others, is nonempty. This will demonstrate the existence of certain exponentially rare objects. We note that naive sampling will not encounter these objects. Algorithmic ver-

sions of this result, which actually find "the needle in the haystack," were obtained by J. Beck and subsequently by N. Alon (1991).

Erdős not only set up derandomization challenges but also invented an important derandomization tool in a 1973 paper with John Selfridge: the "method of conditional expectations." The method has since been extended and resulted in the derandomization of large classes of randomized algorithms.

For decades hardly anyone other than Erdős recognized the significance of the probabilistic method. The situation changed with the 1974 publication of Probabilistic Methods in Combinatorics by Erdős and Joel Spencer. This thin volume had a major impact on all areas of discrete mathematics.

References. We refer as [M4] to bibliography item [4] of the memorial article by this writer appearing elsewhere in this issue. Most papers of Erdős cited above can be found either in The Art of Counting [M4] or the bibliographies of the survey articles in [M12]. An enormous amount of relevant material appears in various chapters of the monumental Handbook of Combinatorics (3) below. Further references:

References

node systems and the behavior of the generated processes. These questions have been in the main stream of classical approximation theory.

However, within a very short time, Erdős began to formulate his own problems and outlined new paths to search, such as the closer investigation of the Lebesgue function of Lagrange interpolation, questions on the optimal Lebesgue constant, and rough and fine theories of different approximating tools. The first paper in his series "Problems and results on the theory of interpolation" appeared in 1958, followed by periodic updates (1961, 1968, 1976, 1980, 1983, 1991).

Over the years Erdős obtained (mainly with co-authors) fundamental and very strong theorems. We may mention the 1980 result on the a.e. (almost everywhere) divergence of Lagrange interpolation on an arbitrary system of nodes\(^2\), the Erdős condition on convergent interpolatory processes (with A. Kroó and J. Szabados, 1989), and the results on a.e. divergence of the arithmetic mean of Lagrange interpolation based on Chebyshev nodes (with G. Grünwald, 1937; an error in their proof was eliminated in a paper with G. Halasz, 1991).

Questions in approximation theory are closely related to the behavior of polynomials. So it is no surprise that Erdős wrote many papers dealing with the related problems about polynomials (Remez and other inequalities, the distribution of roots, length of polynomials, geometry of polynomials, etc.). Rather than going into the details of this subject, I conclude this survey with two influential “appetizers” and refer the interested reader to the monographs [4, 5].

Erdős’s work invariably attracted a great deal of attention and continues to influence the work of many mathematicians. This survey includes several lists of authors inspired by specific results of Erdős. References to their papers can be found in the bibliographies of the works listed in our “References.”

One of the most often-quoted results in approximation theory appeared in a 1937 paper by Erdős and Paul Turán in the Annals of Math. In this inaugural opus of their 3-piece series “On interpolation” the young authors proved the remarkable positive result that for any continuous function \(f\) the Lagrange interpolation polynomials converge in mean to \(f\) if the interpolation is taken over the roots of the system of orthogonal polynomials with respect to any weight function. More precisely they proved that for every \(f \in C\) and weight \(w\)

\[
(1) \quad \int_{-1}^{1} (f(x) - L_n(f, w, x))^2 w(x) \, dx \leq \sqrt{\delta E_{n-1}}(f).
\]

\(^2\)Note by the organizer: The coauthor of this striking result is P. Vértesi.

Erdős enjoyed working with several mathematicians on entirely different problems simultaneously. Left to right: G. Grätzer, Erdős, Paul Turán, and Alfréd Rényi at Dobogókő, Hungary, 1959. Turán was one of Erdős’s closest friends and his first major collaborator. Erdős and Turán worked together on a variety of subjects in number theory, classical analysis, combinatorics, and statistical group theory.

Here \(X = \{x_{kn}; 1 \leq k \leq n; n \in \mathbb{N}\} \subset f: [-1, 1] \) is an interpolatory matrix (i.e., for fixed \(n, x_{kn}\) are different); \(L_n(f, X, x) \in P_{n-1}\) is the \(n\)-th Lagrange interpolatory polynomial based on the nodes \(\{x_{kn}\}; 1 \leq k \leq n; w\) is a weight on \([-1, 1]\), i.e., \(w \geq 0\) and \(\int w > 0\); if \(\{x_{kn} = x_{kn}(w)\}\) where \(x_{kn}(w), 1 \leq k \leq n\) are the roots of the \(n\)-th orthonormal polynomial \((p_n(w))\) with respect to \(w, n \in \mathbb{N}\) (i.e., \(\int p_n(w)p_m(w)w = \delta_{nm}\)), then \(L_n(f, w)\) replaces \(L_n(f, X)\); finally, \(E_n(f) = \min_{P \in P_{n}} \|f - P\|\) where \(\|\ldots\|\) stands for the maximum norm on \(I\). Note that by Weierstrass’s Theorem, the right-hand side converges to 0 as \(n \to \infty\).

To appreciate this mean-convergence theorem, we state a fundamental negative result of G. Faber (1914), which says that for every \(X \subset I\) there is an \(f \in C\) with

\[
(2) \quad \limsup_{n \to \infty} \|L_n(f, X, x)\| = \infty.
\]

A natural question that challenged many mathematicians was to replace the exponent 2 with a larger one. Such results are known for special matrices. For instance, for the case of \(X = T = \frac{1}{2} \cos \frac{2k-1}{2n} \pi\) (Chebyshev matrix) Erdős and Feldheim proved in 1936 that
The corresponding trigonometric case is due to J. Marcinkiewicz. As it turned out almost forty years later, however, generally the exponent 2 cannot be improved. This nice result is due

Lebesgue estimated the difference \( L_n(f) - f \) by

\[
\lim_{n \to \infty} \frac{1}{n} \int_1^T |f(x) - L_n(f, T, x)|^p \frac{1}{\sqrt{1 - x^2}} \, dx = 0
\]

holds for any continuous \( f \) with arbitrary \( p > 0 \). The corresponding trigonometric case is due to J. Marcinkiewicz. As it turned out almost forty years later, however, generally the exponent 2 cannot be improved. This nice result is due to P. Nevai. Similar problems were considered by, among others, R. Askey, V. M. Badkov, B. Della Vecchia, G. Freud, G. Mastroianni, B. Muckenhoupt, D. S. Lubinsky, A. K. Varma, and Y. Xu (cf. [2]).

Lebesgue estimated the difference \( L_n(f) - f \) by

\[
|L_n(f, X, x) - f(x)| \leq \left( \lambda_n(X, x) + 1 \right) E_{n-1}(f).
\]

Here the \( n \)-th Lebesgue function \( \lambda_n(X, x) \) is defined as

\[
\lambda_n(X, x) := \sum_{k=1}^n |\xi_k(X, x)|^2,
\]

where the \( \xi_k(X, x) \) \( k \leq n \) are the (unique) fundamental polynomials corresponding to \( X \) (i.e., \( \xi_k(X, x) = \delta_{kj} \), \( k = j \geq n \), \( n \in \mathbb{N} \)). Relation (3) shows that the Lebesgue function \( \lambda_n(X, x) \) and the Lebesgue constant \( \Lambda_n(X) := \|\lambda_n(X)\| \) play a fundamental role concerning the convergence-divergence behavior of Lagrange interpolation.

In the seminal first paper in the "Problems ..." series (1958), Erdős proved that for any fixed \( X \subset [-1, 1] \), real \( \alpha > 0 \), \( A > 0 \), the measure of the set for which

\[
\lambda_n(X, x) \leq A, \quad x \in \mathbb{R}, \quad n \geq n_0(A, \alpha),
\]

is less than \( \varepsilon \).

The basic ideas of this work were used, developed, and completed by Erdős and many (co)authors (G. Halász, D. Newman, J. Knoppenberger, J. Szabados, A. K. Varma, P. Vértesi, Y. G. Shi) in a series of papers. These papers resulted in more or less "best possible" theorems on the behavior of \( \lambda_n(X, x) \) and similar expressions, and they gave far-reaching generalizations of the Faber theorem and the Grünwald-Marcinkiewicz result (see the papers highlighted in the fourth paragraph of this survey and further references in [1]).

It is natural to investigate the sequence

\[
\Lambda_n^* := \min_{X \subset \mathbb{C}} \lambda_n(X), \quad n \in \mathbb{N}.
\]

In the rather difficult second paper of the "Problems ..." series (1961) Erdős, improving on a joint result with P. Turán (1961), obtained the bound

\[
|\Lambda_n^* - \frac{2}{\pi} \log n| \leq c, \quad n \geq n_0,
\]

but the famous Bernstein-Erdős conjectures on the optimal matrix \( X^* \) for which \( \Lambda_n(X^*) = \Lambda_n^* \) and on the behavior of \( \lambda_n(X^*, x) \) were proved only in 1978 (T. Kilgore, C. deBoor, A. Pinkus, L. Brutman (cf. [1])). The bound (6) also attracted much interest; a long list of papers on this subject is cited in [1].

Let us now consider functions \( f \) satisfying the Lipschitz condition \( |f(x) - f(y)| \leq c|x - y|^\alpha \) with some constant \( c \); \( Lip(\alpha) \) denotes the class of such functions. For \( f \in Lip(\alpha) \), \( 0 < \alpha < 1 \), (3) yields the bound

\[
\|L_n(f, X) - f\| \leq cn^{-\alpha}\Lambda_n(X).
\]

In their 1955 joint paper "On the role of the Lebesgue function in the theory of Lagrange interpolation" Erdős and Turán established the following surprising facts.

Let us suppose that \( \Lambda_n(X) \sim n^\beta (\beta > 0) \). Then if \( \alpha > \beta \), we have uniform convergence for any \( f \in Lip(\alpha) \); if \( \alpha < \frac{\beta}{\beta + 1} \), then for some \( f_1 \in Lip(\alpha) \), \( \|L_n(f_1, X)\| \) is unbounded as \( n \to \infty \). However, if \( \frac{\beta}{\beta + 1} < \alpha < \beta \), then both convergence and divergence can happen.

This means that in the third case the convergence-divergence behavior of \( L_n(f, X) \) is not determined by the order of \( \Lambda_n(X) \) alone; we have to take a closer look at the matrix \( X \) itself. Erdős and Turán refer to the interval \( [\beta/(\beta + 2), \beta] \) as the domain of a "finer theory" and point out a number of analogous situations for further study.

This is an extremely influential work. Over the years dozens of papers tried to settle corresponding questions (rough and fine theory) for the trigonometric case, other operators, Hermite-Fejer interpolation, etc. (cf. [1]).

Now here are two results on polynomials. According to the Bernstein-Markov inequality,

\[
|p_n'(x)| \leq \min \left( \frac{n}{\sqrt{1 - x^2}}, n^2 \right) \cdot \|p_n\|, \quad |x| \leq 1, \quad p_n \in \mathcal{P}_n.
\]

However, as Erdős has shown in a short paper (1949), we can do better if we restrict the zeros of the polynomial. Namely, if \( p_n \in \mathcal{P}_n \) has no root in \(( -1, 1 ) \), then

\[
|p_n'(x)| \leq \min \left( \frac{4\sqrt{n}}{1 - x^2}, \frac{en}{2} \right) \cdot \|p_n\|, \quad |x| \leq 1.
\]

This result was one of the starting points of investigations on polynomials with restricted zeros and initiated many interesting general problems (cf. the works of P. Borwein, T. Erdélyi, M. von Golitschek, G. G. Lorentz, Y. Makovoz, A. Máté, J. Szabados, A. K. Varma, and others mentioned in the monograph [3]).

Let me close this survey with comments on another short paper by Erdős, "On the distribution
of roots of orthogonal polynomials." In this 1972 paper, which represents a bridge between approximation theory and polynomials, Erdős showed that certain weights \( w \) with infinite support have the so-called arcsine distribution; i.e., the distribution of the contracted zeros of the corresponding orthogonal polynomials is similar to the root-distribution of the Chebyshev polynomials ("Erdős-type weights," as they are referred to today).3)

During the last fifteen to twenty years investigations of so-called weighted approximations on \( \mathbb{R} \) (approximating \( f(x)w(x) \) by \( p_n(x)w(x) \), \( p_n \in P_n, x \in \mathbb{R} \)) have been very intensive; many approximating tools and formulae were developed (mainly for Erdős- and Freud-type weights) by G. Freud, A. Levin, D. S. Lubinsky, H. N. Mhaskar, P. Nevai, E. A. Rahmanov, E. B. Saff, J. L. Ullman, V. Totik, R. S. Varga, and their students (cf. the monograph [5] and the references therein). The next stage should be the investigation of the previously mentioned problems concerning weighted interpolation. The first steps have already been done; they clearly mark that Paul Erdős's ideas are very much alive.

References


3Let \( w(x) = e^{-\varphi(x)} \). If \( \varphi(x) = |x|^\alpha, \alpha > 1, x \in \mathbb{R} \) (Freud-weight), then \( w \) is not arcsine; on the other hand for \( \varphi_k(x) = \exp(\exp(\ldots \exp(|x|^{\alpha_k})\ldots)) \) (\( k \geq 1 \) times), \( \alpha > 0 \), \( x \in \mathbb{R} \) (Erdős-weight), \( w \) is arcsine (cf. Erdős-Freud (1974)).
The journal Asymptotic Analysis fulfills a twofold function. It aims at publishing original mathematical results in the theory of asymptotic problems affected by the presence of small or large parameters on the one hand, and at giving specific indications of their possible applications to different fields of natural sciences on the other hand.

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Report on the 1997 Survey of New Doctoral Recipients

This report presents a statistical profile of recipients of doctoral degrees awarded by departments in the mathematical sciences at universities in the United States during the period July 1, 1996, through June 30, 1997. It includes a preliminary analysis of the employment market for 1996-1997 doctoral recipients and a demographic profile summarizing characteristics of citizenship status, gender, and racial/ethnic group. Table 1 provides the response rates for the 1997 Survey of New Doctoral Recipients. Please see page 40 for a description of the Groups, newly defined for the 1996 Survey.

Table 1: Response Rates

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<td>Group II</td>
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</tr>
<tr>
<td>Group III</td>
<td>65 of 72 including 15 with 0 degrees</td>
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<tr>
<td>Group IV</td>
<td>60 of 81 including 6 with 0 degrees</td>
</tr>
<tr>
<td>Group Va</td>
<td>15 of 18</td>
</tr>
<tr>
<td>Group Vb</td>
<td>11 of 31 including 2 with 0 degrees</td>
</tr>
</tbody>
</table>

Revised Procedure for Survey of Employment Status

In prior years, the Data Committee has determined the employment status of doctoral recipients in two stages: departments were asked in May about the employment status of that year's doctoral recipients (using the Doctorates Granted form), and the individual recipients themselves were polled during the summer (using the Salaries and Professional Experience or SAPE form). Obviously, the employment information obtained from individuals is more accurate than the preliminary data obtained from departments, and it is the department data updated by the SAPE form that has been presented in previous First Reports from the Committee.

Beginning with the current year, the summer sampling of individual degree recipients using the SAPE form has been replaced by a fall mailing using an instrument known as Employment Experiences of New Doctoral Recipients. This new procedure will gather additional information and permit comparisons with employment patterns in other disciplines, but its timing prevents having the more accurate employment data from individuals available for the Committee's First Report.

To permit comparisons with last year's employment data, some of that data has been adjusted using 1995-1996 departmental responses.

This first report on the 1997 Survey includes information about the employment of 1996-1997 new doctoral recipients and salary data on faculty members in four-year colleges and universities. The report is based on information collected from questionnaires distributed in May to departments in the mathematical sciences in colleges and universities in the United States. A further questionnaire concerned with data on fall enrollments, majors, and departmental size was distributed in September. These data will appear in the Second Report on the 1997 Survey in a summer 1998 issue of the Notices.

The 1997 Annual AMS-IMS-MAA Survey represents the forty-first in an annual series begun in 1957 by the Society. The 1997 Survey is under the direction of the AMS-IMS-MAA Data Committee, whose members are Paul W. Davis (chair), Malay Ghosh, Mary W. Gray, Don O. Loftsgaarden, James W. Maxwell (ex officio), M. Beth Ruskai, Ann K. Stehney, and Ann E. Watkins. The committee is assisted by AMS staff member Kinda Remick. Comments or suggestions regarding this Survey Report may be directed to the committee.
Highlights
Based on responses from departments alone (see Revised Employment Status Survey Procedure), the preliminary unemployment rate among the 1,158 new doctoral recipients from the 1996-1997 academic year has dropped to 6.8 percent, a significant change from the prior year’s adjusted figure of 10.1 percent. This fraction is the lowest since the fall 1990 rate of 5.7 percent. Of those doctoral recipients employed in the U.S., 63.9 percent hold jobs in academia, down from the prior year’s adjusted figure of 70.1 percent. The fraction employed in nonacademic positions has increased significantly from 29.9 percent to 36.1 percent.

Of the 1996-1997 doctoral recipients, 3.3 percent hold part-time positions and 7.5 percent are employed at the same institution that awarded their degree, though not necessarily in the same department. Adjusted figures from 1995-1996 are 2.7 percent part-time and 6.1 percent in the same institution.

Women account for 28.7 percent of U.S. citizens receiving doctorates, the highest proportion ever reported. Among U.S. citizen doctoral recipients, 9 are black (6 men, 3 women) and 14 are Mexican American, Puerto Rican, or other Hispanic (9 men, 5 women). The former total is the same as last year’s, while the latter is an increase of 5.

The total number of 1,158 doctoral degrees awarded by U.S. mathematical sciences departments is nearly unchanged from last year’s 1,153, the first moderation in the peak-to-peak oscillations of about 150 degrees that characterized the preceding four years. Of those degrees, 516 were awarded to U.S. citizens, an increase of 4.5 percent from last year’s fall count of 493; 642 non-U.S. citizens received doctorates, down slightly from 657 in 1995-1996.

The 1997 fall count of the total number of new doctoral recipients of 1,158 represents only a slight increase from the 1996 fall count of 1,153. After four years of the fall count oscillating by about 150 individuals every other year, the count has leveled off near the midpoint for the second year in a row.

Table 28 records the annual number of new doctoral recipients in the mathematical sciences in the U.S. from the year 1992-1993, exclusive of Group Vb. The response rate for Group Vb, which includes some departments in engineering and management science, is the lowest of all groups.

The Annual Survey of New Doctoral Recipients provides a view of the employment market for new Ph.D.s in the mathematical sciences from the perspective of job applicants. Additional information about recruitment by four-year colleges and universities is reported in the Second Report of the Annual Survey; see the 1996 Second Report, Notices, September 1997, pages 911-921, for data on the numbers of positions departments attempted to fill and characteristics of the people hired for fall 1996.

As described in "Revised Procedure of Survey of Employment Status" at the beginning of this

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*Non-U.S. citizens who return to their country of citizenship and whose status is reported as "unknown" or "still seeking employment".

Table 3B: Employment Status of 1996–1997 U.S. New Doctoral Recipients by Type of Granting Department

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<th>TYPE OF DOCTORAL DEGREE-GRANTING DEPARTMENT</th>
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<th>ROW SUBTOTAL</th>
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*Non-U.S. citizens who return to their country of citizenship and whose status is reported as "unknown" or "still seeking employment".

JANUARY 1998 NOTICES OF THE AMS 35
Table 3C: Percentage of New Doctoral Recipients Unemployed (as reported in the respective Annual Survey Reports 1991–1997)

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<th>Year</th>
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<td>6.8</td>
<td></td>
</tr>
</tbody>
</table>


Beyond the unemployment statistics that are explicitly reported in Tables 3A, 3B, and 3C, the 1997 Survey provides other indicators about the job market. For example, 31 (3.3 percent) new doctoral recipients are reported to hold part-time positions, and 71 (7.5 percent) new doctoral recipients hold employment at the same institution that awarded their degree, although not necessarily in the same department in which the degree was earned. To compare with the corresponding statistics in 1996, 26 positions (2.7 percent) were part-time and 59 (6.1 percent) were held by doctoral recipients in the same institutions where they earned their doctoral degrees.

Most new doctoral recipients seek and accept academic positions. Of the 731 new doctoral recipients employed in the U.S., a total of 467 (63.9 percent) hold jobs in academia (including research institutes). For comparison, last year’s adjusted data showed 695 new doctoral recipients employed in the U.S., including 487 (70.1 percent) in academic positions. Thus total U.S. employment of new doctoral recipients has increased by 5.2 percent. The percentage of positions in academia decreased by 4.1 percent. Concomitantly, the number of nonacademic positions in the U.S. taken by new doctoral recipients increased from 29.9 percent to 36.1 percent of those employed in the U.S.

The 467 U.S. academic positions this year include a total of 211 in U.S. doctoral degree-granting departments (Groups I–V). This number is 9.8 percent lower than last year’s adjusted count (234 positions in Groups I–V). The number of new doctoral recipients employed by master’s and bachelor’s degree-granting colleges and universities (Groups M and B) increased by 7 (4.4 percent) from the number reported last year. While the number of new doctoral recipients hired by research institutes decreased (by 23.1 percent), the number of new doctoral recipients hired by government increased (by 14.3 percent) and hiring by business and industry increased markedly (by 28.9 percent) from last year. Employment of the new doctoral recipients by business and industry constitutes 31.7 percent of all U.S. employment of these new doctoral recipients. Last year, 25.9 percent were hired by business and industry.

Table 3B reveals the dependence of employment patterns on the type of department from which the doctoral degree is received. The patterns of compartmentalization and stratification of the job market for new doctoral recipients are even stronger than the patterns seen in the 1996 Survey. For example, Table 3B shows that new doctoral recipients hired for positions
in doctoral degree-granting mathematics departments (Groups I, II, III) are drawn predominantly from these same departments: 95.3 percent of the positions filled in Groups I, II, and III are held by those who received their degrees from Group I, II, or III departments. Similarly, 93.9 percent of the Group IV jobs held by new doctoral recipients went to Group IV degree recipients. These percentages compare with 91.5 percent and 87.1 percent, respectively, from the 1996 adjusted figures.

Women represent 24.8 percent of the population of new doctoral recipients, up from 21.6 percent in 1995–1996, but the proportion is not uniform across different types of departments. For example, 21.9 percent of the new doctoral recipients in mathematics (Groups I+II+III) are women (up from 20.7 percent last year), and 37.6 percent of the new doctoral recipients from statistics departments are women (up from 26.7 percent last year). The proportion of women among new doctoral recipients hired by doctoral degree-granting mathematics departments (20.6 percent) is slightly less than their proportion among mathematics doctoral recipients. The rate of unemployment for the female new doctoral recipients (7.8 percent) is greater than the rate for the male new doctoral recipients (6.5 percent).

Table 3B shows different rates of unemployment for doctoral recipients from the five groups. The percentages unemployed, among those whose employment status is known, are Group I (Public)-7.9 percent, Group I (Private)-2.7 percent, Group II-10.1 percent, Group III-4.2 percent, Group IV-4.2 percent, and Group V-12.3 percent.

Table 3D shows the pattern of employment within broad job categories broken down by the citizenship status of the new doctoral recipients. The citizenship status is known for all of the 1,158 new doctoral recipients. For those whose job status is known, the rate of unemployment for non-U.S. citizens is more than 3 percentage points lower than that for U.S. citizens (5.3 percent for noncitizens and 8.4 percent for citizens). Nevertheless, the unemployment rate for U.S. citizens is 2.3 percentage points below the level of last year’s adjusted data. The percentage of U.S. citizens in U.S. nonacademic jobs is lower than the percentage of noncitizens in the same category (23.0 percent of citizens versus 32.6 percent of noncitizens). The percentage of U.S. citizens holding positions in U.S. doctoral degree-granting departments (22.1 percent) is slightly lower than the percentage for non-U.S. citizens (22.6 percent). U.S. citizens hold positions in nondoctoral-degree granting U.S. departments in substantially higher proportion than do noncitizens (39.2 percent of citizens compared to 12.0 percent of noncitizens). All percentages exclude new doctoral recipients whose job status is unknown.

Of the temporary residents who received doctorates this year, 49.9 percent obtained U.S. employment, while 64.0 percent of the permanent residents found U.S. employment.

**Gender, Ethnicity, and Citizenship of U.S. New Doctoral Recipients, 1996–1997**

Table 4 presents a breakdown according to gender, ethnic group, and citizenship of the new doctoral recipients. The information reported in this table was obtained in summary form from the departments granting the degrees.

The citizenship status is known for all of the 1,158 new doctoral recipients, including 516 U.S. citizens. The number of U.S. citizen doctoral recipients is 4.0 percent more than the 1995–1996 figure of 496. Table 5 shows the changes from year to year in the numbers and proportions of U.S. citizens.

The percentage of U.S. citizens among the new doctoral recipients is 44.5 percent, a slight increase from last year’s percentage of 44.4 percent. A total of 642 noncitizens were awarded doctoral degrees by U.S. institutions in 1996–1997. This represents a decrease of 4 individuals (0.6 percent) from last year’s count of

<table>
<thead>
<tr>
<th>Table 3D: Employment Status of 1996–1997 U.S. New Doctoral Recipients by Citizenship Status</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TYPE OF EMPLOYER</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>U.S. Academic, Ph.D. Department</td>
</tr>
<tr>
<td>U.S. Academic, non-Ph.D. Department</td>
</tr>
<tr>
<td>U.S. Research Institute</td>
</tr>
<tr>
<td>U.S. Nonacademic</td>
</tr>
<tr>
<td>Foreign Academic</td>
</tr>
<tr>
<td>Foreign Nonacademic</td>
</tr>
<tr>
<td>Not seeking employment</td>
</tr>
<tr>
<td>Still seeking employment</td>
</tr>
<tr>
<td>Unknown (U.S. address given)</td>
</tr>
<tr>
<td>Unknown (foreign address given)</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
</tr>
</tbody>
</table>

* Column totals are rounded to the nearest whole percent.
The 1996-1997 count is 94.5 percent greater than the number awarded by U.S. institutions ten years ago (330 in 1984-1985).

Among the U.S. citizens receiving doctoral degrees in the mathematical sciences, 9 are black (6 men and 3 women) and 14 are Mexican American, Puerto Rican, or other Hispanic (9 men and 5 women). The former remained the same as compared to last year, while the latter increased by 5 individuals.

Women account for 28.7 percent of the U.S. citizens receiving doctoral degrees in the mathematical sciences from U.S. universities. This is the highest percentage ever reported. The total number of U.S. citizen women who were 1996-1997 doctoral recipients (148) increased by 27.6 percent from last year's reported 116, and is 3 more than the previous highest number, reported in 1992-1993 (see Table 6).

Note that in Tables 5 and 6 all years prior to 1982-1983 include doctoral recipients from computer science departments.

Acknowledgments
The Annual AMS-IMS-MAA Survey attempts to provide an accurate appraisal and analysis of various aspects of the academic mathematical sciences scene for the use and benefit of the community and for filling the information needs of the professional organizations. Every year, college and university departments in the United States are invited to respond. The Annual Survey relies heavily on the conscientious efforts of the dedicated staff members of these departments for the quality of its information. On behalf of the AMS-IMS-MAA Data Committee and the Annual Survey staff, we thank the many secretarial and administrative staff members in the mathematical sciences departments for their cooperation and assistance in responding to the survey questionnaires.

### Table 4: Gender, Ethnicity, and Citizenship of 1996-1997 U.S. New Doctoral Recipients

<table>
<thead>
<tr>
<th>RACIAL/ETHNIC GROUP</th>
<th>CITIZENSHIP MEN</th>
<th>CITIZENSHIP WOMEN</th>
</tr>
</thead>
<tbody>
<tr>
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<td>U.S. CITIZEN</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Permanent Visa</td>
<td>Temporary Visa</td>
</tr>
<tr>
<td>Asian or Pacific Islander</td>
<td>16</td>
<td>51</td>
</tr>
<tr>
<td>Black (non-Hispanic)</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>American Indian or Alaskan Native</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Hispanic</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>White (non-Hispanic)</td>
<td>335</td>
<td>40</td>
</tr>
<tr>
<td>Unknown</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>368</td>
<td>95</td>
</tr>
</tbody>
</table>

|                             |                  |                  |                  |                  |
|                             | U.S. CITIZEN    |                  |                  |                  |
|                             | Permanent Visa  | Temporary Visa    | Unknown Visa     | Total Women |
| Asian or Pacific Islander   | 5               | 29               | 58               | 3           | 95  |
| Black (non-Hispanic)       | 3               | 0                | 3                | 0           | 6   |
| American Indian or Alaskan Native | 0   | 0                | 0                | 0         | 1   |
| Hispanic                   | 5               | 1                | 7                | 0           | 13  |
| White (non-Hispanic)       | 135             | 11               | 26               | 1          | 173 |
| Unknown                    | 0               | 0                | 0                | 0          | 0   |
| TOTAL                      | 148             | 41               | 94               | 4         | 287 |

|                             |                  |                  |                  |                  |
|                             |                  |                  |                  |                  |
|                             |                  |                  |                  |                  |

### Bibliography


Table 5: U.S. Citizen Doctoral Recipients

<table>
<thead>
<tr>
<th>Year</th>
<th>Adjusted Total Doctorates Granted by U.S. Institutions</th>
<th>Total U.S. Citizen Doctoral Recipients</th>
<th>%</th>
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</thead>
<tbody>
<tr>
<td>76-77</td>
<td>901</td>
<td>689</td>
<td>76</td>
</tr>
<tr>
<td>77-78</td>
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<td>73</td>
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<td>78-79</td>
<td>806</td>
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<td>74</td>
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<td>79-80</td>
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<td>578</td>
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</tr>
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<td>81-82</td>
<td>798</td>
<td>519</td>
<td>65</td>
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<td>82-83</td>
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<td>85-86</td>
<td>755</td>
<td>386</td>
<td>51</td>
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<tr>
<td>86-87</td>
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<td>362</td>
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<td>798</td>
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<td>45</td>
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<td>88-89</td>
<td>884</td>
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<td>46</td>
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</tr>
<tr>
<td>96-97</td>
<td>1158</td>
<td>516</td>
<td>45</td>
</tr>
</tbody>
</table>

*Number of doctoral recipients whose citizenship is known. Total may vary from that reported on Table 3D of the respective First Reports as the data is gathered on different surveys.

Graph 5A: U.S. Citizen Doctoral Recipients

Table 6: U.S. Citizen Doctoral Recipients by Sex

<table>
<thead>
<tr>
<th>Year</th>
<th>Total U.S. Citizen Doctoral Recipients</th>
<th>Male</th>
<th>Female</th>
<th>% Female</th>
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</thead>
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<td>20</td>
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<td>81</td>
<td>20</td>
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<td>85-86</td>
<td>386</td>
<td>304</td>
<td>82</td>
<td>21</td>
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<td>86-87</td>
<td>362</td>
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<td>20</td>
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<td>96-97</td>
<td>516</td>
<td>368</td>
<td>148</td>
<td>29</td>
</tr>
</tbody>
</table>
Reclassification of Departments

As has been the case for a number of years, much of the data in these reports is presented for departments divided into groups according to several characteristics, the principal one being the highest degree offered in the mathematical sciences. Doctorate-granting departments of mathematics are further subdivided according to their ranking of "scholarly quality of program faculty" as reported in the 1995 publication Research-Doctorate Programs in the United States: Continuity and Change. These rankings update those reported in a previous study published in 1982. Consequently, the departments which now comprise Groups I, II, and III differ significantly from those used prior to the 1996 Survey.

The subdivision of the Group I institutions into Group I Public and Group I Private was new for last year's survey. With the increase in number of the Group I departments from 39 to 48, the AMS-IMS-MAA Data Committee judged that a further subdivision along the lines of public and private would provide more meaningful reporting of the data for these departments.

Brief descriptions of the groupings used for reporting purposes are as follows:

- Group I is composed of 48 departments with scores in the 3.00-5.00 range.
- Group II is composed of 56 departments with scores in the 2.00-2.99 range.
- Group III contains the remaining U.S. departments reporting a doctoral program, including a number of departments not included in the 1995 ranking program faculty.
- Group IV contains U.S. departments (or programs) of statistics, biostatistics, and biometrics reporting a doctoral program.
- Group V contains U.S. departments (or programs) in applied mathematics/applied science, operations research, and management science which report a doctoral program.
- Group Va is applied mathematics/applied science; Group Vb is operations research and management science.
- Group M contains U.S. departments granting a master's degree as the highest graduate degree.
- Group B contains U.S. departments granting a baccalaureate degree only.

Salary Survey for Faculty

The charts on the following pages display faculty salary data for Groups I Public, I Private, I, II, III, IV, V, M, and B: faculty salary distribution by rank, mean salaries by rank, information on quartiles by rank, and the number of usable returns for the group. Since groupings used for the mathematics departments in this year's report differ from years prior to 1995-1996, comparisons are possible only to last year's data. Departments were asked to report the number of faculty whose 1997-1998 academic-year salaries fell within given salary intervals. Reporting salary data in this fashion eliminates some of the concerns about confidentiality but does not permit determination of actual quartiles. What can be determined is the salary interval in which the quartiles occur; the salary intervals containing the quartiles are denoted by $<n, n+5>$.
### Group I Public Faculty Salaries
Doctoral degree-granting departments of mathematics (25)  
21 usable responses (84%)

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
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<td>&lt;40,45&gt;</td>
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<td>47,451</td>
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<td>&lt;90,95&gt;</td>
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<td>&lt;105,110</td>
<td>99,518</td>
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</tbody>
</table>

1997-1998 Academic Year Salaries (in thousands of dollars)

### Group I Private Faculty Salaries
Doctoral degree-granting departments of mathematics (23)  
16 usable responses (70%)

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Assistant Professor</td>
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<tr>
<td>Full Professor</td>
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<td>115,120</td>
<td>&gt; 120</td>
<td></td>
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</tbody>
</table>

1997-1998 Academic Year Salaries (in thousands of dollars)
Group II Faculty Salaries

Doctoral degree-granting departments of mathematics (56)
45 usable responses (80%)

<table>
<thead>
<tr>
<th>Rank</th>
<th>No. Reported</th>
<th>Q1</th>
<th>Median</th>
<th>Q3</th>
<th>Mean</th>
<th>1996-1997 Mean</th>
</tr>
</thead>
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1997-1998 Academic Year Salaries (in thousands of dollars)

Group III Faculty Salaries

Doctoral degree-granting departments of mathematics (72)
58 usable responses (81%)

<table>
<thead>
<tr>
<th>Rank</th>
<th>No. Reported</th>
<th>Q1</th>
<th>Median</th>
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<th>Mean</th>
<th>1996-1997 Mean</th>
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<td>&lt;40,45&gt;</td>
<td>&lt;45,50&gt;</td>
<td>&lt;50,55&gt;</td>
<td>50,643</td>
<td>48,426</td>
</tr>
<tr>
<td>Full Professor</td>
<td>552</td>
<td>&lt;55,60&gt;</td>
<td>&lt;60,65&gt;</td>
<td>&lt;70,75&gt;</td>
<td>67,337</td>
<td>64,406</td>
</tr>
</tbody>
</table>

1997-1998 Academic Year Salaries (in thousands of dollars)
Group IV Faculty Salaries
Doctoral degree-granting departments of statistics, biostatistics, biometrics (77)
53 usable responses (69%)

<table>
<thead>
<tr>
<th>Rank</th>
<th>No. Reported</th>
<th>Q1</th>
<th>Median</th>
<th>Q3</th>
<th>Mean</th>
<th>Mean</th>
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</thead>
<tbody>
<tr>
<td>Assistant Professor</td>
<td>123</td>
<td>&lt;45,50&gt;</td>
<td>&lt;50,55&gt;</td>
<td>&gt;50,55&gt;</td>
<td>49,668</td>
<td>46,836</td>
</tr>
<tr>
<td>Associate Professor</td>
<td>154</td>
<td>&lt;50,55&gt;</td>
<td>&lt;60,65&gt;</td>
<td>&gt;60,65&gt;</td>
<td>57,112</td>
<td>54,714</td>
</tr>
<tr>
<td>Full Professor</td>
<td>378</td>
<td>&lt;65,70&gt;</td>
<td>&lt;75,80&gt;</td>
<td>&lt;95,100&gt;</td>
<td>82,577</td>
<td>79,469</td>
</tr>
</tbody>
</table>

Group V Faculty Salaries
Doctoral degree-granting departments of applied mathematics and oper. res. (31)
16 usable responses (52%)

<table>
<thead>
<tr>
<th>Rank</th>
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<th>Median</th>
<th>Q3</th>
<th>Mean</th>
<th>Mean</th>
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</thead>
<tbody>
<tr>
<td>Assistant Professor</td>
<td>32</td>
<td>&lt;50,55&gt;</td>
<td>&lt;60,65&gt;</td>
<td>&gt;60,65&gt;</td>
<td>59,407</td>
<td>55,122</td>
</tr>
<tr>
<td>Associate Professor</td>
<td>44</td>
<td>&lt;55,60&gt;</td>
<td>&lt;65,70&gt;</td>
<td>&gt;65,70&gt;</td>
<td>60,606</td>
<td>59,133</td>
</tr>
<tr>
<td>Full Professor</td>
<td>114</td>
<td>&lt;70,75&gt;</td>
<td>&lt;85,90&gt;</td>
<td>&lt;100,105&gt;</td>
<td>91,202</td>
<td>87,205</td>
</tr>
</tbody>
</table>

1997-1998 Academic Year Salaries (in thousands of dollars)
Group M Faculty Salaries
Master's degree-granting departments of mathematics (234)
132 usable responses (56%)

<table>
<thead>
<tr>
<th>Rank</th>
<th>No. Reported</th>
<th>Q1 Median</th>
<th>Q3 Median</th>
<th>Q1 Mean</th>
<th>Q3 Mean</th>
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</thead>
<tbody>
<tr>
<td>Assistant Professor</td>
<td>552</td>
<td>&lt;35, 40&gt;</td>
<td>&lt;40, 45&gt;</td>
<td>39,984</td>
<td>39,722</td>
</tr>
<tr>
<td>Associate Professor</td>
<td>809</td>
<td>&lt;40, 45&gt;</td>
<td>&lt;50, 55&gt;</td>
<td>48,876</td>
<td>48,275</td>
</tr>
<tr>
<td>Full Professor</td>
<td>1022</td>
<td>&lt;50, 55&gt;</td>
<td>&lt;60, 65&gt;</td>
<td>61,778</td>
<td>61,594</td>
</tr>
</tbody>
</table>

1997-1998 Academic Year Salaries (in thousands of dollars)

Group B Faculty Salaries
Bachelor's degree-granting departments of mathematics (923)
364 usable responses (39%)

<table>
<thead>
<tr>
<th>Rank</th>
<th>No. Reported</th>
<th>Q1 Median</th>
<th>Q3 Median</th>
<th>Q1 Mean</th>
<th>Q3 Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assistant Professor</td>
<td>778</td>
<td>&lt;30, 35&gt;</td>
<td>&lt;40, 45&gt;</td>
<td>37,905</td>
<td>32,993</td>
</tr>
<tr>
<td>Associate Professor</td>
<td>883</td>
<td>&lt;40, 45&gt;</td>
<td>&lt;50, 55&gt;</td>
<td>46,377</td>
<td>45,268</td>
</tr>
<tr>
<td>Full Professor</td>
<td>981</td>
<td>&lt;45, 50&gt;</td>
<td>&lt;65, 70&gt;</td>
<td>58,107</td>
<td>57,151</td>
</tr>
</tbody>
</table>

1997-1998 Academic Year Salaries (in thousands of dollars)
Doctoral Degrees Conferred
1996-1997

ALABAMA

Auburn University (12)
Discrete and Statistical Sciences
Boling, Patricia, Bowtie algorithm for Steiner triple systems.
Kirkpatrick, Kimberly, Small graph decompositions.
Pike, David A., Hamilton decompositions of graphs.
Raines, Michael Edwin, Embedding partial extended triple systems and partial totally symmetric quasigroups.
Rinker, Susan Serrano, Multi two-path designs.
Wu, Yi-Hong, Discrete logarithm cryptosystems.
Yin, Carol Moore, Generalized Steiner systems.

Mathematics
DeLucia, Luis Gualberto, Dense mixed sphere packings and thin mixed sphere coverings.
Fang, Fengchun, Positive solutions of a class of boundary value problems.
Lauer, Susan Denese, Positive solutions of boundary value problems for nonlinear difference equations.
Smith, Kerry Dale, On normality, countable paracompactness and related properties.
West, Jane Elizabeth Kirchner, Subgroup transitivity in primary abelian groups.

University of Alabama, Huntsville (1)
Mathematical Sciences
Shi, Xingzhong, Numerical investigation of the stable nocturnal boundary layer.

University of Alabama, Tuscaloosa (1)
Applied Statistics
Balgopal, Ramaswamy, Applications of the Frobenius norm criterion in multivariate analysis.

ALASKA

University of Alaska (1)
Mathematical Sciences
Luca, Florian, The algebra of Green and Mackey functors.

ARIZONA

Arizona State University (3)
Mathematics
Han, Gil-Jun, On determinacy and unfolding of degenerate equilibria with a linear part $X' = y, y' = 0$.

University of Arizona (7)
Applied Mathematics
Samsonovich, Alexei, Attractor map theory of the hippocampal representation of space.
Warrick, Abbie Lynn, Application of wavelet and Radon based techniques to the internal wake problem in synthetic aperture radar images.
Wong, Tityik, Contributions to the theory of stochastic orders.

MATHEMATICS

Cheng, Yu-Wen, Endomorphisms of modules over valuation domains.
Dang, Son Xu, The C function for affine Kac-Moody algebras.
El Hadrami, Mohamed Lernine Ould, Poisson algebras and convexity.
Keisling, John, Approach to equilibrium for Markovian infinite particle systems with exclusion interaction.

ARKANSAS

University of Arkansas, Fayetteville (1)
Mathematical Sciences
Tecelezhgi, Beimnet, Endomorphisms of symmetric semigroups on a finite set.

CALIFORNIA

California Institute of Technology (8)
Applied Mathematics
Baustein, Anatoly, Nonlinear wave equations with shear.
Haroldsen, David, The numerical calculation of three-dimensional water waves using a boundary integral method.
Rathinam, Muruhan, Differentially flat nonlinear control systems.
Regelson, Moira, Problem structure and function classification using hidden Markov models.

Mathematics
Binder, Ilia, Rotation spectrum of planar domains.
Jackson, Frances, Sum-dual characterizations of the translation group on $\mathbb{R}$.
Kiselev, Alexander, Absolutely continuous spectrum of one-dimensional Schrödinger operators and Jacobi matrices with slowly decreasing potentials.
Li, Xuhua, Some results on projective equivalence relations.

The above list contains the names and thesis titles of recipients of doctoral degrees in the mathematical sciences (July 1, 1996, to June 30, 1997) reported in the 1997 Annual AMS-IMS-MAA Survey by 220 departments in 155 universities in the United States. Each entry contains the name of the recipient and the thesis title. The number in parentheses following the name of the university is the number of degrees listed for that university. A supplementary list, containing names received since compilation of this list, will appear in a summer 1998 issue of the Notices.
Claremont Graduate School (4)
MATHEMATICS
Luzardo-Flores, Jose Alberto, Neural networks for approximation and control of continuous time nonlinear systems.
Molony, Jeffrey Louis, Studies in geometric theory: Nonlinear dynamical systems.
Xiong, Kaliqi, Analysis of a class of nonlinear dynamical systems and applications to neural networks.

Stanford University (11)
MATHEMATICS
Abreu, Miguel Tribolet, Topology of symplectomorphism groups of $S^2 \times S^2$.
Bayrooi, Afshin, Volume growth of geodesic balls in simply connected solvable Lie groups.
Bray, Hubert Lewis, Isoperimetric surfaces and the Penrose conjecture in general relativity.
Gritsch, Ursula, Morse theory for the Yang-Mills functional over equivariant four-manifolds and equivariant homotopy theory.
Hind, Richard, Filling by holomorphic disks with weakly pseudoconvex boundary conditions.
Hoffman, Christopher Eric, A Markov random field which is $k$ but not Bernoulli and other constructions.
Luperio, Ernesto, Real Holomorphic Betti periodicity, loop groups, and stabilization of monopoles.
Roskies, Julie Rina, The minimal representation of $SO(4,3)$ over a $\mathfrak{p}$-adic field.

University of California, Berkeley (34)
BIOSTATISTICS
Hogeboom, Charissa Jean, Studying the relationship between change and initial value in clustered data subject to regression toward the mean.
Perrell, Sandra, Malani’s modified Kaplan-Meier estimator using the $k$th nearest neighbor algorithm.
Rizzardi, Mark, She loves me, she loves me not: Pondering over an ordinal-valued time series of tropical flowers.
INDUSTRIAL ENGINEERING AND OPERATIONS RESEARCH
Kang, Jeenyoung, A method for target scheduling for semiconductor wafer fabrication based on event-based optimization, modeling and discrete event simulation.

MATHEMATICS
Matanachai, Sittichai, Balancing objectives for mixed-model paced assembly lines.
Patankar, Ajit, Information management in next generation CIM systems.
Shorte, John, Physical and mathematical foundations of probabilistic engineering design with application to rotors.
Tseng, Chung-Li, On power system generation unit commitment problems.

University of California, Davis (9)
MATHEMATICS
Epstein, Judith Karen, On the invariants and isotopies of Legendrian and transverse knots.
Good, Joseph Henry, Embeddings of $sl(2,C)$ into the ring of differential operators.
Kimura, Masato, Commutative algebras of differential operators with matrix coefficients.
Pilliod, James Edward, Jr., A second-order unsplitted method for modeling flows in two-dimensional compressible flows.
Stecking, Michelle Marie, Almost normal surfaces in $3$-manifolds.
Truong, Binh Xuan, Generation of gravitational waves by acoustic wave interactions.
Winckler, Thomas Kohey, Stable cohomology of the invariants of the Lie subalgebra $L_{3n}$ of the Lie algebra of Hamiltonian vector fields.

STATISTICS
Jones, Geoffrey, The statistics of multiple immunosassay.

University of California, Los Angeles (16)
MATHEMATICS
Beineke, Jennifer, Renormalization of certain integrals defining triple product $L$-functions.
Cardona, Fernanda, Reidemeister theory for maps of pairs.
Chen, Jung-Kai (Alfred), Birational geometry of irregular varieties.
Dehghanpour, Fawzia, Meta-stability, nucleation and growth.
Floresi, Rita, Quantum homogeneous projective varieties.
Li, Archie, Incompressible Navier-Stokes flow about multiple moving bodies.
Lum, Christopher, Exact triangles in Galois cohomology and dihedral group extensions.
Michaelli, George, Multilevel homogeneity analysis.
Morrell, Maria, Non-existence of compact $\mathbb{S}$-torus manifolds.
Petrescu, Mihai, Existence of continuous families of complex projective spaces over finite fields.
Sharapov, Ilya, Multilevel subspace correction for large scale optimization problems.
Sweet, Ted, One dimensional real manifolds.
<table>
<thead>
<tr>
<th>University of California, Riverside</th>
<th>MATHEMATICS</th>
</tr>
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<tbody>
<tr>
<td>Tchernov, Vladimir, Vassiliev invariants of degree one of knots and links in $\mathbb{R}^3$ and $S^3$ fibrations.</td>
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<table>
<thead>
<tr>
<th>Mathematics and Computer Sciences</th>
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<tr>
<td>Chang, Hong, An algorithm for solving the ultimate pit problem with spatial consideration and a parallel implementation.</td>
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<tr>
<th>Colorado State University (11)</th>
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<tbody>
<tr>
<td>Mathematics</td>
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<tr>
<td>Hahn, David Williams, Quadruple covers of algebraic varieties.</td>
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<tr>
<th>Statistics</th>
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<tr>
<td>Schenider, Kimberly, Local to global for endomorphisms.</td>
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<tr>
<th>University of Denver (3)</th>
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<tbody>
<tr>
<td>Mathematics and Computer Science</td>
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<tr>
<td>Burt, Andrew, Algorithmically generating explanations of transformational algorithmic processes.</td>
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<tr>
<th>University of Northern Colorado (2)</th>
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<tbody>
<tr>
<td>Mathematical Sciences</td>
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<tr>
<td>Isom, Matthew, The effect of a writing-influenced curriculum on student beliefs about mathematics and mathematics achievement.</td>
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<tr>
<th>Connecticut (10)</th>
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<tbody>
<tr>
<td>Mathematics</td>
</tr>
<tr>
<td>Dai, Hong, Measuring and analyzing volatility risk in individual income.</td>
</tr>
</tbody>
</table>

Tazartes, Claudia, A systematic approach to selecting dualizing functions for use in pseudospectral electron correlation methods.

Vaysieb, Eduard, $\ast$-Operations and $\ast$-representations of cosemisimple Hopf algebras.

Webster, Corran, Local operator spaces and applications.

University of Colorado, Boulder (3) |
| Mathematics |
| Conroy, Mathew, Bilinear forms on residue classes. |

<table>
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<tr>
<th>University of Colorado, Denver (5)</th>
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<tbody>
<tr>
<td>Mathematics</td>
</tr>
<tr>
<td>Bandey, Victor, Black box multigrid for convection-diffusion equations on advanced computers.</td>
</tr>
</tbody>
</table>

Barth, Teri, Implementation of the conjugate gradient method using short multiple recursions.

Dean, David, An analysis of the stochastic approaches to the problems of flow and transport in porous media.

McKenna, Patricia, p-competition graphs and p-neighborhood graphs.


University of Denver (3) |
| Mathematics and Computer Science |
| Burt, Andrew, Algorithmically generating explanations of transformational algorithmic processes. |

Kannan, Rujgopal, Quadruple covers of algebraic varieties. |

Mohammad, Hassan Mikhail, Hopf ideals in a universal Hopf algebra, with applications. |

McKenna, Timothy, A characterization of imma for finite dimensional Hilbert space effects. |

University of Northern Colorado (2) |
| Mathematical Sciences |
| Isom, Matthew, The effect of a writing-influenced curriculum on student beliefs about mathematics and mathematics achievement. |

Mingus, Tabitha, A qualitative and quantitative study examining the effect a conceptual, constructivist approach to teaching linear algebra has on student attitudes and beliefs about mathematics. |

University of California, Santa Barbara (4) |
| Mathematics |
| Brookfield, Gary John, Monoids and categories of Noetherian modules. |

Coodey, Mark Raymond, Examining monotone operators using pictures and convex functions. |

Statistics and Applied Probability |
<table>
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<tbody>
<tr>
<td>Cho, Pokwon, Sequential estimation of the number of classes in a multinomial distribution.</td>
</tr>
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Muni, Aditi, Optimal termination testing procedure. |

University of Southern California (7) |
| Mathematics |
| Allen, Randall, Circle packings and conformal characterization. |

Kim, Insook, Rates of asymptotic regularity for the case of unbounded trajectories. |


Moon, Kyunghee, Gauss class groups. |

Murthy, P. Sivasubramanian, Harmonics and skew products and in time varying differential equations. |

Piterbarg, Vladimir V., Expansions and contractions of stochastic flows. |

Tanasevich, Miroslav S., Joint central limit theorem for sample-varying competing patterns. |

University of California, San Diego (7) |
| Mathematics |
| Carson, Trevor R., Logarithmic Sobolev inequalities for the free loop group. |

Cross, Carolyn Mae, Differentials of measure-preserving flows on path space. |

Deutsch, Reena, Survival prediction following HIV infection: Interval censored infection times and subsequent cognitive impairment and mortality. |

Howards, Hugh Nelson, Curves and surfaces in three-manifolds. |

Pollett, Christopher John, Arithmetic theories with prenex normal form induction. |

Yang, Jinghui, On recursive Boolean algebra. |

University of Colorado, Boulder (3) |
| Mathematics |
| Conroy, Mathew, Bilinear forms on residue classes. |

Hagler, Brian, A transformation of orthogonal polynomial sequences into orthogonal Laurent polynomial sequences. |

McNamee, John, On unstable complex James numbers. |

University of Colorado, Denver (5) |
| Mathematics |
| Bandey, Victor, Black box multigrid for convection-diffusion equations on advanced computers. |

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CONNECTICUT |
| University of Connecticut (10) |
| Mathematics |
| Dai, Hong, Measuring and analyzing volatility risk in individual income. |
Hill, Sharon, Numerical and theoretical analysis of the variational formulation of a wave water problem.

Krog, Karl Peter, Characterization of balanced and cobalanced Butler groups.

Pinchbeck, David, Nondiscrete groups of Möbius transformation.

Radicovic, Dragan, The bootstrap for empirical process under dependence.

Statistics

Ghosh, Sujit K., Modelling and analysis of multiple event survival data.

Larose, Daniel T., Bayesian approaches to meta-analysis.

Lou, Kuo-ren, Some aspects of Bayesian robustness.

Qiou, Zuqiang, Bayesian inference for stable processes.

Vlachos, Pantelis, Nonparametric Bayesian clinical trials design for multivariate patient response.

Wesleyan University (2)

Mathematics

Bassler, Otto Bradley, d topological entropy and pressure for amenable group actions.

McGrail, Treacey Baldwin, Model-theoretic results on ordinary and partial differential fields.

Yale University (20)

Biostatistics

Qi, Keqin, A model for incorporating the unspecified cases into cancer trends by histologic type.

Stack, Catherine, Fitting logistic regression models to two-stage case control data using existing methods and Bayesian techniques.

Mathematics

Aarao, Jorge Oswaldo Gomes, A transport equation of mixed type.

Bennett, Nicholas N., Signal analysis of chips: Detection, oscillatory kernels, and anisotropic wavelets.

Beveidge, Andrew John, Stopping rules and time reversal for finite Markov chains.

Farag, Hany M., Some affirmative results towards the Besicovich 1/2-conjecture.

Gao, Yan, Superrigidity for isometric group actions on CAT(0) spaces.

Graham, Stephen Emerson, An extension of the Kauffman-Mursaghi theorem.

Guglielmi, Ronald Jean Marie, Wavelet feature definition and extraction for classification and image.

Hurwood, William Ivin, System level fault diagnosis under static, dynamic, and distributed models.

Khovanov, Mikhail Gelfand, Graphical calculus, canonical bases and Kazhdan-Lusztig theory.

Kim, Julee, Hecke algebras of symplectic groups over p-adic fields and supercuspidal representations.

Mohnenkamp, Martin James, A fast transform for spherical harmonics.

Oh, Hee, Discrete subgroups generated by lattices in opposite horospherical subgroups.

Pelloni, Beatrice, Spectral methods for the numerical solution of nonlinear dispersive wave equation.

Statistics

Frick, Ronald D., Jr., Nonparametric control charts for multivariate data.

Lynch, Kevin, Mixture detection using oscillation properties of matched densities differences.

Reiminger-Scherer, Jonathan, Mixture models for block clustering.

Xie, Qun, Minimax coding and prediction.

Xu, Yuewu, Unidentifiable asymptotic problems.

Florida Institute of Technology (3)

Applied Mathematics

Alharbi, Abir, A neurocomputing approach to solving partial differential equations.

Richter, Stephen, System eigenvalue placement by decentralized feedback.

Wu, Limin, Regularization methods and algorithms for least squares and Kroncker product least squares problems.

Florida State University (5)

Mathematics

Berloff, Natalia G., Solitary and periodic solutions of nonlinear nonintegrable equations.

Duan, Zhanghui, Modified cubic lattice model, diamond lattice model, and study loop entanglement of semicrystalline polyethylene.

Gao, Shangzuo, Algorithms for determination of embedding dimensions for nonlinear analysis of chaotic time series and a study of fractal dimensions and predictabilities of weather attractors over the eastern United States.

Shusen, Ding, Conjugate A-Harmonic tensors.

Statistics

Wu, Shuai-Ming (Tom), Asymptotic bounds on the overflow probability in Markov-modulated fluid models.

University of Florida (3)

Industrial and Systems Engineering

Angelis, Diana Isaza, The effect of activity-based costing on traditional operations research models.

Mathematics

Peterson, Kevin, The stress spaces of bipartite frameworks.

Wang, Xibing, A construction of diffusion techniques.

University of Miami (4)

Mathematics and Computer Science

Browdy, Anne, The cohomology of lattices of partitions with restricted block size.

Garcia, Felix, Periodic solutions of a class of fourth-order nonlinear ordinary differential equations.

Giovinazzo, Alicia, Conceptual writing and its impact on performance in mathematical processes in college algebra.

Stine, Jay, Pre-Hausdorff objects in topological categories.

University of South Florida (6)

Mathematics

Belyi, Sergy, Operator-valued R-functions in the theory of linear dynamic systems.

Dhar, Subhankar, Probability measures on stochastic matrices.
Ding, Zouchua, Contribution to the theory of the existence of zeros of perturbations of nonlinear M-accretive operators in Banach spaces.

Eliahou, Mohamed, Identification of the parameters of a multivariate normal distribution by the distribution of the minimum.

Rieck, Michael, Pseudo-orthogonal complementary subspaces and hyperbolic partner graphs.

Veselov, Vladimir, A compactification of the Fatou mapping as a dynamical system.

GEORGIA

Emory University (7)

BIOSTATISTICS

Dunson, David B., Dose dependent cluster size and implications in quantitative risk assessment.

Durham, Laura K., Nonparametric exploration of waiting vaccine effects using survival data.

Sternberg, Maya R., Discrete time nonparametric estimation for chain of events data subject to interval censoring and truncation.

MATHEMATICS AND COMPUTER SCIENCE

Fuller, Allen George, On \([K_{1,3}, Z_2]\)-free graphs.

Goddard, Edward (Ted) Wayne, Ordered sets: Colorings and complexity.

Thoma, Lubos, Essays in extremal combinatorics.

Vysotina, Victoria, Generalized solution of the boundary-value problem on \(S^n\) for polyhedrons with prescribed integral curvature.

Georgia Institute of Technology (4)

MATHEMATICS

Dai, Wanyang, Brownian approximations for queuing networks with finite buffers: Modeling, heavy traffic analysis and double covers of genus three curves.

Leeds, Kevin Nathaniel, Lattice dynamical systems.

Dai, Wanyang, Zouhua, Shanh, Nonparametric regression with time series errors.

University of Georgia (7)

MATHEMATICS

Grantham, Jon, Frobenius pseudoprimes.

Smead, David, Homeomorphisms of three-manifolds containing genuine laminations.

Yin, Huasong, Deformation of special subvarieties of divisors associated to double covers of genus three curves.

Zhang, Hong, Asymptotic analyses of Levy flow.

HAWAII

University of Hawaii (1)

MATHEMATICS

Sun, Bohao, Stratifications and sufficiency of weighted jets.

IDAHO

Idaho State University (2)

MATHEMATICS

Molinsky, Michael, Math outside the math department: is it inevitable?

Pringle, Brian Craig, Splines.

University of Idaho (4)

MATHEMATICS

Bloomsburg, Pete, A refinement of the Erdos-Szekeres theorem.

Rieck, Michael, Branch and cut methods for mixed 0-1 convex programming.

Sternberg, Amy R., Structural stability for numerical methods.

Veselov, Vladimir, Approximation by bivariate splines with minimal support.

University of Hawaii, Carbondale (2)

MATHEMATICS

Barker, Fred, Dose dependent cluster size and implications in quantitative risk assessment.

Gurevich, Alex, Boundary regularity for free boundary problems.

Hanna, Mark M., Extra smoothness conditions for the wave equation.

Ma, Bing, On Bloch-Kato conjecture of Tamagawa number for Hecke characters of imaginary quadratic field.

Grantham, Jon, Contributions to the theory of the existence of zeros of perturbations of nonlinear M-accretive operators in Banach spaces.

Southern Illinois University, Carbondale (2)

MATHEMATICS

Gurgenidze, Barun, Spectral extremal for graphs.

Hara, Masahito, Boundary regularity for free boundary problems.

University of Chicago (14)

MATHEMATICS

Barham, Abdulrahim M., Robust confidence intervals for functions of variances and variance components.

Chiu, Yi-Lin, Measures of association and regression models for ordinal variables.

Dong, Guang, Estimation of product of parameters of a multivariate normal distribution by the distribution of the minimum.

Dutta, Goutam, A multi-period optimization based decision support system for strategic and operational planning.

Kim, Eungab, Stochastic scheduling for manufacturing systems.

Meltzer, Sanjay, Integrated models of facility location and network design.

Pringle, Brian, On Bloch-Kato conjecture of Tamagawa number for Hecke characters of imaginary quadratic field.

Rieck, Michael, Branch and cut methods for mixed 0-1 convex programming.

Summers, Gary, Industrial dynamics: An evolutionary model for an interactive simulation.

University of Georgia (7)

MATHEMATICS

Fiske, Michael, Non-autonomous systems applicable to neural computation.

Eliahou, Mohamed, Identification of the parameters of a multivariate normal distribution by the distribution of the minimum.

Dai, Wanyang, Zouhua, Shanh, Nonparametric regression with time series errors.

Veselov, Vladimir, Approximation by bivariate splines with minimal support.

University of Hawaii, Carbondale (2)

MATHEMATICS

Barker, Fred, Dose dependent cluster size and implications in quantitative risk assessment.

Gurevich, Alex, Boundary regularity for free boundary problems.

Hanna, Mark M., Extra smoothness conditions for the wave equation.

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Louisiana State University, Baton Rouge (9)
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**Boston University** (5)

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**WAYNE STATE UNIVERSITY (2)**

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Geoffroy, Pedro Jose, Poisson regression for overdispersed and correlated data.

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**MATHEMATICS**

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**MISSOURI**

**ST. LOUIS UNIVERSITY (1)**

**MATHEMATICS AND COMPUTER SCIENCE**

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**MATHEMATICS**

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**University of Nebraska, Lincoln (8)**

**MATHEMATICS AND STATISTICS**

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Pitchett, Stephanie, Generators of fractal ideal objects in the projective plane.
Morelli, Mike, Disconjugacy of third order linear difference equations.
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Rytle, Robert, Pseudo-varieties of inverse monoids.
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**NEW HAMPSHIRE**

**Dartmouth College (3)**

**MATHEMATICS**

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Gunter, Lawrence, Transformation monoids of algebraic number rings.
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**University of New Hampshire (3)**

**MATHEMATICS**

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Soucy-McCrane, Sharon Marie, Student interactions and mathematics discourse: A study of the development of discussions in a fifth grade classroom.

**NEW JERSEY**

**New Jersey Institute of Technology (1)**

**MATHEMATICS**

Pelesko, John, Diffusive and wavelike phenomena in thermal processing of materials.

**Princeton University (23)**

**APPLIED AND COMPUTATIONAL MATHEMATICS**

Gandhi, Amar S., From level to level: Course-graining/scaling in ecology.
Palsson, Eirikur, The CAMP signaling system in dicytostelium discoideum.

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Helfgott, Michel, Integrated calculus.
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Swanson, Wendy, Negative binomial estimation and testing: Comparison to minimum disparity methods.
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Tao, Terence, Three regularity results in harmonic analysis.

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Yip, Nungkwan, Stochastic perturbations in curvature driven flows.

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NEW MEXICO

New Mexico State University (1)

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NEW YORK

City University of New York, Graduate Center (10)

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Nicolezou, Bogdan, Kinematic and MHD dynamo action with multiple velocity modes.

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**State University of New York, Albany** (4)

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**State University of New York, Buffalo** (5)

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Graham, Mary Jane, A numerical study of Richtmyer-Meshkov instability driven by cylindrical shocks.

Harnett, Joan, Capital accumulation with population dynamics.


Hwang, Kwisung, Exact distributions of extreme value statistics for urn models with epidemiological applications.

Kaye, Kathryn, Stable cost allocations on minimum spanning tree networks.

Kone, Fatoumata, Estimating the volatility of stock markets.

Lewis, Herbert, The fleet coordination problem.

Li, Qian, Wave interactions and bifurcation for front tracking in three dimensions.

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Pass, Andrea, The analysis of continuous interfaces using compressible multi-component flow with front tracking.

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Lorek, Wladyslaw, Generalized Cauchy-Riemann operators in symplectic geometry.

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**Syracuse University** (4)

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Hutson, Alan, Quantile function estimation and applications.
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Roy, Abhijit, Transient analysis of queueing systems.

NORTH CAROLINA

Duke University, Raleigh (6)

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Desimone, Heather, Prediction using orthogonalized model mixing.
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Kao, Kuo-Yuan, Sums of hot and tepid mathematical games.

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Bowling Green State University (4)

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Case Western Reserve University (4)

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University of Pennsylvania (7)

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Brown University (8)

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Hull, Thomas C., Some problems in List coloring bipartite graphs.

SOUTH CAROLINA

Clemson University (4)

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TENNESSEE

University of Memphis (6)

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**Vanderbilt University** (2)

**MATHEMATICS**

Beshears, Aaron Christian, *G-iso-variant structure sets and stratified structure sets.*


**Texas**

**Rice University** (13)

**COMPUTATIONAL AND APPLIED MATHEMATICS**

Abd El-Mageed, Maissa, *3D First arrival traveltimes and amplitudes via eikonal and transport finite difference solvers.*

Argaez, Miguel, *Exact and inexact Newton linesearch interior-point algorithms for nonlinear programming problems.*

Butera, Gwyneth, *The solution of a class of limited diversification portfolio selection problems.*

Das, Indranil, *Nonlinear multicriteria optimization and robust optimality.*

de Oliveira, Aurelio, *A class of preconditioners for large-scale linear systems for interior point methods for linear programming.*

Kie, Hector, *Krylov-secant methods for solving large-scale systems of coupled nonlinear parabolic equations.*

McCarthy, C. Maeve, *An investigation of the optimal design of the tallest unloaded column.*

Nolan, Clif, *Global analysis of linearized inversion for the acoustic wave equation.*


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Prokhorov, Igor, *Morse-Bott functions and the Witten Laplacian.*

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**Southern Methodist University** (5)

**MATHEMATICS**

Napierala, Malgorzata, *Univariate and multivariate, sequential and parallel integration on finite ranges.*

**STATISTICAL SCIENCE**

Ernst, Michael, *Permutation tests of bivariate interchangeability.*

Tang, Liang-jun, *Censored data: A large sample study of CDF estimates under constraints.*

Wan, Ying, *Significance testing for the robust Sib pair linkage method.*

Wang, Jinping, *Experimental design and statistical analysis in serial dilution assays.*

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Speegle, Aletta, *Sandwich composition rings.*

Speegle, Darrin, *S-essential wavelets and the into C(K) extension property.*

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Yi, Seongbaek, *An automatic bandwidth selector using one-sided cross-validation.*

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Balogh, Andras, *Local feedback regularization of three dimensional Navier-Stokes equations on bounded domains.*

Lauro, Ciro, *Output regulation for linear distributed parameter systems.*

Pinter, Gabriella, *Global attractors for damped abstract nonlinear hyperbolic systems.*

Xu, Wen, *Two sample comparisons with mixed discrete and continuous variates.*

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**MATHEMATICS**

Abrahm, Ross, *Automorphism groups of Abelian p-groups.*

Benningfield, Kirk, *Uniquely divisible topological semigroups.*

DeLaVina, Ermelinda, *Ramseyan properties and conjectures of Ji.""

Gillis, David, *Symmetric ODE's and coupled systems.*


Ruan, Guoqia, *Numerical solutions of some type of slightly compressible flow.*

Sanchez, Francisco, *On some splitting methods for the numerical solutions of the Navier-Stokes equations.*

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Zhai, Canfang, *Computation of rotating wave solutions of reaction diffusion systems.*

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**MATHEMATICS**

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Chua, James, *Tensor products of Banach spaces.*

**University of Texas, Arlington** (3)

**MATHEMATICS**

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**MATHEMATICS**

Androulakis, George, *Isomorphically polyhedral Banach spaces and mixed Tsirelson spaces of arbitrary distortion.*


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Dworkin, Steven, *Ergodic theory, X-ray diffraction and tilings of Euclidean space.*

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UTAH

University of Utah (6)

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Utah State University (2)

MATHEMATICS AND STATISTICS

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Yang, Junming, Properties of robust model selection.

VERMONT

University of Vermont (1)

MATHEMATICS AND STATISTICS

Zheng, Qifu, Generalized Watson transforms and applications.

VIRGINIA

University of Virginia (14)

APPLIED MATHEMATICS AND MECHANICS

Bourk, Rebecca, Temperature potential analysis of a compressible gas in a rapidly rotating cylinder.

Marchand, Richard James, Finite element approximations of control problems arising in nonlinear shell theory.

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Robeva, Raina, The sharp Markov property for Gaussian random fields and a problem of spectral synthesis in certain function spaces.

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Virginia Commonwealth University (2)

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Virginia Polytechnic Institute and State University (15)

MATHEMATICS

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Borisuk, Mark, Bifurcation analysis of a model of the frog egg cell cycle.

Cerezo, Graciela, Solution representation and identification for singular neutral functional differential equations.

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Mohammed, Salem, Mixed-integer mathematical programming optimization models and algorithms for an oil tanker routing and scheduling program.

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Rubio, Aurora, Distributed parameter control of thermal fluids.

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Welch, Wendell T., Nonlinear baroclinic adjustment and wavenumber selection as a mechanism for atmospheric heat transport.

Yang, Zhijun, A Cartesian grid method for elliptic boundary value problems in irregular regions.

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MATHEMATICS, STATISTICS AND COMPUTER SCIENCE

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University of Wisconsin, Madison (32)

MATHEMATICS

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MATHEMATICAL SCIENCES

Cai, Luchuan, Convergence and properties of wavelets on compact intervals.

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Lukic, Milan, Stochastic processes having sample paths in reproducing kernel Hilbert spaces with an application to white noise analysis.

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WYOMING

University of Wyoming (5)

MATHEMATICS

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Paul Erdős (1913–1996)
László Babai and Joel Spencer

Uncle Paul
Joel Spencer

Paul Erdős was a searcher, a searcher for mathematical truth.
Paul's place in the mathematical pantheon will be a matter of strong debate, for in that rarefied atmosphere he had a unique style. The late Ernst Straus said it best in a commemoration of Erdős's seventieth birthday.

In our century, in which mathematics is so strongly dominated by "theory constructors" he has remained the prince of problem solvers and the absolute monarch of problem posers. One of my friends—a great mathematician in his own right—complained to me that "Erdős only gives us corollaries of the great metatheorems which remain unformulated in the back of his mind."
I think there is much truth to that observation, but I don't agree that it would have been either feasible or desirable for Erdős to stop producing corollaries and concentrate on the formulation of his metatheorems. In many ways Paul Erdős is the Euler of our times, just as the "special" problems that Euler solved pointed the way to analytic and algebraic number theory, topology, combinatorics, function spaces, etc., so the methods and results of Erdős's work already let us see the outline of great new disciplines, such as combinatorial and probabilistic number theory, combinatorial geometry, probabilistic and transfinite combinatorics and graph theory, as well as many more yet to arise from his ideas.

Straus, who worked as an assistant to Albert Einstein, noted that Einstein chose physics over mathematics because he feared that one would waste one's powers in pursuing the many beautiful and attractive questions of mathematics without finding the central questions. Straus goes on,

Erdős has consistently and successfully violated every one of Einstein's prescriptions. He has succumbed to the seduction of every beautiful problem he
he encountered—and a great many have succumbed to him. This just proves to me that in the search for truth there is room for Don Juan's like Erdős and Sir Galahad's like Einstein.

I believe, and I am certainly most prejudiced on this score, that Paul's legacy will be strongest in discrete math. Paul's interest in this area dates back to a marvelous paper with George Szekeres in 1935, but it was after World War II that it really flourished. The rise of the discrete over the past half century has, I feel, two main causes. The first was the computer—how wonderful that this physical object has led to such intriguing mathematical questions. The second, with due respect to the many others, was the constant attention of Paul Erdős, with his famous admonition "Prove and conjecture!" Ramsey theory, extremal graph theory, random graphs—how many turrets in our mathematical castle were built one brick at a time with Paul's theorems and, equally important, his frequent and always penetrating conjectures.

My own research specialty, the probabilistic method, could surely be called the Erdős method. It was begun in 1947 with a three-page paper in the Bulletin of the American Mathematical Society. Paul proved the existence of a graph having certain Ramsey property without actually constructing it. In modern language he showed that an appropriately defined random graph would have the property with positive probability and hence that there must exist a graph with the property. For the next twenty years Paul was a "voice in the wilderness"; his colleagues admired his amazing results, but adaption of the methodology was slow. But Paul persevered—he was always driven by his personal sense of mathematical aesthetics, in which he had supreme confidence—and today the method is widely used in both discrete math and theoretical computer science.

There is no dispute over Paul's contribution to the spirit of mathematics. Paul Erdős was the most inspirational man I have ever met. I began working with Paul in the late 1960s, a tumultuous time when "do your own thing" was the adumbration that resonated so powerfully. But while others spoke of it, this was Paul's modus operandi. He had no job; he worked constantly. He had no home; the world was his home. Possessions were a nuisance, money a bore. He lived on a web of trust, traveling ceaselessly from center to center, spreading his mathematical pollen.

What drew so many of us into his circle? What explains the joy we have in speaking of this gentle man? Why do we love to tell Erdős stories? I have thought a great deal about this, and I think it comes down to a matter of belief or faith. We mathematicians know the beauties of our subject, and we hold a belief in its transcendent quality. God created the integers, the rest is the work of Man. Mathematical truth is immutable; it lies outside physical reality. When we show, for example, that two $n$-th powers never add up to an $n$-th power for $n \geq 3$, we have discovered a truth. This is our belief; this is our core motivating force. Yet our attempts to describe this belief to our nonmathematical friends are akin to describing the Almighty to an atheist. Paul embodied this belief in mathematical truth. His enormous talents and energies were given entirely to the Temple of Mathematics. He harbored no doubts about the importance, the absoluteness, of his quest. To see his faith was to be given faith. The religious world might better have understood Paul's special personal qualities. We knew him as Uncle Paul.

I do hope that one cornerstone of Paul's theology, if you will, will long survive. I refer to The Book. The Book consists of all the theorems of mathematics. For each theorem there is in The Book just one proof. It is the most aesthetic proof, the most insightful proof, what Paul called The Book proof. When one of Paul's myriad conjectures was resolved in an "ugly" way, Paul would be very happy to congratulate the prover, but would add, "Now, let's look for The Book proof." This platonic ideal spoke strongly to those of us in his circle. The mathematics was there; we had only to discover it. The intensity and the selflessness of the search for truth were described by the writer Jorge Luis Borges in his story "The Library of Babel". The narrator is a worker in this library, which contains on its infinite shelves all wisdom. He wanders its infinite corridors in search of what Paul Erdős might have called The Book. He cries out,

To me, it does not seem unlikely that on some shelf of the universe there lies a total book. I pray the unknown gods that some man—even if only one man, and though it may have been thousands of years ago!—may have examined and read it. If honor and wisdom and happiness are not for me, let them be for others. May heaven exist though my place be in hell. Let me be outraged and annihilated but may Thy enormous Library be justified, for one instant, in one being.

In the summer of 1985 I drove Paul to what many of us fondly remember as Yellow Pig Camp—a mathematics camp for talented high school students at Hampshire College. It was a beautiful day. The students loved Uncle Paul, and Paul enjoyed nothing more than the company of eager young minds. In my introduction to his lecture I discussed The Book, but I made the mistake of describing it as being "held by God". Paul began his lecture with a gentle correction that I shall never
Paul Erdős Just Left Town

László Babai

"Ask Uncle Paul before you spend months on a problem." Thus János Komlós summed up his many years of experience with Paul Erdős, the easily accessible magic font of knowledge.

Sadly, this recipe cannot be used anymore. Uncle Paul, who so cared for all of us, died of two successive heart attacks in Warsaw on September 20, 1996, while attending a graph theory workshop at the Banach Center.

The word spread like a brushfire; within a day most of the mathematical world knew. We gazed into our screens that brought the news, dumb-founded and struggling not to believe. Erdős had been a constant in our lives. He touched our minds as well as our hearts. His wry jokes about old age and stupidity had been around longer than most of us could remember; yet even at eighty he produced more papers per year than most of us do in a lifetime.

The mourners included Erdős's countless friends, coauthors, and all of us who had, time and again, observed his frail figure in conference lobbies across the globe, sunk in a chair, his mind open to link up with anyone interested in a mathematical problem.

Inimitable Style

A mathematician of unique style and vision, Erdős will remain on the short list of those whose work defines the mathematics of the twentieth century. Erdős's interests covered a multitude of branches of mathematics. Foremost among them were number theory, combinatorics (including graph theory), set theory, classical analysis (especially the theory of interpolation), and discrete geometry, but his work extended to many other fields, including probability theory, topology, group theory, complex functions, and more, spreading over 40 percent of the two-digit classifications of the Mathematical Reviews [13].

With over 1,500 papers to his name, Erdős was the most prolific mathematician of our time. He considered mathematics to be a social activity; he wrote joint papers with more than 450 coauthors. A mathematical prophet of the jet age, Erdős maintained no permanent home base and was constantly on the move from coast to coast, continent to continent, to visit his ever-growing circle of disciples. He traveled with a small suitcase containing all his earthly belongings. "Property is nuisance," he used to say, paraphrasing the French socialists who thought property was sin. For most of his life Erdős had no regular income. When in 1984 he was awarded the $50,000 Wolf Prize (shared with differential geomter Shing-Shen Chern), he promptly gave it away, keeping only $720 for himself.

Far from being a mathematical robot, Erdős was intensely interested in his human environment. He enjoyed classical music (which he called "noise"), he was well read in history, and he was informed about politics and society. Above all, he cared for the well-being of his friends and colleagues. "His money and his connections are available to promising students and mathematicians at all levels," wrote Ernst Straus in an eloquent tribute to Paul Erdős on the occasion of Erdős's seventieth birthday [17]. Erdős gave money to Ramanujan's widow (whom he never met), to relatives, colleagues, and students in need, including total strangers; he donated money to every worthy cause that came his way, which is amazing, given how little he had.

"How is the epsilon?" Erdős would inquire about the baby of a friend. Another type of epsilon, ranking very high among Erdős's concerns, was fledgling mathematical talent. Erdős made connections with many a gifted high school student and maintained the contact through phone calls and correspondence. He suggested problems, solved and unsolved, for them to work on and was intensely interested in their progress. These epsilons were his children. His favorite epsilon was Lajos Pósa, whom Erdős helped to write an influential paper on Hamilton cycles when Pósa was thirteen!

Although Erdős spent less than 10 percent of his time in Hungary after 1934, many of his foremost protégés are from his native country.

Then again, Erdős's interest in mentoring and collaboration knew no boundaries. Here is a characteristic story: In Hawaii, a brilliant high school senior by the name of David Williamson proves that an odd perfect number (if there is one) must have exactly one prime factor that is congruent to 1 (mod 4). He asks his mentor, a university professor, whether the result is known. The professor does not know the answer but suggests to David that he write to Paul Erdős, who has just left town. The student does not need to wait long for the reply:

\[2 \text{Cf. Erdős's 1971 article on "Child prodigies."} \]

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1 Erdős's name is pronounced "air-dish"; the "i" in "dish" sounds like the one in "first".

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Dear Mr. Williamson: (1985 IV 12)

Many thanks for your letter, which only reached me yesterday. The result you proved is in fact due to Euler. He also proved ... Perhaps the following problem of mine will interest you ...

"This letter to a high school student won't rank very high on Erdős's list of accomplishments, but it did mean a lot to me," comments Williamson, now an IBM researcher and a rising star in combinatorial optimization.

H. Halberstam and K. F. Roth preface their monograph on Sequences (of integers) with this acknowledgment: "Anyone who turns the pages of this book will immediately recognize the predominance of results due to Paul Erdős. Insofar as the substance of this book may be said to define a distinct branch of mathematics—and its wide range of topics in classical number theory appears to justify this claim—Erdős is certainly its founder...." The same can be said about an astonishing number of diverse areas of mathematics. Erdős's love of all these subjects resonates in the concluding words of the cited acknowledgment, shared by countless authors: "[Erdős's] unique insight and encyclopedic knowledge were, of course, invaluable, but the authors are no less indebted to him for his constant interest and encouragement."

A major way in which Erdős exerted his influence was in the open problems he posed. Straus writes: "In this century, in which mathematics is so strongly dominated by 'theory constructors,' he has remained the prince of problem solvers and the absolute monarch of problem posers."

With an incessant flow of elementary questions, Erdős breathed new life into a number of fields, including such seemingly dormant areas as Euclidean plane geometry, and helped create entire new disciplines, such as combinatorial number theory, Ramsey theory, transfinite combinatorics, extremal set theory, and the study of random structures.

Erdős's inimitable style of communicating directions of study in terms of interminable sequences of easily stated open problems helped focus attention on certain structures and phenomena more effectively than any philosophical pronouncements or project statements could have.

Erdős's childlike enthusiasm was contagious; it moved legions to attack his problems. Although Erdős never discussed the "big picture," it became evident to anyone who had some experience with problems Erdős disseminated (whether Erdős's own or someone else's) that they were pieces in a magnificent jigsaw puzzle; as a rule, both the results and the requisite techniques turned out to be profoundly relevant to large unexplored territories.

The Wizard from Budapest

Paul Erdős was born on March 26, 1913, in Budapest to Hungarian-Jewish parents. Erdős's birth was marred by tragedy: his sisters (ages five and three) contracted septic scarlet fever and died within a day while Paul's mother was in the maternity ward. A year and a half later World War I broke out, and very soon Erdős's father was captured by the Russians and taken as a POW to Siberia for six years. By the age of four Paul was able to multiply 4-digit numbers in his head. He would ask visitors their date of birth and tell them how many seconds they had lived.

Both of Erdős's parents were high school mathematics teachers, and Erdős received much of his early education from them. Erdős always remembered his parents with great affection. At sixteen his father introduced him to some of his lifetime favorite subjects: infinite series and set theory.

Erdős became an ardent solver of the problems proposed each month in KöMaL, the Mathematical and Physical Journal for Secondary Schools. Founded in 1893, this periodical is generally credited with a large share of Hungarian students' success in mathematics [15]. Erdős remained faithful to KöMaL and published several articles in it about problems in elementary plane geometry. At fourteen László Lovász came
In 1926 editor Andor Faragó started publishing the photographs of the best problem solvers of the Mathematical and Physical Journal for Secondary Schools ("KőMaL", Budapest), creating an invaluable archive. Top row: Erdős at 14 (1927) and at 17 (1930). Bottom row: Erdős' closest friends, Paul Turán at 17 (1927) and Tibor Gallai (aka Grünwald) at 18 (1930). KőMaL helped create the community of young math enthusiasts for over a century and is generally credited with a large share of Hungarian students' success in mathematics.

across one of these articles (1962) and was so enchanted that he read it "at least twenty times" and went on to become one of the most influential combinatorists of our time.

Back in the late 1920s it was on the pages of KőMaL that Erdős first encountered the names of his lifelong friends and collaborators, Paul Turán (1910-1976) and Tibor Gallai (then known as Grünwald) (1912-1992), among a large number of other young math enthusiasts.

As winners of national mathematics competitions, Erdős, Turán, and Gallai were admitted to Pázmány University, Budapest, in spite of the anti-Semitic "Numerus Clausus" law. The great analyst Leopold Fejér, professor at Pázmány University, Dénes König, professor at the Technical University of Budapest and author of the first monograph on graph theory (1936), and logician and number theorist László Kalmár from Szeged were major influences on young Erdős.

Under the shadow of the increasingly hostile social climate of the interwar period, Erdős and his friends escaped on weekly excursions into the hills of Budapest and discussed mathematics and politics. They forged friendships "that were the most lasting that I have ever known and which outlived...a vicious world war and our scattering to the four corners of the world," writes old pal George Szekeres in his moving foreword to The Art of Counting [4].

The political sympathies of this circle of friends lay with the left, including the underground Communists, the only organized force actively opposed to the extreme right menace. "L.A. is studying Jordan's theorem," Erdős would announce to his friends, having learned that their colleague László Alpár had been arrested (the prison walls represented the topological sphere in question).

Mathematics was the main subject in their conversations. With Erdős at the center these young people began to formulate exciting questions that would reverberate in a million forms throughout Erdős's work.

By the age of nineteen Erdős essentially completed his Ph.D. thesis, formally under Fejér. But the subject of Erdős's thesis was number theory; he proved the existence of prime numbers between $n$ and $2n$ belonging to certain arithmetic progressions. Erdős's proofs were striking for their elegance. By the time Erdős graduated (1934) his name was known among the leading number theorists of the time. Issai Schur called him "der Zauberer von Budapest" [18]. Louis Joel Mordell arranged a four-year fellowship for him to Manchester.

Erdős spent the years from 1934 to 1938 in Britain on the Manchester fellowship. "His wanderlust was already in evidence," remarks Béla Bollobás [2]; "from 1934 he hardly ever slept in the same bed for seven consecutive nights, frequently leaving Manchester for Cambridge, London, Bristol, and other universities." During the Manchester years he was working mostly on number theory; but he also initiated work in combinatorics and Ramsey theory, most notably with Richard Rado (1906-1989), his lifelong friend and collaborator, a German-Jewish expatriate who had just escaped the Nazis. Notably the Erdős–Ko–Rado theorem, one of the key results in extremal set theory, was conceived during this period. The result became an instant classic upon publication twenty-three years later! At the same time Erdős maintained his mathematical contacts with his friends in Budapest, working especially with Turán and Géza Grünwald on analysis and with Gallai on graph theory.

Safe but Jobless in America

Erdős always listened to the news on the radio. On September 3, 1938, he sensed the imminence of the desperate times looming over Europe. He bade a hasty goodbye to his parents, left Hungary the same day, and soon left the Continent. He moved to the U.S. and did not return to the Old World for a decade.

In 1938-39 he held a fellowship at the Institute for Advanced Study with a stipend of $1,500 for the year. Even in 1995, more than 1,300 papers later, Erdős remembered 1938-39 as his best year.
The crop included two seminal papers, with M. Kac and A. Wintner, on the distribution of values of additive functions. The paper with Kac established a central limit theorem for a class of additive functions. "Thus with a little impudence we would say that probabilistic number theory was born," Erdős wrote in 1995 [11].

In a mathematical adventure not uncommon for Erdős, he settled in short order the then outstanding unsolved problem of dimension theory: the (inductive) dimension of the set of rational points in Hilbert space. The experts expected the dimension to be zero or infinity, since this space is homeomorphic to its square. Erdős surprised the world by proving that the dimension is one.

In spite of these and other major results, Erdős's fellowship at the Institute was not renewed, and subsequently he was without a job for considerable periods of time and survived on small loans from colleagues. His financial situation improved temporarily with a "research instructorship" at Purdue in 1943, but after 1945 he was without a job again. Meanwhile, the flow of groundbreaking results continued unabated. Erdős's paper "On the law of the iterated logarithm" appeared in 1942; the first study of "inaccessible cardinals," fundamental to modern set theory, saw light in a paper by Erdős and Tarski in 1943, and the Erdős-Stone theorem, which opened up the field of extremal graph theory, appeared in 1946.

Throughout the war Erdős was in continual anguish over the fates of his parents and friends. Erdős's father died of a heart attack in Budapest in 1942. His mother fell into depression. There was no postal service between the U.S. and Hungary; Erdős tried in vain to contact his mother through intermediaries.

Hitler's forces descended upon Hungary on March 19, 1944. Within weeks the clockwork of the "Final Solution" engulfed Hungarian Jewry. Among those who perished were most of Erdős's relatives, including four of his mother's five siblings; many of Erdős's young friends, including Ervin Feldheim and Géza Grünwald, Erdős's early coauthors on the theory of interpolation; and also Dániel Arany, the founder of KöMaL, and Andor Faragó, the legendary editor and publisher of KöMaL through the interwar period. Dénes König, who had introduced Erdős and the world to graph theory, committed suicide when ordered by the janitor to move to the ghetto.

As if by a miracle, Erdős's beloved mother survived, as did Erdős's intimate friends Turán and Gallai. Another survivor was Vera Sós, Gallai's brilliant high school student. Sós later married Turán, and two decades later she became one of Erdős's foremost collaborators in combinatorics.

In July 1948 Erdős met Atle Selberg at the Institute for Advanced Study, and from their brief encounter an elementary proof of the Prime Number Theorem emerged. This result was prominently mentioned in Selberg's Fields Medal citation in 1950 and in Erdős's Cole Prize citation (AMS) in 1951. It is a sad note on the history of number theory that a controversy over the genesis of this seminal work prevented these two great mathematicians from further collaboration.

Erdős's correspondence was phenomenal. This sample letter was written in 1961 at the Technion (Israel), where Erdős held the title of a "permanent visiting professor." The letter, written in Hungarian, is addressed to Vera Sós and her husband, Paul Turán. Vera and TP, Pollak's proof runs as follows: Let \( A_1, \ldots \). The second page describes a proof by Rado. In the concluding paragraphs Erdős asks Turán to provide the address of a relative, reports that an article with Bollobás is nearly done, and emphatically urges Vera to finish an article (CIKK = article). Closing: Give my love to the e-s [a reference to the two children of Sós and Turán], Good-bye, E.P.
In autumn 1948 Erdős briefly visited Hungary. He rejoiced with his mother and his old friends who had survived.

By 1949 the Soviet-orchestrated conversion of Hungary into a communist state was in full swing, the borders hermetically closed, and Erdős was again unable to visit home for several years.

In 1952 Erdős finally landed a secure job at Notre Dame University. He lost that job two years later to McCarthyist paranoia: because of his connections to communist countries (number theorist Hua in China, Erdős's mother in Hungary) and his refusal to condemn Marx, the Immigration Service denied his reentry permit. Erdős could have stayed in the States, but he chose freedom over convenience, attended the International Congress of Mathematicians in Amsterdam without the reentry permit, and was unable to return to the U.S. for nine years (except for a brief visit on a “special visa”). In 1963, when Erdős’s name was finally removed from the list of “undesirable aliens,” he informed his audience at an AMS meeting with his characteristic humor that “Sam finally admitted me because he thinks I am too old and decrepit to overthrow him.”

“It is a sad commentary on our time and country that this man—so totally immersed in scholarly work, so remote from the political arena, a free spirit who lives by the highest moral standards—could be harassed by bureaucrats in high position whose duty is to protect our freedoms,” wrote Michael Golomb in the May 1977 issue of Science, commenting on the incident that deprived the U.S. mathematical community of the presence of Erdős for nine years and Erdős of his last regular job and his permanent-resident status in the U.S.

Once Erdős set foot on American soil, he took the country by storm. He acquired new friends at a phenomenal rate. At the 1963 meeting he met Ron Graham, who soon became one of his closest collaborators in number theory and combinatorics and for decades provided Erdős with a home base in New Jersey. A decade later Erdős was adopted into the family of graph theorist Ralph Faudree in Memphis; Faudree’s home became a fixed point on Erdős’s meandering trail, and Faudree became Erdős’s prolific coauthor on Ramsey-type problems in graph theory.

Back in 1954 a job in Israel “saved [Erdős] from starvation,” as he used to recall with gratitude. In 1955 the Technion appointed him a “permanent visiting professor,” a title he held until his death. After this appointment, he was listed in his passport as a resident of Israel, while maintaining his Hungarian citizenship. He forged close ties with the mathematical community of Israel. In 1976 he founded an award in Israel in memory of his par­ent’s accomplishment of young mathematicians. (He founded a similar award in Hungary in 1972.) The award carries great prestige. From his Wolf Prize (1984) Erdős endowed a postdoctoral fellowship at the Technion to commemorate his mother. Leading combinatorist Noga Alon first met Erdős at the Technion as a college freshman in 1975. Three years later Erdős told him a problem which became the subject of his M.Sc. thesis. “My very first paper was on an extremal problem suggested by Erdős; the first serious book in combinatorics I read was The Art of Counting [4]. ... I suppose I would have been a mathematician even if I had never met Erdős, but my work would have surely been totally different,” says Alon.

In 1957 Erdős became affiliated with the Mathematical Institute of the Hungarian Academy of Science, another permanent affiliation he would maintain for the rest of his life. Although Hungary remained under communist rule for three more
decades, after 1956 Erdős gained the singular privilege of being able to visit Hungary and leave. This allowed him to initiate and maintain several of his most prolific collaborations. With Rényi he created a fascinating new synthesis of combinatorics and probability in their landmark study “The evolution of random graphs” (1960, 1961). With Turán he studied interpolation and invented statistical group theory. With Hajnal he expounded combinatorial set theory. At a hillside resort of the Hungarian Academy of Science he enjoyed his mother's company and turned the place into a mathematician's Mecca; he worked simultaneously on diverse subjects with all his visitors. 

Erdős's uncompromising view on freedom and dignity compelled him to take a voluntary exile from Hungary in 1973 after the Hungarian government denied visas to Israeli mathematicians, including old friends of Erdős, who wished to attend a conference held in Hungary to celebrate Erdős's sixtieth birthday. "Joe is being trivi4 again," Erdős would declare, expressing his contempt. Erdős lifted his self-exile three years later to attend the deathbed of his dear friend, Paul Turán.

With his legendary suitcase Erdős circled the globe several times a year. He spent most of his time in the U.S., Canada, Hungary, Israel, the U.K., France, and The Netherlands, but visited many other countries around the globe with fair frequency, including a number of visits to Australia. His mother accompanied him on his journeys from 1964 until her death in Calgary in 1971 at the age of ninety-one.

After his mother's death Erdős became depressed, and he fought this by putting in 19-hour workdays. He continued to produce important results and conjectures at ever-increasing rates and initiated joint work with ever-new generations of mathematicians. Among the many to whom Erdós provided a thesis topic was Joel Spencer; Joel received at least fifteen honorary doctorates. He became a member of the national scientific academies of eight countries, including the U.S. National Academy of Sciences (1979) and the Royal Society (1989). Shortly before his death Erdős renounced his honorary degree from the University of Waterloo over what he saw as unfair treatment of combinatorist J.A. Bondy. “He died with his boots on,” remarked Ron Graham. Two days before his death he gave a splendid talk at the Banach Center. A day later he finished his last single-authored paper. With a ticket in his wallet he was ready to move on to the next conference: number theory in Lithuania.

Regardless of the sediments washed up around his figure by the ever-growing flow of legends, his brilliance in mathematics, the purity of his character, and his compassionate, hands-on humanism will clearly and irrevocably stand out.

"I am the epsilon from Szeged.
-14-year old math whiz Attila Máté introducing himself to Erdős's mother

Children become letters.
-Erdős's mother

Mathematicians become Collected Papers.
-Erdős, paraphrasing his mother

A surprising application of number theory.
-Paul Turán about his 1935 joint paper with Erdős published in Tomsk (Soviet Union). Turán used a reprint as his sole ID when a Soviet military patrol stopped him in the streets of liberated Budapest in 1945. The patrol was impressed, and Turán was saved from a trip to the GULAG.

I read the article at least twenty times.
-László Lovász about an article by Erdős on plane geometry in the Mathematical Journal for Secondary Schools. Lovász was 13 at the time.

I learned enormous quantities by collaborating with many members of the Erdős School.
-Avi Widgerson, Nevanlinna Prize laureate

In the search for truth there is room for Don Juan's like Erdős and Sir Galahad's like Einstein.
-E. G. Straus, who had worked with both Einstein and Erdős

By tragic coincidence, none of his close friends from the Banach Semester Erdős attended was in town at the time of his last struggle with the S.F.5

We do not know his last words. But his legacy is enormous. It lives on in the minds of his disciples, in his innumerable proofs and conjectures, in exciting gaps between upper and lower bounds, in tantalizing derandomization challenges presented by probabilistic proofs of existence, in our

4Trivi: truncation of "trivial." This Erdős-ese term translates roughly to "small-minded," "mean-spirited" (person, government, etc.).

5S.F.: Supreme Fascist, Erdős-ese for the God who sends us flu, misplaces our passports, and hides the pages of The Book from us.
pered with revealing stories on four decades of prolific collaboration [14], [12] also includes an entertaining article with a variety of statistics on Erdős's work and collaborations [13].

The bibliography below includes the books and book chapters written by Paul Erdős. [10] is a wonderful volume which captivated this writer at 16.

A video documentary on Erdős entitled “N Is a Number-A Portrait of Paul Erdős,” by George Paul Csicsery, is available from the MAA.

For more references we recommend the Web page http://www.cs.uchicago.edu/groups/theory/erdos.html.

Erdős's mother, Anna (1880-1971), joined her son on his journeys around the globe at age 84 and travelled with him everywhere until her death at 91. This photo shows mother and son in Melbourne, 1969.

own asymptotic questions, and in memories of a kind and generous human being who lived on a web of trust[^6], who, by his example, taught us trust and compassion.

Recommended Reading
[4] is a selection of Erdős's work in finite combinatorics. [18] is a profound yet enjoyable survey of all areas of Erdős's early work except set theory. It was written in 1963 by Paul Turán, Erdős's soul mate in several areas. [16] and [12] are two pairs of recent volumes containing a wealth of material on Paul Erdős and his mathematics. Both [16], vols. 1-2, and [12], vol. 2, contain up-to-date (at the time of publication) bibliographies of Erdős. A very special paper by Erdős appears in [16], vol. 2, on his favorite theorems [11]. For a biographic study of Erdős we refer to [1], [12] is a thoughtfully edited pair of volumes containing a number of superb survey articles on Erdős's work. The highlight of the volume is an article by Béla Bollobás, who summarizes Erdős's mathematical spectrum in thirty thoroughly enjoyable pages, in addition to providing eight pages of biography [3]. András Hajnal, Erdős's No. 1 collaborator, contributed an informative article to [12] on Erdős's set theory, a

[^6]: Phrase coined by Joel Spencer.

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Niels Vigand Pedersen, one of the leading mathematicians in the representation theory of solvable and nilpotent Lie groups, passed away on November 24, 1996, at the age of forty-seven. During his relatively short career he discovered many new themes and results in this area. His untimely death is a real tragedy for his mathematical colleagues and for mathematics in Denmark in general.

Let me begin with a few biographical details. Niels was born on March 12, 1949, and grew up near the village of Algestrup, not very far from Copenhagen. He started studying mathematics and physics at the University of Copenhagen when he was nineteen. His brilliance showed up almost at once, and he obtained his master's degree in 1975 with a thesis written under the guidance of Esben Kehlet. He became interested in the theory of representations of nilpotent and solvable Lie groups when he came across the remarkable papers of Dixmier, Kirillov, Moore, Auslander, Kostant, and Pukanszky in this subject, and this interest became deeper through visits to the Universities of Pennsylvania and Berkeley and contacts with Pukanszky and Michele Vergne. These experiences were critical in his maturation and development. His interaction with Pukanszky was especially deep and fruitful. They became good friends and remained so throughout their lives.

Niels joined the University of Copenhagen as a lektor (associate professor) in 1986 and remained there till the end. He was a very inspiring lecturer, and his interest in physics and other sciences allowed him to reach out to a very wide circle of students. In recognition of his ability as well as his dedication to teaching, he was given the teaching award of the science faculty in 1994.

I shall discuss his scientific work a little later in more detail, but let me mention here that he had great interest in computer algebra, especially in the development of algorithms at a very sophisticated level. He really understood the intimate relationship between proofs and their implementability by algorithms. Actually, in a case that I knew personally, the computerized calculations led him to a beautiful conjecture that he then was able to prove, to his great satisfaction. He represented Denmark in Euromath for some time, and I am sure his knowledge and enthusiasm for the role of computers in modern mathematics was a source of great help and inspiration to his colleagues in that organization.

He became the chair of the mathematics institute at the University of Copenhagen in 1993. It was not a particularly easy time to be at the helm, since the institutes of mathematics, mathematical statistics, and actuarial mathematics were struggling to come to terms with a number of difficult issues. To try to resolve them, an advisory group was created to review the work of these institutes. I was invited to be a member of this group. I visited

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This is an abridged version of a talk given at the conference on "Analysis on Lie groups and homogeneous spaces" held in Copenhagen, August 20-23, 1997.

For these I am indebted to an obituary written by Professor Henrik Schlichtkrull of the University of Copenhagen.
Copenhagen several times during the next two years. It was during these visits that I came to know Niels really well and to admire his science and personality. The task before our group was a complicated one, and the principal reason why we were able to come up with a unanimous report that was substantially acceptable to the institutes concerned was the collaboration of Niels. He was the epitome of courtesy and consideration for us, but at the same time his decisiveness and integrity were very instrumental in communicating to the group the views and interests of the institutes. His charm, sense of humor, and total lack of pretension made it very easy for us to do our job well.

The central themes of the theory of unitary representations of nilpotent and solvable Lie groups were well understood by the time Niels started his career, and it is a tribute to his penetration and persistance that he was able to obtain many beautiful results in this mature topic. Starting from around 1988, he discovered a more direct approach to many aspects of this theory that did not rely on induction but was based on ideas from quantization and symplectic geometry. In what follows I shall attempt in a limited way to give the reader a feeling for this aspect of his work. He carried out his program in the papers [1]-[5] and had obtained results for many additional papers when his life was cut short. I think these papers reveal him at his characteristic best. One of the guiding principles in the representation theory of Lie groups is that there is—or should be—a correspondence between the irreducible unitary representations of a Lie group and the orbits of the action of the Lie group on the dual of its Lie algebra. Actually this is one of the most fertile and profound principles that governs all of representation theory, not only of solvable groups, but also of semisimple groups. It relates representation theory to symplectic geometry, dynamical systems, and quantization, which are themes of unsurpassed beauty and scope. To mention only one aspect of this correspondence, the orbits, being symplectic manifolds, allow one to do Hamiltonian mechanics on them, and the unitary representation associated to an orbit may therefore be regarded as the quantization of the kinematics of this Hamiltonian manifold. Thus, in some way, the structure and geometry of the orbits give one a brief glimpse into the much richer world of irreducible unitary representations of the group.

Let $G$ be a Lie group, connected and simply connected, and $g$ its Lie algebra. Then $G$ has a natural action on $g$ through its adjoint representation $x \rightarrow Ad(x)$, and hence a natural action on $g^*$, the dual of $g$. We write $(x,X) \rightarrow xX$ and $(x,\ell) \rightarrow x\ell$ for these actions. For any $\ell \in g^*$ let $G_\ell$ be its stabilizer in $G$, and let $g_\ell$ be the Lie algebra of $G_\ell$. The orbit $O_\ell = G/ G_\ell$ of $\ell$ is then a regularly embedded submanifold and carries a natural $G$-invariant symplectic structure. In fact, the bilinear form

$$(X,Y) \rightarrow \ell([X,Y]) \quad (X,Y \in g)$$

has $g_\ell$ for its radical and so induces a symplectic form on $g/ g_\ell \times g/ g_\ell$, which can be identified with $T_\ell(O_\ell) \times T_\ell(O_\ell)$; here $T_\ell(O_\ell)$ is the tangent space to $O_\ell$ at $\ell$. This form can then be transported to all the points of the orbit by the action of $G$, and the resulting 2-form $\omega_\ell$ is smooth and closed. One can then in various ways construct a line bundle on a suitable quotient space of $O_\ell$ on which $G$ acts, and the resulting action of $G$ on the space of sections of this line bundle is a representation of $G$ that is associated to the orbit $O_\ell$. The theories of Kirillov, Moore-Auslander-Kostant, Pukanszky, and others all have the goal of describing these line bundles precisely and showing that all irreducible unitary representations of the group $G$ may be obtained by this procedure when $G$ is nilpotent or, more generally, solvable. This procedure, with its many generalizations and variants, is known as geometric quantization. In fact, if $G$ is the three-dimensional Heisenberg group, it leads to the representation that is central to (one-dimensional) quantum mechanics, involving the famous operators $\hat{q}, \hat{p}$ and the commutation rule

$$\hat{p}\hat{q} - \hat{q}\hat{p} = \frac{i}{\hbar} \ell.$$ 

The Kirillov theory, which dealt with nilpotent groups and which served as the model for all subsequent work along this path, is especially elegant and beautiful. Given $\ell$, one chooses a maximal isotropic subspace of $g$ for the form $\omega_\ell$ that is also a subalgebra, say $h_\ell$; if $H_\ell$ is the analytic subgroup of $G$ defined by $h_\ell$, then $H_\ell$ is closed and carries a unitary character (= one-dimensional representation) $\chi_\ell$ such that

$$X_\ell(\exp X) = e^{i\ell(X)} \quad (X \in h_\ell).$$

The unitary representation of $G$ obtained by inducing $\chi_\ell$ from $H_\ell$ is then irreducible, and the class
of this representation depends only on the orbit $O_\ell$ and not on the choice of $\ell$ within the orbit or the choice of $h_\ell$ ($h_\ell$ is called a real polarization at $\ell$). All irreducible unitary representations of $G$ are obtained this way. With suitable modifications, some of which require new ideas going beyond the Kirillov theory, this scheme can be extended to all solvable $G$; the extension is particularly nice when $G$ is in addition exponential, namely, when the exponential map is a diffeomorphism from $g$ to $G$. Then $G_\ell$ is connected and the above description extends with few changes (for an excellent description of these basic facts, see [7]). Now $O = O_\ell$ is foliated by the orbits $H_{\ell} \cdot \ell$, and the quotient space of the orbit by this foliation is the space $M = G/H_\ell$ where $f$ is a fixed point of $O_\ell$. $M$ is the configuration space, the functions on $M$ define the position observables; and the functions that are linear on the fibres of the map

$$O_\ell \rightarrow M, \quad sf \rightarrow sH_\ell$$

are the momenta. In this context it is of course natural to ask whether one can construct global coordinates

$$q_1, q_2, \ldots, q_{d/2}, p_1, p_2, \ldots, p_{d/2} \quad (d = \text{dim}(O))$$

on $O$ so that the symplectic form reduces to

$$dp_1 \wedge dq_1 + \cdots + dp_{d/2} \wedge dq_{d/2}.$$ 

Such coordinates are called canonical, and they always exist locally; this is the statement of the classical theorem of Darboux. But enlarging a canonical chart globally or even semiglobally is another matter. That this can be done for nilpotent groups was known to be true [6, 8] when Niels got interested in this problem. He wanted to develop a computer algorithm for writing down the canonical coordinates for all nilpotent groups and all coadjoint orbits. But, as he told me when I was visiting Copenhagen in 1988, he noticed that the algorithm also applied to many solvable groups and supplied global canonical coordinates on the coadjoint orbits [1]. He was then able to prove a very general theorem from which the existence of the canonical coordinates followed for all coadjoint orbits of all exponential solvable groups [2]. This is a perfect illustration of how his mind operated; there was total harmony between the computational and conceptual aspects of mathematics in his mind. A recent calculation of mine (with a student) in the Lie theoretic aspects of the dynamics of Riemann (= self-gravitating) ellipsoids and ellipses has shown that for the case of the rotating ellipses (which, for instance, model rotating galaxies), although the Lie group in question is not solvable, nevertheless there is a reduction to the solvable case, and by the theorem of Niels one can explicitly construct the canonical coordinates.

Niels deduced the existence of global canonical coordinates from a more general theorem that he was able to establish. He considers a connected $G$ not necessarily solvable and a coadjoint orbit $O$ for $G$. To simplify matters, I shall assume that $G$ is exponential solvable. Thus for any point $\ell \in O$, $G_{\ell}$, the stabilizer of $\ell$ in $G$, is connected with Lie algebra $g_\ell$, and $\ell \rightarrow h_\ell$ is a covariant real polarization ($\ell \in O$). Clearly $g_\ell \subset h_\ell$. The analytic subgroup $H_{\ell}$ defined by $h_\ell$ is known to be always closed, the leaves of the polarization $\ell \rightarrow h_\ell$ are the orbits $H_{\ell} \cdot \ell$, and the quotient of $O$ by the foliation determined by the polarization is a manifold $M$ identified with $G/H$ where $H = H_{\ell}$ for a fixed $f \in O$. Under the condition

$$Hf = f + h_{\text{ann}}$$

where $h_{\text{ann}}$ is the annihilator of $h_\ell$, known as the Pukanszky condition, the orbits $H_{\ell} \cdot \ell$ are flat affine spaces. It is known that if $G$ is exponential solvable and $f \in g^{*}$ is arbitrary, there is always a real polarization $h_\ell$ that satisfies the Pukanszky condition. The smooth locally defined functions on $M$, also viewed as smooth locally defined functions on $O$ via the natural map $\pi : O \rightarrow M$, form a sheaf $Q$ on $M$, the sheaf of the position observables; for any two local sections $q_1, q_2$ of this sheaf we have

$$\{q_1 \circ \pi, q_2 \circ \pi\} = 0.$$ 

To introduce the momenta, we have to consider the larger sheaf $P$ on $M$ with the property that, for any open set $U \subset M$, $P(U)$ is the space of smooth functions $p$ on $\pi^{-1}(U)$ that normalize the space of position observables on $\pi^{-1}(U)$ (with respect to $\{ \cdot , \cdot \}$; i.e., for each $q \in Q(U)$

$$\{q, \pi q \} = q' \circ \pi$$

for some $q' \in Q(U)$

$$(U \text{ open in } M).$$

Then

$$U \rightarrow P(U)$$

is a sheaf of Lie algebras and at the same time a sheaf of modules for the sheaf of functions $Q$. On the other hand, each $X \in g$ may be viewed as a linear function on $g^{*}$, and the restriction of this function to $O$ is denoted by $\psi^X$; thus $\psi^X(\ell) = (X, \ell)$. It is an easy exercise to show that these functions are global sections of the sheaf $P$. Niels shows that
The functions in \( P(U) \) are precisely those that can be expressed in the form

\[
\psi = \sum_{n=1}^{d/2} a_n p_n + a_0
\]

where \( a_0, a_1, \ldots, a_{d/2} \in C^\infty(U) \). In particular, for any \( X \in \mathfrak{g} \) we can write the global expression

\[
\psi^X = \sum_{n=1}^{d/2} a_{X,n} p_n + a_{X,0} \quad (a_{X,n}, a_{X,0} \in C^\infty(M)).
\]

Identifying \( M \) with \( \mathbb{R}^{d/2} \) via the coordinates \( q_a \), Niels obtains the following theorem: There exists a unique unitary representation \( \pi \) of \( G \) on \( \mathcal{H} = L^2(\mathbb{R}^{d/2}) \) such that \( \mathcal{C}^\infty(\mathbb{R}^{d/2}) \subset \mathcal{H} \) (the subscript \( \infty \) refers to the subspace of smooth vectors) and such that for all \( X \in \mathfrak{g} \) and all \( f \in \mathcal{C}^\infty(\mathbb{R}^{d/2}) \),

\[
d\pi(X)f = \sum_{n=1}^{d/2} a_{X,n} \frac{\partial f}{\partial q_n} + i a_{X,0} f + \frac{1}{2} \sum_{n=1}^{d/2} \frac{\partial^2 f}{\partial q_n^2}.
\]

Niels was able to show, without using induction, that in the nilpotent case the image of the universal enveloping algebra under \( d\pi \) is precisely the Weyl algebra of polynomial coefficient differential operators on \( \mathbb{R}^{d/2} \).

The paper [4] is a change of direction in his work. In it Niels studies matrix coefficients and quantization for nilpotent groups. I would like to venture the suggestion that he wanted to develop a complete operator Fourier transform theory on nilpotent groups, and the results of [4] were to be the foundation for such a theory. If \( \pi \) is an irreducible unitary representation of a connected simply connected nilpotent group \( G \), then for any function \( \varphi \) in the Schwartz space of \( G \) (defined by carrying over the Schwartz space of \( q_a \) via the exponential map), \( \pi(\varphi) \) is a smooth operator\(^2\) and the map \( \varphi \rightarrow \pi(\varphi) \) is surjective. But this map is far from injective, and for an operator transform theory one has to somehow "invert" this map. By deep Fourier analysis Niels achieves this. He constructs a subspace \( \mathcal{g}_e \) of \( \mathfrak{g} \) where \( e \) is a set of discrete parameters of the orbit corresponding to \( \pi \) and shows that the map \( \varphi \rightarrow \pi(\varphi) \) factors through the restriction

\[
\varphi \circ \exp |_{\mathcal{g}_e}
\]

inducing an isomorphism of the Schwartz space \( S(\mathcal{g}_e) \) with the nuclear space of smooth operators associated to \( \pi \), and gets an explicit formula for the inverse of this map. He then sets up an isomorphism between the Schwartz space \( S(O) \) of the orbit \( O \) associated to \( \pi \) and \( S(\mathcal{g}_e) \). In fact, for \( a \in S(O) \) define \( \tilde{a} \) as a function on \( \mathfrak{g}_e \) by

\[^2\text{A bounded operator } A \text{ in the space of } \pi \text{ is smooth if } d\pi(u)A \text{ and } A d\pi(u) \text{ are bounded operators for all elements } u \text{ of the universal enveloping algebra of } \mathfrak{g}.\]
\[ \tilde{a}(X) = \int_0 a(\ell)e^{-i(X,\ell)}d\beta_0(\ell) \quad (X \in g) \]

where \( \beta_0 \) is the canonical (suitably normalized) invariant measure on \( O \). Then \( \tilde{a} \) is in \( C^\infty(g) \), and its restriction to \( g_e \) is in \( S(g_e) \). The map

\[ a \rightarrow \tilde{a} \big|_{g_e} \]

is the topological linear isomorphism between \( S(O) \) and \( S(g_e) \) described above. Niels uses this isomorphism to set up a far-reaching generalization of the Weyl correspondence in quantum mechanics taking functions in \( S(O) \) to smooth operators in the space of \( \pi \). This correspondence extends to the duals of these spaces and reduces to the Weyl correspondence when the group is the Heisenberg group. The assignment

\[ a \rightarrow Op_\pi(a) \]

that he constructs is a topological linear \( \ast \)-isomorphism of \( S(O) \) with the nuclear space of smooth operators in the space of \( \pi \) that extends to an isomorphism \( Op_\pi \) between the dual spaces and has many elegant properties. Among these are

\[ \text{Tr}(Op_\pi(a)) = \int_0 a(\ell)d\beta_0(\ell) \]
\[ \text{Tr}(Op_\pi(a)Op_\pi(b)) = \int_0 a(\ell)b(\ell)d\beta_0(\ell) \]
\[ Op_\pi(\psi^X) = d\pi(X). \]

It follows from these that the image of the polynomial functions on \( O \) is the image of the enveloping algebra under \( d\pi \).

He mentions in the introduction to this paper that he had obtained extensions of many of these results to the case when \( G \) is solvable. In addition to these there were a number of additional results and computer algorithms that he had mentioned from time to time, both in his papers and to his friends in private conversation. At the time of this writing, attempts were being made to recover what he did and to put it in some definitive form.\(^3\)

Niels was diagnosed in the fall of 1995 as having a malignant tumor in the brain. Surgery was performed, and he was able to spend a few weeks with his family, but he was stricken again and never recovered. In the year between the discovery of his illness and his passing away, he kept his composure and continued some teaching and thinking about mathematics almost to the very end. His courage in the face of such adversity was truly inspirational and revealed what a special person he was and how irreplaceable his loss was going to be. The end came on November 24, 1996, and left his family and friends in a state of utter helplessness and profound grief. But viewed from an ancient perspective of how a person's life ought to be spent in pursuit of deeper knowledge and harmony, the journey of Niels Vigand Pedersen was an exemplary one.

References


\(^3\)Information on downloading the programs and examples of solvable Lie groups will be available at http://www.math.purdue.edu/~rcp/pedersen.html.
A Sketch of an Intellectual Biography

Anthony Phillips

Chih-Han Sah, who died in Stony Brook on July 22, 1997, was born in Beijing in 1934 into an old and distinguished family. An ancestor of his was Genghis Khan's commander in Foochow. Han's father, Adam Pen-Tung Sah, earned a Ph.D. in physics from Worcester Polytechnic University in the 1920s, wrote the general physics text that was the standard in China from 1930 until 1950, rose to become president of Xiamen University, and served as secretary general of the Academica Sinica from 1945 until his death in 1949. Han's mother, Shu-Shen Huang, was an exceptional athlete: she represented China in the Olympic Games, competing in javelin and discus. Later she took a master's degree in mathematics from the University of Illinois and taught mathematics at Slippery Rock State College in Pennsylvania until she retired.

Han's father spent the 1935-36 academic year on sabbatical in the United States. During a visit to Ohio State University the Sahs made the acquaintance of William and Dorothy Everitt, who turned out to play a crucial role in the education of Han and of his older brother, Chih-Tang (Tom): when Han's father died in 1949, the Everitts took on the two boys as unofficial foster children. The boys were able to move from the chaos of postwar China to the calm and stability of Urbana, Illinois, where William Everitt was now dean of engineering.

Han had just turned fourteen. Before leaving China he had been hustled from one school to another, with several years during the war of no school at all, but he had managed to complete the tenth grade. In Urbana he came into the university's experimental high school as a sophomore. Though starting with only "a 200-word [English] vocabulary at perhaps the kindergarten level" as he described it, he was able to skip the eleventh grade and to finish as the class valedictorian. He recounted this scene from his first year:

"I had been sitting in class mute (the custom in China) for two weeks when the teacher decided to give a quiz on factorization of polynomials. I finished the quiz about thirty seconds after she had finished writing the questions on the blackboard, including .. . one about $X^4 + X^2 Y^2 + Y^4$, and turned it in. Some ten minutes later, after she finished some other paperwork, and while the rest of the class was still struggling with the quiz, she looked at what she obviously expected to be a blank sheet. The change of expression on her face was a marvel to watch...."

Han started the University of Illinois as an engineering physics major. Here is how he described his transition to mathematics:

"When I was an undergraduate lab assistant in the physics accelerator lab, I found that I could not understand the purpose of the nuclear physics experiment we were running. I decided to read up on quantum mechanics in the library. To my frustration, I discovered that I could not understand the mathematics used in the texts. Not long after, I asked my best friend in college what he was studying in the way of mathematics. I was shocked to find that I could not read past the first few pages..."
Chi-Han Sah

of his book with the esoteric title *Theory of Groups*. Since my physics teachers all told me that I had already overdosed on mathematics, I decided to ask my math professor about the propriety of beginning to study some pure math. (I had in mind the vague idea of spending most of my fourth college year to that end.) His answer was: "It is too late to begin studying pure math at the age of 19." Two weeks later, I pigheaddly decided to graduate early and applied to the Mathematics Department to study math full-time. ... Soon I was, despite warnings from my science teachers, firmly seduced by 'useless' mathematics. At the same time, I never lost my interest in science, engineering, and the much more difficult and fascinating endeavors in the humanities.

Kenneth Mount, who had been a fellow student and friend of Han's at "Uni-Hi", went on with him to the university. He reports: "We were never in the same classes together, since I became a math major before he did. We did work on problems together. Indeed, that was a daily and nightly occurrence. We spent many hours playing 'pick a group', which was a version of twenty questions." This is an early and typical example of Han's enthusiasm for discussing mathematics and of his often playful approach to the subject.

Han earned a master's degree in mathematics from Illinois. He then entered the graduate program at Princeton, where he wrote a thesis under the direction of Timothy O'Meara. O'Meara told me how he would run into Han in the Common Room, ask him how he was doing, and suggest one or two further problems—Han would turn up the next day with the answers. "He glided through his entire thesis like that."

Han's ebullient mathematical personality flourished at Princeton. Here are some of Barry Mazur's reminiscences:

"Han Sah was the real energy behind a small band of us graduate students, the hours of our days studded with the 'grad-student-run seminars' that you mentioned. It was to those seminars, and not the formal Princeton classes, that our passions were truly directed. Han's enthusiasm shaped many of those seminars, and, happily, he had many enthusiasms:

"We must learn about quantum mechanics! We soon found ourselves taking turns covering blackboards with the disembodied 'brackets' coming out of the pages of Dirac's *Principles of Quantum Mechanics.*

"We heard, or made up, the gossip that Chevalley adamantly REFUSED to draw pictures when he did his algebraic geometry. The idealism, the wild-eyed rigor and asceticism of this gesture fired our imagination: we also decided 'WE DRAW NO PICTURES!' and in another graduate student seminar we macheted our way through Chevalley's *Introduction to the Theory of Algebraic Functions of One Variable.*

"But there were other seminars replete with pictures. Chevalley, with pictures or without, was a great favorite for seminars, with others of his books (e.g., *Theory of Lie Groups*) being text and pretext.

"Besides the seminars, there was (along with John Stallings and Jim Stasheff) the constant quest for examples and (much more delicious) counter-examples in topology and algebra. Here pictures were often THE driving force, and here sometimes I think we relished our failures as much as our successes. If some property about functions on, or mappings from, the unit interval eluded us, our revelling carol would be: 'WE DON'T EVEN KNOW THE UNIT INTERVAL!' No sooner, however, did we find a topological space, or ring, or group with some weird property but the cry went out for one with a yet weirder property. Han was our resident finite group theorist and adroit at finding finite groups obeying whatever prescription was called for. Both our inspiration and our tutor.

"The force of Han's enthusiasm carried you along; it was catching. And when it was Han's turn to lecture to us, he would do so with a cheerful, staccato, relatively fast delivery, with a singing voice, and a cloud of chalk."

Han graduated from Princeton with a Ph.D. in 1959 but stayed on one more year as an instructor. From 1960 to 1963 he served as a Benjamin Peirce Instructor at Harvard. He continued in the research direction of his thesis, mainly on finite groups and on quadratic forms over fields of characteristic 2. While he was at Harvard he developed an introductory course in Abstract Algebra; his notes became a textbook with the same title that was published in 1967 by Academic Press and that is still a standard, if formidable, reference.

In 1963 Han joined the University of Pennsylvania faculty. There he collaborated with Oscar Goldman on locally compact rings. Also, through his work with Leonard Charlap on the classification of flat Riemannian manifolds, he began working on the homology and cohomology of groups,
topics that would preoccupy him for the rest of his career.

In 1970 Han came to Stony Brook, where he stayed. He continued his research in finite groups and group cohomology but also began work on applications of group cohomology, to Hilbert's Third Problem, about "scissors congruences". He published a volume on the topic in the Pitman Research Notes Series. This book came to the attention of Johan Dupont, who told the participants in Han's memorial gathering how surprised he had been that someone else was thinking about scissors congruences. Thus began a transatlantic collaboration and a close friendship that lasted until Han's death.

The mathematics department at Stony Brook is fortunate in its proximity to the Institute for Theoretical Physics. This serendipidity has been commented on elsewhere, in connection with the "dictionary" between gauge field theory and differential geometry. But Han soon became the reference of choice for physicists working on exactly solvable models, and their discussions led to joint work: with Barry McCoy, Jacques Perk, and Shuang Tang, and with Eduardo Ramos and Robert Shrock. In recent years his various interests came together: he and Dupont published a paper in Communications in Mathematical Physics on "Dilogarithm identities in conformal field theory and in group homology". As Han said himself, "I never lost my interest in science...." Although he loved our "useless" mathematics, he was very happy when it could be used in elucidating problems in physics and chemistry. One of his main concerns about the education of mathematics majors was that they were not getting the solid exposure to science courses that would allow them the satisfaction of applying their mathematical knowledge to real-life situations and also allow them access to the vast source of mathematical problems and phenomena encoded in the physical world.

His Role in Education

Judith Roitman and Mark Saul

In recent years Chih-Han Sah became increasingly interested in mathematics education. His work in education is difficult to reconstruct, since so much of it took place behind the scenes: in private conversations or as an advisor on other people's projects (often with no official recognition). When asked by Al Cuoco for an autobiographical statement, Han wrote, "I am a confirmed believer in the Avis philosophy. Let somebody else be #1 and take the brunt. I am for #2 and hide in the background."

In the early 1990s Han became involved with the Gelfand Outreach Program in Mathematics (GOPM), an American adaptation of M. Gelfand's Soviet Union-wide correspondence school. Han helped to develop new material for this program and to pilot special applications for teacher training and in-school instruction. A pilot program in Puerto Rico continues as one of the most productive parts of this project.

Han was one of the leaders of an innovative proposal to the National Science Foundation that would have established a national program for postdoctoral fellows with responsibilities in both mathematics and K-12 education. A pilot version of this program exists and is quite successful at Case Western Reserve, but despite strong support from many mathematicians a national program has not yet been funded.

Han was a thoughtful critic of reform in both calculus and K-12 education. His specific contributions here are again difficult to document, taking the form of memos, e-mail, and phone conversations rather than position papers or public talks. But he was the best kind of critic, the kind who, for example, would look up student records to see what actually happened rather than relying on his own notion of what he had expected. He was deeply concerned about the fate of individual students and took the "long view" on assessing educational programs.

The most public of his involvements in education was the e-mail list mathed he established in August 1993. This grew out of his concern with education reform, most specifically out of a series of e-mail conversations with Hung-Hsi Wu and Dick Askey, who shared his concern. It was Han who

"The force of Han's enthusiasm carried you along; it was catching. And when it was Han's turn to lecture to us, he would do so with a cheerful, staccato, relatively fast delivery, with a singing voice, and a cloud of chalk."
took the conversation to a broader audience by adding first a few people, then more and more until he had a full-fledged list to manage; and, typically for Han, he managed the whole time-consuming e-list structure himself—with all of its open participants and auditors. Most remarkably, Han was bigger than his own opinions. He took pains to include people whose views were bound to differ from his own. He sought out researchers in mathematics education as well as in pure and applied mathematics. He included classroom teachers as well as university professors. And he took great pains to keep the discussion civil as well as passionate. As Hung Hsi Wu writes, "Ultimately time may prove that the way Han handled the mathed group was his greatest contribution to education."

But for many of us, the most treasured contributions that Chih-Han Sah made to mathematics education were his tireless private and semipublic discussions, ranging, as Al Cuoco writes, "from mathematics to education to household repairs," and memorably on the history of Chinese mathematics. In private conversation or on one of the public lists of which Han was a member, he would respond to questions related to school mathematics in enthusiastic and profound ways. Here is a description of one such conversation, from Al Cuoco:

"About 8 p.m. one evening I sent him a message asking if he knew how a planimeter (a mechanical device for finding areas of closed curves) worked. He responded immediately that he didn't but would find out. The next morning at 5 a.m. I found a three-page message in which Han proposed two devices that would do the integration (complete with proofs that they worked). In other words, he found out about planimeters by inventing two of them. Later he looked at the devices that are actually used, videotaped a couple, found references in nineteenth-century calculus books, and wrote a long post for mathed, calling it his 'planimeter adventure.' He took me along on many similar adventures, always looking at new ideas with a passionate combination of seriousness and delight, with a grin that I could picture long before I saw it firsthand."

His Mathematical Works

Johan Dupont and Vladimir Retakh

Han's interests in mathematics have varied over a broad range of subjects: group theory, quadratic forms, rings, Riemann surfaces, algebraic topology, scissors congruences, algebraic K-theory, polylogarithms, combinatorial geometry, applications to electrical engineering, conformal quantum field theory and statistical quantum mechanics, and structures of fullerenes in chemistry.

He started his work in mathematics with finite group theory. Together with R. Brauer, Han edited the proceedings of one of the most influential meetings in the 1960s, which helped set the classification program of finite simple groups on the road.

His famous works with O. Goldman in the theory of locally compact rings led to a number of interesting results and new tools, such as the Goldman-Sah product. He also studied questions of the existence of normal complements and automorphisms in group theory and finite quotient groups connected with Riemann surfaces.

In view of the strong geometric environment at Stony Brook, it is not surprising that he became increasingly involved in geometric problems. Perhaps his best-known contributions are in connection with the subject of "scissors congruences" of polytopes in Euclidean, spherical, or hyperbolic n-space, a field in which he was to become a world authority.

Two polytopes are called scissors congruent (s.c.) if they can be cut into the same finite number of subpolytopes such that the pieces of the two polytopes are pairwise congruent by means of isometries of the geometry in question. This notion occurs in connection with an elementary definition of the concept of "area" in the Euclidean plane and has a long history. The first explicit proof that polygons in the plane have the same area if and only if they are s.c. seems to have been given by W. Wallace (1807). But already Gauss (1844) noticed that a similar elementary approach to the concept of "volume" of polyhedra in 3-space is lacking, and, referring to this, Hilbert (1900) stated as the third problem on his famous list the challenge of finding two polyhedra of the same volume that are not s.c. This problem was immediately solved in this form by M. Dehn (1900), who introduced additional necessary conditions for two polyhedra to be s.c. and showed that these are not satisfied for the regular cube and regular tetrahedron. (An earlier proof by R. Bricard (1896) used a more restricted notion of s.c.) The subject of s.c. was subsequently forgotten except among a few geometers.

Han was introduced to the subject in the mid-1970s by D. Sullivan, and in 1979 his book Hilbert's Third Problem: Scissors Congruence was published in the Pitman Research Notes Series. The main result was the beautiful theorem that in all dimensions the so-called Hadwiger invariants determine Euclidean polytopes up to translational s.c. (i.e., the

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proved (but not published) a few years before by two Danish mathematicians, B. Jessen and A. Thorup. A more important contribution of the Pitman Notes is that they pointed to the close relation between the notion of scissors congruences and homological algebra, in particular the cohomology theory of groups (in this case, of the group of isometries involved).

For a long time the subject of s.c. was considered somewhat exotic and removed from mainstream mathematics, even by the workers in the field. But according to Han this was unjustified for two reasons. One is the historical fact that the subject of s.c. is related to such fundamental mathematical concepts as “area” and “volume”. The other is that more than once an important mathematical idea has appeared as a special case in the context of s.c. long before it was formally introduced. Thus Dehn’s conditions for s.c. involved an example of the tensor product of two abelian groups thirty years before such a tensor product was defined by Whitney. Also the group of polytopes (nowadays called the s.c. group), defined by B. Jessen in 1941 in a paper written in Danish, is really the algebraic $K$-group in the sense of Quillen (1971) for the category of polyhedra with congruences as the morphisms.

Today, thanks to the efforts of Han and his collaborators, this area of research is fully integrated into modern mathematics, having close connections to well-established fields such as homological algebra and algebraic K-theory, characteristic classes for flat bundles and foliations, hyperbolic 3-manifolds, and even (though more speculatively) subjects like motivic cohomology and conformal field theory.

For instance, by a classical geometric construction (going back to Gerling, a contemporary of Gauss), the s.c. group is 2-divisible also in non-Euclidean geometry, and the generalization to $p$-divisibility for any prime $p$ for hyperbolic 3-space led to the proof of the first nonsolvable case (for $SL(2, \mathbb{C})$) of the so-called Friedlander-Milnor Conjecture on the homology of the discrete underlying group of a Lie group.

In the opposite direction, applications of well-known theorems in algebraic K-theory by Borel and Suslin have greatly clarified the structure of the s.c. group in spherical and hyperbolic 3-space, and the remaining problem is equivalent to the so-called “rigidity question” in algebraic K-theory. In particular, explicit necessary and sufficient conditions are now known for s.c. in these geometries provided the vertices of the polyhedra are defined over the field of algebraic numbers.

Han made several other beautiful contributions to s.c., but he also worked on a wide range of problems in all kinds of mathematics extending into physics and chemistry (“buckyballs”). He was one of the “unofficial” conduits of mathematical information to physics colleagues.

As he once wrote: “My 'engineering upbringing' is such that I am not selective in terms of areas—they are all interesting to me (I only understand very small parts of what I read and hear but usually can find someone that is an expert to explain to me the details).” He was happy when he could help other people solve their problems, especially when the problems involved elementary algebra, geometry, and number theory. Very early on he arranged seminars with physicists and had numerous discussions with them, trying to overcome their traditional preoccupation with analysis and believing that they needed more algebra and geometry. He was always very open minded and generous, both in scientific matters and in personal relations, and he will be greatly missed.

References

Experiences of AMS-AAAS Media Fellows

Liz Veomett and Ben Stein

Since 1975 the American Association for the Advancement of Science has sponsored the Mass Media Science and Engineering Fellows Program, which places science and engineering students in summer media internships. Last year was the first time the AMS participated, and two mathematics students had internships: Liz Veomett, a first-year student at Oregon State University, and Ben Stein, a third-year student at the University of Massachusetts-Amherst spent their summers working at Business Week and National Geographic Television respectively. Science and engineering students, including undergraduate majors, graduate students, and postdocs, are eligible for the program. The application deadline is January 15, 1998.

Those interested in informally discussing the program can contact Samuel M. Rankin III, at the AMS Washington office, 202-588-1100, smr@ams.org.

Interested students may get more information by calling 202-326-6760, using the e-mail address asking@aaas.org, consulting the Web address http://www.nextwave.org/ehr/3_4_0.html, or contacting the Mass Media Science and Engineering Fellows Program, AAAS, 1200 New York Avenue, NW, Washington, DC 20005.

—Susan Landau

Liz Veomett

This summer I became a science journalist. I spent ten weeks writing science articles for Business Week. I wrote numerous short news pieces and two substantial ones. I covered topics ranging from intravascular ultrasound to the use of image algebra for interpreting pictures. I interviewed scientists both from academia and from industry. By the end of the summer, public relations professionals were calling me up, asking me to write about their clients. And my work was being published in a prominent magazine.

At first I was surprised that a national publication would be interested in the writing of a math graduate student. I worried about being deluged with tasks such as setting up interviews while someone more qualified wrote the stories. But from the start I was allowed to take charge of my own articles, from suggesting the topics to approving the editing. Editors and producers recognize that the quality of a person’s work is more important than the number of journalism classes she has taken. Scientists must be good at gathering, interpreting, and organizing information. And journalists use these same skills daily.

When my undergraduate advisor suggested that I apply for the AAAS fellowship, I had never given much thought to science journalism. I assumed Business Week science consisted of such subjects as a thorough analysis of the management strategies at Lucent Technologies or frequent updates on the speed of the latest Pentium processor, but not hard science. I did not think business professionals would care about the details of scientific advancement. Why would it be included in their magazine?

Of course science is as vibrant and important in the magazine as in the rest of this world. I had lectured freshman precalculus students about the value and variety of mathematics in our world. However, when it came to recognizing math in the media, I was as ignorant as they were.

Although journalists frequently cover scientific topics, many journalism majors avoided science and math as students. As a result, they have little practice thinking scientifically, are unfamiliar with scientific jargon, and have little background knowledge to draw upon. So it can be difficult for them to spot errors in their articles. Scientists, particu-
larly mathematicians, are very concerned with getting the details right. Though I was not an expert in the subjects about which I wrote, I knew when and how to ask questions. I was not intimidated by technicalities and had experience from which to approach the stories. Scientists insist that information be presented accurately; several times over the summer I made sure that superlatives like "never" or "best possible" were taken out of edited versions of my stories. Furthermore, scientists can sniff out stories that other journalists may overlook. I received the same packet of press releases as the rest of the science staff at Business Week, but often I suggested stories that the staff had overlooked. The resulting articles would not have been written without my input.

Now why would a mathematics graduate student want to spend her summer writing science articles for a business magazine? Wouldn't she benefit more from teaching or working on research? I had the opportunity to rediscover the wonder of science and learn about research I never realized existed. (Did you know sound waves can actually be used for refrigeration? And pellets of yeast and sugar may ward off corn rootworm as effectively as toxic pesticides?) Focusing on narrow research topics had caused me to lose sight of the big picture. I returned to grad school with a better perspective.

I became a better teacher. Science writing for the general public is not so different from teaching the typical college freshman (or any student). I had to organize information, make analogies, and ensure that I was conveying both the correct idea and its importance.

I also learned the value of good public relations. The same schools and research institutions were mentioned in the magazine time and again throughout the summer. These places were not the only ones doing good science, but they had a public relations staff that wrote effective press releases that were distributed widely and frequently. Their researchers made time to talk to the press. Their reputations, and that of their institutions, improved in the eyes of the public.

The mathematical community benefits from supporting science writing programs such as the one I participated in. I think every mathematician has at some point read a newspaper article that presented wrong or misleading mathematical principles. Sending people with a good understanding of science to work with journalists results in better stories. Because of a perception that the general public does not like math, journalists hide it under words like "technology" or "better method". The People don't realize that new mathematical principles are actually discovered and applied today. Inclusion of scientists in the media chain can change this—for the benefit of both science and society. I've gained a new role in the media and feel very privileged that I held an AAAS Media Fellowship last summer.

**Ben Stein**

I'm a graduate student in mathematical statistics at the University of Massachusetts-Amherst. Last spring I was cloistered in my office at UMass preparing for comprehensive exams, but only days later I was interning in the Natural History Unit of the National Geographic Television on an AAAS Science and Engineering Mass Media Fellowship.

My job was to bridge the gap between science and the science that is portrayed in the media. But the types of documentaries being produced were a far cry from those fields in which I had any expertise—the focus was on seals and insects, not point estimates and hypothesis tests. To contribute I had to open my mind and take on some projects about which I knew very little at first.

Oddly enough, one of my earliest duties was to address a mathematical question: if we have video of an animal swimming underwater, can we figure out its speed? And if so, can we do it if the camera is attached to the animal's back? This question was in reference to the so-called Crittercam, which my mentor was using to get up-close images of marine animals without the disturbances of a human photographer. As it turned out, all the theory I needed came from trigonometry and elementary optics. While the model might have been simplistic, it still gave reasonable estimates on the velocities, so I was satisfied with my first dabble into the world of mathematical modelling.

This effort wasn't entirely what I came to National Geographic TV for. One project immediately caught my eye. My mentor was saddled with the makings of a documentary on wolves in the U.S. I found the project a mess. There were hours of footage of varying quality. My job was to write a 1,000-word treatment that told an interesting, cohesive story; my constraint was to use only the footage that already existed.

The most compelling footage was the most disturbing. Hunting Alaskan wolves is legal, and several hundred are killed each year. One Alaskan wolf researcher wants to curtail trapping, which can lead to a long and lingering death and is the way most wolves are hunted. This researcher sent hours of his own footage to National Geographic.

I was quite moved by his films. But I realized that I couldn't let this footage control my understanding of the issue. Since the wolf population has remained stable from year to year, most established and well-respected wolf biologists see no danger in the Alaskan hunting policies. What could have been a "how-sad-it-is-that-hunters-are-killing-wolves" documentary turned into a multifaceted story that featured two wolf researchers: a maverick Alaskan who wants us to rethink wolf control policy and a well-respected wolf...
biologist who does not see Alaskan wolf control as a concern.

While not conscious of it at the time, my approach to the material was the same as any good scientist's. As mathematicians, we are trained to think analytically and not to accept statements without proof. I applied the same methodology and ended up with an interesting story about wolves.

As I looked more deeply into the arguments of my two featured researchers, I found that the disagreement became a statistical one. The more conservative argument hinged on the fact that wolf populations have remained stable, thus providing quantitative evidence that wolf hunting is doing no harm. But my iconoclast questioned this, asking if we should look past the numbers and, instead, at the long-term changes in behavior and genetics that hunting could bring about. After all, wolves have been around for millions of years as a dominant species in the food chain. Now that they are hunted like any other prey, how will they be impacted? This question is more qualitative and raises the issue of whether a basic statistical analysis is even relevant.

Since this project needed so much work, it took up most of my ten weeks; nevertheless, my product seemed small in comparison to my effort. I put the story together, but the documentary still needed a writer and an editor to finish production. How frustrating it was for me to leave the documentary in midstream!

These main projects were challenging, and there were many other interesting problems during the summer. Sometimes my abilities were challenged at unexpected times. Working with nonmathematicians, I found it very difficult to answer a question as simple as "What do you do at UMass?" I have just started my research in imaging, and I've never had to explain it to an educated mathematical novice before. Some of the people who asked me about it were supervising my work; if I could articulate what I studied, I would give them a better idea of what I could do.

This ability to communicate will be of prime importance to me as I get older. Mathematicians need to know how to explain the importance of research to a lawmaker, university president, or industry leader. But I know that my skills will be constantly challenged as my research becomes more and more complex. I think that those who allow themselves to leave the comforts of graduate school and enter into this mysterious world of the media will benefit from the change in environment. While the summer was frustrating at times, I always found the work fascinating and applied my skills with satisfying results.
Interview with Gail Burrill

Gail Burrill became president of the National Council of Teachers of Mathematics (NCTM) in 1996. She earned her bachelor's degree from Marquette University and her master's degree from Loyola University in Chicago, both in mathematics. She has been a high school mathematics teacher in suburban Milwaukee for over twenty-five years, teaching everything from prealgebra through calculus. She has a special interest in statistics and worked on several quantitative literacy programs through the American Statistical Association, the most recent a curriculum project called "Data Driven Mathematics". At present she is a researcher at the University of Wisconsin Center for Education Research, where she has been working on a middle school mathematics curriculum, "Math in Context". She was named a Presidential Awardee for Teaching Mathematics and Science in 1985 and a Wisconsin Distinguished Mathematic Educator in 1986. In 1994 she was elected a Fellow of the American Statistical Association. She has written numerous articles on statistics and mathematics education, as well as textbooks and curriculum materials.

At the Joint Mathematics Meetings in Baltimore Burrill will deliver an AMS-MAA-NCTM Joint Invited Address entitled "K-12 Mathematics Education in the Twenty-first Century". Her lecture will be at 11:10 a.m. on Thursday, January 8, 1998.

The following interview was conducted by Notices senior writer Allyn Jackson.

**Notices:** In 1989 the NCTM issued its first set of Standards, which have received wide attention and have spurred other disciplinary areas to issue standards. One of the major projects of the NCTM right now is the updating of its Standards. Can you describe the motivation behind this project?

**Burrill:** The first NCTM Standards weren't intended to be the final product. Education should evolve as we continue to learn about how kids learn and understand and as the face of math continues to shift. By the time the revised Standards come out, it will have been eleven years since the first Standards appeared. And in that span of eleven years, we've learned a lot. We know more now than we did before about ways to put curricula together that will help kids learn. Technology has changed dramatically over the past ten years, and that's had an impact on the important mathematics kids need to know. There is a need to build stronger articulation between the grade-level bands. We also recognize that anytime you do a first draft of something, you may need to strengthen it. And that's certainly the case with the NCTM Standards.

**Notices:** There is a network of groups working on different aspects of the updating of the Standards. Can you briefly describe this network?

**Burrill:** It's a multilayered effort. First, we have teams of five writers for each grade-level band: prekindergarten to second grade, third to fifth grade, sixth to eighth grade, and ninth to twelfth grade. Joan Ferrini-Mundy is the overall chair for the writing teams. Second, we have a commission, chaired by Mary Lindquist, that oversees the interaction between the writers and the rest of the community.
"We disenfranchised three-fourths of the student population and raised a nation of people who are literally afraid of mathematics."

with a vested interest in mathematics education. We have also enlisted support from people who have strong knowledge in particular areas such as technology or equity issues.

Notices: I'd like to ask you about the notion of mathematical proof, which most mathematicians think is extremely important to get across in mathematics education. Is this going to be an important aspect of the updated Standards?

Burrill: I can't articulate what the Standards writers have yet to write, but I can say that I think most of us agree that proof is a very important part of mathematics. So it would seem to me that this belief is going to be reflected in their work, particularly if the concern of the AMS is reinforced, as I think it will be, by other groups.

Notices: Some people felt that emphasis on proof was lacking in the original Standards.

Burrill: In the original Standards we had tables which listed on one side topics that should receive increased emphasis and on the other side topics that should receive decreased emphasis. And some people took the word "decrease" to mean "none". For example, in the Standards one of the topics we suggested should receive decreased attention was the two-column proof. That does not mean "throw it out altogether"! In traditional high school geometry students were spending most of the year proving, in many cases, trivial statements and putting them into this two-column proof format with little understanding of what they were proving. The notion in the Standards was not to abandon proof but to switch some of the empha-

sis from always having proofs in the two-column format to helping kids understand what proof is really about.

One of the things I hope to see is an effort, starting in elementary school, to lay the foundations for sound reasoning so students begin to learn to make mathematical judgments based on evidence and begin to have an understanding of what proof really is. We didn't lay these foundations very well before. We need a stronger emphasis on reasoning and thinking as a background before kids begin to formalize their reasoning processes.

Notices: In the 1980s mathematics education reform was introduced in England. In 1995 the London Mathematical Society, together with two other organizations, produced a report about the reform called "Tackling the Mathematics Problem". The report was critical of students' declining technical facility and lack of understanding of proof. This seems similar to some of the criticisms in the U.S. about mathematics education reform. Do you see parallels between the two? Will what happened in England help the updating of the NCTM Standards?

Burrill: I don't have in-depth knowledge about either the reform or the report, but I worry about this kind of thing. For instance, in California people have been saying the students' performance had been terrible because the state has adopted new standards. Someone asked how they knew they were actually being implemented and had contributed to the decline of the student performance, and it turns out that nobody knew whether or not the reforms were actually being used in classrooms. They didn't seem to have any real evidence. In many cases, it was just one person who heard something, or somebody had read a statement and misinterpreted it in one way or another. It's very hard to gather this kind of evidence. The closest evidence we have in the U.S. is TIMSS [Third International Mathematics and Science Study], and it says that many of our teachers know about mathematics education reform, but when it comes to implementing it, they haven't moved beyond the isolated techniques to focusing on higher-level thinking and reasoning, which is the real message in the Standards. We need to get better evidence before we can actually make statements about the influence of the reform.

There never was a golden era of mathematics education. We did produce—and I was part of it actually—some wonderful students right after Sputnik. But we concentrated all of our energies on a very, very few students. We disenfranchised three-fourths of the student population and raised a nation of people who are literally afraid of mathematics. They don't want to help their children with mathematics because it's too hard; they never "got it". We can't afford to do things that way anymore. Everybody needs to be mathematically literate in
order to function in the kind of world in which they're going to be living.

Notices: The idea of "mathematics for all" is a major theme of the Standards. Within that framework, can you ensure that the mathematically talented also get what they need?

Burrill: Mathematically gifted children are part of the "all". I think it's important that we continue to find ways to nurture and to challenge those kids. It's not enough to just let them sprout by themselves. They need guidance and help and opportunities. It certainly needs to be a priority.

Notices: Is that going to be part of the updated Standards?

Burrill: Of course. I can't tell you how it will happen for sure, because the way the NCTM set up the Standards revision was to pick very good people and put them in charge.

Notices: Do you think kids' mathematical abilities have declined in the time you've been teaching?

Burrill: No, I do not. When I started teaching, in my school there were two precalculus classes and two second-year algebra classes. The school enrollment is about the same now as when I started there. When I left, there were two calculus classes, four precalculus classes, and six second-year algebra classes. Over that time we at least doubled the enrollment in our upper-level math classes. And the kids that I had were doing more high-powered thinking and reasoning about mathematics. They were asking me questions that I had to go home and look up or discuss with my colleagues to a much greater degree than they were when I first started teaching.

Notices: I'd like to ask you about teacher background and qualifications. Many people worry that teachers don't have enough background to teach in the traditional way or in the reform way. Do you think that these worries are justified?

Burrill: I think these worries are very much justified. It's a matter of very much concern to me that we're placing demands on teachers for which we have not prepared them. We have many teachers who are not certified in mathematics. About 37 percent of mathematics teachers in our high schools do not have minors in mathematics or mathematics education, and about 89 percent of teachers in grades 5-8 do not. And that means that these teachers have a minimal background in mathematics. In many schools in many states, to teach K-8 mathematics all you need to have is one or two survey mathematics courses. We're asking these teachers to teach things like discrete math and statistics and algebra and geometry, to go beyond the arithmetic level, but we haven't given them the background and content knowledge that they need in order to make sense of what they're supposed to teach. And that's real scary.

Right now, many places are experiencing teacher shortages. For example, Milwaukee is desperately in need of teachers. I know of at least two suburban areas where they called all over looking for people to take very good teaching jobs and found no one. So they have retired community people who are holding down the fort. The need for teachers—especially highly qualified teachers who know their mathematics and how to teach it—is critical.

Taken together, this means that we need to have a real emphasis on long-term, coordinated professional development as well as strong pre-service programs that will prepare teachers to teach the math kids need to know.

Notices: This year President Clinton proposed the development of a national 8th-grade mathematics test. Congress didn't fund it, so the idea may be dead. Do you think it would be a good idea?

Burrill: I think it presents a really wonderful opportunity, but it also has potentially some serious disadvantages. It could establish a common platform for important mathematics students should know by grade 8, set high expectations for kids throughout the United States, and provide feedback that parents and teachers could find useful. We need, however, to put in place the support mechanisms and resources that teachers and schools would need in order to actually change what they're doing and help bring their students to the level where they have the background to do well on the test. If we could get the attention and energy of the United States focused on high standards and good performance in mathematics, think how wonderful it would be.

There's the potential danger, however, that if kids don't do well and we don't have interventions in place to help them and their teachers, it could turn into another round of bashing teachers and bashing schools where students have low performance. We already know some districts do poorly. We don't need another test to give us the same information. So there could be a lot of blaming, or we could begin to rank districts and schools in ways that I don't think this test was ever intended to set the stage for. So, while on one hand there are lots of really good and exciting things that can happen from it,
The latter is performed only in the countable case. The former is complete in all cardinalities. The main classification splits into the sporadic and as well as upwards, and can do so repeatedly (though it is assumed that of the interesting cases is given. This work generalizes

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The Structure of $k$-CS-Transitive Cycle-Free Partial Orders

Richard Warren, University of Leeds, England

The class of cycle-free partial orders (CFPOs) is defined, and the CFPOs fulfilling a natural transitivity assumption, called $k$-connected set transitivity ($k$-CS-transitivity), are analyzed in some detail. Classification in many of the interesting cases is given. This work generalizes Droste's classification of the countable $k$-transitive trees ($k-2$). In a CFPO, the structure can branch downwards as well as upwards, and can do so repeatedly (though it never returns to the starting point by a cycle). Mostly it is assumed that $k=3$ and that all maximal chains are finite. The main classification splits into the sporadic and skeletal cases. The former is complete in all cardinalities. The latter is performed only in the countable case. The classification is considerably more complicated than for trees, and skeletal CFPOs exhibit rich, elaborate and rather surprising behavior.

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Notices: Starting in 1968, the government funded a huge study called Project Follow-Through. It cost a billion dollars and ran almost thirty years. The purpose was to examine how different teaching methods or philosophies affected student performance. What they found was that the traditional, "direct instruction" method was the most effective. Are you familiar with this study?

Burrill: I have never heard of it. I believe in designing lessons using appropriate strategies to enable kids to learn. And that means sometimes you need to stand up and lecture, sometimes you need to explore and investigate, sometimes they need to work by themselves. Some problems are good for teamwork where each person does a different part, some problems are good for teamwork where students brainstorm about best ways to solve the problem, and some problems you just need to do by yourself. So to say that any one method is the right method I think is not correct. One thing that research has found and reform has emphasized is that everybody comes to understand and know in different ways. If a student has a misconception about, say, something in probability and they come to my class and I teach them all the right things but I never confront their misconceptions, the thing that they don't get about probability, then a year later—and, again, research backs this up—they will abandon all the right ways that I taught them, go back to their misconceptions, and make decisions based on those misconceptions. If we don't build on the thinking and the reasoning that kids bring to mathematical situations, we're never going to be able to move them beyond their own misunderstandings.

Burrill: Right. And it's much easier for me as a teacher to have one way to do it—the way I learned or the way the book showed me. But if that's not the way that the kid understands it, or if the kid brings a different understanding to what they think I'm saying, I have to be ready to shift. I have to know enough mathematics in order to give me the freedom to make that shift. And one of the scary things is that when you listen to kids, they ask you questions that take you down different paths, and you as the teacher need to know if those paths lead to the same end in mathematics, and you have to decide whether they are mathematically beneficial. You need to know a lot of mathematics to make those choices to help kids learn what they are supposed to learn.
On October 22 Senators Phil Gramm (R-TX) and Joe Lieberman (D-CT) introduced a bill calling for doubling the federal budget for civilian research over the next ten years. At the same time the presidents of 105 scientific societies issued a "Unified Statement" endorsing the bill's general aim. At a Capitol Hill press conference that day Gramm and Lieberman were joined by Pete Domenici (R-NM), chair of the Senate Budget Committee, who has lent his support to the bill. The three legislators were flanked by about thirty presidents and representatives of the scientific societies that had endorsed the joint statement.

In attendance was AMS president Arthur Jaffe, who has helped to marshal the scientific community to press for increased federal support for research. These efforts have "really blossomed into something which can be part of a grassroots movement for science," he says. "I think there's a great chance that we can succeed." Jaffe, together with Samuel M. Rankin III of the AMS Washington Office, has been among the key figures mobilizing the scientific societies. In particular, Jaffe and Rankin played a central role in writing the "Unified Statement".

The Gramm-Lieberman bill specifies yearly authorizations that by 2008 would double the budgets of a number of federal agencies, including the National Science Foundation, the National Aeronautics and Space Administration, and the National Institute for Standards and Technology. The doubling does not take inflation into account, so in constant dollars the budgets would not in fact double. Aggregate dollar amounts are given for research and development at these agencies, though separate amounts are broken out for the National Institutes of Health.

Gramm noted that in 1965, 5.7% of every dollar spent by the federal government went toward research, while today that figure is only 1.9%. "Increasingly, Congress and the executive branch have invested in programs with big political constituencies," he remarked. If the U.S. is to insure a high standard of living, high wages for workers, and good health for its citizens, then "we have to invest in science and technology."

The senators are relying on the bipartisan appeal of science to win support for the bill. "We're not going to add cosponsors until we can add a Democrat and a Republican," said Gramm. They have made a first step: Jeff Bingaman, Domenici's Democratic counterpart from New Mexico, has also given his support to the bill. The goal is to get fifty-one cosponsors for the bill in the Senate.

Gramm and Lieberman have begun talking to congressional representatives to build support for a companion measure in the House. George Brown (D-CA), who over the years has been a strong supporter of science in the House, introduced in 1997 a bill that would increase research and development funding by 5% a year, a figure which, depending on how the split between research and development is made, could be consistent with the aim of the Gramm-Lieberman bill.

The statement by the scientific societies does not directly endorse the Gramm-Lieberman bill, because some of the societies that signed on were not comfortable supporting specific legislation, and some were unhappy that the research funding agencies of the Department of Defense were not
included in the bill. Indeed, the societies' statement mentions the Department of Defense as one of the government entities that has contributed to the national research effort.

The DOD funds a fair amount of basic research, but funding levels have dropped in recent years. Including the DOD agencies in the Gramm-Lieberman bill would have entailed political complications that the bill's sponsors were trying to avoid. Jaffe said that some of the scientific society presidents had urged Gramm and Lieberman to include the DOD research agencies in their bill, but "that seems not to be politically possible." Because DOD agencies account for 40% of all federal funding for mathematics research, the health of these agencies "is a very serious issue." He says he will work on it with the Joint Policy Board for Mathematics (JPBM).

The Gramm-Lieberman bill, while a positive sign for support of science, could end up having no effect on actual spending levels. This is because the bill contains only budget authorizations, while it is through appropriations bills that money is actually allocated. According to Lisa Thompson, who has long observed the Washington science policy scene as JPBM congressional liaison, the Gramm-Lieberman bill is helpful but cannot be pushed too far "because the appropriators are very insistent on their right to make appropriations" as they see fit.

Furthermore, because the bill involves so many different agencies, it would have to pass through many different Senate and House committees, reducing its chances of being passed. Another obstacle is the drive to reduce spending; although the pressure of the budget deficit has eased recently, "any deficit hawk is going to look at this bill with suspicion," says Thompson. Nevertheless, if the scientific societies can activate their memberships to press Congress to support this bill, they could have an impact.

And this is just what Rankin is working on, in collaboration with other societies. "We will begin a grassroots effort to obtain endorsements from other senators for the Unified Statement, especially targeting senators who are members of the Committee on Appropriations," he says. They will also work on encouraging government agency heads to push the administration and the Office of Management and Budget to increase research funding.

In concert with these efforts, Jaffe is continuing to work with the representatives of some of the other societies to get statements of support for scientific research from industry, in particular the financial industry. The most important thing is that it should not be only politicians making these decisions, says Jaffe. "Scientists and mathematicians are an important group with input into the way things are done."

In addition to Jaffe, mathematics was represented at the press conference by Marcia Sward, executive director of the Mathematical Association of America, who stood in for MAA president Gerald Alexanderson. Alexanderson signed the statement, as did John Guckenheimer, president of the Society for Industrial and Applied Mathematics, and Sylvia Wiegand, president of the Association for Women in Mathematics. The presidents of the American Statistical Association, the Institute for Mathematical Statistics, and the Institute for Operations Research and Management Sciences also signed on.

Three society representatives spoke at the press conference: D. Allan Bromley, president of the American Physical Society and science adviser to President Bush; Ronald Breslow, past-president of the American Chemical Society; and Winfred Phillips, president-nominee of the American Society of Mechanical Engineers.
American Mathematical Society

Recently Published Titles from the AMS

The Classification of the Finite Simple Groups, Number 3
Daniel Gorenstein, Richard Lyons, Rutgers University, New Brunswick, NJ, and Ronald Solomon, Ohio State University, Columbus

This book offers a single source of basic facts about the structure of the finite simple groups with emphasis on a detailed description of their local subgroup structures, coverings and automorphisms. The method is by examination of the specific groups, rather than by the development of an abstract theory of simple groups. While the purpose of the book is to provide the background for the proof of the classification of the finite simple groups—dictating the choice of topics—the subject matter is covered in such depth and detail that the book should be of interest to anyone seeking information about the structure of the finite simple groups.


Discrete Mathematics in the Schools
Joseph G. Rosenstein, Rutgers University, New Brunswick, NJ, Deborah S. Franzblau, City University of New York (CLNY), Staten Island, and Fred S. Roberts, Rutgers University, New Brunswick, NJ, Editors

This volume is a collection of articles written by experienced primary, secondary, and collegiate educators. The book explains why discrete mathematics should be taught in K-12 classrooms and offers practical guidance on how to do so.

Features:
• Classroom activities and an annotated list of resources.
• Authors who are directors of innovative programs and who are well known for their work.
• A description of discrete mathematics providing the opportunity for a fresh start for students who have been previously unsuccessful in mathematics.
• Discussion on discrete mathematics as it is used to achieve the goals of the current effort to improve mathematics education.
• Guidance on topics, resources and teaching; a valuable guide for both pre-service and in-service professional development.

This volume is co-published with the National Council of Teachers of Mathematics (NCTM), Reston, VA.

DIMACS: Series in Discrete Mathematics and Theoretical Computer Science, Volume 36, 1997; 452 pages; Hardcover; ISBN 0-8218-0448-0; List $30; All AMS members $24; Order code DIMACS/36/RT81

Homeomorphisms in Analysis
Casper Goffman, Purdue University, West Lafayette, IN, Togo Nishiura, Wayne State University, Detroit, MI, and Daniel Waterman, Syracuse University, NY

The book is well written, packed with information and makes a novel contribution to the literature. Much of what is in the book is important material that is new for the first time ready accessible — readers will appreciate the many comments that provide historical or motivational perspectives.

—Professor Andrej Bruckner,
University of California, Santa Barbara

This book features the interplay of two main branches of mathematics: topology and real analysis. The material of the book is largely contained in the research publications of the authors and their students from the past 50 years. Parts of analysis are touched upon in a unique way, for example, Lebesque measurability, Baire classes of functions, differentiability, C0 and C1 functions, the Blumberg theorem, bounded variation in the sense of Cesari, and various theorems on Fourier series and generalized bounded variation of a function.

Mathematical Surveys and Monographs, Volume 54, 1997; 216 pages; Hardcover; ISBN 0-8218-0414-0; List $69; Individual member $41; Order code SURV/54/RT81

Knotted Surfaces and Their Diagrams
J. Scott Carter, University of South Alabama, Mobile, and Masahico Saito, University of South Florida, Tampa

In this book the authors develop the theory of knotted surfaces in analogy with the classical case of knotted curves in 3-dimensional space.

The book contains over 200 illustrations that illuminate the text. Examples are worked out in detail, and readers have the opportunity to learn first-hand a series of remarkable geometric techniques.

Mathematical Surveys and Monographs, Volume 55, 1998; 258 pages; Hardcover; ISBN 0-8218-0953-2; List $69; Individual member $41; Order code SURV/55/RT81

Mathematical Hierarchies and Biology
Boris Mirkin, DIMACS, Rutgers University, Piscataway, NJ, F. R. McMorris, University of Louisville, KY, Fred S. Roberts, Rutgers University, New Brunswick, NJ, and Andrew Rahezsky, Columbus University, New York, NY, Editors

The mathematical approach to the study of hierarchies presents the theoretical basis for many important areas of current scientific investigation. Biology has benefited from this research and has also stimulated the mathematical study of hierarchies.

The papers in this volume provide a contemporary sample of many new results in hierarchy theory with applications in biology, psychology, data analysis, and systems engineering.


Proceedings of the Ashkelon Workshop on Complex Function Theory (May 1996)
Lawrence Zalcman, Bar-Ilan University, Ramat-Gan, Israel, Editor

This volume presents a snapshot view of current Israel activity in complex function theory and provides impressive evidence of the vigor, enthusiasm, and success with which classical complex analysis is cultivated in Israel today.

Israel Mathematical Conference Proceedings, Volume 11, 1997; 245 pages; Softcover; List $59; Individual member $35; Order code IMCP/11/RT81

Second Order Equations of Elliptic and Parabolic Type
E. M. Landis, Moscow State University, Russia

Most books on elliptic and parabolic equations emphasize existence and uniqueness of solutions. By contrast, this book focuses on the qualitative properties of solutions. In addition to the discussion of classical results for equations with smooth coefficients (Schauder estimates and the solvability of the Dirichlet problem for elliptic equations; the Dirichlet problem for the heat equation), the book describes properties of solutions to second order elliptic and parabolic equations with measurable coefficients near the boundary and at infinity.

The book presents a fine elementary introduction to the theory of elliptic and parabolic equations of second order. The precise and clear exposition is suitable for graduate students as well as for research mathematicians who want to get acquainted with this area of the theory of partial differential equations.

Translations of Mathematical Monographs, Volume 171, 1997; 203 pages; Hardcover; ISBN 0-8218-0685-7; List $99; Individual member $59; Order code MMONO/171/RT81

Supplementary Reading

All prices subject to change. Charges for delivery are $3.00 per order. For optional air delivery outside of the continental U.S. please include $6.50 per item. Prepayment required. Order from American Mathematical Society, P.O. Box 6248, Providence, RI 02906-6248, U.S.A. For credit card orders, fax (401) 455-4416 or call toll-free 800-321-4AMS (4267) in the U.S. and Canada, (401) 455-4000 worldwide. Or place your order through the AMS bookstore at http://www.ams.org/bookstore/. Residents of Canada, please include 7% GST.
David Hoffman Receives American Vinci Award

DAVID HOFFMAN has received the American Vinci Award of Excellence from the LVMH Moët Hennessy-Luís Vuitton Foundation. The award is one of three presented on the occasion of the tenth anniversary of 1997 Science pour l’Art, sponsored by the foundation. Hoffman, head of the Scientific Graphics Initiative at the Mathematical Sciences Research Institute in Berkeley, received the award on October 21, 1997, at a ceremony held at the United Nations in New York. The other awards went to Santiago Calatrava, an architect and engineer in Switzerland, and to Rolf Landauer, a researcher in information theory and physics at the IBM T. J. Watson Research Center.

Hoffman was cited for using “mathematical and computational methods to discover new minimal surfaces and to understand their global behavior.” His work has led to software that is useful not only in mathematical research but also in laboratory experiments in material science. It has also been used to create works of art, which have been shown in museums and galleries. Some of the images may be found on the MSRI Web site at http://www.msri.org/Computing/david/MSMMA.

—Allyn Jackson

Dusa McDuff Receives AWIS Award

DUSA MCDUFF of the State University of New York at Stony Brook has received the 1997 Outstanding Woman Scientist Award from the Metropolitan New York Chapter of the Association for Women in Science. The award recognizes outstanding women scientists and engineers in the New York area from a wide variety of scientific disciplines. Two others, a professor of chemical engineering and a professor of ophthalmology, also received the award. The awards ceremony took place in November at the building of the Association of University Women in Manhattan.

—Allyn Jackson

Trjitzinsky Memorial Awards Presented

The AMS has made awards to six undergraduate mathematics majors through the Waldemar J. Trjitzinsky Memorial Fund. The fund is made possible by a bequest from the estate of Waldemar J., Barbara G., and Juliette Trjitzinsky. The will of Barbara Trjitzinsky stipulates that the income from the bequest should be used to establish a fund in honor of the memory of her husband to assist needy students in mathematics.

Each year the AMS selects four geographically distributed schools to which it makes one-time awards of roughly $3,750 each. The mathematics departments at these schools then choose students to receive the funds to assist them in their pursuit of careers in mathematics. The schools are selected in a random drawing from the pool of AMS institutional members. This year the four institutions receiving the award funds were Georgetown University, Loyola Marymount University, New York University, and Southern Illinois University at Carbondale.

Georgetown University selected MARTIN AKGUC to receive the award. He is a mathematics major now in his second year. Born in the village of Schwyz in Switzerland, he came to the U.S. during high school and enrolled in Georgetown
University in 1996. He plans to go to medical school or enter teaching after he graduates. According to mathematics department chair Hans Engler, Akguc has solid academic standing and is the sophomore mathematics major with the greatest financial need.

Loyola Marymount University chose to split the award among three seniors who will complete their degrees in May 1998: LAURA STEINER, CLAUDIA CATALAN, and ELIZABETH MADRIGAL. According to mathematics department chair Michael D. Grady, Steiner was chosen “because of her work ethic and her interest in mathematics,” which began in the fourth grade. After graduation Steiner plans to teach high school mathematics. Catalan served as secretary and historian of the department’s Mathematics Club. Currently a volunteer in a middle school, she plans to pursue a Ph.D. in mathematics education. In addition to a major in mathematics, Madrigal will also receive a minor in chemistry. A Spanish-English bilingual tutor in middle schools, she plans to get a master’s degree in education and teach high school.

New York University chose EMILY PRESS to receive the award. She is a mathematics major in her senior year, with a grade point average of 3.88. Undergraduate studies director Melvin Hauser describes Press as “one of our most accomplished students.” She receives an Alumni Scholarship, loans, and work-study grants to support her education. After graduation she plans to pursue a doctorate and teach at the college level. She is also interested in Japanese language and literature.

Southern Illinois University at Carbondale presented the award to LAURA WASSER. She is a sophomore mathematics major who plans to teach high school. According to Andrew G. Earnest, chair-elect of the mathematics department, Wasser graduated first in her class in high school and completed her first-year mathematics courses at the university “with outstanding grades.” She was selected on the basis of need, scholarship, and her early progress in the mathematics program.

For more information about the Trjitzinsky Fund contact Timothy J. Goggins, Development Officer, AMS, P. O. Box 6248, Providence, RI 02940-6248; e-mail: tjg@ams.org.

—Allyn Jackson

### Visiting Mathematicians

**Supplementary List**

Mathematicians visiting other institutions during the 1997-98 academic year were listed in the June/July 1997 issue of the Notices, pp. 715-717, the September 1997 issue of the Notices, p. 945, and the November 1997 issue of the Notices, p. 1329. The following is an update to that list (home country is listed in parentheses).

MAURICE DE GOSSON (Sweden), Yale University, Geometric Quantization, 8/97-1/98.

### Deaths

ARTHUR T. BEYER, of Oxnard, California, died in August 1997. Born on December 7, 1930, he was a member of the Society for 39 years.

LAWRENCE C. BIEDENHARN, of the University of Texas at Austin, died February 12, 1996. Born on November 18, 1922, he was a member of the Society for 34 years.

NOLA A. HAYNES, associate professor emeritus at the University of Missouri, died on December 21, 1996. Born on January 9, 1897, she was a member of the Society for 70 years.

GEORGE A. HUTCHINSON, consultant and visiting researcher at the University of Maryland, died on September 17, 1997. Born on April 24, 1936, he was a member of the Society for 38 years.

ERIC C. MILNER, of the University of Calgary, died on July 20, 1997. Born in May 1928, he was a member of the Society for 26 years.

REESE T. PROSSER, of Dartmouth College, died June 30, 1996. Born on May 18, 1927, he was a member of the Society for 44 years.

EUGENE RITTER, chief emeritus at NSWC, died November 2, 1993. Born on March 28, 1909, he was a member of the Society for 56 years.

CARL TELLEFSEN, of Roswell, New Mexico, died on April 29, 1986. Born on August 22, 1908, he was a member of the Society for 23 years.

AKIHITO UCHIYAMA, of Tohoku University, Japan, died on August 11, 1997. Born on December 27, 1947, he was a member of the Society for 21 years.

RICK A. WHITAKER, of Grain Valley, Missouri, died on September 1, 1997. Born on August 27, 1952, he was a member of the Society for 10 years.
Mathematics Opportunities

Burroughs-Wellcome Grants for Interdisciplinary Education

The Burroughs-Wellcome Fund has a program to encourage the interdisciplinary training of promising graduate and postdoctoral students from the mathematical, physical, chemical, and computational sciences so they can better apply their unique knowledge and talents to biological problems. Grants of $350,000 to $500,000 per year for five years will be made to four to six institutions.

The program is not intended to introduce more graduate and postdoctoral students into the research system, but rather to promote a different kind of training and a change in institutional behavior. Emphasis will be placed on supporting new programs or existing programs that will change graduate and postdoctoral training in a meaningful way, as opposed to programs seeking more funding for conventional activities already under way. Degree-granting institutions in the United States and Canada are invited to propose graduate or postdoctoral training programs or a combination of both. Several affiliate organizations within an institution may join together to submit an application. Consortia representing several institutions also may submit applications as long as one academic institution is prepared to oversee the program and administer the grant. Ancillary activities—such as undergraduate student research programs, faculty seed grants, or invited lectures—may be included as part of the proposal. However, the program's primary emphasis is on promoting the training and research activities of graduate and postdoctoral students rather than on supporting faculty research projects.

The Burroughs-Wellcome Fund is an independent private foundation established to advance the medical sciences by supporting research and other scientific and educational activities. BWF was founded in 1955 as the corporate foundation of the pharmaceutical firm Burroughs-Wellcome Co. In 1993 a generous gift from the Fund’s sister philanthropy in the United Kingdom, the Wellcome Trust, enabled BWF to become fully independent from the company, which was acquired by Glaxo in 1995. The Burroughs-Wellcome Fund has no affiliation with the pharmaceutical enterprise now known as Glaxo Wellcome or with any other corporation.

The deadline for submission of proposals is February 2, 1998. Further information on the program is available on the World Wide Web at http://www.bwfund.org/BROCHURE/interf98.htm. Or contact: Burroughs-Wellcome Fund, 4709 Creekstone Drive, Suite 100, Durham, NC 27703; telephone 919-991-5100; fax 919-941-5884; e-mail: info@bwfund.org.

—{}from Burroughs-Wellcome Fund Announcement

News from the Mittag-Leffler Institute

At the Mittag-Leffler Institute in Djursholm, Sweden, the academic year 1998–1999 will be devoted to "Topology and geometry of quantum fields".

The organizing committee consists of Torsten Ekedahl, University of Stockholm; Jouko Mickelsson, Royal Institute of Technology, Stockholm; and Antti Niemi and Oleg Viro, University of Uppsala.
Mathematics Opportunities

The application deadline for postdoctoral fellowships is March 31, 1998. For further information, consult the Mittag-Leffler Web site at http://www.m1.kva.se/. Or write to: Mittag-Leffler Institute, Auravägen 17, S-182 62 Djursholm, Sweden.

—Mittag-Leffler Institute Announcement

Summer Program at Bryn Mawr

With funding from the National Science Foundation, the mathematics department at Bryn Mawr College has established a program called Enhancing Diversity in Graduate Education (EDGE). This program is designed to strengthen the ability of women students to successfully complete graduate programs in the mathematical sciences.

The summer program consists of two core courses in analysis and algebra/linear algebra and minicourses in other areas. There will also be short-term visitors from academia and industry, guest lectures, mentors, and problem sessions. A follow-up mentoring program and support network will be established within the participants' respective graduate programs.

Applicants should be women who are (i) graduating seniors who have applied to graduate programs in the mathematical sciences, (ii) recent recipients of undergraduate degrees who are now entering graduate programs, or (iii) first-year graduate students. Final acceptance to the program is contingent upon acceptance to a graduate program in the mathematical sciences. The program will be held June 15-July 10, 1998, at Bryn Mawr. Participants will receive an $1,800 stipend plus room and board.

The deadline to apply is March 1, 1998. For further information, consult the Web site http://www.brynmawr.edu/Acads/Math/. Or write to: EDGE Program, Department of Mathematics, Bryn Mawr College, Bryn Mawr, PA 19010.

—Department of Mathematics, Bryn Mawr College

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
DHAHRAN, SAUDI ARABIA

DEPARTMENT OF MATHEMATICAL SCIENCES

THE MATHEMATICAL SCIENCES DEPARTMENT OF KING FAHD UNIVERSITY OF PETROLEUM & MINERALS, DHAHRAN, SAUDI ARABIA, INVITES APPLICANTS FOR FACULTYPOSITIONS AT THE LEVEL OF ASSISTANT PROFESSOR AND ABOVE. CANDIDATES WITH THE FOLLOWING SPECIALIZATION ARE SOUGHT: ANALYSIS, APPLIED MATHEMATICS, NUMERICAL ANALYSIS, PROBABILITY THEORY, STOCHASTIC PROCESS & STATISTICS. APPLICANTS FROM OTHER FIELDS WILL ALSO BE CONSIDERED.

APPLICANTS SHOULD HOLD A Ph.D. DEGREE AND ARE EXPECTED TO TEACH UNDERGRADUATE & GRADUATE COURSES, AND SHOULD ALSO BE COMMITTED TO RESEARCH.

THE DEPARTMENT OF MATHEMATICAL SCIENCES CURRENTLY HAS OVER 50 FACULTY MEMBERS, IN A WIDE RANGE OF AREAS OF SPECIALIZATION. THE DEPARTMENT HAS B.S, M.S AND Ph.D. PROGRAMS IN MATHEMATICS.

The University offers a two-year renewable contract with a competitive salary commensurate with qualifications and experience; benefits according to the policy that include annual repatriation air tickets for up to four persons; monthly transportation allowance; two months' paid leave; educational assistance grants for school-age dependent children; gratuity; and rent-free air conditioned, furnished accommodation on campus with basic utilities.

The campus has a range of recreational and other facilities, including a medical and dental clinic. Faculty have access to an extensive Library, computing; research and teaching laboratories facilities.

Please send cover letter and resume to:

Dean of Faculty & Personnel Affairs
King Fahd University of Petroleum & Minerals
Dept. No. 9723
Dhahran 31261, Saudi Arabia
For Your Information

Notices on the Web Has a New Look

Starting with the current issue, January 1998, the appearance of the Notices on the Web will change. Previously, Notices material was encoded in HTML and appeared as text on the screen, with very little formatting. Thus the appearance of the Web version of the Notices was completely different from that of the paper Notices. In particular, mathematical expressions appeared as \TeX\ coding, and users had to follow links in order to view pictures and illustrations.

Under the new system, Notices pages are rendered as PDF files, which means that on-screen pages have exactly the same format as they do on paper. This greatly improves the on-screen appearance of the Notices, especially because it allows users to view formatted mathematics on-screen. In addition, users can print Notices pages that look just like those in the paper journal. Live links to other Web pages are available. Plans are being developed to offer the ability to search the Notices files locally on e-MATH; this capability will be made available sometime in 1998.

To view the PDF files, users must have the Acrobat Reader software from Adobe Systems. The software is available free of charge and is very simple to use. Most Web browsers, when they encounter a PDF file and Acrobat is not installed on the local machine, will automatically direct the user to the Web site at Adobe from which Acrobat can be downloaded. Alternatively, the Notices home page on the Web, http://www.ams.org/notices/, offers a link to the Adobe Web site where one can obtain the software.

Top U.S. Education Official to Speak in Baltimore

Richard W. Riley, U.S. secretary of education, will speak at the Joint Mathematics Meetings in Baltimore in January. His talk, on the subject of the proposed national eighth-grade test in mathematics, will take place on Friday, January 9, at 3:10 p.m. For further information about the meetings please consult the "Meetings and Conferences" section of this issue of the Notices, or the Web site http://www.ams.org/amsmtgs/2014_intro.html.

—Allyn Jackson
1998 AMS Election
Nominations by Petition

Vice-President or Member-at-Large
One position of vice-president and member of the Council ex officio for a term of three years is to be filled in the election of 1998. The Council intends to nominate at least two candidates, among whom may be candidates nominated by petition as described in the rules and procedures.

Five positions of member-at-large of the Council for a term of three years are to be filled in the same election. The Council intends to nominate at least ten candidates, among whom may be candidates nominated by petition in the manner described in the rules and procedures.

Petitions are presented to the Council, which, according to Section 2 of Article VII of the bylaws, makes the nominations. The Council of 23 January 1979 stated the intent of the Council of nominating all persons on whose behalf there were valid petitions.

Prior to presentation to the Council, petitions in support of a candidate for the position of vice-president or of member-at-large of the Council must have at least fifty valid signatures and must conform to several rules and operational considerations, which are described below.

Editorial Boards Committee
Two places on the Editorial Boards Committee will be filled by election. There will be four continuing members of the Editorial Boards Committee.

The President will name at least four candidates for these two places, among whom may be candidates nominated by petition in the manner described in the rules and procedures.

The candidate's assent and petitions bearing at least 100 valid signatures are required for a name to be placed on the ballot. In addition, several other rules and operational considerations, described below, should be followed.

Nominating Committee
Three places on the Nominating Committee will be filled by election. There will be six continuing members of the Nominating Committee.

The President will name at least six candidates for these three places, among whom may be candidates nominated by petition in the manner described in the rules and procedures.

The candidate's assent and petitions bearing at least 100 valid signatures are required for a name to be placed on the ballot. In addition, several other rules and operational considerations, described below, should be followed.

Rules and Procedures
Use separate copies of the form for each candidate for vice-president, member-at-large, or member of the Nominating and Editorial Boards Committees.

1. To be considered, petitions must be addressed to Robert M. Fossum, Secretary, P.O. Box 6248, Providence, Rhode Island 02940, and must arrive by 28 February 1998.

2. The name of the candidate must be given as it appears in the Combined Membership List (CML). If the name does not appear in the CML, as in the case of a new member or by error, it must be as it appears in the mailing lists, for example on the mailing label of the Notices. If the name does not identify the candidate uniquely, append the member code, which may be obtained from the candidate's mailing label or the Providence office.

3. The petition for a single candidate may consist of several sheets each bearing the statement of the petition, including the name of the position, and signatures. The name of the candidate must be exactly the same on all sheets.

4. On the next page is a sample form for petitions. Copies may be obtained from the secretary; however, petitioners may make and use photocopies or reasonable facsimiles.

5. A signature is valid when it is clearly that of the member whose name and address is given in the left-hand column.

6. The signature may be in the style chosen by the signer. However, the printed name and address will be checked against the Combined Membership List and the mailing lists. No attempt will be made to match variants of names with the form of name in the CML. A name neither in the CML nor on the mailing lists is not that of a member. (Example: The name Robert M. Fossum is that of a member. The name R. Fossum appears not to be.)

7. When a petition meeting these various requirements appears, the secretary will ask the candidate to indicate willingness to be included on the ballot. Petitioners can facilitate the procedure by accompanying the petitions with a signed statement from the candidate giving consent.
The undersigned members of the American Mathematical Society propose the name of ________ as a candidate for the position of (check one):

- [ ] Vice President
- [ ] Member-at-Large of the Council
- [ ] Member of the Nominating Committee
- [ ] Member of the Editorial Boards Committee


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African Americans in Mathematics
Nathaniel Dean, Bell Laboratories, Murray Hill, NJ, Editor
This volume contains research and expository papers by African-American mathematicians on issues related to their involvement in the mathematical sciences. Little is known, taught, or written about African-American mathematicians. Information is lacking on their past and present contributions and on the qualitative and quantitative nature of their existence in and distribution throughout mathematics. This lack of information leads to a number of questions that have to date remained unanswered. This volume provides details and pointers to help answer some of these questions.

The Convenient Setting of Global Analysis
Andreas Kriegl and Peter W. Michor, Universit"at Wien, Austria
This book lays the foundations of differential calculus in infinite dimensions and discusses those applications in infinite dimensional differential geometry and global analysis not involving Sobolev completions and fixed point theory. The approach is simple: a mapping is called smooth if it maps smooth curves to smooth curves. Up to Frechet spaces, this notion of smoothness coincides with all known reasonable concepts. In the same spirit, calculus of holomorphic mappings (including Hartogs' theorem and holomorphic uniform boundedness theorems) and calculus of real analytic mappings are developed. Existence of smooth partitions of unity, the foundations of manifold theory in infinite dimensions, the relation between tangent vectors and derivations, and differential forms are discussed thoroughly. Special emphasis is given to the notion of regular infinite dimensional Lie groups.

Elliptic Functions and Elliptic Integrals
Viktor Prasolov, Independent University of Moscow, Russia, and Yuri Solovyov, Moscow State University, Russia
This book is devoted to the geometry and arithmetic of elliptic curves and to elliptic functions with applications to algebra and number theory. It includes modern interpretations of some famous classical geometric theorems such as Abel's theorem on the lemniscate and Hermite's solution of the fifth degree equation by means of theta functions. Suitable as a text, the book is self-contained and assumes only the prerequisites of the standard one-year courses of algebra and analysis.

Introduction to Complex Analysis
Junjiro Noguchi, Tokyo Institute of Technology, Japan
This book describes a classical introductory part of complex analysis for university students in the sciences and engineering and could serve as a text or reference book. It places emphasis on rigorous proofs, presenting the subject as a fundamental mathematical theory. The volume begins with a problem dealing with curves related to Cauchy's integral theorem. To deal with it rigorously, the author gives detailed descriptions of the homotopy of plane curves.
Add this Cover Sheet to all of your Academic Job Applications

How to use this form

1. Using the facing page or a photocopy, (or a TeX version which can be downloaded from the e-math "Employment Information" menu, http://www.ams.org/profession/employ.html), fill in the answers which apply to all of your academic applications. Make photocopies.

2. As you mail each application, fill in the remaining questions neatly on one cover sheet and include it on top of your application materials.

The Joint Committee on Employment Opportunities has adopted the cover sheet on the facing page as an aid to job applicants and prospective employers. The form is now available on e-math in a TeX format which can be downloaded and edited. The purpose of the cover form is to aid department staff in tracking and responding to each application.

Mathematics Departments in Bachelor's, Master's and Doctorate granting institutions have been contacted and are expecting to receive the form from each applicant, along with any other application materials they require. Obviously, not all departments will utilize the cover form information in the same manner. Please direct all general questions and comments about the form to: emp-info@ams.org or call the Professional Programs and Services Department, AMS, at 800-321-4267 extension 4105.

JCEO Recommendations for Professional Standards in Hiring Practices

The JCEO believes that every applicant is entitled to the courtesy of a prompt and accurate response that provides timely information about his/her status. Specifically, the JCEO urges all institutions to do the following after receiving an application:

(1) Acknowledge receipt of the application—immediately; and
(2) Provide information as to the current status of the application, as soon as possible.

The JCEO recommends a triage-based response, informing the applicant that he/she
(a) is not being considered further;
(b) is not among the top candidates; or
(c) is a strong match for the position.
### Academic Employment in Mathematics

**AMS STANDARD COVER SHEET**

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<td>If the Ph.D. is not presently held, date on which you expect to receive</td>
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*Indicate the mathematical subject area(s) in which you have done research using, if applicable, the 1991 Mathematics Subject Classification printed on the back of this form. If listing more than one number, list first the one number which best describes your current primary interest.*

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<th>Primary Interest</th>
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*Give a brief synopsis of your current research interests (e.g., finite group actions on four-manifolds). Avoid special mathematical symbols and please do not write outside of the boxed area.*

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<th>Most recent, if any, position held post Ph.D.</th>
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*Indicate the position for which you are applying and position posting code, if applicable*

If unsuccessful for this position, would you like to be considered for a temporary position?

- [ ] Yes  [ ] No

If yes, please check the appropriate boxes.

- [ ] Postdoctoral Position
- [ ] 2+ Year Position
- [ ] 1 Year Position

*List the names, affiliations, and e-mail addresses of up to four individuals who will provide letters of recommendation if asked. Mark the box provided for each individual whom you have already asked to send a letter.*

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<td>History and biography</td>
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<td>Logic and foundations</td>
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<td>04</td>
<td>Set theory</td>
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<td>Combinatorics</td>
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<td>06</td>
<td>Order, lattices, ordered algebraic structures</td>
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<td>General mathematical systems</td>
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<td>Number theory</td>
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<td>Field theory and polynomials</td>
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<td>Commutative rings and algebras</td>
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<td>14</td>
<td>Algebraic geometry</td>
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<td>15</td>
<td>Linear and multilinear algebra, matrix theory</td>
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<td>16</td>
<td>Associative rings and algebras</td>
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<td>Nonassociative rings and algebras</td>
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<td>18</td>
<td>Category theory, homological algebra</td>
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<td>19</td>
<td>K-theory</td>
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<td>Group theory and generalizations</td>
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<td>Topological groups, Lie groups</td>
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<td>26</td>
<td>Real functions</td>
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<td>Measure and integration</td>
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<td>Functions of a complex variable</td>
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<td>Potential theory</td>
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<td>Several complex variables and analytic spaces</td>
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<td>Special functions</td>
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<td>Ordinary differential equations</td>
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<td>Partial differential equations</td>
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<td>39</td>
<td>Finite differences and functional equations</td>
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<td>Sequences, series, summability</td>
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<td>41</td>
<td>Approximations and expansions</td>
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<td>42</td>
<td>Fourier analysis</td>
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<td>43</td>
<td>Abstract harmonic analysis</td>
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<td>44</td>
<td>Integral transforms, operational calculus</td>
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<td>Integral equations</td>
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<td>Operator theory</td>
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<td>49</td>
<td>Calculus of variations, optimal control</td>
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<td>Geometry</td>
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<td>52</td>
<td>Convex and discrete geometry</td>
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<td>Differential geometry</td>
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<td>General topology</td>
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<td>Algebraic topology</td>
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<td>Manifolds and cell complexes</td>
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<td>58</td>
<td>Global analysis, analysis on manifolds</td>
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<td>60</td>
<td>Probability theory and stochastic processes</td>
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<td>62</td>
<td>Statistics</td>
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<td>65</td>
<td>Numerical analysis</td>
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<td>68</td>
<td>Computer science</td>
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<td>70</td>
<td>Mechanics of particles and systems</td>
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<td>73</td>
<td>Mechanics of solids</td>
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<td>76</td>
<td>Fluid mechanics</td>
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<td>78</td>
<td>Optics, electromagnetic theory</td>
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<td>Classical thermodynamics, heat transfer</td>
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<td>81</td>
<td>Quantum theory</td>
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<td>82</td>
<td>Statistical mechanics, structure of matter</td>
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<td>83</td>
<td>Relativity and gravitational theory</td>
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<td>Astronomy and astrophysics</td>
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<td>Geophysics</td>
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<td>90</td>
<td>Economics, operations research, programming, games</td>
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<td>Biology and other natural sciences, behavioral sciences</td>
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<td>93</td>
<td>Systems theory, control</td>
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<td>94</td>
<td>Information and communication, circuits</td>
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</table>
The Reference section of the Notices is intended to provide the reader with frequently sought information in an easily accessible manner. New information is printed as it becomes available and is referenced after the first printing. As soon as information is updated or otherwise changed, it will be noted in this section.

Upcoming Deadlines

MPS Advisory Committee
The following lists the names and affiliations of the members of the Advisory Committee for Mathematical and Physical Sciences of the National Science Foundation. The date of the expiration of each member’s term is given after his or her name.

George Castro (ex-officio), San Jose University.
Praveen Chaudhari (10/99), IBM T. J. Watson Research Center.
Ronald Coifman (10/98), Yale University.
Susan Graham (10/98), University of California, Berkeley.
Judy Giordan (10/99), International Flavors and Fragrances.
David Goodstein (10/99), California Institute of Technology.
Norman Hackerman (10/00), Robert A. Welch Foundation.

Lynn Jelinski (10/99), Cornell University.
Jiri Jonas (10/00), Beckman Institute.
Michael Knotek (10/00), Argonne National Laboratory.
James Langer (10/99), University of California, Santa Barbara.
Richard McCrory (10/00), University of Colorado.
Joseph Miller (10/98), University of California, Santa Cruz.
Harry Morrison (10/99), Purdue University.
Gerard Mourou (10/00), University of Michigan.
Mara Prentiss (10/98), Harvard University.
Isiah Warner (10/99), Louisiana State University.
Carol S. Wood (10/00), Wesleyan University.
Margaret Wright (chair; 10/98), Bell Laboratories.

The address is: Directorate for Mathematical and Physical Sciences, National Science Foundation, 4201 Wilson Boulevard, Suite 1005, Arlington, VA 22230. The Web address is http://www.nsf.gov/mps/.

Where to Find It
A brief index to information which appears in this and previous issues of the Notices.
AMS e-mail addresses
October 1997, p. 1118
AMS Ethical Guidelines
June 1995, p. 694
AMS officers and committee members
September 1997, p. 972
Board on Mathematical Sciences and Staff
May 1997, p. 597
Bylaws of the American Mathematical Society
November 1997, p. 1339
Classification of degree-granting departments of mathematics
January 1997, p. 48
Mathematical Sciences Education Board and Staff (1996-1997)
May 1997, p. 597
Mathematics Research Institutes contact information
May 1997, p. 598
National Science Board of NSF
November 1996, p. 1380
NSF Mathematical and Physical Sciences Advisory Board
May 1997, p. 597
Officers of the Society 1996 and 1997 (Council, Executive Committee, Publications Committees, Board of Trustees)
May 1997, p. 593
Program officers for federal funding agencies (DoD, DoE, NSF)
October 1997, pp. 1150-1151
This journal provides a forum for mathematical work in related fields broadly described as conformal geometry and dynamics. This includes complex dynamics (and real dynamics using complex techniques), Kleinian groups, hyperbolic geometry, Teichmüller theory, and quasiconformal mappings.

Current volume includes...

Thirty-three yes or no questions about mappings, measures, and metrics

Juha Heinonen and Stephen Semmes

Properties of convergence groups and spaces

Eric M. Freden

Branch sets of uniformly quasiregular maps

G. J. Martin

Dynamics of the family $\lambda \tan z$

Linda Keen and Janina Kotus

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For details on special offers or for further information, contact AMS Membership and Customer Services.

For further information, visit our Web site!

http://www.ams.org/ecgd/
Mathematics Calendar

January 1998

Organizing Committee: T. Ekedahl (Univ. of Stockholm), J. Mickelsson (Royal Institute of Technology, Stockholm), A. Niemi (Univ. of Uppsala), and O. Viro (Univ. of Uppsala).
Information: J. Mickelsson, Department of Theoretical Physics, KTH, S-100 44 Stockholm, Sweden; e-mail: jouko@theophys.kth.se; A. Niemi, Dept. of Theoretical Physics, Box 803, S-751 08 Uppsala, Sweden; e-mail: niemi@teorfys.uu.se; O. Viro, Dept. of Mathematics, Box 480, S-751 06 Uppsala, Sweden; e-mail: viro@math.uu.edu.

*1998-99 Special Year on Large Scale Discrete Optimization, DIMACS Center, Rutgers University, Piscataway, New Jersey.
Focus: This Special Year is motivated by developments in the past ten years. There have been three simultaneous advances: at the algorithmic level, with new and interesting algorithms for solving large scale discrete problems both exactly and approximately; at the implementation level, providing codes and systems for solving such problems; and at the practical level, with interests in the fastest solution of real-world problems. Examples of such applications include airline crew scheduling, chemical process design, and telecommunication network design. Our goal in this year is to unite these groups. The confluence of exciting recent work on approximation and other algorithms and greatly improved software/hardware for optimization makes large scale discrete optimization a practical, useful approach to solving problems of practical interest.

Opportunities to Participate: The Special Year will include: Workshops: A variety of workshop and mini-workshop topics are under consideration. A pre-Special Year workshop on Large Scale Discrete Optimization is already planned for May 27-29, 1998. Visitor Programs: Applications for travel and local support. Postdoctoral Positions: Two postdoctoral positions will be offered in this area. Publications: We anticipate that a variety of publications, including AMS-DIMACS books, technical reports, abstracts and notes on the WWW, and DIMACS Modules will result from the Special Year. Possible Workshops: We are still in the early stages of planning for workshops, but possible topics for workshops (4-5 days) and mini-workshops (1-2 days) include: Large Scale Discrete Optimization in Engineering; Large Scale Discrete Optimization in Production and Scheduling; Large Scale Discrete Optimization in Transportation; Large Scale Discrete Optimization in Robotics and Vision; Algorithms for Large Scale Discrete Optimization; Semidefinite Programming and Large Scale Discrete Optimization; Constraint Programming and Large Scale Discrete Optimization; Large Scale Discrete Optimization in Data Mining. In addition, there will be at least one Computational Challenge addressing one or more problems in large scale discrete optimization. Those with suggestions for workshops or those interested in aiding the organization of workshops should contact the organizing committee.
Organizers: Organizers for the Special Year are: E. Boros (Rutgers/DIMACS, local chair), W. Pulleyblank (IBM), M. Trick (Carnegie Mellon, general chair), B. Vanderbei (Princeton/DIMACS), V. Vazirani (Georgia Tech). Researchers interested in early discussions about visiting are encouraged to contact the organizing committee by e-mail to dimacs98@mat.gsia.cmu.edu; information about workshops, etc., will be made available on DIMACS's WWW site and in many newsletters and electronic sites.

This section contains announcements of meetings and conferences of interest to some segment of the mathematical public, including ad hoc, local, or regional meetings, and meetings and symposia devoted to specialized topics, as well as announcements of regularly scheduled meetings of national or international mathematical organizations. A complete list of meetings of the Society can be found on the last page of each issue.

An announcement will be published in the Notices if it contains a call for papers and specifies the place, date, subject (when applicable), and the speakers; a second 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 every third issue until it has been held and a reference will be given in parentheses to the month, year, and page of the issue in which the complete information appeared. Asterisks (*) mark those announcements containing new or revised information.

In general, announcements of meetings and conferences held in North America carry only the date, title of meeting, place of meeting, names of speakers (or sometimes a general statement on the program), deadlines for abstracts or contributed papers, and source of further information. Meetings held outside the North American area may carry more detailed information. In any case, if there is any application deadline with respect to participation in the meeting, this fact should be noted. All communications on meetings and conferences in the mathematical sciences should be sent to the Editor of the Notices in care of the American Mathematical Society in Providence or electronically to notices@ams.org or mathcal@ams.org.

In order to allow participants to arrange their travel plans, organizers of meetings are urged to submit information for these listings early enough to allow them to appear in more than one issue of the Notices prior to the meeting in question. To achieve this, listings should be received in Providence six months prior to the scheduled date of the meeting.

The complete listing of the Mathematics Calendar will be published only in the September issue of the Notices. The March, June, and December issues will include, along with new announcements, references to any previously announced meetings and conferences occurring within the twelve-month period following the month of those issues. New information about meetings and conferences that will occur later than the twelve-month period will be announced once in full and will not be repeated until the date of the conference or meeting falls within the twelve-month period.

The Mathematics Calendar, as well as Meetings and Conferences of the AMS, is now available electronically through e-MATH on the World Wide Web. To access e-MATH, use the URL: http://e-math.ams.org/ for those with VT100-type terminals or for those without WWW browsing software, connect to e-MATH via Telnet (telnet e-math.ams.org; login and password e-math) and use the Lynx option from the main menu.
**February 1998**

5-7 The Fourth Barcelona Logic Meeting, Universitat Autonoma de Barcelona, Bellaterra, Spain.

Aims: This is the fourth in a series of meetings devoted to areas of mathematical logic.

Invited Speakers: M. Baaz (Technische Universität Wien), J. L. Balcazar (Univ. Politecnica de Catalunya), A. Baudisch ( Humboldt Univ., Berlin), G. Cherlin (Univ. of Rutgers), V. A. Gorbonos (Inst. of Mathematics, Novosibirsk), A. Louveau (Univ. Paris VI), T. Recio (Univ. de Santiago), A. Torrens (Univ. de Barcelona), H. Woodin (Univ. of California at Berkeley).

Communications: Those wishing to present short communications are invited to submit two copies of a one-page abstract before December 1, 1997, to: CRM, Apartado 50, 08193 Bellaterra (Barcelona), Spain.

Organizing Committee: I. Bagaria, E. Casanovas, R. Elgueta, S. Friedman, D. Mundici, B. Poizat, J. Rebagliato.

Information: http://www.crm.es/.

20-21 Hyperbolic Geometry (First Announcement), University of Southampton, Southampton, United Kingdom.

Speakers: W. Ballmann (Univ. of Bonn), B. Bowditch (Univ. of Southampton), M. Kapovich (Univ. of Utah), A. Lubotzky (Hebrew Univ.), Y. Minsky (SUNY at Stony Brook), and C. Series (Univ. of Warwick). The talks will be Friday afternoon and Saturday morning. Details concerning overnight accommodations and the Friday night banquet will be made available in the second announcement.

Information: Please contact one of the organizers: G. Niblo, (g.niblo@maths.soton.ac.uk) and J. Anderson (jra@maths.soton.ac.uk). Our regular mail address is: Faculty of Mathematical Studies, Univ. of Southampton, Southampton SO17 1BJ; tel: 01703-593612; fax: 01703-593147.

23-28 Arithmetic of Algebraic Cycles and Motivic Cohomology, Newton Institute, Cambridge, United Kingdom.


Topics: Among the topics to be addressed are: motivic cohomology, computations of Chow groups over various base fields, some aspects of higher class field theory.


Information: Applications to: J.-L. Colliot-Thélène, Département de Mathématiques, Université Paris-Sud, Bât. 425, 91405 Orsay Cedex, France; e-mail: colliot@math.u-psud.fr. Closing date for applications: November 15, 1997.


Topics: Topics for the conference include but are not limited to the following: limit theorems for stochastic processes, stochastic analysis, Markov processes, diffusion, Dirichlet forms, queueing theory, modelling of telecommunication system, white noise analysis, quantum stochastic analysis, stochastic models in finance, applied probability approximation, long-range dependence, self-similar processes, statistics of stochastic processes, stochastic control, random set and fuzzy processes.


Contributed Talks: The organizers are soliciting contributed talks of 20-minute duration within the topics of the conference. Abstracts should be submitted to the conference secretary either by ordinary mail, e-mail, or fax. Abstracts should contain author’s affiliation and e-mail address.


Abstract: Abstracts for invited lectures and contributed talks should not contain more than 200 words each and should be submitted to the organizing secretary no later than December 1, 1997, through e-mail or regular mail (e-mail is strongly preferred). Submissions through e-mail should be sent to the following address: cam@queue.kai.ist.ac.kr or cam@math.kai.ist.ac.kr.

Information: For the registration form and further information, you may also visit the Internet site http://math.kai.ist.ac.kr/~cam/.

**March 1998**


Goal: This conference is the first Arizona Winter School on Arithmetical Algebraic Geometry. The goal is to expose graduate students and young researchers in number theory and algebraic geometry to current topics in arithmetic geometry in a short span of time and in an intense interactive environment with the presence of experts in the field. There will also be a professional...
development component that is intended to provide an opportunity for young researchers to acquire practical skills relevant to their careers.

**Topics:** The topic for this year is "Diophantine Geometry Related to the ABC Conjecture." A series of survey lectures will be delivered by D. W. Masser, and numerous talks of both an introductory and specialized nature are planned. The focus of the professional development component will be the teaching of mathematics. Perspectives from mathematics education research and from the classroom experience of mathematicians will be presented. The component will include roundtable discussions by participants as well as lectures.

**Organizers:** A. Buium, M. Kim, and F. Voloch.
**Confirmed Speakers:** A. Buium, H. Darmon, D. W. Masser, B. Mazur, L. Szpiro, P. Vojta, and F. Voloch.

**Information:** See the Web at [http://www.math.arizona.edu/~SWCenter/](http://www.math.arizona.edu/~SWCenter/) or send a message to major@math.arizona.edu with "subscribe aw98" in the body.

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**April 1998**

- **20-24 International Conference on Theoretical Computer Science in Honour of Professor Manuel Blum's 60th Birthday.** City University of Hong Kong, Hong Kong.
- **Speakers:** D. Angluin (Yale), B. Bach (Wisconsin), C. Bennett (IBM, Yorktown), A. Blum (Carnegie Mellon), A. Borodin (Toronto), M. Furst (Carnegie Mellon), S. Goldwasser (MIT), K. R. R. Kop (Washington), L. Levin (Boston), M. L. (Waterloo), S. McIver (MIT), M. Miller (Carnegie Mellon), M. Minsky (MIT), C. Padadmirini (UC, Berkeley), M. Rabin (Harvard and Hebrew University), S. Rudich (Carnegie Mellon), M. Sipser (MIT), U. Vazirani (UC, Berkeley), V. Vazirani (Georgia Tech), S. Winograd (IBM, Yorktown), A. Yao (Princeton), F. Yao (Xerox Corp.).
- **Call for Papers:** Titles and abstracts of contributed papers must be received by January 31, 1998. The abstracts should be typed in LaTeX, not exceed one page, and sent to M. Lau by e-mail.

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**Mathematics Calendar**

- **23-28 EC Summer School: Arithmetic Geometry; Part I: Instructional Conference: Current Trends in Arithmetic Algebraic Geometry, Newton Institute, Cambridge, United Kingdom.**
  **Grants:** The conference is supported by a grant from the European Community, which will provide funding towards the registration, travel, and subsistence costs of selected young (under 35 years) participants. Applications from women and anyone living in Greece, Ireland, Portugal, and other less favored regions of the European Community are particularly encouraged. Other limited funds exist for participants from outside the EC. Self-supporting applicants of any age and nationality are welcome.
  **Applications:** The workshop will take place at the Institute on the 26th of May, 1998. Applications for participants will be provided at Wolfson Court, adjacent to the Institute. The conference package costs £280, which includes registration fees, accommodations, breakfast and evening meals, plus lunch and refreshments during the days that lectures take place.
  **Information:** Further information and application forms are available from the WWW at [http://www.newton.cam.ac.uk/programs/alg.html](http://www.newton.cam.ac.uk/programs/alg.html), where information about the main program and general information about the Newton Institute can be found. Completed application forms should be sent to H. Dawson, 20 Clarkson Road, Cambridge, CB3 0EH, UK; or via e-mail: h.dawson@newton.cam.ac.uk. Closing date for the receipt of applications is November 30, 1997.

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**Aims:** This conference is aimed at faculty members, graduate students, and visitors from universities in the central U.S.

**Confirmed Invited Speakers:** J. Flaherty (RI), B. Gear (NEC Research Inst., Inc.), E. Twizell (Brunel Univ., England).

**Organizers:** A. Khalig (a.khalig@wriu.edu, 309-298-1502); D. Voss (d.voss1@wriu.edu, 309-298-1502).

**Deadline:** If you are interested in giving a contributed talk in the form of an oral presentation or a poster session, submit a title and short abstract (indicating the form of presentation) by March 16, 1998, either through the conference Web page, via e-mail to nadaya@wriu.edu, or to one of the organizers. There is no registration fee.

**Information:** Information about the conference will be available on the Web at [http://www/EC1998/](http://www/EC1998/) or via e-mail to nadaya@wriu.edu.

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**26-June 27 Commutative Algebra, Homological Algebra, and Representation Theory, Italy.**

**Main Sponsor:** INdAM (Istituto Nazionale di Alta Matematica).
**Description:** An intensive period of study and research in honor of D. Buchsbaum, divided into four parts: Part 1. (Univ. of...
May 1998

*3-6 Fourier Analysis and Applications (FAA98), Kuwait University, Kuwait.

Sponsors: The conference is sponsored and organized jointly by Kuwait University (KU) and Kuwait Foundation for the Advancement of Sciences (KFAS).

Objectives: Presentation and discussion of recent developments in the theory and applications of Fourier Analysis; to provide a forum for mathematicians, engineers, and other scientists to exchange ideas.

Scientific Committee: A. Boettcher (TU Chemnitz), P. Butzer (RWTH Aachen), G. Heinig (KU), S. Mazhar (KU), M. Nashed (Univ. of Delaware), G. Strang (MIT), V. K. Tuan (KU).

Topics: Trigonometric series and approximations, Fourier and integral transforms, fast Fourier techniques, wavelets, and applications to differential and integral equations.

Call for Papers: Anyone interested in attending should submit an application (preferably by e-mail) to the organizing committee. In addition, a one-page abstract, sent by e-mail or on a diskette in a TeX format, is required of those who wish to give a talk. The deadline for applications and abstracts is February 28, 1998. Notification of acceptance will be sent by March 15, 1998. A refereed proceeding is planned to be published soon after the conference.

Financial Support: There is no registration fee. Local accommodations, transportation, and conference dinner will be covered by the organizers. Limited travel support is provided in some cases.

Information: F. Al-Musallam, FAA98 Organizing Committee, Dept. of Mathematics and Computer Science, Kuwait University, P.O. Box 5999, Safat 13060, Kuwait; tel: +96-4813129; fax: +96-4817201; e-mail: FAA98@KUNIV.EDU.KW.

April 1998

*2-4 8th NSF-CBMS Regional Research Conference on Wavelet Analysis as a Tool for Computational and Harmonic Analysis, University of Central Florida, Orlando, Florida.

Principal Speaker: R. R. Coifman (Yale Univ.). Additional invited lectures by other leaders will also be featured, and ample opportunity is planned for information discussion as well.

Organizer: L. Debnath, Dept. of Mathematics, Univ. of Central Florida, Orlando, FL 32816; tel: 407-823-2478 or 407-823-2754; fax: 407-823-6253; e-mail: ldebnath@pegasus.cc.ucf.edu or ldebnath@pegasus.cc.ucf.edu. For more information contact L. Debnath.

Participation: Open to mathematicians and scientists working at research level on the theoretical or practical aspects of wavelet analysis. Some support is available for travel and local expenses. Application for participation and possible support should be made by January 30, 1998. Late applications will be considered as space permits. Women and minority scientists are strongly encouraged to participate. Inclusion of a short resume and/or statement of current research interests from junior faculty and graduate students seeking funding would be helpful for selection.

*18-24 Laminations and Foliations in Dynamics, Geometry, and Topology, Institute for Mathematical Sciences, State University of New York at Stony Brook, Stony Brook, New York.

Topics: Riemann surface and hyperbolic laminations and their relation to conformal dynamics; laminations and currents in higher dimensional holomorphic dynamics; analytic differential equations; groupoids and non-commutative geometry; geodesic laminations and foliations on surfaces and in 3-manifolds; foliations, symplectic and contact structures.


Support: We hope to have some funds available to support a number of participants, particularly graduate students and postdocs. To apply for support, contact us at one of the addresses below. Applications of graduate students and postdocs should be backed by one recommendation letter.

Information: If you plan to attend, please contact us at: http://www.math.sunysb.edu/solenoid; or via e-mail at solenoid@math.sunysb.edu; fax: 516-632-7631 c/o G. Sculli; or mail to Laminations Conference, Institute for Math. Sciences, SUNY at Stony Brook, Stony Brook, NY 11794.

June 1998


Deadlines: November 3, 1997, is the deadline for submitting minisymposium proposal forms and for minisymposium speakers to submit 150-word extended abstracts, and for submitting 150-word extended abstracts for contributed presentations.

Conference Chair: J. A. DeSanto.

Information: Minisymposium proposals and abstract submissions are invited. For further information about the conference and how to send your abstracts, visit the
SIAM Web page at: http://www.siam.org/meetings/wp98/wp98home.htm, or contact the SIAM Conference Department by e-mail at: meetings@siam.org; tel: 215-382-9800; fax: 215-386-7999.

10-12 From Erdős to Algorithms: Applications of the Probabilistic Method, DIMACS Center, Rutgers University, Piscataway, New Jersey


Focus: The "probabilistic method" is a legacy of Paul Erdős that continues to grow and flourish and have powerful applications in all parts of the mathematical sciences. We will explore current results in discrete mathematics that use probabilistic existence arguments and require the use of sophisticated probability concepts. We will further explore the connection to modern issues in computer science by examining the possible implementations of probabilistic existence arguments by randomized or deterministic algorithms.


12-13 The Third Biennial Symposium on Mathematical Modeling in the Undergraduate Curriculum, University of Wisconsin, La Crosse, Wisconsin

Sponsors: The Mathematics Department of the University of Wisconsin in La Crosse and the Consortium for Mathematics and its Applications (COMAP) are hosting this symposium to bring together mathematicians, scientists, and university educators for the purpose of sharing ideas, projects, and problems related to mathematical modeling in the undergraduate curriculum.

Call for Papers: We invite submissions for 25-minute or 50-minute presentations focusing on any aspect of mathematical modeling. Both mathematical and pedagogical themes are welcome, and a student presentation session will be included.

Submission: Submissions (limited to 15 pages) should include a cover page giving the title of the paper, names and affiliations of authors, a brief abstract, and the contact author's name, address, phone number, fax number, and e-mail address.


25-27 International Conference on Scientific Computing and Mathematical Modeling IMACS'98, Alicante, Spain

Conference Topics: Stiff computations, computational fluid dynamics, grid generation, mathematical biology, seismic data processing, environmental models, networking, recent algorithms for nonlinear partial differential equations and ordinary differential equations, parallel computing, molecular dynamics, computational physics and chemistry, engineering applications, structural mechanics modeling, optimization and queueing applications.

Invited Speakers: D. Bhardwaj (C-DAC, India), J. Cash (Imperial College, London, UK), E. Fernandez-Cara (Univ. de Sevilla, Spain), L. Fishman (Univ. of New Orleans, USA), J. Fleckinger (Univ. of Toulouse, France), B. Garcia-Archilla (Spain), B. Hon (Hong Kong), J. Kansa (Lawrence Livermore Nat'l Lab, USA), Milovanovic (Univ. of NIS, Serbia), M. Onofri (Univ. of Rome, Italy), J. J. N. Roig (Spain), D. Schultz (Univ. of Wisconsin, Milwaukie), J. Thompson (Mississippi State Univ. USA), J. Ziebarth (NASA-Ames, USA).

Call for Papers: We invite articles for presentations. Detailed abstracts of three pages, including figures and tables, should be submitted to organizing chairperson by January 10, 1998. All abstracts will be reviewed.

Organizers: S. K. Dey, Department of Mathematics, Eastern Illinois University, Charleston, IL 61920; tel: 217-581-5727; fax: 217-581-6384; e-mail: cfzfeld@eiu.edu; J. M. Ferrandiz, Dept. de Analisis Matematico y Matematica Aplicada, Universidad de Al­ icante, P.O. Box 99, E-03080 Alicante, Spain; tel: 34-6-590-3731; fax: 34-6-590-3804; e-mail: j.m.ferrandiz@ua.es.


28-July 3 Conference on Computer-Aided Verification (CAV'98), Vancouver, British Columbia

Topics: Modeling and specification formalisms, algorithms and tools, verification techniques, applications and case studies, verification in practice.

Submission: Submissions are invited in two categories. (1) Regular papers: Submission of a regular paper should be an extended abstract not exceeding ten pages. The submission should contain original research and sufficient detail to assess the merits and relevance of the contribution. (2) Tool presentations: Tool submission should be an abstract not exceeding four pages. The same page limit (four) applies to the conference proceedings. The submission should describe the tool and its novel features. Authors may submit papers as self-contained PostScript files via anonymous ftp to ftp.cs.ubc.ca, directory pub/incoming, e-mailing notification to cay98- submit@cs.ubc.ca. Alternatively, authors may submit a paper by e-mailing a self-contained PostScript version to the same address. Deadline for submissions is January 15, 1998.

Program Committee: M. Abadi, R. Ahu, A. Bouajjani, J. Burch, O. Coudert, W. Damm, O.

*28-July 3 The Third St. Petersburg Workshop on Simulation, St. Petersburg, Russia.

Program: The workshop will be devoted to the development and application of sophisticated mathematical techniques to the solution of actual problems in stochastic simulation and applied statistics, especially in experimental design.

Call for Papers: Original papers on workshop topics are solicited. Authors should submit two hard copies (no more than six pages) typed in a one-column format and an electronic version in LaTeX (using 1p checked) 2000, March 31, 1998. Proceedings will be available to the participants at the beginning of the workshop. To participate without presentation of a paper, it is necessary to send a completed registration form by March 30, 1998.

Organizers: W. E. Biles, e-mail: veblle01@ulkyve.ou.edu; V. V. Fedorov, e-mail: fedorov@welsun.epm.onf.gov; V. Melas, e-mail: ViatechIsrael.Melas@pobox.spbu.ru; W. K. Wong, e-mail: wkong@sunlab.ph.ucla.edu.

Information: The full list of organizing committee members and additional information can be found on the Web site: http://www.niim.spb.su/.

*29-July 3 Arakelov Theory, Values of L-Functions, Newton Institute, Cambridge, United Kingdom.


Topics: Among the topics to be addressed are: the Grothendieck formula and its generalizations, regulators, diophantine approximation, Arakelov geometry.


Information: Applications are to be sent to: H. Dawson, Isaac Newton Institute, 20 Clarkson Road, Cambridge, CB3 0EH, UK; e-mail: h.dawson@newton.cam.ac.uk. Closing date for applications: March 31, 1998.

July 1998

*6-10 International Conference on Ordered Algebraic Structures and Related Areas (OAS '98), The Center for Chinese and American Studies, Nanjing University, Nanjing, P. R. China.

Objectives: This conference will highlight significant recent developments in ordered algebraic structures and related areas. The aims of the conference are to bring together researchers working in these areas and to provide a forum for the participants to meet and jointly explore unsolved problems of common interest in an informal atmosphere. The following areas will be emphasized: ordered groups and infinite permutation groups; other ordered algebraic structures including semilattices, lattices, ordered sets, ordered semigroups, ordered rings, and ordered modules, etc.; and semigroups, groups, and universal algebra. Researchers in neighboring areas whose interests fit the general aims of the conference are encouraged to participate.

Program: The scientific program of the conference will consist of plenary hour lectures and special sessions of 30-minute contributed talks.

Organizers: P. Conrad (Lawrence, USA), K. Denecke (Potsdam, Germany), M. Giraudet (Paris, France), W. C. Holland (Bowling Green, USA, chair), A. C. Kim (Pusan, South Korea), W. Kopytov (Novosibirsk, Russia), N. Y. Medvedev (Alta, Russia), I. Rival (Alberta, Canada), K. P. Shum (Hong Kong, China), D. R. Ton (Nanjing, China), C. Tsiknakis (Nashville, USA).

Deadlines: Deadline for registration: March 1, 1998; deadline for submitting abstracts: May 1, 1998.

Information: D.R. Ton, dao-rong@public1.ptt.ja.cn; or: 309-305, 3 Xikang Road, Nanjing, 210024, P. R. China. Current conference information is available on the OAS '98 Web page: http://www.math.vanderbilt.edu/ oas98/.


Program: The application of mathematics to biology is a rapidly expanding area, and we will present an introduction to this topic. This will include both the formulation of models in population biology and epidemiology and the mathematical analysis of these models. Examples at both the elementary and advanced levels will be presented. Mathematical topics will include qualitative analysis of autonomous differential equations and systems, difference and delay equations. Applications will include continuous and discrete populations for single and interacting species, general compartmental models in epidemiology, interaction of demographic and epidemiological effects, and behavioral effects in sexually transmitted diseases. Simulations making use of Mathematica and Maple will be included for illustration of qualitative behavior.
Speakers: F. Brauer (Univ. of Wisconsin), C. Castillo-Chavez (Cornell Univ.), and D. Sanchez (Texas A& M Univ.).

Sponsors: Rocky Mountain Mathematics Consortium and the Univ. of Wyoming. NSF support pending.


Information: A.D. Porter, Mathematics Department, Univ. of Wyoming, Laramie, WY 82061; e-mail: adporter@uwyo.edu.

12-August 1 IAS/Park City Mathematics Institute, Park City, Utah.

Topic: The 1998 research topic is Representation Theory of Lie Groups. The summer session is open to researchers, undergraduate faculty, researchers in mathematics education, graduate students, undergraduate students, and high school mathematics teachers.

Organizers: J. Adams (Univ. of Maryland) and D. Vogan (MIT).

Graduate Summer School Lecturers: A. Knapp (SUNY at Stony Brook); J.S. Li (Univ. of Maryland); K. Vilonen (Brandeis Univ.); D. Vogan (MIT); R. Zierau (Oklahoma State Univ.).

Undergraduate Program Lecturers: W. Barker (Bowdoin College); R. Howe (Yale Univ.).

High School Teacher Program Lecturers: N. Fischer (Univ. of Illinois at Chicago); C. Hayes (McCallum High School, Austin, Texas); J. King (Univ. of Washington); J. Polking (Rice Univ.); and P. J. Sally (Univ. of Chicago).


Information: PCMI Summer Session applications are available by contacting IAS/PCMI, Institute for Advanced Study, Olden Lane, Princeton, NJ 08540; 1-800-726-4427; e-mail: pcmi@math.ias.edu. Applications and brochure are also available on the internet: http://www.ias.edu/park.htm.

13-17 International Colloquium on Automata, Languages, and Programming (ICALP'98), Aalborg, Denmark.

Topics: Computability, automata, formal languages, new computing paradigms, term rewriting, analysis and design of algorithms, computational geometry, computational complexity, symbolic and algebraic computation, cryptography and security, data types and data structures, theory of databases and knowledge bases, semantics of programming languages, program specification and verification, foundations of functional and logic programming, parallel and distributed computation, theory of concurrency, theory of robotics, theory of logical design and layout.

Submissions: Authors are invited to submit seven copies of an extended abstract not exceeding 12 pages by January 14, 1998. Electronic submission of papers is solicited. Instructions can be found at http://www.cs.au.dk/icalp98/submission.html. In addition, suggestions for workshops are invited. These must be sent by December 1, 1997, to K. G. Larsen, ICALP'98, Dept. of Computer Science, Aalborg Univ., Fredrik Bajers Vej 7E, DK-9220 Aalborg, Denmark; e-mail: icalp98-submission@cs.au.dk.


13-17 1998 SIAM Annual Meeting, University of Toronto, Toronto, Ontario, Canada.

Information: Participate now! Visit http://www.siam.org/meetings/annual98/simhome.html to access the meeting, call for papers, and registration information, or contact meetings@siam.org.

19-24 International Symposium on Optical Science, Engineering, and Instrumentation, Vision Geometry VII (SDI/1), San Diego, California.

Conference Chairs: J. Latecki (Univ. Hamburg); R. A. Melter (Long Island Univ.); Y. Wu (American Univ.).


Keynote Speaker: G. Herman (Univ. of Pennsylvania).

Aim: This conference is designed to bring together researchers who use geometric theory and techniques to solve problems related to computer vision. Specific solutions as well as overviews of more general topics are welcome.

Abstracts: Abstracts are solicited on the following topics: digital geometry and topology, geometry-based image segmentation, morphology-related vision, computational geometry related to vision, convexity problems in vision. To submit an abstract electronically, use our online submission form at http://www.siam.org/forms/sd98_submission_form.html.

Deadlines: Paper abstracts due from authors: December 22, 1997 (postmeeting proceedings); manuscripts due from authors: June 22, 1998 (postmeeting proceedings); the complete call for papers will be available on or before October 13, 1997, at http://www.siam.org/info/ed.

Participant Registration Fee: Authors and coauthors are accorded a reduced symposium registration fee. Participants who attend the symposium and pay the reduced fee may also apply for a six-month, nonvoting membership in SPIE if never before a member (membership includes OE Reports and Optical Engineering Journal). Details are available at the on-site registration desk or by contacting SPIE Member Services: membership@spie.org, or by calling 360-676-3290 and asking for member records.

October 1998


Organizer: D. Field (General Motors Corp.).

Information: We invite you to participate in this workshop. For more information about the workshop, or how to submit a minisymposium proposal, or to contribute a presentation, visit http://www.siam.org/meetings/cd98/cd98home.htm, or contact meetings@siam.org.

The following new announcements will not be repeated until the criteria in the next to the last paragraph at the bottom of the first page of this section are met.

April 1999

*17-19 Weekend Algebra Conference, University of Southern Mississippi, Hattiesburg, Mississippi.

Organizers: T. H. Fay, e-mail: tfhay@nozart.math.usm.edu; W. Hornor, e-mail: william_hornor@bull.cc.usm.edu; G. L. Walls, e-mail: gary.valls@usm.edu.

Information: In keeping with the tradition of the annual regional algebra conferences, talks (20-30 minutes) in all areas of algebra are welcome. Graduate students are particularly encouraged to attend. Also in keeping with the tradition of these conferences, no funding is available for travel expenses. Those interested in attending this conference are requested to contact the organizers to indicate their level of participation (speaking, attending, bringing students, putting on mailing list for future announcements, etc.). Potential speakers should notify one of the organizers of their interest by giving a tentative title of their talk. This information is helpful in planning for the traditional social functions (dinner, picnic, coffee and doughnuts, etc.).

March 2001

*16-18 AMS Southeastern Sectional Meeting, University of South Carolina, Columbia, South Carolina.

Information: R. Casseia, e-mail: rgc@ams.org.
New Publications Offered by the AMS

General and Interdisciplinary

Selected Papers on Harmonic Analysis, Groups, and Invariants
Katsumi Nomizu, Brown University, Providence, RI, Editor

This volume contains papers that originally appeared in Japanese in the journal Sūgaku. Ordinarily the papers would appear in the AMS translation of that journal, but to expedite publication the Society has chosen to publish them as a volume of selected papers. The papers range over a variety of topics, including representation theory, differential geometry, invariant theory, and complex analysis. This text will also be of interest to those working in algebra and algebraic geometry and geometry and topology.

Contents: T. Kobayashi, Harmonic analysis on homogeneous manifolds of reductive type and unitary representation theory; M. A. Guest and Y. Ogura, Actions of loop groups, deformations of harmonic maps, and their applications; T. Umeda, The Capelli identities, a century after; K. Koike, On representation of the classical groups; K. Salt, Around the theory of the generalized weight system: Relations with singularity theory, the generalized Weyl group and its invariant theory, etc.

American Mathematical Society Translations—Series 2, Volume 183

Number Theory

Computational Perspectives on Number Theory
Proceedings of a Conference in Honor of A. O. L. Atkin
D. A. Buell, Center for Computing Sciences, Bowie, MD, and J. T. Teitelbaum, University of Illinois at Chicago, Editors

This volume contains papers presented at the conference "Computational Perspectives on Number Theory" held at the University of Illinois at Chicago in honor of the retirement of A. O. L. Atkin. In keeping with Atkin's interests and work, the papers cover a range of topics, including algebraic number theory, p-adic modular forms and modular curves. Many of the papers reflect Atkin's particular interest in computational and algorithmic questions.

Titles in this series are co-published with International Press, Cambridge, MA.


AMS/IP Studies in Advanced Mathematics, Volume 7
Wavelets, Multiwavelets, and Their Applications

Akram Aldroubi, Vanderbilt University, Nashville, TN, and EnBing Lin, University of Toledo, OH, Editors

This volume contains refereed research articles on the active area of wavelets and multiwavelets. The book draws upon work presented by experts in the field during the special session on "Wavelets, Multiwavelets and Their Applications" at the Joint Mathematics Meetings in San Diego (January 1997).

Wavelets were implicit in mathematics, physics, signal or image processing, and numerical analysis long before they were given the status of a unified scientific field in the late 1980s. They continue to be one of the few subjects that have attracted considerable interest from the mathematical community as well as from other diverse disciplines where they have had promising applications. The topic is in full evolution, with many active research efforts emerging from the fruitful interaction of various mathematical subjects and other scientific disciplines.

This text will also be of interest to those working in applications.


Contemporary Mathematics


Partial Differential Equations

Lawrence C. Evans, University of California, Berkeley

This text gives a comprehensive survey of modern techniques in the theoretical study of partial differential equations (PDEs) with particular emphasis on nonlinear equations. The exposition is divided into three parts: 1) representation formulas for solutions, 2) theory for linear partial differential equations, and 3) theory for nonlinear partial differential equations.

Included are complete treatments of the method of characteristics; energy methods within Sobolev spaces; regularity for second-order elliptic, parabolic and hyperbolic equations; maximum principles; the multidimensional calculus of variations; viscosity solutions of Hamilton-Jacobi equations; shock waves and entropy criteria for conservation laws; and much more.

The author summarizes the relevant mathematics required to understand current research in PDEs, especially nonlinear PDEs. While he has reworked and simplified much of the classical theory (particularly the method of characteristics), he primarily emphasizes the modern interplay between functional analytic insights and calculus-type estimates within the context of Sobolev spaces. Treatment of all topics is complete and self-contained. The book's wide scope and clear exposition make it a suitable text for a graduate course in PDEs.

Contents: Introduction; Part I. Representation Formulas for Solutions: Four important linear PDE; Nonlinear first-order PDE; Other ways to represent solutions; Part II. Theory for Linear Partial Differential Equations: Sobolev spaces; Second-order elliptic equations; Linear evolution equations; Part III. Theory for Nonlinear Partial Differential Equations: The calculus of variations; Nonvariational techniques; Hamilton-Jacobi equations; Systems of conservation laws; Appendices; Bibliography; Index.

Graduate Studies in Mathematics

Geometry and Topology

Gauge Theory and the Topology of Four-Manifolds
Robert Friedman and John W. Morgan, Columbia University, New York, NY, Editors

The lectures in this volume provide a perspective on how 4-manifold theory was studied before the discovery of modern-day Seiberg-Witten theory. One reason the progress using the Seiberg-Witten invariants was so spectacular was that those studying SU(2)-gauge theory had more than ten years' experience with the subject. The tools had been honed, the correct questions formulated, and the basic strategies well understood. The knowledge immediately bore fruit in the technically simpler environment of the Seiberg-Witten theory.

Gauge theory long predates Donaldson's applications of the subject to 4-manifold topology, where the central concern was the geometry of the moduli space. One reason for the interest in this study is the connection between the gauge theory moduli spaces of a Kähler manifold and the algebro-geometric moduli space of stable holomorphic bundles over the manifold. The extra geometric richness of the SU(2)-moduli spaces may one day be important for purposes beyond the algebraic invariants that have been studied to date. It is for this reason that the results presented in this volume will be essential.

Members of the Mathematical Association of America (MAA) and the National Council of Teachers of Mathematics (NCTM) receive a 20% discount from list price.

Contents: D. Gieseker, Geometric Invariant Theory and the Moduli of Bundles: Geometric invariant theory; The numerical criterion; The moduli of stable bundles; References; J. Li, Anti-Self-Dual Connections and Stable Vector Bundles: Introduction; Hermitian bundles, Hermitian connections, and their curvatures; Hermitian-Einstein connections and stable vector bundles; The existence of Hermitian-Einstein metrics; References; J. W. Morgan, An Introduction to Gauge Theory: The context of gauge theory; Principal bundles and connections; Curvature and characteristic classes; The space of connections; The ASD equations and the moduli space; Compactness and gluing theorems; The Donaldson polynomial invariants; The connected sum theorem; References; R. J. Stern, Computing Donaldson Invariants: Overview; -2 spheres and the blowup formula; Simple-type criteria and elliptic surfaces; Elementary rational blowdowns; Taut configurations and Horikawa surfaces; References; C. H. Taubes and J. A. Bryan, Donaldson-Floer Theory: Introduction; Quantization; Simplicial decomposition of $M_g$; Half-infinite dimensional spaces; References.

IAS/Park City Mathematics Series, Volume 4

Probability

Local Properties of Distributions of Stochastic Functionals
Yu. A. Davydov, University of Lille I, Villeneuve d'Ascq, France, M. A. Lifshits, MANCOMTECH Training Center, St. Petersburg, Russia, and N. V. Smorodina, Radiation Hygiene Institute, St. Petersburg, Russia

This book investigates the distributions of functionals defined on the sample paths of stochastic processes. It contains systematic exposition and applications of three general research methods developed by the authors.

(i) The method of stratifications is used to study the problem of absolute continuity of distribution for different classes of functionals under very mild smoothness assumptions. It can be used also for evaluation of the distribution density of the functional.

(ii) The method of differential operators is based on the abstract formalism of differential calculus and proves to be a powerful tool for the investigation of the smoothness properties of the distributions.

(iii) The structure method, which is a later modification of the method of stratifications, is used to derive strong limit theorems (in the variation metric) for the distributions of stochastic functionals under weak convergence of the processes.

Various application examples concern the functionals of Gaussian, Poisson and diffusion processes as well as partial sum processes from the Donsker-Prokhorov scheme.

The research methods and basic results in this book are presented here in monograph form for the first time. The text would be suitable for a graduate course in the theory of stochastic processes and related topics.

Contents: Preliminaries; Methods for studying distributions of functionals; Gaussian functionals; Poisson functionals; Local limit theorems; Bibliographical notes; Bibliography; Index.

Translations of Mathematical Monographs, Volume 173
Professional Resources from the AMS

Assistantships and Graduate Fellowships in the Mathematical Sciences 1997–1998
1997; ISBN 0-8218-0814-1; 135 pages; Softcover; Individual member $12, List $20, Order Code ASST/97C181

Combined Membership List 1997–1998

How to Teach Mathematics: a personal perspective
Steven G. Krantz, Washington University, St. Louis, MO

An original contribution to the educational literature on teaching mathematics at the post-secondary level. The book itself is an explicit proof of the author’s claim ‘teaching can be rewarding, useful, and fun’.
—Zentralblatt für Mathematik

1993; ISBN 0-8218-0197-X; 76 pages; Softcover; All AMS members $12, List $15, Order Code HTMCI81

Mathematical Sciences Professional Directory
1998; ISBN 0-8218-0934-2; approximately 224 pages; Softcover; List $50, Institutional member $40, Order Code PRODIR/98C181

Math into LaTeX
An Introduction to $\LaTeX$ and AMS-$\LaTeX$
George Grätzer, University of Manitoba, Winnipeg, Canada

Published by Birkhäuser.

1995; ISBN 0-8176-3805-9; 451 pages; Softcover; All AMS members $39.50, List $49.50, Order Code MLTEC81

The Mathematician’s CD: A Collection of Resources from the AMS
1997; ISBN 0-8218-0892-3; All AMS members $16, List $19.95, Order Code AMSCDCI81

The MathResource™ Interactive Math Dictionary
Jonathan Borwein, Simon Fraser University, Burnaby, BC, Canada, Carolyn Watters, Acadia University, Wolfville, NS, Canada, and Ephraim Borisovski, University of Glasgow, Scotland

I really like the interactive math dictionary. I have let some of my students use it for project work to try and get feedback from them. I have had only positive results. The most common response from the students seems to be “wow!” I mentioned that this software is available and probably would be a good idea that students entering Science/Math/Engineering at university have access to it.

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FEATURED TITLE

Donald G. Babbitt and Jane E. Kister, Editors
This collection of reprinted Featured Reviews published in Mathematical Reviews (MR) in 1995 and 1996 makes widely available peer reviews of some of the best mathematics recently published.

http://www.ams.org/bookstore/
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| **CALIFORNIA STATE UNIVERSITY, CHICO**
Department of Mathematics and Statistics

The department announces a tenure-track position in mathematics education at the assistant professor level beginning in the 1998-99 academic year. Minimum requirements: a doctorate in mathematics education, mathematics, or a related field, including at least the equivalent of a strong Masters degree in mathematics; evidence of quality teaching; a commitment to working with preservice and inservice teachers; capacity for excellence in research, writing, or other scholarly activities. The current salary range is $37,956-$45,672 per academic year, depending on the level of appointment. Qualified candidates should submit a letter of application (including a statement of professional goals which addresses the qualifications and experiences required), a vita, and three letters of recommendation (including at least one relating to teaching effectiveness) to: Dr. Jim Jones, Mathematics Education Search Committee, Department of Mathematics and Statistics, CSU, Chico, Chico, CA 95929-0525. Closing date: February 20, 1998. CSU, Chico, is an EEO-AA/ADA/IRCA employer that is committed to a culturally diverse work force, hence all qualified individuals are encouraged to apply.

### CALIFORNIA STATE UNIVERSITY, FULLERTON
Department of Mathematics

The Department of Mathematics at California State University, Fullerton, has an opening for a tenure-track professorship in statistics beginning fall 1998. Consideration may be given for a higher rank if the applicant has appropriate qualifications. Teaching responsibilities will include computer-based statistics courses, and courses in the core mathematics curriculum. Preference will be given to an individual with a wide range of interests or experience in applications and/or industrial outreach. The department has 24 full-time faculty, and offers undergraduate degree programs in statistics, pure mathematics, applied mathematics, and teaching mathematics. We also offer a Masters degree in applied mathematics with industrial applications, and in teaching mathematics. We have modern computing facilities for faculty and students, and have faculty with research interests in mathematical and applied statistics, differential equations, modeling, optimization, mathematical physics, dynamical systems, and mathematics education. Applicants should have high potential in undergraduate teaching and research, possess excellent communication skills, and be familiar with modern statistical computing. Demonstrated excellence in teaching and research will be given extra consideration. Salary will be commensurate with experience. Candidates should send a letter summarizing their background in statistical methodology or experience in applications, undergraduate teaching, software proficiency, and scholarly research activities. A curriculum vita and at least three letters of reference should also be included. Transcripts of undergraduate and graduate work may be requested later. Women and minorities are especially encouraged to apply. Applications should be sent to: Chair, Search Committee, Department of Mathematics, California State University, Fullerton, Fullerton CA 92834-6856. For full consideration they should be received by February 27, 1998. Cal State Fullerton is an Affirmative Action/Equal Opportunity/Title IX/ADA Employer.

### HARVEY MUDD COLLEGE
Associate or Assistant Professor of Mathematics

Harvey Mudd College invites applications for one tenure-track position in mathematics at the associate professor or assistant professor level. Excellence in teaching is absolutely essential, as is evidence of a strong and ongoing research program. Candidates for associate professor must have a demonstrated record of superior teaching and an established research program. Preference will be given to applicants in applied mathematics, especially in the areas of applied analysis, PDEs, ODEs, dynamical systems, or integral equations. Applicants should also have wide mathematical interests and be able to teach across the undergraduate mathematics curriculum. Candidates must be willing to supervise undergraduate research and

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**Suggested uses** for classified advertising are positions available, books or lecture notes for sale, books being sought, exchange or rental of houses, and typing services.

The **1997 rate** is $100 per inch or fraction thereof on a single column (one-inch minimum), calculated from top of headline. Any fractional text of 1/2 inch or more will be charged at the next inch rate. No discounts for multiple ads or the same ad in consecutive issues. For an additional $10 charge, announcements can be placed anonymously. Correspondence will be forwarded.

Advertisements in the "Positions Available" classified section will be set with a minimum one-line headline, consisting of the institution name above body copy, unless additional headline copy is specified by the advertiser. Headlines will be centered in boldface at no extra charge. Ads will appear in the language in which they are submitted.

There are no member discounts for classified ads. Dictation over the telephone will not be accepted for classified advertising.

**Upcoming deadlines** for classified advertising are as follows: January issue—November 18, 1997; March issue—December 19, 1997; April issue—January 21, 1998; May issue—February 23, 1998; June/July issue—April 24, 1998; August issue—May 15, 1998.

**U.S. laws prohibit** discrimination in employment on the basis of color, age, sex, race, religion, or national origin. "Positions Available" advertisements from institutions outside the U.S. cannot be published unless they are accompanied by a statement that the institution does not discriminate on these grounds whether or not it is subject to U.S. laws. Details and specific wording may be found on page 1373 (vol. 44).

**Situations wanted advertisements** from involuntarily unemployed mathematicians are accepted under certain conditions for free publication. Call toll-free 800-321-4AMS (321-4267) in the U.S. and Canada, or 401-455-4084 worldwide, for further information.

**Submission:** Promotions Department, AMS, P.O. Box 6248, Providence, Rhode Island 02940, or via fax, 401-331-3842, or send e-mail to classified@ams.org. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 02904. Advertisers will be billed upon publication.
Harvey Mudd College is a highly selective undergraduate institution of science and engineering. One year of high school calculus is required for admission to HMC. More than one-third of the student body are National Merit Scholarship finalists. The college enrolls about 630 students and is associated with four other undergraduate colleges and the Claremont Graduate University, forming together an academic community of about 5,000 students. There are over 40 mathematicians in Claremont.

Applicants should send a curriculum vitae, a description of their teaching philosophy and accomplishments, and a description of their current research and research goals. Applicants should also arrange to have three letters of reference sent directly to the address that appears below. Letters should, as much as possible, assess the quality of the applicant's scholarship, record and potential as a mathematician, and abilities as a teacher. Preference will be given to applications received before January 15, 1998. Harvey Mudd College is an Equal Opportunity Employer and is strongly committed to the recruitment of candidates historically underrepresented on college faculties.

**Address for applications:**
Search Committee
Department of Mathematics
Harvey Mudd College
Claremont, CA 91711-5990

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**SAINT MARY'S COLLEGE**

**Tenure-track Associate Professor**

We seek candidates with a Ph.D. in computer science (or mathematics) for a tenure-track appointment as associate professor beginning fall 1998; an appointment to another rank will be considered in exceptional cases. The successful candidate will assist the Department of Mathematics and Computer Science in the development of an interdisciplinary computer science major within a liberal arts environment. All candidates should have expertise in an area of application of computer science, and demonstrated success teaching an interdisciplinary undergraduate curriculum. They should be excellent undergraduate teachers, have an active research program. Saint Mary's College is a liberal arts, Catholic, co-educational college operated by the Christian Brothers, located 20 miles east of San Francisco. Send a letter of application which addresses the candidate's match to the qualifications listed above, and a curriculum vitae to J. R. Sangwine-Yager, Search Committee, Saint Mary's College, P. O. Box 3517, Moraga, CA 94575-3517. Send three (3) letters of recommendation, at least two of which discuss the candidate's match to the qualifications listed above. The deadline is January 30, 1998; position open until filled. Saint Mary's College is an Equal Opportunity Employer.

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**UNIVERSITY OF CALIFORNIA, BERKELEY**

**Department of Statistics**

Pending final budgetary approval, applications are invited for a special full-time Neyman Visiting Assistant Professor position, beginning fall 1998 or spring 1999. The appointment is of a two-year duration (but can be shorter by mutual agreement) and is not renewable. Applicants should have exhibited exceptional research potential in any of the following areas: theoretical or applied statistics, computational statistics, probability theory, applied probability. Applicants will be expected to teach effectively as well as carry out a vigorous program of research. Minimum salary $39,600; salary commensurate with experience. Apply, including résumé, names, and (preferably e-mail) addresses of three references, by January 20, 1998, to: Chair, Department of Statistics #3860, University of California, Berkeley, CA 94720; fax 510-642-7892; e-mail: recruit@stat.berkeley.edu. The University of California is an Equal Opportunity/Affirmative Action Employer.

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**COLORADO**

**UNIVERSITY OF COLORADO AT BOULDER**

**Instructorship Appointment**

**Department of Applied Mathematics**

Applications are invited for a nontenure-track instructorship beginning fall semester 1998. The position is initially for a period of one year. However, with satisfactory performance we expect the position could be renewed for up to two additional years. Preference will be given to those candidates with a research emphasis in the areas of mathematics and applied mathematics, but exceptionally strong candidates in other areas of applied mathematics may be considered. Areas of concentration within the department include physical applied mathematics, nonlinear phenomena, scientific computing, stochastic analysis, and dynamical systems. Applications are due by January 31, 1998. The position is initially for a period of one year, but may be renewed for up to two additional years. Preference will be given to those candidates with a research emphasis in the areas of mathematics and applied mathematics, but exceptionally strong candidates in other areas of applied mathematics may be considered. Areas of concentration within the department include physical applied mathematics, nonlinear phenomena, scientific computing, stochastic analysis, and dynamical systems. Applications are due by January 31, 1998. The position is initially for a period of one year, but may be renewed for up to two additional years.

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**GEORGIA**

**GEORGIA INSTITUTE OF TECHNOLOGY**

The School of Mathematics expects to have visiting and tenure-track positions at various levels in pure and applied mathematics and statistics, beginning in fall 1998. The School intends to expand its areas of expertise and foresees the potential for 10–15 new appointments in the next five years. Candidates with strong research and teaching records or potential should arrange for a resume at least three letters of reference, and a summary of future research plans to be sent to The Hiring Committee, School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332-0160. Georgia Tech, an institution of the University System of Georgia, is an Equal Opportunity/Affirmative Action Employer.

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**GEORGIA INSTITUTE OF TECHNOLOGY**

The Southeast Applied Analysis Center (SAAC), the Southeast Applied Analysis Center (SAAC), the School of Mathematics, invites applications for postdoctoral/visiting positions in applied mathematics. Fields of interest include combinatorics and algorithms, scientific computing, stochastic processes, and differential equations and modeling. Applicants should arrange for a curriculum vitae, at least three letters of recommendation, and a summary of research plans to be sent to Professor Leonid A. Bunimovich, Director, SAAC, School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332-0160. Georgia Tech, a member of the University System of Georgia, is an Equal Opportunity/Affirmative Action Employer.

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**COLOMBIA**

**THE UNIVERSITY OF CHICAGO**

**L. E. Dickson Instructorships and Assistant Professorships in Mathematics**

**1997–1998**

The Dickson Instructorships enable young mathematicians to pursue their professional careers within the University of Chicago's tradition and environment of vigorous mathematical research. They are intended for persons who have recently completed the doctorate in mathematics and/or soon will, and whose work shows remarkable promise in mathematical research and teaching. The appointments are for two years.

The Assistant Professorships are similar in character, but are intended for persons further along in their careers, typically two or three years past the doctorate. These positions are reserved for mathematicians whose work has been of outstandingly high caliber. Applicants are expected to have
the potential to become leading figures in their fields. The appointments are for three years.

Instructional duties for both positions comprise the teaching of at most four one-quarter courses per year and include teaching opportunities at both the graduate and undergraduate level. NSF Postdoctoral Fellowships may be held concurrently with a reduced teaching load.

Junior Faculty Positions are open for application until January 2, 1998. Application forms may be obtained from:

Appointments Secretary
Department of Mathematics
The University of Chicago
5734 South University Avenue
Chicago, Illinois 60637
E-mail address: apptsec@math.uchicago.edu
Phone: 312-702-0965
Fax: 312-702-9787

From the time of its original charter, the principle of the University of Chicago has been to appoint scholars without regard to race, color, religion, sex, national origin, or physical disability.

ILLINOIS WESLEYAN UNIVERSITY
Bloomington, Illinois 61702
Department of Mathematics

The Department of Mathematics of Illinois Wesleyan University invites applications for one tenure-track position and one or more one-year visiting positions. Employment would begin in August 1998, and the teaching load would be six courses per year. All candidates should possess a Ph.D. in mathematics and a dedication to quality teaching in an independent liberal arts university. For any position, preference may be given to those candidates having experience in the integration of technology into undergraduate instruction.

Candidiates for the tenure-track position must have a Ph.D. with research specialty in either probability or mathematical statistics. The successful candidate will be expected to work closely with undergraduate mathematics majors who are planning careers in actuarial science. In particular, candidates for this position should be interested in directing undergraduate research projects. Preference may be given to candidates who have passed actuarial exams and to candidates who are willing to develop upper-level special topics courses in mathematics for these students. Candidates for this position should submit transcripts of all graduate work.

For a visiting position, preference may be given to those candidates who have good teaching credentials. Preference may also be given to those candidates who have special qualifications to address curricular needs in our department for the 1998-99 academic year.

Illinois Wesleyan University has approximately 1,900 undergraduate students. It is a highly selective university. For example, in 1994 the average ACT for Illinois Wesleyan's entering class of freshmen was 27.9, while the average ACT for freshman mathematics majors was 30.0. In past years over 4 percent of the undergraduate population at Illinois Wesleyan have declared majors in mathematics. Our mathematics faculty possesses a healthy balance between applied and pure mathematics. Our current areas of professional expertise include algebra, approximation theory, differential equations, dynamical systems, electrical engineering, linear algebra, logic, operations research, operator theory, topology, topos theory, and wavelet analysis. We encourage our majors to complete undergraduate research projects. Our department is also actively involved in the integration of technology into many of our courses. For example, we have four different ways to complete freshman calculus, one of which is a three-course sequence in calculus/Mathematica taught in an NSF-sponsored Sun/Spark computer lab. We also maintain a Sun/Spark computer lab for mathematical modeling and one other Unix-based computer lab.

Candidates for any of the positions should submit a letter of application, a vita, an AMS Cover Sheet, and three letters of recommendation to Melvyn W. Jeter, Head, Department of Mathematics, Illinois Wesleyan University, P. O. Box 2900, Bloomington, IL 61702-2900. Candidates who submit their applications after January 30, 1998, may not receive full consideration. Applications before December 30, 1997, are encouraged. Women and minorities are encouraged to apply. Illinois Wesleyan is an Equal Opportunity Employer.

INDIANA
BALL STATE UNIVERSITY
Muncie, Indiana
Department of Mathematical Sciences
Assistant Professor

Two tenure-track positions available August 21, 1998. Minimum qualifications: all requirements for a doctorate in one of the mathematical sciences completed by time of appointment. Preferred qualifications: research interests compatible with present faculty, particularly candidates in the areas of Lie groups, computational/numerical mathematics, and stochastic analysis; documentation of successful college or university teaching experience and evidence of research potential. Responsibilities include teaching approximately 8 to 9 hours per semester, predominantly at the undergraduate level; research in mathematics; and professional service. In addition, one or more fixed-term (not tenure-track) positions may also be available beginning the same date. The Department of Mathematical Sciences includes faculty in pure and applied mathematics, statistics, actuarial science, and mathematics education. The department offers a range of academic programs leading to BA, BS, MA, MS, and MAE degrees in these areas. The department's URL is http://www.cs.bsu.edu/~math/.

Competitive salary and benefits package. Send letter of application, vita, standard cover sheet (available from the AMS or from the department), curriculum vitae; research summary; and three letters of reference, at least one of which substantially addresses the applicant's teaching ability and performance to: Professor Ralph Bremingan, Chair, Mathematics Search Committee, Department of Mathematical Sciences, Ball State University, Muncie, IN 47306 (e-mail: research@math.bsu.edu). Applicants should also notify the Committee Chair if they intend to attend the 1998 AMS/MAA Joint Meetings in Baltimore. Review of applications begins immediately and continues until the position is filled.

Ball State University is an Equal Opportunity/Affirmative Action Employer and is strongly and actively committed to diversity within its community.

EARLHAM COLLEGE

The Mathematics Department invites applications for a tenure-track faculty position. We seek a person with a Ph.D. in mathematics or computer science, preferably with a demonstrated interest in applied mathematics and/or computer science.

Our department has a longstanding commitment to teaching mathematics in a way that produces students who understand and know how to use mathematics. We have a small, high-quality program focused on preparing our majors to go on in mathematics or related areas. We are committed to furthering the mathematical understanding and skills of other Earlham students. We have begun to build a program to reach many of these students by bringing mathematics to them in upper level courses within their own disciplines, enhancing their mathematical literacy.

The College has a number of interdisciplinary programs, including African and African American Studies, Environmental Science, Management and Women's Studies. Each faculty member is encouraged to participate in and contribute to such programs.

Earlham College is an Equal Opportunity Employer. We particularly welcome women and minority applicants because Earlham is committed to building a vigorous academic community that reflects the gender and racial diversity of the society at large. Earlham is affiliated with the Religious Society of Friends, and we welcome applications from people sympathetic to social justice, simplicity, consensus seeking, and other Quaker values.

Send a letter of application, vita, a statement of your teaching philosophy,
transcripts, and three letters of recommendation to: Mic Jackson, Convenor, Mathematics Department, Earlham College, Richmond, IN 47374-0959, micj@earlham.edu. Application review begins January, 1998. The search will remain open until the position is filled. Employment begins July 1, 1998.

UNIVERSITY OF NOTRE DAME
Department of Mathematics
Notre Dame, IN 46556
McAndrews Visiting Assistant Professorship

The Mathematics Department invites applications for a postdoctoral position in mathematical logic. The position is for the academic year 1998/1999, with renewal for a second year assured provided that teaching performance is satisfactory. The teaching load is three courses per year. Preference will be given to candidates with research interests in computability (recursion theory), but strong candidates in other areas of logic will receive serious consideration. Preference will be given to applicants who received their degrees after May 1995. The materials for a complete application consist of a cover letter, CV, a short thesis summary, and three letters of recommendation. At least one of the letters should address the candidate's ability to communicate effectively in the classroom. These materials should be sent by Jan. 1, 1997, to Alexander J. Hahn, Chair, Department of Mathematics, University of Notre Dame, Notre Dame, IN 46556. Evaluation of candidates will begin in January.

IOWA
IOWA STATE UNIVERSITY

The Department of Mathematics invites applications for two tenure-track positions at the rank of assistant professor, to begin in August, 1998. Candidates should have a Ph.D. in mathematics or applied mathematics or a related field and should exhibit evidence of outstanding research potential, normally including significant contributions beyond the doctoral dissertation. A strong commitment to excellence in teaching is also expected.

The area of priority for one of the positions is mathematical control theory, including control of dynamical systems and PDEs. Iowa State University has a campus-wide control group, including faculty from the departments of Mathematics, Electrical and Computer Engineering, Aerospace Engineering and Engineering Mechanics, Mechanical Engineering, and Statistics. The successful applicant is expected to collaborate in an interdisciplinary setting.

The area of priority for the second position is stochastic analyses and applications. Although applications from strong candidates in all areas of probability theory are welcome, preference will be given to candidates specializing in stochastic differential equations. We especially seek an individual who can collaborate with one or more of our strong groups in probability, PDEs, control theory, and numerical PDEs, all of whom have an interest in stochastic processes.

Iowa State University is a Category I research university according to the classification of the Carnegie Foundation. We are a land grant university with special strengths in engineering and the applied sciences. The University operates the Ames Laboratory, a research laboratory of the Department of Energy. As a result, campus-wide opportunities for interdisciplinary interactions are especially rich. Additional information about the activities of the Department of Mathematics can be found at our Web site (http://www.math.iastate.edu/).

Candidates should send a complete AMS Cover Sheet, a curriculum vitae that includes a publication list, graduate school transcripts, and a brief statement about their current and future research programs to: Dr. Max Guenzburger, Chair, Department of Mathematics, Iowa State University, 400 Carver Hall, Ames, IA 50011-2064. They should also arrange to have three letters of recommendation concerning research and one concerning teaching sent directly to the above address. The deadline for completed applications is February 15, 1998, although applications will be considered until the positions are filled.

Iowa State University is an Affirmative Action, Equal Opportunity Employer and strongly encourages applications from women, minorities, and underrepresented groups.

LOUISIANA
TULANE UNIVERSITY
Department of Mathematics

Applications are invited for two tenure-track positions beginning in the fall 1998 semester, subject to final administrative and budgetary approval. Applications will be guaranteed full consideration if complete by December 19, 1997. The search will be closed only after a suitable pool of qualified applicants is obtained. Applicants should have completed their Ph.D. by the beginning of the fall 1998 semester and provide evidence of excellence in both teaching and research. Our highest priority for one position is in the field of scientific computation. Applications in all fields of pure and applied mathematics will be considered in filling the second position.

Tulane University is an Affirmative Action/Equal Opportunity Employer which is committed to increasing the diversity of its faculty. We therefore especially encourage applications from members of underrepresented groups. Applications should be sent c/o Search Committee, Mathematics Department, Tulane University, New Orleans, LA 70118. Electronic applications will be accepted and the use of the AMS Cover Sheet is encouraged. A complete application should include a vita, statements on research and teaching, as well as three letters of recommendation commenting on both research and teaching.

MARYLAND

UNIVERSITY OF MARYLAND BALTIMORE COUNTY
Chairperson
Department of Mathematics and Statistics

The University of Maryland Baltimore County (UMBC) invites applications for the position of chair of the Department of Mathematics and Statistics. The successful candidate is expected to lead the faculty in the development of the department's instructional and research programs, including the anticipated filling of several open faculty positions over the next several years. Candidates should have earned a doctoral degree in mathematics, statistics, or a closely related field, and be qualified for appointment at the rank of full professor. The successful candidate is expected to be committed to excellence in undergraduate and graduate education, possess superior leadership and communication skills, and to maintain a strong research record.

The Department of Mathematics and Statistics offers programs leading to BA, BS, MS and PhD degrees in applied mathematics and statistics. There are currently 22 full-time faculty members, 25 full-time and 30 part-time graduate students and 150 majors. Further details can be obtained from the department's Web site at http://www.math.umbc.edu/

UMBC has a faculty of over 400 members and approximately 10,000 students at both the undergraduate and graduate levels. Its research is focused in the areas of science, technology, and public policy. Total research funding is currently near $43 million. UMBC is located on a wooded, 450 acre site in the Baltimore-Washington corridor near major industries, federal laboratories, and sponsoring agencies.

Candidates should submit a CV, statement of professional goals, and the names, addresses, and telephone numbers of four references to Dr. Geoffrey P. Summers, Chair Math/Stat. Search Committee, c/o Department of Mathematics and Statistics, UMBC, 1000 Hilltop Circle, Baltimore, MD 21250. Screening of candidates will begin immediately and will continue until the position is filled. UMBC is an EOE/AA employer.
UNIVERSITY OF MARYLAND
UNIVERSITY COLLEGE
Teach in Asia or Europe

University of Maryland University College continually seeks excellent teachers for openings on U.S. military bases overseas. Appointments begin August, 1998. Requirements include M.A. or Ph.D., recent U.S. university teaching experience, and U.S. citizenship. Competence to teach in another discipline is desirable. Benefits include transportation, health insurance, military base privileges (PX, commissary, etc.), and TIAA/CREF. Frequent relocation and the cost of schooling make these positions difficult for those with children. Further information can be found at: http://www.umuc.edu or rhoffman@polaris.umuc.edu.

Send résumé to Dr. Rosemary Hoffman, University of Maryland University College Overseas Program, College Park, MD 20742-1642. AA/EEO.

MASSACHUSETTS INSTITUTE
OF TECHNOLOGY
Department of Mathematics
Cambridge, MA 02139-4307

One or two assistant professor or higher levels in applied mathematics will probably become available in the fall 1998 for persons typically about two or more years beyond their doctorates. Applications should be completed by January 15. Applicants please arrange to have sent (a) a vita; (b) three letters of reference; (c) a description of your most recent research; (d) the research which you plan for the next three years to; Committee on Applied Mathematics, Room 2-345, Department of Mathematics, Massachusetts Institute of Technology, Cambridge, MA 02139-4307. M.I.T. is an Equal Opportunity, Affirmative Action Employer.

MASSACHUSETTS INSTITUTE
OF TECHNOLOGY
Department of Mathematics
Cambridge, MA 02139-4307

A limited number of instructorships and lectureships in applied mathematics are available for recent Ph.D.s. Appointments will be made mainly on the basis of superior research potential. Applications should be completed by January 15. Applicants please arrange to have sent (a) a vita; (b) three letters of reference; (c) a description of your most recent research; (d) the research which you plan for the next few years to; Committee on Applied Mathematics, Room 2-345, Department of Mathematics, Massachusetts Institute of Technology, Cambridge, MA 02139-4307. M.I.T. is an Equal Opportunity, Affirmative Action Employer.

WILLIAMS COLLEGE
Department of Mathematics
Williamstown, Massachusetts 01267

Two full-time visiting positions in mathematics or statistics for the 1998-99 year, probably at the rank of assistant professor; in exceptional cases, however, more advanced appointments may be considered. Excellence in teaching and research, and Ph.D. required. For one of the positions the ability to teach statistics courses is a plus.

Please have a vita and three letters of recommendation on teaching and research sent to Visitor Hiring Committee. Evaluation of applications will begin November 15 and continue until the position is filled. As an EEO/AA Employer, Williams especially welcomes applications from women and minority candidates.

MICHIGAN

UNIVERSITY OF MICHIGAN
Department of Mathematics
Interdisciplinary Mathematics

Assistant professor positions are available through an Interdisciplinary Initiative in the Department of Mathematics. Positions are supported by NSF award to Michigan Research Group. The positions are intended to be three years in duration with a two course per year teaching load. In addition to a strong mathematical background, successful candidates will have a research program with links to areas outside mathematics such as engineering or the natural sciences. The Mathematics Department at Michigan has an active group in interdisciplinary mathematics; areas of research include fluid dynamics and numerical analysis, control theory and mechanics, mathematical logic, mathematical physics, algorithms and complexity, optics, and finance. Applications, including a vita, brief description of research interests and interdisciplinary activities, and four letters of recommendation (one specifically commenting on teaching) should be sent to: Interdisciplinary Initiative, Department of Mathematics, University of Michigan, Ann Arbor, MI 48109-1109. For full consideration complete applications should be received before January 15, 1998. The University of Michigan is a nondiscriminatory Affirmative Action Employer.

MISSISSIPPI

THE UNIVERSITY OF SOUTHERN MISSISSIPPI
Department of Mathematics
Hattiesburg, MS 39406-5045

Applications are invited for a tenure-track mathematics position at the assistant professor level beginning August, 1998. The successful candidate will be a serious computational mathematician able to contribute actively to the doctoral program in scientific computing. A doctorate in pure or applied mathematics or a closely related discipline is required. Closing date is open, but selection will begin as early as February, 1998. At the above address send a letter of application, research summary, transcripts, curriculum vitae, brief statement of professional goals, and the names of three references to: Michael Mascagni, Search Committee Chair.

MISSOURI

SOUTHWEST MISSOURI STATE UNIVERSITY
Mathematics Education

The Department of Mathematics at Southwest Missouri State University anticipates
an assistant professor position in mathematics education beginning August, 1998. This is a tenure-track position. Applicants must have a Ph.D. or Ed.D. in mathematics education or a doctorate in mathematics with extensive experience in teacher preparation, evidence of excellence in teaching, potential for research, commitment to professional activities, and effective communication skills. Preference will be given to applicants with elementary or secondary experience, and research interests compatible with those of current faculty. Duties include teaching, research, and service. Send a letter of interest, vitae, graduate transcript, description of current research, and three letters of reference sent to: Mathematics Education Position, Dr. Kurt Killion, Chair of Search Committee, Department of Mathematics, Southwest Missouri State University, Springfield, MO 65804-0994. To ensure full consideration, application materials should be received by February 1, 1998. SMSU is an AA/EQ institution.

NEBRASKA

CREIGHTON UNIVERSITY

Clare Boothe Luce Endowed Chair for Women in Mathematics or Computer Science

Creighton University invites applications from outstanding women candidates for appointment to the Clare Booth Luce Endowed Chair for Women in Mathematics or Computer Science, beginning fall 1998. Candidates are expected to be excellent scholar-teachers, who will serve as mentors and role models for undergraduate women interested in careers in scientific research. Initial appointment will be at the rank of assistant professor. A Ph.D. in mathematics or computer science is required. All specialties will be considered. Candidates are expected to be committed to a productive research program, and teach courses both at undergraduate and graduate level. One year initial appointment, renewable up to a total of five years. At the end of the five years term, the chair holder will automatically be considered for tenure and promotion in the department. Salary and benefits befitting a person of outstanding potential. Creighton University is a Jesuit, Catholic institution that encourages applications from qualified individuals of all backgrounds who believe they can contribute to the distinctive educational traditions of the university. Applicants must submit a current curriculum vitae; three letters of recommendation independently of the candidate; pertinent transcripts of all college-level work; current evidence of outstanding teaching effectiveness (if available), and some indication of their research potential. Applications should be addressed to: D. S. Malik, Chair, Search Committee, Department of Mathematics and Computer Science, Omaha, NE 68178-2090. Completed dossiers must be received by March 1, 1998. Creighton is an Equal Opportunity/Affirmative Action Employer and seeks a wide range of applications for this position so that one of our core values—ethnic and cultural diversity—may be realized.

UNIVERSITY OF NEBRASKA-LINCOLN

Department of Mathematics and Statistics

Applications are invited for a tenure-track position at the assistant/associate professor level starting in fall 1998. Candidates must have a Ph.D. in mathematics by August of 1998. Candidates must demonstrate evidence of excellent teaching ability and outstanding research potential in an area that can contribute to the department’s involvement in the Arts and Sciences Discrete and Experimental Mathematics Area of Strength. Strong preference will be given to candidates with interests in geometric or combinatorial group theory, semigroup theory or a closely related area, although outstanding candidates in other areas may also be considered. Ability to contribute to the department’s mathematics education activities is a plus. For more details on this position see our Web site at http://www.math.unl.edu/. Send vita and three letters of recommendation to the DEM Search Committee, Department of Mathematics and Statistics, University of Nebraska-Lincoln, Lincoln, NE 68588-0323. The review of applications will begin February 1, 1998, and continue until suitable candidates are selected. Women and minority candidates are particularly encouraged to apply. The University of Nebraska is committed to a pluralistic campus community through Affirmative Action and Equal Opportunity, and is responsive to the needs of dual career couples. We assure reasonable accommodation under the Americans with Disabilities Act. Please contact Mavis Hettenga at 402-472-4995 for assistance.

NEW JERSEY

THE COLLEGE OF NEW JERSEY

Department of Mathematics and Statistics

Assistant Professor

Two tenure-track positions teaching 12 hours per semester including general education courses. Required: Ph.D. or Ed.D., demonstrated commitment to quality teaching, strong research potential. Preference for one position will be given to candidates preparing to teach introductory courses and for both positions to candidates with postdoctoral experience in teaching and research. Send vita and three letters of recommendation, at least one of which addresses teaching ability to: Search Committee,

PRINCETON UNIVERSITY

Lewis Thomas Fellows Program

A fellowship program has been established for outstanding young scientists to work in the Department of Molecular Biology. The program provides opportunities to exceptional individuals holding Ph.D. degrees (or the equivalent) in the areas of physics, chemistry, computer science, or computational approaches to biology who wish to gain expertise in molecular biology. Research will be carried out in collaboration with members of the Department of Molecular Biology at Princeton University. Fellows will be appointed for two years, with the potential for one additional year of support. The application deadline is December 15, 1997, for a nominal start date of September 1, 1998. For information about the program and the Department of Molecular Biology, visit our Web site at http://www.molbio.princeton.edu/.

Applications must include a curriculum vitae, list of publications, brief statement (3 pages) of research interests and goals, and the names of three referees who have been asked to send references. Address applications to: Lewis Thomas Fellowship Committee, Department of Molecular Biology, Princeton University, Princeton, NJ 08544-1014.

Princeton University is an Affirmative Action/Equal Opportunity Employer and welcomes applications from women and members of minority groups.

RUTGERS UNIVERSITY

Department of Mathematics and Computer Science

Assistant Professor of Mathematics

The Department of Mathematics and Computer Science invites applications for an anticipated tenure-track assistant professor position to begin September 1998. Candidates must have a Ph.D., a strong research record, show outstanding promise for future work in mathematics, and demonstrate a commitment to effective teaching. In addition, candidates should be committed to a pluralistic campus community through Affirmative Action, and be responsive to the needs of dual career couples. We assure reasonable accommodation under the Americans with Disabilities Act. Please contact Mavis Hettenga at 402-472-4995 for assistance.

Rutgers University is an Equal Opportunity/Affirmative Action Employer.

NEW YORK

BROOKLYN COLLEGE
CITY UNIVERSITY OF NEW YORK
Department of Mathematics

The Department of Mathematics of Brooklyn College of the City University of New York announces a tenure-track assistant professorship in mathematics. The successful applicant will possess a Ph.D. degree and will have the ability to teach and work on curriculum in one of the areas that the department is working to develop: applied statistics, operations research, mathematics applicable to the decision sciences, or a related area. The candidate should also have experience in using computers in teaching. Commitments to research, teaching, and curriculum development are essential. Duties will include teaching a range of undergraduate mathematics courses as well as joining an ongoing process of curriculum development. Salary is commensurate with qualifications and experience within the range $29,931 to $45,672.

Candidates should send a résumé and arrange to have three letters of reference sent to Prof. George S. Shapiro, Chairperson, Department of Mathematics, Brooklyn College, 2900 Bedford Avenue, Brooklyn, NY 11210-2889. Applications received by February 10, 1998, will receive full consideration. AA/EEO/M/V/H/F.

THE STATE UNIVERSITY OF NEW YORK
COLLEGE AT POTSDAM

The State University of New York College at Potsdam invites applications for one (possibly two) anticipated full-time tenure-track position(s) effective September 1, 1998, at the rank of assistant professor. Responsibilities of the position are to teach twelve hours per semester of undergraduate and first-year graduate courses. Required qualifications are a Ph.D. in any area of mathematics with a strong interest in and preparation for teaching undergraduate major mathematics courses. In addition, some preparation in computer science is desirable though not essential. Applications, which must include a letter of interest, a statement of the applicant’s philosophy of teaching, a résumé, three letters of recommendation describing teaching experience and abilities, and a transcript (a copy is acceptable), should be sent to Dr. Cheryl Chute Miller, Staffing Committee Chair, Math. Department, SUNY Potsdam, Potsdam, NY 13676 (millercc@potsdam.edu). To ensure full consideration, complete applications must be received by January 30, 1998.

NORTH CAROLINA

DUKE UNIVERSITY
Department of Mathematics & Center for Mathematics and Computation in the Life Sciences and Medicine

Applications are invited for two postdoctoral positions in mathematical biology. Each position, carrying the title of Research Associate, has a two-year term beginning 1 July 1998, a competitive salary, and excellent fringe benefits.

Research associates will be expected to (1) continue research projects in which they are already engaged, and/or (2) conduct collaborative research with Center members; and/or (3) conduct research in collaboration with one or more research groups in the Department of Zoology, the Department of Biomedical Engineering, or the Departments of Duke University Medical Center.

Research associates will have no teaching responsibilities except for participation in a one-week workshop for undergraduates. However, instructional opportunities are available in the Department of Mathematics for those who wish to acquire teaching credentials.

Applications will be accepted from Ph.D.s in mathematics, biology, engineering, and related disciplines, but preference will be shown to recent Ph.D.s in mathematics. Applications will be considered beginning 1 January 1998; applications will be accepted until the positions are filled. Duke University is an Equal Opportunity/Affirmative Action Employer.

Applicants should send curriculum vitae, two letters of recommendation, and a summary of current research and research interests to Professor Michael Reed Department of Mathematics Duke University Box 90320 Durham, NC 27708-0320 reed@math.duke.edu

WAKE FOREST UNIVERSITY
Department of Mathematics and Computer Science

Applications are invited for a tenure-track position in mathematics at the assistant professor level beginning August 1998. Duties include teaching mathematics at the undergraduate and graduate levels and participating in continuing research. A Ph.D. in mathematics is required. Leadership and participation in the department major in mathematical economics is also required; this is a joint major with the Department of Economics. Research areas of interest include optimization, control theory, and dynamical systems, but other areas of research will be considered. Women and minorities are encouraged to apply. The department has 24 members and offers a B.S. and M.A. in mathematics, a B.S. and M.S. in computer science, and a B.S. in each of mathematical economics and mathematical business. Send a letter of application and resume to Richard D. Carmichael, Chair, Department of Mathematics and Computer Science, Wake Forest University, P. O. Box 7388, Winston-Salem, NC 27109-7388. AA/EEO Employer.

OHIO

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Department Chair

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OHIO UNIVERSITY
Department of Mathematics

Applications are invited for a tenure-track assistant professor position in set-theoretic topology, effective September 1, 1998. A Ph.D. in mathematics is required. Applicants must show exceptional promise in research and teaching. Preference will be given to candidates whose research interests complement those of the department faculty. The salary is competitive and there is an excellent fringe benefit package. A review of applications will begin January 1998. Send a letter of application, résumé, and three letters of recommendation to: Search Committee Chair, Department of Mathematics, 321 Morton Hall, Ohio University, Athens, Ohio 45701. Ohio University is an Equal Opportunity/Affirmative Action Employer. Women and minorities are encouraged to apply.

THE OHIO STATE UNIVERSITY
Director of Mathematics-Statistics Learning Center

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We are seeking a dynamic, energetic individual with innovative ideas, and outstanding communication skills. Qualifications include an advanced degree in mathematics, statistics, or mathematics education; demonstrated excellence in teaching mathematical sciences at the college level; and some experience in administration.

The position is a twelve-month, full-time, administrative and professional staff appointment. Salary will be commensurate with qualifications and experience. Send a resume and letter of interest to Prof. W. J. Davis Jr., MSLC Search Committee, Department of Mathematics, The Ohio State University, 231 West 18th Avenue, Columbus OH 43210.

Evaluation of applications will begin in early December, 1997, and will continue until a suitable candidate is found. The Ohio State University is an Affirmative Action/Equal Opportunity Employer.

Send inquiries for information to david@math.ohio-state.edu. Learn more at http://www.math.ohio-state.edu and http://www.stat.ohio-state.edu/

OKLAHOMA
THE UNIVERSITY OF OKLAHOMA
Department of Mathematics

Applications are invited for two full-time, tenure-track positions beginning August 16, 1998. The positions are initially budgeted at the assistant professor level, but an appointment at the associate professor level may be possible for an exceptional candidate with qualifications and experience appropriate to that rank. Normal duties consist of teaching two courses per semester, conducting research, and rendering service to the department, university, and profession at a level appropriate to the faculty member's experience. Both positions require an earned doctorate and research interests that are compatible with those of the existing faculty; preference will be given to applicants with potential or demonstrated excellence in research and prior successful graduate teaching experience. For one of the positions, additional preference will be given to applicants with research interests in applied or computational mathematics. Salary and benefits are competitive. For full consideration, applicants should send a completed AMS Cover Sheet, curriculum vitae, a description of current and planned research, and three letters of recommendation (at least one of which must address the applicant's teaching experience and proficiency) sent to:

Search Committee
Department of Mathematics
University of Oklahoma
Norman, OK 73019-0315
Phone: 405-325-6711
Fax: 405-325-7484
e-mail: search@math.ou.edu

Screening of applications will begin on February 15, 1998, and will continue until the position is filled.

The University of Oklahoma is an Equal Opportunity/Affirmative Action Employer. Women and minorities are encouraged to apply. OU has a policy of being responsive to the needs of dual-career couples.

SOUTH CAROLINA
UNIVERSITY OF SOUTH CAROLINA
Department of Mathematics

The Department of Mathematics expects openings for tenure-track positions starting in fall 1998 and invites applications primarily at the junior level. Applications completed by January 8, 1998, will receive full consideration. While applications in all areas of mathematics will be considered, those whose interests mesh well with the strengths of the department will be given preference. The Ph.D. degree or its equivalent is required as well as an established record of significant research accomplishments. All appointments will be consistent with the department's commitment to excellence in research and teaching at the undergraduate and graduate levels. A complete application should include a detailed résumé with a summary of research accomplishments and goals, a completed copy of the AMS Standard Cover Sheet (see the Notices), and four letters of recommendation. All material should be sent to:

Robert M. Stephenson, Jr., Chairman
Department of Mathematics
University of South Carolina
Columbia, SC 29708

We encourage applicants to use the AMS Cover Sheet located on our World Wide Web site, http://www.math.sc.edu/~jobs98/. The University of South Carolina is an Affirmative Action/Equal Opportunity Employer.

UTAH
UTAH STATE UNIVERSITY
Head
Department of Mathematics and Statistics

Applications are invited for the position of head of the Department of Mathematics and Statistics at Utah State University, a Carnegie Research 1, Land-Grant Institution. The department is one of six in the College of Science. It offers degree programs at the bachelors and masters levels in mathematics, statistics, and mathematics education, and a Ph.D. in mathematical sciences. The department has approximately 35 faculty members whose research interests span a variety of areas in pure mathematics, applied mathematics, computational mathematics, and statistics. The applicant must qualify for a full professorship at USU, have an earned doctorate in any area of pure or applied mathematics or statistics, have strong administrative skills, an established research record, preferably with external funding, and a commitment to excellence in teaching, research, and service. The applicant must also support scholarly activity in all areas of mathematics, statistics, and mathematics education.

The salary is negotiable. The University offers excellent medical, retirement, and professional benefits. With a student body of 20,000, USU is located in a valley at the northern end of the Wasatch Range of the Rocky Mountains. Opportunities for a wide range of outdoor activities are plentiful. More information about the university and department can be found at the Web site http://www.usu.edu, and information regarding professional
amneties and benefits can be found at http://www.uwyo.edu/psinfo/. The committee will begin screening applications on February 10, 1998, and the position will be open until filled. Employment begins July 1, 1998. By regular mail, send a letter of application, a resume, a telephone number, and an e-mail address, and have four letters of recommendation sent to the address below. Two of the letters should address administrative skills.

Chairman, Screening Committee Mathematics and Statistics Head Utah State University Logan, UT 84322-3900

Utah State is an Equal Opportunity/Affirmative Action Employer.

WYOMING

UNIVERSITY OF WYOMING

Applied Mathematics

The Department of Mathematics invites applications for a tenure-track assistant professorship in applied mathematics. We seek candidates with an earned doctorate, proven teaching ability, and strong research in areas of interest in the department, including numerical analysis, partial differential equations, fluid mechanics, and porous media. Applications received by January 15, 1998, will receive first consideration. For more information visit our Web site, http://math.uwyo.edu/.

The University of Wyoming is an Equal Opportunity/Affirmative Action Employer, and we encourage applications from women and underrepresented minorities. Please send vita, three letters of reference, and a statement of teaching qualifications to Myron B. Allen, Head, Department of Mathematics, University of Wyoming, Laramie, WY 82071-3036.

UNIVERSITY OF WYOMING

Department of Mathematics

Tenure-Track Position in Analysis

The University of Wyoming mathematics department (Web site http://math.uwyo.edu/) invites applications for a tenure-track assistant professorship in analysis to start August 1998. Applicants must demonstrate strong ability in research, breadth of mathematical knowledge, strong commitment to undergraduate and graduate teaching, and willingness to supervise master's and doctoral students. Candidates in all areas of analysis will be considered; however, we are particularly interested in strengthening our existing research in function theory, functional, geometric, and harmonic analysis.

Complete applications consist of curriculum vitae, including publication list, a summary of research interests, a statement of teaching qualifications, and three letters of recommendation, sent directly to Myron B. Allen, Head, Department of Mathematics, University of Wyoming, Laramie, WY 82071-3036. Applications received by January 15, 1998, will receive first consideration. The University of Wyoming is an Affirmative Action/Equal Opportunity Employer, and we encourage women and underrepresented minorities to apply.

CANADA

McMaster University

Department of Mathematics & Statistics

1280 Main Street West, Hamilton, Ontario, Canada L8S 4K1

Telephone: (905) 525-9140
Fax: (905) 522-0935
E-mail: math@mcmail.mcmaster.ca
Telex: 061-8347

Analysis

The Department of Mathematics & Statistics, McMaster University, invites applications for a tenure-track (probationary) assistant professorship starting July 1, 1998.

Candidates should have a Ph.D. and proven research ability in a major area of analysis, as well as capability in teaching. The salary will be based on qualifications and experience. This position is subject to final budgetary approval.

McMaster is committed to Employment Equity and encourages applications from all qualified candidates, including aboriginal peoples, persons with disabilities, members of visible minorities and women. In accordance with Canadian Immigration requirements, this advertisement is directed to Canadian citizens and permanent residents.

Applications, including curriculum vitae and three letters of reference, should be received before December 1, 1997 by:

I. Hambleton, Chair
Mathematics & Statistics
McMaster University
Hamilton, Ontario
Canada, L8S 4K1

McMaster University

Department of Mathematics & Statistics

Britton Post-Doctoral Fellowship in Mathematics

Applications are invited for the Britton Post-Doctoral Fellowship in Mathematics. Named after Dr. Ronald Britton, The Britton Fellowship is intended for talented research mathematicians with a recent Ph.D.

The Britton Fellowship is open to candidates of any nationality and selection will be based upon the candidate's research potential. In this year's competition, preference will be given to candidates working in arithmetic algebraic geometry.

McMaster is committed to Employment Equity and encourages applications from all qualified candidates, including aboriginal peoples, persons with disabilities, members of visible minorities and women.

The Britton Fellowship is tenable for a period of two years beginning July 1, 1998, at a salary of $35,000 per year plus a research grant of $5,000. Duties include research and the teaching of one course per year.

Applications, including three letters of reference, should be received before January 1, 1998 by:

I. Hambleton, Chair
or
V.P. Snith, Sc.D., F.R.S.C.
Britton Professor of Mathematics
Mathematics & Statistics
McMaster University
Hamilton, Ontario
Canada, L8S 4K1

We appreciate all replies to this advertisement, but only those applicants being seriously considered will be contacted.

McMaster University

Department of Mathematics & Statistics

Post-Doctoral Instructorships in Mathematics

Applications are invited for post-doctoral fellowship positions in the Department of Mathematics & Statistics. These fellowships provide an opportunity to spend up to two years engaged in research, with
Groups and Computation II
Larry Finkelstein, Northeastern University, Boston, MA, and William M. Kantor, University of Oregon, Eugene, Editors

The workshop "Groups and Computations" took place at the Center for Discrete Mathematics and Theoretical Computer Science (DIMACS) at Rutgers University in June 1995. This and an earlier workshop (see Groups and Computation, Finkelstein and Kantor, ©1993, American Mathematical Society) held in October 1991 was aimed at merging theory and practice within the broad area of computation with groups.

The scientific program consisted of invited lectures and research announcements, as well as informal discussions and software demonstrations. The eight extended talks discussed randomized, permutation groups, matrix groups, software systems, fast Fourier transforms and their applications to signal processing and data analysis, computations with finite presented groups, and implementation and complexity questions. As in the previous workshop, speakers ranged from established researchers to graduate students.

DIMACS: Series in Discrete Mathematics and Theoretical Computer Science, Volume 28; 1997; 382 pages; Hardcover; ISBN 0-8218-0315-1; List $525; Individual member $47; order code DIMACS/29NA

Partial Order Methods in Verification

This book presents surveys on the theory and practice of modeling, specifying, and validating concurrent systems. It contains surveys of techniques used in tools developed for automatic validation of systems. Other papers present recent developments in concurrency theory, logics of programs, model-checking, automata and formal languages theory.

The volume contains the proceedings from the workshop, Partial Order Methods in Verification, which was held in Princeton, NJ, in July 1996. The workshop focused on both the practical and the theoretical aspects of using partial order models, including automata and formal languages, category theory, concurrency theory, logic, process algebra, program semantics, specification and verification, topology, and trace theory. The book also includes a lively e-mail debate that took place about the importance of the partial order dichotomy in modeling concurrency.

DIMACS: Series in Discrete Mathematics and Theoretical Computer Science, Volume 29; 1997; 403 pages; Hardcover; ISBN 0-8218-0579-7; List $85; Individual member $51; order code DIMACS/29NA

Spectral Graph Theory
Fan R. K. Chung, University of Pennsylvania, Philadelphia

This monograph is an interwoven tale of eigenvalues and their use in unlocking a thousand secrets about graphs. The stories will be told—how the spectrum reveals fundamental properties of a graph, how spectral graph theory links the discrete universe to the continuous one through geometric, analytic and algebraic techniques, and how, through eigenvalues, theory and applications in communications and computer science come together in symbiotic harmony.

—from the Preface

Beautifully written and elegantly presented, this book is based on 10 lectures given at the CBMS workshop on spectral graph theory in June 1994 at Fresno State University. Chung's well-written exposition can be likened to a conversation with a good teacher—one who not only gives you the facts, but tells you what is really going on, why it is worth doing, and how it is related to familiar ideas in other areas. The monograph is accessible to the nonexpert who is interested in reading about this evolving area of mathematics.

CBMS Regional Conference Series in Mathematics, Number 92; 1997; 200 pages; Softcover; ISBN 0-8218-0315-1; List $25; All individuals $20; order code CBMS/92NA
Volume 3, 1997

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General Interest

Advances in Mathematical Sciences: CRM's 25 Years
Luc Vinet, Centre de Recherches Mathématiques, Université de Montréal, PQ, Canada, Editor
This volume commemorates the 25th anniversary of the Centre de Recherches Mathématiques (CRM)—a national institute for research in the mathematical sciences in Canada. It includes contributions by eminent scientists who have been closely involved with the CRM. Various topics in pure and applied mathematics, statistics, theoretical physics, and mathematical biology are covered. Original research papers, reviews, as well as historical notes and reminiscences are included in the volume.

African Americans in Mathematics
Nathaniel Dean, Bell Laboratories, Murray Hill, NJ, Editor
Little is known, taught, or written about African-American mathematicians. Information is lacking on their past and present contributions and on the qualitative and quantitative nature of their presence in and distribution throughout mathematics. This lack of information leads to a number of questions that have to date remained unanswered. This volume provides details and pointers to help answer some of these questions.

Features:
- Research articles by distinguished African-American mathematicians.
- Accomplishments of African-American researchers in the mathematical sciences.
- Articles that explore issues important to the African-American community and to the mathematics community as a whole.
- Inspiration for African-American students who wish to pursue advancement in the mathematical sciences.

DIMACS: Series in Discrete Mathematics and Theoretical Computer Science, Volume 34; 1997; 205 pages; Hardcover; ISBN 0-8218-0678-5; List $49; Individual member $31; Order code DIMACS/34NA

Featured Reviews in Mathematical Reviews 1995–1996

Reviews of Outstanding Recent Books and Papers
Donald G. Babbitt, Publisher, American Mathematical Society, Providence, RI, and Jane E. Kister, Associate Executive Editor, Mathematical Reviews, Ann Arbor, MI, Editors
This collection of reprinted Featured Reviews published in Mathematical Reviews (MR) in 1995 and 1996 makes widely available informed reviews of some of the best mathematics published recently.

This work identifies some of the "best" new publications, papers, and books that are expected to have a significant impact on the area of pure or applied mathematics with which researchers are concerned. All of the papers reviewed here contain interesting new ideas or applications, a deep synthesis of existing ideas, or any combination of these. The volume is intended to lead the user to important new research across all fields covered by MR.

Featured Reviews from Mathematical Reviews; 1998, 380 pages; Softcover; ISBN 0-8218-0771-4; List $39; All AMS members $31; Order code FREV/11NA

Mathematics and Mathematicians

Mathematics in Sweden before 1950
Lars Gårding, Lund University, Sweden
In this book important results are analyzed and re-proved in modern notation, with explanations of their relations to mathematics at the time. The book treats Bäcklund transformations, Mittag-Leffler's theorem, the Phragmén-Lindelöf theorem and Carlén's contributions to the spectral theorem, quantum mechanics, and the asymptotics of eigenvalues and eigenfunctions. Other important features include sketches of personalities and university life.
Co-published with the London Mathematical Society. Members of the LMS may order directly from the AMS at the AMS member price. The LMS is registered with the Charity Commissioners.

Qubba for Al-Kāshī Video

Yvonne Dold-Samploni, Interdisciplinary Institute for Scientific Computing, University of Heidelberg, Germany
This 16-minute videotape describes models for five different types of arches. These arches might form portals or windows or be rotated around a central axis to form a dome. The mathematical constructions are clearly demonstrated on the videotape, which is available on computer animation and is compared to photographs of existing domes in Buchara and Samarkand, where al-Kāshī worked. Explanations are provided in a voice-over on the videotape and in an accompanying booklet.
Published by Yvonne Dold-Samploni and the Institute for Scientific Computing, Heidelberg, Germany, and distributed worldwide by the American Mathematical Society.
1997; NTSC format on one-half inch VHS videotape; approximately 16 minutes; List $49; All AMS members $31; Order code VIDEO/100NA

Selected Papers of Walter E. Thirring with Commentaries
Foreword by Elliott Lieb
Walter E. Thirring, University of Vienna, Austria
... with the huge success of the quantum theory, starting especially with the Schrödinger equation in 1926, came a feeling among the leading physicists that mathematics should keep in the background, or, as one person put it, "elegance is for tailors". From the other side, mid-twentieth century mathematicians were not much more hospitable about intrusions of physics, as we can see, for instance, in Hardy's well known little essay, Walter was one of the first, in the post-war years, to try to put things back together.
—from the Foreword by Elliott Lieb

This book contains Thirring's scientific contributions to mathematical physics, statistical physics, general relativity, quantum field theory and elementary particle theory from 1950 onward.
Collected Works, Volume 8; 1997; 729 pages; Hardcover; ISBN 0-8218-0812-5; List $135; Individual member $81; Order code CWOR8/8NA

Some Points of Analysis and Their History

Lars Gårding, Lund University, Sweden
This book is a collection of small essays containing the history and the proofs of some important and interesting theorems of analysis and partial differential operators in this century. Most of the results in the book are associated with Swedish mathematicians. Also included are the Taniike-Steinberg theorem and Wiener's classical results in harmonic analysis and a delightful essay on the impact of distributions in analysis.
This book is co-published with Higher Education Press (Beijing) and is distributed worldwide, except in the People's Republic of China, by the American Mathematical Society.
University Lecture Series, Volume 11; 1997; 88 pages; Softcover; ISBN 0-8218-0737-7; List $16; All AMS members $13; Order code ULECT/11NA

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- Glasgow Mathematical Association
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Advances in Mathematical Sciences: CRM’s 25 Years
Luc Vinet, Centre de Recherches Mathématiques, Université de Montréal, PQ, Canada, Editor
This volume commemorates the 25th anniversary of the Centre de Recherches Mathématiques (CRM)—a national institute for research in the mathematical sciences in Canada. It includes contributions by eminent scientists who have been closely involved with the CRM. Various topics in pure and applied mathematics, statistics, theoretical physics, and mathematical biology are covered. Original research papers, reviews, as well as historical notes and reminiscences are included in the volume.

Applications of Computational Algebraic Geometry
David A. Cox, Amherst College, MA, and Bernd Sturmfels, University of California, Berkeley, Editors
This book introduces readers to key ideas and applications of computational algebraic geometry. Beginning with the discovery of Grobner bases and fueled by the advent of modern computers and the rediscovery of resultants, computational algebraic geometry has grown rapidly in importance. The fact that "crunching equations" is now as easy as "crunching numbers" has had a profound impact in recent years. At the same time, the mathematics used in computational algebraic geometry is unusually elegant and accessible, which makes the subject easy to learn and easy to apply. This book begins with an introduction to Grobner bases and resultants, then discusses some of the more recent methods for solving systems of polynomial equations. A sampler of possible applications follows, including computer-aided geometric design, complex information systems, integer programming, and algebraic coding theory. The lectures in the book assume no previous acquaintance with the material.

Featured Reviews in Mathematical Reviews 1995–1996
Donald G. Babbitt, Publisher, American Mathematical Society, Providence, RI, and Jane E. Kister, Associate Executive Editor, Mathematical Reviews, Ann Arbor, MI, Editors
This collection of reprinted Featured Reviews published in Mathematical Reviews (MR) in 1995 and 1996 makes widely available informed reviews of some of the best mathematics published recently. All of the papers reviewed here contain interesting new ideas or applications, a deep synthesis of existing ideas, or any combination of these. The volume is intended to lead the user to important new research across all fields covered by MR.

Mathematics and Mathematicians in Sweden before 1950
Lars Gårding, Lund University, Sweden
This book is about mathematics in Sweden between 1630 and 1950—from S. Klagenstierna to M. Riesz, T. Carleman, and A. Beurling. It tells the story of how continental mathematics came to Sweden, how it was received, and how it inspired new results. The book contains a biography of Gösta Mittag-Leffler, the father of Swedish mathematics, who introduced the Wirtingerian theory of analytic functions and dominated a golden age from 1880 to 1910.

Important results are analyzed and re-proved in modern notation, with explanations of their relations to mathematics at the time. The book treats Bäcklund transformations, Mittag-Leffler’s theorem, the Phragmen-Lindelöf theorem and Carleman’s contributions to the spectral theorem, quantum mechanics, and the asymptotics of eigenvalues and eigenfunctions. Other important features include sketches of personalities and university life.

Number Theory
V. Kumar Murty, University of Toronto, ON, Canada, and Michel Waldschmidt, Université Pierre et Marie Curie, Paris, France, Editors
To observe the tenth anniversary of the founding of the Ramanujan Mathematical Society, an international conference on Discrete Mathematics and Number Theory was held in January 1996 in Tiruchirapalli, India. This volume contains proceedings from the number theory component of that conference. Papers are divided into four groups: arithmetic algebraic geometry, automorphic forms, elementary and analytic number theory and applications, and miscellaneous number theory. This work deals with recent progress in current areas of number theory and covers a wide variety of topics.

Partial Differential Equations
Harold Levine, Stanford University, CA
The subject matter partial differential equations (PDEs) has a long history dating from the 18th century and an active contemporary phase. An early phase (with a separate focus on taut string vibrations and heat flow through solid bodies) stimulated developments of great importance for mathematical analysis, such as a wider concept of functions and integration, the existence of trigonometric or Fourier series representations. The direct relevance of PDEs to all manner of mathematical, physical and technical problems continues. This book presents a reasonably broad introductory account of the subject, with due regard for analytical detail, applications, and historical accounts. Titles in this series are co-published with International Press, Cambridge, MA.

Studies on Composition Operators
Farhad Jafari, University of Wyoming, Laramie, Barbara D. MacCluer, University of Virginia, Charlottesville, Carl C. Cowen, Purdue University, West Lafayette, IN, and A. Duane Porter, University of Wyoming, Laramie, Editors
This book reflects the proceedings of the 1996 Rocky Mountain Mathematics Consortium conference on "Composition Operators on Spaces of Analytic Functions" held at the University of Wyoming. Readers will find a collection of high-quality research and expository articles on composition operators in one and several variables. The book highlights open questions and new advances in the classical areas and promotes topics which are largely untapped in the existing text.
Joint Summer Research Conferences in the Mathematical Sciences

Mount Holyoke College
South Hadley, Massachusetts
June 21-July 23, 1998

Please consult the complete announcement for the Joint Summer Research Conferences in the November 1997 issue of the Notices or visit eMATH at www.ams.org/meetings/.

The following is revised information pertaining to the q-Series, Combinatorics and Computer Algebra and the Geometric Group Theory conferences.

q-Series, Combinatorics and Computer Algebra (revised)

Sunday, June 21–Thursday, June 25

Mourad E. H. Ismail, University of South Florida, co-chair
Dennis Stanton, University of Minnesota, co-chair

The area of special functions, and q-series in particular, has seen significant advances in the last twenty years. The idea that generating functions for integer partitions are q-series goes back to Euler, but there are many new classical applications to integer partitions. For example recently Ono and Granville solved the t-core conjecture, while Milne has new expansions for powers of the eta function. There are also a variety of recent problems in combinatorics, analysis and algebra related to q-series.

One major event is the discovery of the Askey-Wilson polynomials and the multivariable generalization to root systems by Macdonald. These polynomials are being studied analytically, combinatorially, and via quantum groups.

Several distinct research teams have established polynomiality in q,t of the q,t-Kostka polynomials, but positivity of the coefficients remains open. It is a very active area and the multiplicity of viewpoints will offer much insight to all.

This is closely related to enumeration of tableaux by q-statistics, and thus to classical enumeration. Andrews' q-Dyson conjecture (a precursor to the Macdonald conjectures) was solved using combinatorial techniques by Zeilberger-Bressoud. The interaction between special functions and enumeration problems has benefited both areas. The evolution of practical and theoretical computer algebra, has made it possible to confirm the validity of many identities in special cases and provided proofs of new results for which analytical proofs were found at a later time. Bill Gosper has made many fascinating conjectures based on computer experiments. P. Paule, C. Krattenthaler and D. Zeilberger have prepared very useful packages. There is an ongoing web project to develop applets for the Askey tableau of orthogonal polynomials and recurrence relations.

The topics to be covered will include:

1. classical q-series, number theory, and orthogonal polynomials
2. multivariable polynomials and quantum groups
3. applications of computer algebra packages to combinatorial problems
4. applications of q-series to physical problems

Preliminary list of speakers: George Andrews, Pennsylvania State University; Richard Askey, University of Wisconsin; Pavel Etinghof, Harvard University; Dominique Foata, Université Louis Pasteur; George Gasper, Northwestern University; Ira Gessel, Brandeis University; R. William Gosper, MACSYMA division; Christian Krattenthaler, University of Vienna; Tom Koornwinder, University of Amsterdam; Steve Milne, Ohio State University; Ken Ono, Institute for Advanced Study; Doron Zeilberger, Temple University.
Geometric Group Theory and Computer Science (revised)

Sunday, July 5–Thursday, July 9

Robert Gilman, Stevens Institute of Technology, chair

Over the last several years an influx of ideas from topology and computer science into combinatorial group theory has led to a new area of research called geometric group theory. The proposed conference is devoted to computer theoretic aspects of geometric group theory. We think that a fruitful area for research is emerging here related to combinatorial group theory, computational group theory, and the theory of automata and formal languages. The goal of the conference is to encourage the development of this area.

Automatic and Word Hyperbolic Groups: Automatic groups and word hyperbolic groups are perhaps the best known products of geometric group theory. At the beginning of the century Max Dehn solved the word and conjugacy problems for fundamental groups of orientable surfaces by making use of the underlying hyperbolic geometry. Dehn’s ideas led to the theory of small cancellation groups and more recently to some striking connections between geometry and finite automata. The geometry of the known compact 3-manifolds is reflected by restrictions on the structure of their fundamental groups, and in many cases the spirit of these restrictions is captured by the fact that multiplication in the fundamental group can be carried out by finite automata. This fact leads to the definition of automatic groups and to previously unsuspected connections with computer science.

Word hyperbolic groups are algebraic analogs of groups acting cocompactly on spaces of negative curvature. They are defined by imposing geometric conditions on the Cayley diagram of a group. It is remarkable that word hyperbolic groups are also characterized by concepts from computer science. They are precisely the groups whose word problem can be solved by a length reducing rewriting system confluent at the identity.

Further Connections with Computer Science: Another line of research, initiated by computer scientists, concerns the structure of a group and the language theoretic properties of its word problem. Here word problem means the formal language of all words defining the identity with respect to a fixed set of generators. This program has produced a number of interesting results, among them the characterization of groups with a free subgroup of finite index as those groups whose word problem is a context-free language, and a complexity-theoretic analog of the Higman Embedding Theorem.

Geometric group theory has also inspired new approaches to computation with finitely presented groups. It is well known that almost all questions about finitely presented groups are recursively unsolvable. In practice, the unsolvability means one writes programs which give the correct answer sometimes and never stop in other cases. The computational challenge is to devise programs which will work often enough to be useful. For example the theory of automatic groups includes both a procedure of theoretical interest for verifying that a finite presentation presents an automatic group, and a practical procedure which is useful for actual computation but which might fail to show that a group is automatic when in fact it is. The latter procedure makes use of rewriting methods like those mentioned above, and it is the basis of a method to enumerate the cosets of finitely generated subgroups of finitely presented groups. The well-known Todd-Coxeter method works for subgroups of finite index, but the new method works for some subgroups infinitely many coset representatives. Rather its output is a finite description of such a list, namely a finite automaton which can test whether or not a word in the generators is on the list.

Preliminary List of Speakers: John Cannon, University of Sydney; David Epstein, Warwick University; Steven Gerven, University of Utah; Susan Hermiller, New Mexico State University; Chuck Miller, University of Melbourne; Sarah Rees, University of Newcastle; Mark Sapir, University of Nebraska; Charles Sims, Rutgers University; Paul Schupp, University of Illinois; John Stallings, University of California, Berkeley.
General Information Regarding Meetings & Conferences of the AMS

**Speakers and Organizers:** The Council has decreed that no paper, whether invited or contributed, may be listed in the program of a meeting of the Society unless an abstract of the paper has been received in Providence prior to the deadline.

Although an individual may present only one ten-minute contributed paper at a meeting, any combination of joint authorship may be accepted, provided no individual speaks more than once. An author can speak by invitation in more than one Special Session at the same meeting.

**Special Sessions:** The number of Special Sessions at an Annual Meeting is limited. Special Sessions at Annual Meetings are held under the supervision of the Program Committee for National Meetings and, for Sectional Meetings, under the supervision of each Section Program Committee. They are administered by the associate secretary in charge of that meeting with staff assistance from the Meetings and Conferences Department in Providence. (See the list of associate secretaries on the next page.)

Each person selected to give an Invited Address is also invited to generate a Special Session, either by personally organizing one or by having it organized by others. Proposals to organize a Special Session are sometimes solicited either by a program committee or by the associate secretary. Other proposals should be submitted to the associate secretary in charge of that meeting (who is an ex officio member of the program committee) at the address listed below. These proposals must be in the hands of the associate secretary at least nine months prior to the meeting at which the Special Session is to be held in order that the committee may consider all the proposals for Special Sessions simultaneously. Special Sessions must be announced in the Notices in a timely fashion so that any Society member who so wishes may submit an abstract for consideration for presentation in the Special Session.

Talks in Special Sessions are usually limited to twenty minutes; however, organizers who wish to allocate more time to individual speakers may do so within certain limits. A great many of the papers presented in Special Sessions at meetings of the Society are invited papers, but any member of the Society who wishes to do so may submit an abstract for consideration for presentation in a Special Session, provided it is received by the abstracts coordinator in Providence prior to the special early deadline for consideration. Contributors should know that there is a limit to the size of a single Special Session, so sometimes all places are filled by invitation. Papers submitted for consideration for inclusion in Special Sessions but not accepted will receive consideration for a contributed paper session, unless specific instructions to the contrary are given.

The Society reserves the right of first refusal for the publication of proceedings of any Special Session. If published by the AMS, these proceedings appear in the book series *Contemporary Mathematics.*

**Contributed Papers:** The Society also accepts abstracts for ten-minute contributed papers. These abstracts will be grouped by related Mathematical Reviews subject classifications into sessions insofar as possible. The title and author of each paper accepted and the time of presentation will be listed in the program of the meeting.

**Other Sessions:** In accordance with policy established by the AMS Committee on Meetings and Conferences, mathematicians interested in organizing a session at an annual or sectional meeting on employment opportunities inside or outside academia for young mathematicians should contact the associate secretary for the meeting with a proposal by the stated deadline. Also, potential organizers for poster sessions on a topic of choice should contact the associate secretary before the deadline.

**Abstracts:** Abstracts for all papers must be received by the abstracts coordinator in Providence by the stated deadline. Unfortunately, late papers cannot be accommodated.

**Electronic submission procedures:** Send a message to abs-submit@ams.org and type help as the subject to review your options, or visit the meetings and conferences home page on the Web at http://www.ams.org/committee/meetings/. Completed electronic abstracts must be submitted to abs-submit@ams.org, typing submission as the subject.

**Submission by U.S. mail:** AMS abstract forms are available at many departments of mathematics or may be requested by contacting the Abstracts Coordinator, AMS Meetings and Conferences Department, P.O. Box 6887, Providence, RI 02940; telephone: 401-455-4146; e-mail: abs-misc@ams.org. Your completed abstract should be sent to the same address by the stated deadline.

See the inside front cover of *Abstracts of Papers Presented to the American Mathematical Society* for information on abstracts published by title and not presented at a meeting.

**Site Selection for Sectional Meetings**

Sectional meeting sites are recommended by the associate secretary for the section and approved by the Secretariat. Recommendations are usually made eighteen to twenty-four months in advance. Host departments supply local information, ten to twelve rooms with overhead projectors for contributed paper sessions and Special Sessions, an auditorium with twin overhead projectors for Invited Addresses, and registration clerks. The Society partially reimburses for the rental of facilities and equipment and for staffing the registration desk. Most host departments volunteer; to do so, or for more information, contact the associate secretary for the section.
Meetings & Conferences
of the AMS

PROGRAM ALERT: In order that AMS meeting programs include the most timely information for each speaker, abstract deadlines have been moved to dates much closer to the meeting. What this means is that most meeting programs will appear in the Notices "after" the meeting takes place. However, complete meeting programs will be available on e-MATH about two to three weeks after the abstract deadline. "Remember", e-MATH is your most comprehensive source for up-to-date meeting information. See http://www.ams.org/meetings/.

Baltimore, Maryland
Baltimore Convention Center
January 7-10, 1998

Meeting #930
Joint Mathematics Meetings, including the 104th Annual Meeting of the AMS, 81st Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL).
Associate secretary: Robert J. Daverman
Announcement issue of Notices: October 1997
Program issue of Notices: January 1998
Issue of Abstracts: Volume 19, Issue 1

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired
For summaries of papers to MAA organizers: Expired

AMS-MAA Event Updates
At the Joint Prize Session on Thursday, the AMS will also present the George David Birkhoff Prize in Applied Mathematics, the Award for Distinguished Public Service, and Citations for Public Service.

AMS Event Updates
Mathematical Reviews (MR) Reception, Friday, 6:00 p.m. to 7:00 p.m. All reviewers are encouraged to come to this reception, as well as others who are interested in MR. Members of the MR Editorial Committee and the MR staff will make some brief comments, and there will be an opportunity for reviewers to ask questions and make comments and suggestions. Refreshments will be provided.

MAA Program Updates
The Calculus War, Leibniz versus Newton, Thursday, 6:30 p.m. to 7:15 p.m. In this dramatic presentation, the characters of Leibniz and Newton appear in costume and present interpretations of their lives and the events surrounding their priority conflict. Those appearing in the presentation are H. W. Straley, Woodberry Forest School, VA; Charlene B. Straley; and Chip Straley, Kaleidoscope Theatre Co., Richmond VA.

Other Organization Program Updates
The panelists for AWM’s panel on Wednesday include Deborah Tepper Haimo, University of California at San Diego; Rhonda J. Hughes, Bryn Mawr College; Craig L. Huneke, Purdue University; Stephen F. Kennedy, Carleton College; Suzanne M. Lenhart, University of Tennessee; and Dawn A. Lott-Crumpel, New Jersey Institute of Technology. At the conclusion of the panel, AWM will recognize its Alice T. Schafer Prize honorees.

The Joint Policy Board for Mathematics’ panel discussion on Mathematics Awareness Week (MAW) on Wednesday afternoon is organized by Ansuman Bagchi, Worcester Polytechnic Institute.
National Association of Mathematicians
Granville-Brown Session of Presentations by Recent Doctoral Recipients in the Mathematical Sciences, Friday at 2:15 p.m., moderated by James C. Turner Jr., Arizona State University. Presenters include Errol Rowe, North Carolina A & T University, Probabilistic approach to a class of PDE systems; Alfred Noel, Northeastern University, Maintaining structural properties in numerically solving the differential Riccati equation; Michael Kean, Norfolk State University, Solutions of a certain family of diophantine equations of degree 4; Alan Togbe, University of Laval, New directions in finite termination on techniques; Pamela Williams, Rice University, Finite sums and products in weak rings; Elaine Terry, St. Joseph's University, and others to be announced.

The Cox-Talbot address will be given after the NAM Banquet on Friday evening by Nathaniel Pollard Jr., Bowie State University, on Some 21st century challenges and opportunities for minorities in mathematics, science, and engineering.

NAM's panel discussion on Saturday morning is titled A profile for an undergraduate in the department of mathematics at a minority institution for the 21st century, and includes Genevieve M. Knight, Coppin State College; Stella Roberson Ashford, Southern University; William A. Hawkins Jr., University of the District of Columbia/MAA; and Tasha Innis, University of Maryland, College Park, as panelists. Leon C. Woodson, Morgan State University, is the moderator.

The Claytor Lecture will be given on Saturday afternoon by Joshua Leslie, Howard University, on Lie's third theorem in infinite dimensions.

Registration at the Meetings
Individuals who registered by November 20 and who so elected will have their badge and the final program mailed to them before the meetings. All other registrants will receive the final program at the meetings. The additional information below is to assist those who will register at the meetings to both members and nonmembers. These one-day fees are not applicable to librarians, high school teachers, unemployed or emeritus participants, or high school, undergraduate, or graduate students.

Joint Mathematics Meetings
Member of AMS, ASL, Canadian Mathematical Society (CMS), MAA $202
Emeritus Member of AMS, MAA $45
Nonmember $312
Temporarily Employed $125
Graduate Student/Unemployed $45
Librarians/High School Teachers $45
Developing Country Participant $45
Undergraduate Students $26
High School Students $5
Guest $5

Joint Mathematics Meetings One Day
Member of AMS, CMS, MAA $121
Nonmember $172

MAA Minicourses (if openings available)
Minicourses #1-4, 10-16 $45
Minicourses #5-9 $65

Employment Register
Employer (First Table) $250
Employer (Second Table) $75
Employer Posting Only 50
Applicant $75

AMS Short Course
Student/Unemployed $45
Emeritus Member of AMS, MAA $45
All Other Participants $90

MAA Short Course
MAA member/Joint Meeting participant $125
Nonmember/non-Joint Meeting participant $75
Student $50

Accommodations and Travel
Participants who did not reserve a room during advance registration but who would like to obtain a room at one of the hotels listed on pages 1204 and 1205 in the October issue of the Notices should call the hotels directly after December 19. However, we regret that after that date the MMSB can no longer guarantee availability of rooms or of the special convention rates.

Please see the October issue for special discount fare information on USAirways, as well as driving directions to the Baltimore Convention Center.

Registration Dates, Times, and Locations
AMS Short Course
Maryland Suites Foyer, Hyatt Regency Baltimore
Monday, January 5 8:00 a.m. to 4:00 p.m.

MAA Short Course
Outside Chesapeake Room, Hyatt Regency Baltimore
Monday, January 5 7:30 a.m. to 9:00 a.m.

Joint Mathematics Meetings and MAA Minicourses
Charles Street Lobby, Baltimore Convention Center
Tuesday, January 6 3:00 p.m. to 7:00 p.m.
Wednesday-Friday,
January 7-9 7:30 a.m. to 4:00 p.m.
Saturday, January 10 7:30 a.m. to 2:00 p.m.

Employment Register
Exhibit Hall B, Baltimore Convention Center
Wednesday, January 7 7:30 a.m. to 4:00 p.m.
(registration only)
Thursday, January 8 7:00 a.m. to 4:40 p.m.
(schedule distribution and interviews only)
Friday, January 9 8:15 a.m. to 4:40 p.m.
(interviews only)

Employment Register participants must register and fill out interview request forms on Wednesday, January 7. There will be no registration on Thursday and Friday; only interviews will take place on these days.

Louisville, Kentucky
University of Louisville, Shelby Campus

March 20-21, 1998

Meeting #931
Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of Notices: January 1998
Program issue of Notices: May 1998
Issue of Abstracts: Volume 19, Issue 2

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: January 28, 1998

Invited Addresses
Anders Bjorner, Royal Institute of Technology, Stockholm, Sweden, The combinatorial topology of graph properties.
Andrew Bruckner, University of California at Santa Barbara, The X, Y, Z's in the characterization problem for derivatives.
Philippe DiFrancesco, University of North Carolina at Chapel Hill, Folding and coloring problems in mathematics and physics.
Abigail Thompson, University of California at Davis, Recognizing the 3-sphere.

Special Sessions
Algebraic Combinatorics (Code: AMS SS N1), Anders Bjorner, Royal Institute of Technology, and Michelle L. Wachs, University of Miami.
Applied Probability and Actuarial Science (Code: AMS SS P1), Grzegorz Rempala, Krzysztof Ostraszewski, Ewa M. Kubicka, and Bogdan Gapinski, University of Louisville.
Banach Space Theory (Code: AMS SS F1), Patrick N. Dowling and Beata Randrianantoanina, Miami University, Ohio.
Boundary Value Problems for Differential Equations (Code: AMS SS J1), Paul W. Eloe, University of Dayton.
Combinatorics and Enumerative Geometry (Code: AMS SS A1), Kequan Ding, University of Illinois, Urbana-Champaign, and Chi Wang, University of Louisville.
Combinatorics and Graph Theory (Code: AMS SS B1), Andre E. Kezdy, Grzegorz Kubicki, and Jenoe Lehel, University of Louisville.
Discrete Mathematics, Classification Theory, and Consensus (Code: AMS SS C1), Robert C. Powers, University of Louisville.
Fractal Geometry and Related Topics (Code: AMS SS D1), Ka-Sing Lau, University of Pittsburgh, and Weibin Zeng, University of Louisville.
Functional Equations and Inequalities (Code: AMS SS E1), Thomas Riedel and Prasanna Sahoo, University of Louisville.
Geometry of Affine Space (Code: AMS SS M1), Gene Freudenburg, University of Southern Indiana, and David Wright, Washington University.
Low-Dimensional Topology (Code: AMS SS R1), Abigail A. Thompson, University of California, Davis, and Martin Scharlemann, University of California, Santa Barbara.
Modern Function Theory (Code: AMS SS Q1), David Minda and David A. Herron, University of Cincinnati.
Real Analysis (Code: AMS SS G1), Udayan B. Darji and Lee Larson, University of Louisville.
Meetings & Conferences

Semigroups, Algorithms, and Universal Algebra (Code: AMS SS H1), Ralph N. McKenzie, Vanderbilt University, and Steven Seif, University of Louisville.

Spectral Geometry (Code: AMS SS K1), Ruth Gornet, Texas Tech University, and Peter Anton Perry, University of Kentucky.

Spectral Theory, Mathematical Physics, and Disordered Media (Code: AMS SS L1), Peter David Hislop, University of Kentucky, and Gunter H. Stolz, University of Alabama at Birmingham.

The Use of the History of Mathematics and Science in the University and School Classroom (Code: AMS SS II), Richard M. Davitt, University of Louisville.

Accommodations

Participants should make their own arrangements directly with the hotel of their choice and state that they will be attending the AMS Southeastern Section Meeting. All rooms will be on a space available basis after the deadline given. The AMS is not responsible for rate changes or for the quality of the accommodations selected. There is no public transportation from the hotels to the campus and back. The hotels are not within walking distance except the Shelby Campus Dormitories. The Department of Mathematics has arranged for limited shuttle service between the campus and the area hotels. There will be one run in the morning and one in the evening. Because of a city-wide truck show the weekend of the meeting, the number of rooms available is very limited. Please make reservations as soon as possible to guarantee accommodations.

University of Louisville, Shelby Campus Dormitories, University of Louisville, Shelby Campus, 502-852-8377; $13.00 double, $18.00 single; two rooms share a bath; towels and linens provided; walk to meetings. Deadline is March 9.

Wilson Inn, 9802 Bunsen Parkway; 502-499-0000; $44.95/2 Queen beds; $59.95/1 King or 2 Queens w/ sofa; $54.95 1 King w/ sofa; continental breakfast included. Deadline is February 19.

Breckinridge Inn, 2800 Breckinridge Lane; 502-456-5050; $65/suite (sleeps four), $85.00/2 Queen beds. Deadline is February 25.

Ramada Inn, 4805 Brownsboro Road; 502-893-2551; $85.00/1 King or 2 doubles. Deadline is February 19.

Doubletree Club Hotel, 9700 Bluegrass Parkway; 502-491-4830; $99.00/king or 2 Queen beds; $10 charge for each additional adult. Deadline is February 26.

Food Service

There will be no food services available on campus because of Spring Break. There are several within walking distance. Listings will be available at the registration desk.

Local Information

For a copy of the visitors guide put together by the Louisville Visitors Bureau call 800-796-5595 or see their Web site at www.louisville-visitor.com. The Department of Mathematics maintains a Web site at www.louisville.edu/a-s/math/.

Other Activities

AMS Book Sale: Examine the newest titles from AMS! Most books will be available at a special 50% discount offered only at meetings. AMS representatives will be on hand to demonstrate and discuss the newest electronic journals, the preprint server and other products and members services available on e-MATH. Complimentary coffee will be served, courtesy of AMS Membership Services.

Parking

Ample free parking will be available next to Burhans Hall throughout the meeting.

Registration and Meeting Information

The registration desk will be located in the lobby of Burhans Hall. The hours of operation will be 7:30 a.m. to 5:00 p.m. on Friday and 7:30 a.m. to noon on Saturday. Lectures will take place in Burhans Hall and the Founders Union Building.

Registration fees: (payable on-site only) $30/AMS members; $45/nonmembers; $10/exempt members, students, or unemployed mathematicians. Fees are payable by cash, check, VISA, MasterCard, Discover, or American Express.

Travel

USAirways has been selected as the official airline for the meeting. The AMS can earn complimentary tickets on this carrier. These tickets are used to send meetings staff (not officers or other staff) to Sectional Meetings, thereby keeping the costs of the meeting (and registration fees) down. The following specially negotiated rates are available only for the period March 17-24: 5% discount off first class and any published USAirways promotional round-trip fare, or 10% discount off unrestricted coach fares with seven-day advance reservations and ticketing required. These discounts are valid providing all rules and restrictions are met and are applicable for travel from the continental U.S., Bahamas, Canada, and San Juan, P.R. Discounts are not combinable with other discounts or promotions. Additional restrictions may apply on international travel. For reservations call (or have your travel agent call) 800-334-8644 between 8:00 a.m. and 9:00 p.m. Eastern Daylight Time. Refer to Gold File Number 73670341.

Driving: The Shelby Campus of the University of Louisville is located in eastern Jefferson County, just west of Hurstbourne Lane on Shelbyville Road. From Downtown Louisville take I-64 east, from Lexington take I-64 west: Take the north exit on Hurstbourne Lane to Shelbyville Road. Make a left turn onto Shelbyville Road and the campus will be on your right. From Downtown Louisville take I-65 south, from Nashville take I-65 North: To I-264 east to I-64 east. Take the north exit on Hurstbourne Lane to Shelbyville Road and the campus will be on your right. From the airport: Take I-264 east to I-64 east. Take the north exit on Hurstbourne Lane to Shelbyville Road and the campus will be on your right.

Cab fare: The estimated cab fare from the airport to the area hotels or campus is $20.
Weather: The weather in March is very unpredictable in Louisville. It is often rainy with high temperatures ranging from the 40s to 60s and cool temperatures, in the evening, ranging from the 40s to 50s.

Manhattan, Kansas
Kansas State University
March 27–28, 1998

Meeting #932
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: January 1998
Program issue of Notices: June 1998
Issue of Abstracts: Volume 19, Issue 2

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: December 10, 1997
For abstracts: February 2, 1998

Invited Addresses
Gopal Prasad, University of Michigan-Ann Arbor, Title to be announced.
Mikhail Vishik, University of Texas at Austin, Title to be announced.
Clarence Eugene Wayne, Pennsylvania State University, University Park, Title to be announced.
Zihong Jeff Xia, Northwestern University, Title to be announced.

Special Sessions
Abstract Harmonic Analysis (Code: AMS SS H1), Sadahiro Saeki, Kansas State University.
Cohomology of Finite Groups (Code: AMS SS F1), John S. Maginnis, Kansas State University, and Stephen F. Siegel, University of Massachusetts.
Groups and Geometry (Code: AMS SS I1), Ernest F. Shult, Kansas State University.
Integrable systems and their applications (Code: AMS SS M1), Kirill L. Vaninsky, Kansas State University.

Lie Groups, Algebraic Groups, Their Arithmetic and Representation Theory (Code: AMS SS O1), Gopal Prasad, University of Michigan-Ann Arbor.
Linear Operators and Holomorphic Function Spaces (Code: AMS SS G1), V. V. Peller, Kansas State University.
Mathematics Education and the Internet (Code: AMS SS C1), Andrew G. Bennett, Kansas State University.
Nonlinear Problems (Code: AMS SS D1), Lev Kapitanski, Kansas State University, and Clarence Eugene Wayne, Pennsylvania State University.
Numerical Analysis and Computational Mathematics (Code: AMS SS L1), Qisu Zou and Huanan Yang, Kansas State University.
Quantum Groups and Applications (Code: AMS SS J1), Ya S. Soibelman and Volodymyr V. Lyubashenko, Kansas State University.
Quantum Topology (Code: AMS SS K1), David N. Yetter and Louis Crane, Kansas State University.
Representation Theory of Lie Algebras, Algebraic Groups and Quantum Groups (Code: AMS SS E1), Zongzhu Lin, Kansas State University, and Daniel Ken Nakano, Utah State University.

Accommodations
Participants should make their own arrangements directly with the hotel of their choice and state that they will be attending the AMS Central Section Meeting. The deadline for reservations is March 5. After that date all rooms will be on a space available basis. The AMS is not responsible for rate changes or for the quality of the accommodations.

Best Western, 100 Bluemont Ave., Manhattan, KS; 785-776-4771 or 800-528-1234; $40/single and $44/double; 1.2 miles to meeting.
Holiday Inn, 530 Richards Drive, Manhattan, KS; 785-539-5311; $65/single or double; 1.8 miles to meeting.
Ramada Inn, 1641 Anderson Ave., Manhattan, KS; 785-539-7531 or 800-228-2828; $64/single or double; 0.2 miles to meeting.

Food Service
There are a number of restaurants located in Aggierville which is adjacent to the campus. A list of restaurants will be available at the registration desk.

Local Information
Please visit the Web site maintained by the Department of Mathematics at www.ksu.edu/math/.

Other Activities
AMS Book Sale: Examine the newest titles form AMS! Most books will be available at a special 50% discount offered only at meetings. Complimentary coffee will be served, courtesy of AMS Membership Services.

Parking
Participants staying at the Ramada Inn will find it convenient to park in the hotel lot and walk the 0.2 miles to Cardwell Hall. For participants using other accommodations or driving in for the day, on-campus parking convenient to Cardwell and Ackert Halls is available in lots accessible from Denison Avenue and Claflin Avenue. Participants may use any nonreserved spot in lots designated O, W, T or Z. On Friday, parking permits are available at the registration desk from 8:00 a.m. to 11:00 a.m. at the cost of $1 will be required. Arrangements have been made to allow participants to park, register, and return to place the permit in their cars. Participants arriving on Friday after 11:00 a.m. should get a permit at the Visitors Information Booth located on 17th Street just north of Anderson Avenue near the K-State Union. Permits will not be required on Saturday.

Registration and Meeting Information
The registration desk will be located inside the main entrance to Cardwell Hall, and will be open 8:00 a.m. to 5:00 p.m. on Friday, and 8:00 a.m. to noon on Saturday. Invited Addresses will take place in Cardwell Hall Room 101, and all Special Sessions will take place in Cardwell Hall or Ackert Hall.

Registration fees: (payable on-site only) $30/AMS members; $45/nonmembers; $10/emeritus members, students, or unemployed mathematicians. Fees are payable by cash, check, VISA, MasterCard, Discover, or American Express.

Travel
By Air: For travelers arriving by air, all flights into Manhattan originate in Kansas City, MO, and are operated by USAir Express. From cities served by USAirways, the least expensive option is usually to fly by USAirways into Manhattan via Kansas City. For travelers using other airlines, it is generally less expensive to fly to Kansas City and use ground transport to Manhattan. Options from KC to Manhattan by ground are renting a car (one-way driving time approximately 2.3 hours) or using KC Roadrunner van service (reserve in advance at 800-826-8294—a special conference rate of $56 round-trip has been arranged). Mention the AMS meeting when reserving to get the special rate.

The following specially negotiated rates are available only for the period November 5-12: 5% discount off first class and any published USAirways promotional round-trip fare, or 10% discount off unrestricted coach fares with seven-day advance reservations and ticketing required. These discounts are valid providing all rules and restrictions are met and are applicable for travel from the continental U.S., Bahamas, Canada, and San Juan, P.R. Discounts are not combinable with other discounts or promotions. Additional restrictions may apply on international travel. For reservations call (or have your travel agent call) 800-334-8644 between 8:00 a.m. and 9:00 p.m., Eastern Daylight Time. Refer to Gold File Number 73670341.

Driving: Kansas State University is located in Manhattan, KS, in the Flint Hills of eastern Kansas. Manhattan is 130 miles west of Kansas City, MO, and 140 miles west of the Manhattan International Airport. For travelers arriving by car, those coming from the east on I-70 should take Exit 313 (State Hwy. K-177). Those coming from the west on I-70 should follow the detour signs at Exit 303 and continue on to Exit 304, reversing direction, and exiting at Exit 303 from the west-bound lanes. Take State Hwy. K-18. In both cases, follow signs north to Manhattan and Kansas State University.

Weather: A wide range of weather is possible in Kansas in March. Participants are advised to note regional forecasts near the time of the meeting.

Philadelphia, Pennsylvania

Temple University, Center City (TUCC)

April 4-6, 1998

Meeting #933
Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of Notices: January 1998
Program issue of Notices: June 1998
Issue of Abstracts: Volume 19, Issue 2

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: December 17, 1997
For abstracts: February 11, 1998

Invited Addresses
Tobias H. Colding, Courant Institute-New York University, Title to be announced.
Martin Davis, University of California, Berkeley, Title to be announced.
Ezra Getzler, Max-Planck-Institute and Northwestern University, Title to be announced.
Yanyan Li, Rutgers University, Title to be announced.
Elias M. Stein, Princeton University, Title to be announced.

Special Sessions
Harmonic Analysis and Its Applications to PDEs (Code: AMS SS G1), Cristian E. Gutierrez, Temple University, and Guozhen Lu, Wright State University.
Heat Kernel Analysis on Lie Groups (Code: AMS SS H1), Leonard Gross, Cornell University, and Omar Hijab, Temple University.
Mathematical Pedagogy (Code: AMS SS I1), Orin N. Chein, Temple University.
Modular Identities and Q-Series in Number Theory (Code: AMS SS A1), Marvin I. Knopp and Boris Datskovsky, Temple University.
Nonlinear Partial Differential Equations (Code: AMS SS K1), Yanyan Li, Rutgers University.
PDEs in Several Complex Variables (Code: AMS SS B1), Shiferaw Berhanu and Gerardo Mendoza, Temple University.
Radon Transforms and Tomography (Code: AMS SS C1), Eric L. Grinberg, Temple University, and Eric Todd Quinto, Tufts University.
Rings and Representations (Code: AMS SS E1), Maria E. Lorenz, Ursinus College, and Martin Lorenz, Temple University.
Sparse Matrix Computations (Code: AMS SS M1), Jesse Barlow, Pennsylvania State University, and Daniel B. Szyld, Temple University.

Topology of Manifolds and Varieties (Code: AMS SS F1), Georgia Triantafillou, Temple University, and Sylvain E. Cappell, New York University-Courant Institute.

Special Events
The AMS Eastern Section Meeting at Temple University on April 4-6, 1998, will be immediately followed by the Conference in Honor of Leon Ehrenpreis, taking place on Temple University’s main campus on Monday and Tuesday April 6-7.

Accommodations
Participants should make their own arrangements directly with the hotel of their choice and state that they will be attending the AMS Eastern Section Meeting at Temple University. All rooms will be on a space available basis after the deadline given. The AMS is not responsible for rate changes or for the quality of the accommodations chosen.

Doubletree Hotel, Corner of Broad and Locust, 215-222-8733 or 215-893-1600; $104 single/double; full service hotel; walk to meetings. Deadline March 13.

Holiday Inn-Select, 1800 Market Street, 215-561-7500, $89.95 single/double, full service hotel, walk to meetings. Deadline March 13.

There are many guest houses and inns in the area of Temple University’s Center City campus. You can contact any

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Avenue of the Arts

MARKET ST

15th St & City Hall Station

CHESTNUT ST

SANSOM ST

WALNUT ST

SFRUCE ST

TUCC

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NOTICES OF THE AMS

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of the following services for referrals to these selections or visit the University's Web site for the AMS Eastern Sectional Meeting at www.math.temple.edu/ams:

A Bed and Breakfast Connection, 215-735-1917, 610-687-3565, or out of state 800-448-3619.

Association of Bed and Breakfasts in Philadelphia, 610-783-7838 or 800-344-0123.

University City Guest Houses, 215-387-3731.

Rates for accommodations with these services range from $25-$175 according to the services offered at each individual residence.

Food Service
There are food courts at Liberty Place (16th and Chestnut) and in the basement of the Bellevue (Broad and Walnut). Also at 16th and Walnut there is a Starbucks's coffee shop, just seconds away from TUCC. There is a list of restaurants on the University's Web site at www.math.temple.edu/ams. The list will be available at the registration desk as well.

Local Information
Please visit the Web site maintained by the Temple University Math Department at www.math.temple.edu/ams/.

Other Activities
AMS Book Sale: Examine the newest titles from AMS! Most books will be available at a special 50% discount only at meetings. Complimentary coffee will be served, courtesy of AMS Membership Services.

Parking
There is parking available at the meeting site. The parking lot is located in the alley behind 1616 Walnut, and may be reached from 1616 Walnut by taking a lift onto 17th street and then an immediate left into the alley. Special rates for meeting participants are being negotiated and will be announced at a later date.

Registration and Meeting Information
Registration will take place on the ground level of the building at 1616 Walnut Street. Hours for registration are 7:30 a.m. to 4:00 p.m. on Saturday and Sunday and 7:30 a.m. to 12 noon on Monday.

Registration fees: (payable on-site only) $30/AMS members; $45/nonmembers; $10/emeritus members, students, or unemployed mathematicians. Fees are payable by cash, check, VISA, MasterCard, Discover, or American Express.

Travel
USAirways has been selected as the official airline for the meeting. The AMS can earn complimentary tickets on this carrier. These tickets are used to send meetings staff (not officers or other staff) to Sectional Meetings, thereby keeping the costs of the meeting and registration fees down. The following specially negotiated rates are available only for the period April 1-9: 5% discount off first class and any published USAirways promotional round-trip fare, or 10% discount off unrestricted coach fares with seven-day advance reservations and ticketing required. These discounts are valid providing all rules and restrictions are met and are applicable for travel from the continental U.S., Bahamas, Canada, and San Juan. P.R. Discounts are not combinable with other discounts or promotions. Additional restrictions may apply on international travel. For reservations call (or have your travel agent call) 800-334-8644 between 8:00 a.m. and 9:00 p.m. Eastern Daylight Time. Refer to Gold File Number 73670341.

Directions from Philadelphia International Airport: One option is to take the suburban train and to get off at Suburban Station. From Suburban Station, cross JFK and walk down 16th, and make a right onto Walnut to 1616 Walnut. Commuter Transportation (1-313-941-3252) provides shuttle service from the airport to the downtown hotels with fares about $13 one-way. Taxi is about $35.

Directions from the AMTRAK 30th Street Train Station: On a nice day, this is a pleasant walk to 1616 Walnut. Go out the east door of the station, walk across the bridge to 17th Street, make a right and proceed to 17th and Walnut, at which point you will locate 1616 Walnut. Taxis are available at the east door also.

Driving: From the northeast (Princeton, Rutgers, NYC): Go south on I-95 and get off at the I-676 exit in Philadelphia. Proceed on I-676 west, the Vine Street Expressway. Exit at Broad Street and make a left at 17th Street, about three blocks later. Proceed to Walnut Street, about 5 blocks. Just after crossing Walnut, take a left into the alley to the parking garage. You are now either in the TUCC building or across the alley from it.

From the southwest (Maryland, Baltimore): Go north on I-95 and get off at the I-676 exit in Philadelphia. Proceed on I-676 west, the Vine Street expressway. Exit at Broad Street and make a left at 17th Street, about three blocks later. Proceed to Walnut Street, about 5 blocks. Just after crossing Walnut, take a left into the alley to the parking garage. You are now either in the TUCC building or across the alley from it.

Weather: Weather conditions in Philadelphia in April are generally a mild 50 degrees. For up-to-date weather information, visit the University's Web site at www.math.temple.edu/ams/.

Davis, California
University of California
April 25-26, 1998

Meeting #934
Western Section
Associate secretary: William A. Harris Jr
Announcement issue of Notices: February 1998
Program issue of Notices: June 1998
Issue of Abstracts: Volume 19, Issue 2

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: January 7, 1998
For abstracts: March 4, 1998
Chicago, Illinois
DePaul University-Chicago
September 12-13, 1998

Meeting #935
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: June 1998
Program issue of Notices: November 1998
Issue of Abstracts: Volume 19, Issue 3

Deadlines
For organizers: December 12, 1997
For consideration of contributed papers in Special Sessions: May 26, 1998
For abstracts: July 21, 1998

Invited Addresses
Vitaly Bergelson, Ohio State University, Title to be announced.
Sheldon Katz, Oklahoma State University, Title to be announced.
Ralf Spatzier, University of Michigan, Title to be announced.
Vladimir Voevodsky, Northwestern University, Title to be announced.

Special Sessions
Algebraic Coding (Code: AMS SS C1), William C. Huffman, Loyola University of Chicago, and Vera S. Pless, University of Illinois at Chicago.
Algebraic Combinatorics: Association Schemes and Related Topics (Code: AMS SS L1), Sung Yell Song, Iowa State University.
Commutative Algebra (Code: AMS SS I1), Irena V. Peeva, Massachusetts Institute of Technology, and Michael Stillman, Cornell University.
Complex Dynamics (Code: AMS SS H1), Shmuel Friedland, University of Illinois at Chicago.
Computation of Geometric Structures on Manifolds (Code: AMS SS E1), Melvin G. Rothenberg and Shmuel A. Weinberger, University of Chicago.
Ergodic Theory and Topological Dynamics (Code: AMS SS G1), Roger L. Jones, DePaul University, and Randall McCutcheon, Wesleyan College.
Fourier Analysis (Code: AMS SS E1), Marshall Ash, DePaul University, and Mark A. Pinsky, Northwestern University.
K-Theory and Motivic Cohomology (Code: AMS SS D1), Kevin Knudson, Northwestern University, and Mark Walker, University of Nebraska-Lincoln.
Number Theory (Code: AMS SS I1), Jeremy T. Teitelbaum and Yuri Tschinkel, University of Illinois at Chicago.

Winston-Salem, North Carolina
Wake Forest University
October 9-10, 1998

Meeting #936
Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of Notices: August 1998
Program issue of Notices: December 1998
Issue of Abstracts: Volume 19, Issue 3

Deadlines
For organizers: January 6, 1998
For consideration of contributed papers in Special Sessions: June 23, 1998
For abstracts: August 18, 1998

Special Sessions
Abelian Groups and Modules (Code: AMS SS B1), Ulrich Albrecht, Auburn University.
Combinatorics and Graph Theory (Code: AMS SS A1), Bruce Landman, University of North Carolina.
Noncommutative Algebra (Code: AMS SS C1), Ellen Kirkman and James Kuzmanovich, Wake Forest University.
Recent Results on the Topology of Three-Manifolds (Code: AMS SS D1), Hugh Nelson Howards, Wake Forest University.

State College, Pennsylvania
Pennsylvania State University
October 24-25, 1998

Meeting #937
Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of Notices: August 1998
Program issue of Notices: January 1999
Issue of Abstracts: Volume 19, Issue 4
Meetings & Conferences

Deadlines
For organizers: January 22, 1998
For consideration of contributed papers in Special Sessions: July 7, 1998
For abstracts: September 1, 1998

Invited Addresses
Jeffrey Adams, University of Maryland, College Park, Title to be announced.
Nigel D. Higson, Pennsylvania State University, Title to be Announced.
Tasso J. Kaper, Boston University, Title to be Announced.
Kate Okikiolu, University of California, San Diego and MIT, Title to be announced.

Special Sessions
Modeling of Phase Transitions of Partially Ordered Physical Systems (Code: AMS SS C1), Maria-Carme T. Calderer.

Tucson, Arizona
University of Arizona-Tucson
November 14-15, 1998

Meeting #938
Western Section
Associate secretary: William A. Harris Jr
Announcement issue of Notices: September 1998
Program issue of Notices: To be announced
Issue of Abstracts: Volume 19, Issue 4

Deadlines
For organizers: February 12, 1998
For consideration of contributed papers in Special Sessions: July 29, 1998
For abstracts: September 23, 1998

San Antonio, Texas
San Antonio Convention Center
January 13-16, 1999
Joint Mathematics Meetings, including the 105th Annual Meeting of the AMS, 82nd Meeting of the Mathematical Association of America (MAA), and annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM).
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: October 1998

Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: April 14, 1998
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Gainesville, Florida
University of Florida

March 12-13, 1999
Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: June 11, 1998
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Urbana, Illinois
University of Illinois, Urbana-Champaign

March 18-21, 1999
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: June 18, 1998
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Antonio, Texas
San Antonio Convention Center
January 13-16, 1999
Joint Mathematics Meetings, including the 105th Annual Meeting of the AMS, 82nd Meeting of the Mathematical Association of America (MAA), and annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM).
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: October 1998

Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: April 14, 1998
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Gainesville, Florida
University of Florida

March 12-13, 1999
Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: June 11, 1998
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Urbana, Illinois
University of Illinois, Urbana-Champaign

March 18-21, 1999
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: June 18, 1998
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Special Sessions
Recent Progress in Elementary Geometry (Code: AMS SS A1), John E. Wetzel, University of Illinois-Urbana, and Clark Kimberling, University of Evansville.

Las Vegas, Nevada
University of Nevada-Las Vegas

April 10-11, 1999
Western Section
Associate secretary: William A. Harris Jr
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: July 10, 1998
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Buffalo, New York
State University of New York at Buffalo

April 24-25, 1999
Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: July 24, 1998
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Invited Addresses
Michele M. Audin, University Louis Pasteur, Strasbourg, Title to be announced.
Jeff Smith, Purdue University, Title to be announced.
Alexander A. Voronov, Massachusetts Institute of Technology, Title to be announced.
Gregg J. Zuckerman, Yale University, Title to be announced.

Providence, Rhode Island
Providence College

October 2-3, 1999
Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: January 6, 1999
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Austin, Texas
University of Texas-Austin

October 8-10, 1999
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: January 6, 1999
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Washington, District of Columbia
Sheraton Washington Hotel and Omni Shoreham Hotel

January 19-22, 2000
Joint Mathematics Meetings, including the 106th Annual Meeting of the AMS, 83rd Meeting of the Mathematical Association of America (MAA), with minisymposia and other special events contributed by the Society for Industrial and Applied Mathematics (SIAM), and the annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM).
Associate secretary: William A. Harris Jr
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: April 20, 1999
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Lowell, Massachusetts
University of Massachusetts, Lowell

April 1-2, 2000
Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced
Meetings & Conferences

Deadlines
For organizers: July 1, 1999
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Notre Dame, Indiana
University of Notre Dame
April 7–9, 2000
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: July 7, 1999
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

New Orleans, Louisiana
New Orleans Marriott and ITT Sheraton New Orleans Hotel
January 10–13, 2001
Joint Mathematics Meetings, including the 107th Annual Meeting of the AMS, 84th Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM).
Associate secretary: Lesley M. Sibner
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: April 11, 2000
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Columbia, South Carolina
University of South Carolina
March 16–18, 2001
Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: June 15, 2000
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Williamstown, Massachusetts
Williams College
October 13–14, 2001
Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: January 11, 2001
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
Presenters of Papers

Baltimore, Maryland; January 7-10, 1998

Numbers following the name indicate the speaker's position on the program.

AMS-MAA Invited Lecturer, AMS-MAA Science Policy Lecturer, AMS Invited Lecturer, MAA Invited Lecturer, AWM Emmy Noether Lecturer, NAM William W.S. Claytor Lecturer, MAA Student Lecturer, Special Session Speaker, Graduate Student, Undergraduate Student

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**Probability Theory: Collection of Problems**

A. Ya. Dorogovtsev, Kiev, Ukraine, D. S. Silvestrov, Kiev State University, Ukraine, A. V. Skorokhod, Ukrainian Academy of Sciences, Kiev, and M. I. Yadrenko, Kiev State University, Ukraine

This book is intended for students in pure and applied mathematics. It contains problems in traditional areas of probability theory and problems in the theory of stochastic processes, which have wide applications in various fields such as engineering, economics, and finance. It is a valuable resource for both students and researchers.

**Sign-Based Methods in Linear Statistical Models**

M. V. Boldin, G. I. Simonova, and Yu. N. Turya, Moscow State University, Russia

For nonparametric statistics, the last half of this century was the time when rank-based methods originated, were vigorously developed, reached maturity, and became widely used. The rank-based approach in statistics consists in ranking the observed values and using only the ranks rather than the original numerical data. In fitting relationships to observed data, the ranks of residuals from the fitted dependence are used.

The signed-based approach is based on the assumption that random errors take positive or negative values with equal probabilities. Under this assumption, the sign procedures are distribution-free. These procedures are robust to violations of model assumptions, for instance, to even a considerable number of gross errors in observations. In addition, sign procedures, have high relative asymptotic efficiency, in spite of the obvious loss of information incurred by the use of signs instead of the corresponding numerical values.

In this work, sign-based methods in the framework of linear models are developed. In the first part of the book, there are linear and factor models involving independent observations. In the second part, linear models of time series, primarily autoregressive models, are considered.

Transitions of Mathematical Monographs, Volume 162; 1997; 243 pages; Hardcover; ISBN 0-8218-0371-9; List $69; Individual member $41; Order code MMONO/162NA
Program of the Sessions

Baltimore, Maryland, January 7-10, 1998

Monday, January 5

AMS Short Course Registration
8:00 AM - 4:00 PM

AMS Short Course on Singular Perturbations
9:00 AM - 5:30 PM
Organizers: Robert E. O'Malley Jr., University of Washington
Jane Cronin Scanlon, Rutgers University
9:00 AM Figuring out singular perturbations after a first course in ODEs.
Robert E. O'Malley Jr., University of Washington
10:30 AM Break
10:45 AM The method of multiple scales.
Mark H. Holmes, Rensselaer Polytechnic Institute
2:00 PM Computational methods for singularly perturbed systems.
Joseph Flaherty, Rensselaer Polytechnic Institute
4:30 PM Reception

MAA Short Course on the Introduction to Mathematical Imaging and Image Processing
9:00 AM - 5:00 PM
Organizers: Akram Aldroubi, Vanderbilt University
Dennis Healy, DARPA/Dartmouth College

Tuesday, January 6

AMS Short Course on Singular Perturbations
7:30 AM - 3:30 PM
Organizers: Robert E. O'Malley Jr., University of Washington
Jane Cronin Scanlon, Rutgers University

9:00 AM Geometric methods and dynamical systems theory for singular perturbations.
(4) Tasso J. Kaper, Boston University
10:30 AM Break
10:45 AM Analysis of cellular oscillations.
(5) Jane Cronin Scanlon, Rutgers University
2:00 PM Dynamic metastability and exponential asymptotics.
(6) Michael J. Ward, University of British Columbia

MAA Board of Governors
8:30 AM - 4:00 PM

MAA Short Course on the Introduction to Mathematical Imaging and Image Processing
9:00 AM - 5:00 PM
Organizers: Akram Aldroubi, Vanderbilt University
Dennis Healy, DARPA/Dartmouth College

AMS Council
1:00 PM - 10:00 PM

Joint Meetings Registration
3:00 PM - 7:00 PM

MAA Minicourse #3: Part A
3:00 PM - 5:00 PM
A dynamical systems approach to the differential equations course.
Organizers: Paul R. Blanchard, Boston University
Robert L. Devaney, Boston University

The time limit for each AMS contributed paper in the sessions is ten minutes. The time limit for each MAA contributed paper varies. In the Special Sessions the time limit varies from session to session and within sessions. To maintain the schedule, time limits will be strictly enforced.

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

Papers flagged with a solid triangle (►) have been designated by the author as being of possible interest to undergraduate students.

Abstracts of papers presented in the sessions at this meeting will be found in Volume 19, Issue 1 of Abstracts of papers presented to the American Mathematical Society, ordered according to the numbers in parentheses following the listings.
Wednesday, January 7

Joint Meetings Registration
7:30 AM - 4:00 PM

Mathematical Sciences Employment Register
Registration
7:30 AM - 4:00 PM
Open for receipt of all interview request forms (forms accepted between 9:30 a.m. and 4:00 p.m.; none accepted on Thursday or Friday).

AMS-MAA-MER Special Session on Mathematics and Education Reform, I
8:00 AM - 10:50 AM
Organizers: William Henry Barker, Bowdoin College

MAA Minicourse #4: Part A
3:00 PM - 5:00 PM
Computability and computational complexity: What is this all about?
Organizer: William A. Marion, Valparaiso University

MAA Minicourse #5: Part A
3:00 PM - 5:00 PM
Teaching the history of mathematics using the World Wide Web.
Organizers: Brian E. Smith, McGill University
Mary Robinson, University of New Mexico

MAA Minicourse #4: Part B
7:00 PM - 9:00 PM
Computability and computational complexity: What is this all about?
Organizer: William A. Marion, Valparaiso University

MAA Minicourse #5: Part B
7:00 PM - 9:00 PM
Teaching the history of mathematics using the World Wide Web.
Organizers: Brian E. Smith, McGill University
Mary Robinson, University of New Mexico

AMS Special Session on Computational Commutative Algebra, I
8:00 AM - 10:50 AM
Organizers: William W. Adams, University of Maryland, College Park
Philippe Loustaunau, George Mason University
Lyn Miller, Western Kentucky University

Jerry L. Bona, University of Texas at Austin
Naomi Fisher, University of Illinois at Chicago
Harvey B. Keynes, University of Minnesota, Minneapolis
Kenneth C. Millett, University of California Santa Barbara

8:00 AM
Calculus with precalculus: Lessons learned in implementation.
Doris J. Schattschneider, Kay B. Somers, Moravian College, and Dennis C. Ebersole, Northampton Comm. College (930-98-542)

8:30 AM
Revitalizing entry level mathematics.
Benny D. Evans, Oklahoma State University (930-98-1038)

9:00 AM
Outcomes assessment of teaching methods in remedial mathematics.
Judith Lee Baxter, University of Illinois at Chicago (930-98-110)

9:30 AM
A shift in pedagogical and curricular focus: Impacting students' understanding and attitudes.
Tabitha T. Mingus, Morehead State University, and Richard M. Grassl, University of Northern Colorado (930-98-413)

10:00 AM
Evaluation of non-research activities.
L. Pamela Cook, University of Delaware (930-98-1215)

10:30 AM
Evaluation of faculty—The non-research side.
Richard E. Phillips, Michigan State University (930-98-540)

8:00 AM
Computing with degenerate polynomial systems through toric perturbations.
J. Maurice Rojas, MIT (930-14-76)

8:30 AM
The moving line ideal basis of planar rational curves.
David A. Cox*, Amherst College, Thomas W. Sederberg, Brigham Young University, and Falai Chen, University of Science and Technology of China (930-13-183)

9:00 AM
Tangent and normal cones at singular points of real surfaces. Preliminary report.
Donal O'Shea, Mount Holyoke College and University of Hawaii at Manoa (930-14-174)

9:30 AM
Cohomology of sheaves on a toric variety. Preliminary report.
David Eisenbud, MSRI (930-14-1048)

10:00 AM
A non-Buchberger algorithm for computing Groebner bases of toric ideals.
Serkan Hoosten*, George Mason University, and Rekha Thomas, Texas A&M University (930-13-175)

10:30 AM
On the embedding dimension of the integral closure of an affine domain. Preliminary report.
B. Ulrich, Michigan State University, and Wolmer V. Vasconcelos*, Rutgers University, New Brunswick (930-13-105)
AMS Special Session on History of Mathematical Logic, I
8:00 AM - 10:30 AM
Organizer: John W. Dawson Jr., Pennsylvania State University, York
8:00 AM
  Wim B. Ruitenberg, Marquette University (930-01-486)
- (20) The last fifty years of recursion theory. Preliminary report.
  Anil Nerode, Cornell University, Ithaca, New York 14850 (930-03-595)
9:00 AM
- (21) Set theory genealogy. Preliminary report.
  Jean A. Larson, University of Florida (930-01-216)
9:30 AM
- (22) The mathematical import of Zermelo's well-ordering theorem.
  Akihiro Kanamori, Boston University (930-01-28)
10:00 AM
- (23) Fraenkel and the reception of intuitionism.
  Dirk D. Van Dalen, Phil. Dept. Utrecht University (930-01-257)

AMS Special Session on Homotopy Theory, I
8:00 AM - 10:50 AM
Organizers: W. Stephen Wilson, Johns Hopkins University
Douglas C. Ravenel, University of Rochester
Jean-Pierre G. Meyer, Johns Hopkins University
8:00 AM
- (24) Restricted Kan complexes and higher categories. Preliminary report.
  Andre Joyal, UQAM (930-18-1161)
8:30 AM
- (25) Homotopy.
  Duane Randall, Loyola University New Orleans (930-55-1093)
9:00 AM
- (26) An isomorphism between Bredon and Quinn homology via homotopy colimits. Preliminary report.
  Robert N. Talbert, Bethel College (930-55-938)
9:30 AM
  Dena S. Cowen, John Carroll University (930-55-768)
10:00 AM
- (28) Quasifibrations and the Abel-Jacobi map. Preliminary report.
  Boon W. Ong, University of Rochester (930-55-260)
10:30 AM
- (29) Little polygons operad.
  Satyan Devadoss, Johns Hopkins University (930-55-198)

AMS Special Session on Kleinian Groups and Hyperbolic Manifolds, I
8:00 AM - 10:50 AM
Organizer: James W. Anderson, University of Southampton
8:00 AM
- (30) Boundaries of Teichmüller spaces and geodesic laminations. Preliminary report.
  Jeffrey F. Brock, Stanford University (930-30-1058)
8:30 AM
- (31) Triangle and cube groups. Preliminary report.
  Nicolaas H. Kuiper, (deceased), and Peter L. Waterman*, Northern Illinois University (930-30-867)
9:00 AM
- (32) Limits of hyperbolic 3-manifolds.
  Timothy D. Comar, Valparaiso University (930-57-697)
9:30 AM
- (33) Hyperbolic 3-manifolds with nonintersecting closed geodesics. Preliminary report.
  Ara S. Basmajian*, Connecticut College and University of Oklahoma, and Scott A. Wolpert, University of Maryland (930-57-855)
10:00 AM
- (34) Horoball packing and the volume of hyperbolic 3-manifolds. Preliminary report.
  Chun Cao* and Robert Meyerhoff, Boston College (930-30-777)
10:30 AM
- (35) Fundamental domains for cyclic groups. Preliminary report.
  Todd A. Drumm*, Swarthmore College, and Jonathan Poritz, Georgetown University (930-51-678)

AMS Special Session on Quantum Gravity and Low-Dimensional Topology, I
8:00 AM - 10:50 AM
Organizers: John C. Baez, University of California Riverside
Stephen F. Sawin, Fairfield University
8:00 AM
  Louis H. Kauffman, University of Illinois at Chicago (930-83-82)
8:30 AM
- (37) Quantum theory of Riemannian geometry.
  Abhay Ashtekar, Penn State (930-81-924)
9:00 AM
- (38) A survey of cohomological physics.
  Jon Stasheff, UNC - Chapel Hill (930-18-798)
10:00 AM
- (39) Kontsevich integrals, knot invariants and TQFT.
  Roger Picken, Instituto Superior Técnico, Lisbon, Portugal. (930-55-650)
10:30 AM
- (40) The space of states of canonical quantum gravity,
  diffeo invariance vs field theory.
  Jorge Pullin, Penn State (930-83-617)

AMS Special Session on Recent Progress in the Theory of Operator Algebras and Their Applications, I
8:00 AM - 10:50 AM
Organizers: Randall Lee Crist, Creighton University
Roger Smith, Texas A&M University
8:00 AM
- (41) Crossed products of Hopf C*-algebras and their universal properties.
  May M. Nilsen, University of Nebraska-Lincoln (930-46-470)
Baltimore, MD, Wednesday, January 7 - Program of the Sessions

MAA Minicourse #14: Part A
8:00AM - 10:00AM
Factorization in nest algebras II.
(45) Michalis Anoussis, Aegae University, Samos, Greece, and Elias G. Katsoulis*, East Carolina University, Greenville, NC 27858 (930-47-302)

9:00AM Nest algebras are hyperfinite.
(46) Kenneth R. Davidson, University of Waterloo (930-47-952)

9:30AM Principal bimodules of nest algebras.
(47) Kenneth R. Davidson and John L. Orr*, University of Waterloo (930-47-966)

10:00AM Purely infinite simple C*-algebras generated by a weighted shift and an isometry. Preliminary report.
Shuang Zhang, University of Cincinnati (930-46-1169)

10:30AM The Brauer semigroup. Preliminary report.
(49) Astrid an Huef, Dartmouth College, Iain Raeburn, University of Newcastle, and Dana P. Williams*, Dartmouth College (930-46-249)

AMS Special Session on Value Distribution Theory and Its Related Topics, I
8:00 AM - 10:50 AM
Organizers: Ilpo Laine, University of Joensuu, Finland
Charles F. Osgood, National Security Agency
C. C. Yang, Hong Kong University of Science and Technology

8:00AM Oscillation results for complex linear differential equations.
Ilpo E. Laine*, University of Joensuu, Finland, and Vyk-Man E. Chiang, The Hong Kong University of Science and Technology (930-34-637)

8:30AM Completely invariant Julia sets for polynomial semigroups.
Rich L. Stankewitz, University of Illinois, Urbana-Champaign (930-30-693)

9:00AM Newton’s method, transcendental functions, and complex dynamics.
Kriete Hartje, Goettingen University (930-30-1194)

9:30AM An invariant measure for semigroups of rational functions.
David A. Boyd, University of Illinois, Urbana-Champaign (930-30-687)

10:00AM On the cardinality of the unique range sets for meromorphic and entire functions. Preliminary report.
Liangwen Liao, The Hong Kong University of Science and Technology (930-30-1177)

Simon Hellerstein, University of Wisconsin - Madison (930-30-908)

MAA Minicourse #6: Part A
8:00 AM - 10:55 AM
Mathematical algorithms, models, and graphic representations using spreadsheets.
Organizers: Robert S. Smith, Miami University
Deane E. Arganbright, University of Papua New Guinea
Erich Neuwirth, University of Vienna

AMS Session on Designs and Configurations
8:00 AM - 10:55 AM
8:00AM Modelling PG(n, q) on surfaces and pseudo-surfaces. Preliminary report.
Ramon M. Figueroa-Centeno, Western Michigan University (930-05-651)

8:15AM The Terwilliger algebras of bipartite P and Q-polynomial association schemes. Preliminary report.
John S. Caughman, University of Wisconsin - Madison (930-05-57)

8:30AM The planar and toroidal finite fields. Preliminary report.
Dawn M. Jones, Western Michigan University (930-05-524)

8:45AM Modelling affine planes on surfaces.
(59) Arthur T. White, Western Michigan University (930-05-103)

9:00AM Combinatorial approaches to the no-three-in-line problem. Preliminary report.
Jodi A. Schneider, St. John’s College (930-05-1008)

9:15AM The spectrum for directed bowtie systems.
(61) David A. Pike, East Central University, and Michael E. Raines*, Western Michigan University (930-05-104)

9:30AM A generalization of the Bell and Stirling numbers.
(62) Robert S. Smith, Miami University (930-05-168)

9:45AM Symmetrical Cayley maps with solvable automorphism groups. Preliminary report.
John Martin, Western Michigan University, and Michelle Schultz*, University of Nevada, Las Vegas (930-05-451)

10:00AM Examples of non-free arrangements.
(64) Joseph P. Kung, University of North Texas (930-05-421)

10:15AM Enumeration of words with forbidden patterns. Preliminary report.
Alexander Burstein, University of Pennsylvania (930-05-561)

10:45AM Zero-sum Rado numbers. Preliminary report.
Daniel Schaal, South Dakota State University (930-05-1112)

AMS Session on Functions
8:00 AM - 10:55 AM
8:00AM Plurisubharmonic extremal functions of linear growth. Preliminary report.
David R. Bainbridge, University of Michigan (930-31-1127)

8:15AM Cluster sets of analytic functions on the polydisk.
(69) John H. Riley Jr., Bloomsburg Univ. (930-32-1003)

Victor J. Katz, University of the District of Columbia
Program of the Sessions – Baltimore, MD, Wednesday, January 7 (cont’d.)

8:30 AM  Geometric transplantation formulas for spherical functions. Preliminary report.
William O. Bray, University of Maine (930-33-635)

8:45 AM  Uniqueness for series of orthonormal functions. Preliminary report.
J. Marshall Ash* and Gang Wang, DePaul University (930-42-861)

9:00 AM  \( e^p \) logarithmic Sobolev inequalities. Preliminary report.
Michael Pearson, Mississippi State University (930-42-646)

9:15 AM  Short time behavior of hermite functions on compact Lie groups. Preliminary report.
Jeffrey J. Mitchell, Cornell University (930-33-126)

Boris Bauemer, Louisiana State University (930-44-1162)

9:45 AM  Weak univalence and connectedness of inverse images of continuous functions.
Muddappa Seetharama Gowda, University of Maryland, Baltimore County, and Roman Sznajder*,
Bowie State University (930-90-644)

10:00 AM  Multivariable multipower sampling theorems.
Peter A. McCoy, U.S. Naval Academy and U.S. Naval Research Laboratory (930-94-513)

10:15 AM  A comparison of the sampling theorems of Shannon and Kak.
Nasser Dastrange, Buena Vista University (930-26-435)

10:30 AM  Calculus for jerks. Preliminary report.
Paula L. Kenyon*, Lockheed Martin, and Michael J. Bardzell, Salisbury State University (930-98-1001)

10:45 AM  Diophantine conditions for the linearization of commuting holomorphic functions.
David A. Delatte, University of North Texas (930-34-1144)

AMS Session on Algebraic Geometry and Fields

8:00 AM – 10:40 AM

8:00 AM  Irreducible holonomic \( A_2 \)-modules have rational characteristic varieties. Preliminary report.
Timothy C. McCune, Indiana University (930-14-464)

8:15 AM  Enriques surfaces as a family of bundles.
Hoi Kim, TCRG, Kyongpook Univ. (930-14-496)

8:30 AM  Some amplifications and a correction of Iarrobase's construction of local parameters on \( H \text{fib}^n \).
Mark E. Huibregtse, Skidmore College (on leave 1997-98, visiting Texas A&M University (930-14-895)

8:45 AM  Invariants and association for six lines in \( P^3 \). Preliminary report.
Dana R. Vazzana, University of Michigan at Ann Arbor (930-14-397)

9:00 AM  Variations of mixed Hodge structure.
Gregory J. Pearlstein* and Aroldo Kaplan, University of Massachusetts, Amherst (930-14-1023)

Christine Petersen Black, University of Massachusetts, Amherst (930-14-1078)

9:30 AM  Koszul cohomology and k-normality of a projective variety. Preliminary report.
Alberto Alzati, University of Milano, Italy, and Gian Mario Besana*, Eastern Michigan University (930-14-188)

9:45 AM  The algebraic closure of the Laurent series field in positive characteristic.
Kiran S. Kedlaya, Princeton University (930-12-671)

10:00 AM  Embedding problems and quaternion algebra descent.
John R. Swallow, Davidson College (930-12-846)

10:15 AM  Computing Galois groups of linear differential equations of order four.
Sabrina A. Hessinger, Armstrong Atlantic State University (930-12-1142)

10:30 AM  Explicit reciprocity laws for function-fields of curves via torsion-Witt groups. Preliminary report.
Jonathan Shick, New Orleans, Louisiana (930-13-1187)

MAA Session on Chaotic Dynamics and Fractal Geometry, I

8:00 AM – 10:55 AM

Organizers: Jon W. Scott, Montgomery College
Denny Gulick, University of Maryland, College Park

8:00 AM  The sound of bifurcations.
Steven M. Heterzler* and Robert M. Tardiff, Salisbury State University (930-81-784)

8:15 AM  Legal inverse paths.
Sandra Filebrown, St. Joseph's University (930-81-735)

8:30 AM  Undergraduate research experience in applied dynamics.
Harold M. Hastings*, Marysia T. Weiss, Yihren Wu, Hofstra University, and Martha L. Chong, Tufts University (930-81-741)

8:45 AM  Symbolic dynamics for IFS attractors.
Sonya Bahar, Duke University (930-81-781)

9:05 AM  Chaos: The evolution of a definition.
Pat Touhey, College Misericordia (930-81-752)

9:20 AM  Understanding dynamics in two dimensions—An example.
Ben Shanfelder* and Annalisa Crannell, Franklin & Marshall College (930-81-769)

9:35 AM  Fractals and chaos: A connection.
Hubert J. Ludwig, Ball State University (930-81-761)

9:50 AM  The complete bifurcation diagram.
Chip Ross, Bates College, and Jody Sorensen*, Grand Valley State University (930-81-771)

10:05 AM  Riddled basins of attraction: Inevitable uncertainties in outcomes of experiments.
Edward Ott, University of Maryland (930-81-756)

10:30 AM  Chaotic attractors with discrete planar symmetries.
Nathan Carter*, University of Scranton, Richard Eagles, Lafayette College, and Stephen Grimes, Bucknell University (930-81-774)

MAA Session on Innovations in Teaching Linear Algebra, I

8:00 AM – 10:55 AM

Organizers: David C. Lay, University of Maryland, College Park
Steven J. Leon, University of Massachusetts at Dartmouth

8:00 AM  One-dimensional image reconstruction: As a tool to motivate and visualize a basic concept of linear algebra. Preliminary report.
Andrzej W. Kedzierski, SUNY Geneseo (930-81-552)
8:15 AM  Linear algebra projects on wavelets.
    ►  (102) Edward Aboufadel* and Steven Schlicker, Grand Valley State University (930-F1-543)
8:30 AM  Molecular vibrations and symmetry in linear algebra.
    ►  (103) Tom Halverson*, Macalester College, and Tom Varberg, Princeton University (930-F1-909)
8:45 AM  Can I make money with this polynomial?
    ►  (104) Brenda J. Latka, Lafayette College (930-F1-1103)
9:00 AM  Using affine transformations to generate fractal images.
    ►  (105) Henry J. Ricardo, Medgar Evers College (CUNY) (930-F1-648)
9:20 AM  Matrices, geometry & Mathematica: Matrix theory through the eyes of the singular value decomposition.
    ►  (106) J. J. Uhl*, University of Illinois at Urbana-Champaign, William J. Davis, Ohio State University, Ben J. Halperin, University of Illinois at Urbana-Champaign, and Todd G. Will, Davidson College (930-F1-312)
9:40 AM  ATLAST Mathematica projects.
    ►  (107) Richard D. Neidinger, Davidson College (930-F1-243)
10:00 AM  A computer/writing project on Fourier analysis in linear algebra.
    ►  (108) John A. Rhodes, Bates College (930-F1-483)
    ►  (109) Lisette G. dePillis, Harvey Mudd College, and Caroline N. Haddock*, State University of New York at Geneseo (930-F1-841)
10:40 AM  The importance of a writing component for computer exercises and projects in linear algebra.
    ►  (110) Steven J. Leon, University of Massachusetts Dartmouth (930-F1-806)

MAA Session on Using Real World Data in the Teaching and Learning of Mathematics, I

8:00 AM - 11:00 AM

Organizers: Florence S. Gordon, New York Institute of Technology
            Sheldon P. Gordon, Suffolk Community College
            Iris B. Fetta, Clemson University

8:00 AM  Opening remarks
8:05 AM  Applied calculus and football.
    ►  (111) Iris Brann Fetta, Clemson University (930-G1-854)
8:20 AM  Accessible technology puts students in business.
    ►  (112) Thomas E. Kelley, Metro State College of Denver (930-G1-570)
8:35 AM  Modeling of real data in algebra and finite mathematics courses.
    ►  (113) Ronald J. Harshbarger, University of South Carolina-Beaufort (930-G1-461)
8:50 AM  Teaching applied calculus using real world data.
    ►  (114) Patti Frazer Lock, St. Lawrence University (930-G1-611)
9:05 AM  Thomas Malthus: From the original source to a modern rendition.
    ►  (115) Carl E. Swenson, Seattle University (930-G1-1082)
9:20 AM  Fitting curves to model the sales of compact discs.
    ►  (116) Philip Cheifetz, Nassau Community College (930-G1-376)
9:35 AM  Baseball data in teaching advanced modeling and statistics.
    ►  (117) William P. Fox, USMA (930-G1-630)

9:50 AM  Quantitative problem solving using real applications.
    ►  (118) Kay B. Somers, Moravian College (930-G1-636)
10:05 AM  Assessing what students learn using real world data.
    ►  (119) Sheldon P. Gordon, SUNY College at Farmingdale (930-G1-892)
10:20 AM  Chemistry ABC’s in math classes.
    ►  (120) Rich West, U.S. Military Academy (930-G1-360)
10:35 AM  Calculus students’ interpretation of their computations using real world data. Preliminary report.
    ►  (121) Jack Bookman, Duke University (930-G1-995)
    ►  (122) N. Paul Schembri, East Stroudsburg University (930-G1-515)

MAA Session on Mathematics For Preservice Elementary Teachers, I

8:00 AM - 10:55 AM

Organizers: Albert D. Otto, Illinois State University
            C. Patrick Collier, University of Wisconsin at Oshkosh
            Judith L. Covington, Louisiana State University at Shreveport
            William E. Haver, Virginia Commonwealth University

8:00 AM  Mathematics for preservice elementary teachers—An integrated course in content and methods at DePauw University.
    ►  (123) Janet E. Teegarden, DePauw University (930-N1-319)
8:20 AM  Increasing the math and science preparation of prospective K-8 teachers. Preliminary report.
    ►  (124) Phillip E. McNeill*, Norfolk State University, Sharon Emerson-Stonnell, Longwood College, and Curtiss E. Wall, Norfolk State University (930-N1-366)
8:40 AM  Elementary mathematics education: A capstone experience.
    ►  (125) Michael A. McDonald, Occidental College (930-N1-363)
9:00 AM  Strengthening statewide mathematics requirements for elementary school teachers. Preliminary report.
    ►  (126) William E. Haver*, Virginia Commonwealth University, and Richard D. Anderson, Louisiana State University (930-N1-698)
9:20 AM  Mathematics for preservice elementary teachers at Mary Washington College.
    ►  (127) Marie P. Sheckels* and Patricia M. Dean, Mary Washington College (930-N1-845)
9:40 AM  Enhancing student communication skills through problems of the week.
    ►  (128) Dale R. Oliver*, Phiphylis Z. Chinn, Humboldt State University (930-N1-940)
10:00 AM  Mathematical understanding through conversation. Preliminary report.
    ►  (129) Joan D. Lukas* and Judith A., University of Massachusetts at Boston (930-N1-896)
10:20 AM  Needed experiences for K-8 preservice teachers.
    ►  (130) Cheryl A. Lubinski* and Albert D. Otto, Illinois State University (930-N1-925)
10:40 AM  Probability and statistics for preservice elementary teachers at Western Michigan University. Preliminary report.
    ►  (131) Pam Crawford, Western Michigan University (930-N1-669)
Program of the Sessions - Baltimore, MD, Wednesday, January 7 (cont'd.)

MAA Panel Discussion
8:00 AM - 9:20 AM

The impact of new K-12 instructional materials on teacher preparation programs.
Organizers: Lee L. Zia, University of New Hampshire
           John S. Bradley, National Science Foundation

MAA Panel Discussion
8:00 AM - 9:20 AM

Partnerships in undergraduate education, I.
Organizers: Frank R. Giordano, COMAP
           James H. Lightbourne III, National Science Foundation
           Elizabeth J. Teles, National Science Foundation

Panelists:
Mark H. Holmes, Rensselaer Polytechnic Institute
Dennis DeTurck, University of Pennsylvania
Dorothy W. Wallace, Dartmouth College
Benny Evans, Oklahoma State University

MAA Panel Discussion
9:35 AM - 10:55 AM

How can an MAA teaching consultant help a department?
Organizers: Bonnie Gold, Wabash College
           Richard D. Carmichael, Wake Forest University

MAA Panel Discussion
9:35 AM - 10:55 AM

Partnerships in undergraduate education, II.
Organizers: Frank R. Giordano, COMAP
           James H. Lightbourne III, National Science Foundation
           Elizabeth J. Teles, National Science Foundation

Panelists:
Alan C. Tucker, SUNY at Stony Brook
Steven R. Dunbar, University of Nebraska
Daniel P. Maki, Indiana University
Donald B. Small, U. S. Military Academy

AMS Special Presentation
9:45 AM - 10:45 AM

Mathematical markup language: Enabling math in HTML documents.
Organizers: Patrick D.F. Ion, Mathematical Reviews
           Ralph E. Youngen, AMS

AMS Invited Address
10:05 AM - 10:55 AM

(132) Recent advances in geometric mechanics: Theory and applications.
Tudor Stefan Ratiu, University of California, Santa Cruz

AMS-MAA Invited Address
11:10 AM - NOON

(133) How to handle infinite energies.
Haim Brezis, Université de Paris and Rutgers University (930-82-11)

Book Sales and Exhibits
NOON - 5:00 PM

AMS Colloquium Lectures: Lecture I
1:00 PM - 2:00 PM

(134) Introduction to geometric probability.
Gian-Carlo Rota, Massachusetts Institute of Technology (930-52-41)

MAA Invited Address
2:15 PM - 3:05 PM

(135) The symmetry mystique.
Marjorie Senechal, Smith College

AMS-MAA-MER Special Session on Mathematics and Education Reform, II
2:15 PM - 6:05 PM

Organizers:
William Henry Barker, Bowdoin College
Jerry L. Bona, University of Texas at Austin
Naomi Fisher, University of Illinois at Chicago
Harvey B. Keynes, University of Minnesota, Minneapolis
Kenneth C. Millett, University of California Santa Barbara

2:15 PM (136) Collaborating across communities: An example.
    - Deborah Ball*, University of Michigan, and Hyman Bass, Columbia University (930-97-1170)

2:45 PM (137) Collaborating across communities: The building on strengths colloquium.
    - E. Paul Goldenberg* and Wayne Harvey, EDC (930-97-998)

3:15 PM (138) Educational reform and minority institutions.
    - James C. Turner Jr., Arizona State University (930-98-836)

3:45 PM (139) Curriculum reform at southern university.
    - Preliminary report.
    - Stella R. Ashford, Southern University (930-98-1148)

4:15 PM (140) Trends in calculus reform at the WBHR-AMP institutions. Preliminary report.
    - Joshua A. Leslie and Adeniran Adeboye*, Howard University (930-98-1177)

4:45 PM (141) Ten years of calculus reform: Where we've been and where we're going based on a study conducted at the National Science Foundation.
    - Susan L. Ganter, Worcester Polytechnic Institute (930-98-1028)
AMS Special Session on Applied Dynamics, Geometric Analysis, and Mechanics, I

2:15 PM - 3:35 PM
Organizer: Tudor Ratiu, University of California At Santa Cruz

2:15 PM
The momentum cone of a cotangent bundle. Preliminary report.
Reyer Sjamaar, Cornell University (930-58-890)

3:15 PM
The exponential map on the free loop space is Fredholm.
Gerard K. Misiurek, University of Notre Dame (930-58-297)

AMS Special Session on Computable Mathematics and Its Applications, I

2:15 PM - 6:05 PM
Organizer: Valentina Harizanov, George Washington University

2:15 PM
Recursive mathematics: Where it is coming from and where it might go. Preliminary report.
Anil Nerode, Cornell University (930-03-599)

3:15 PM
Feasible structures with standard universe.
Douglas Cenzer, Department of Mathematics, University of Florida, Gainesville, FL (930-03-449)

4:15 PM
Properties of sets which are excisable from domains of computable real functions.
Iraj Kalantari, Western Illinois University (930-03-1015)

4:45 PM
More on generalized cohesiveness.
Tamara Hummel*, Allegheny College, and Carl G. Jockusch Jr., University of Illinois (930-03-65)

4:45 PM
Generalized cohesiveness.
Tamara Hummel*, Allegheny College, and Carl G. Jockusch Jr.*, University of Illinois (930-03-402)

5:15 PM
Computable fully ordered groups. Preliminary report.
David Reed Solomon, Cornell University (930-03-934)

5:45 PM
A framework for the priority method.
Manuel Lerman, University of Connecticut (930-03-404)

AMS Special Session on Computational Commutative Algebra, II

2:15 PM - 4:35 PM
Organizers: William W. Adams, University of Maryland, College Park
Philippe Loustaunau, George Mason University
Lyn Miller, Western Kentucky University

2:15 PM
Invariants from canonical bases. Preliminary report.
Joseph P. Brennan, North Dakota State University (930-13-182)

2:45 PM
William W. Adams, University of Maryland, Philippe Loustaunau, Systems Planning and Analysis, Inc., and J. Lyn Miller*, Western Kentucky University (930-13-1067)

3:15 PM
Classification of term orders on a module.
Moss E. Sweedler, Cornell University (930-13-490)

4:15 PM
Multivariable elimination using Dixon resultants.
Deepak Kapur, State University of New York at Albany (930-13-158)

AMS Special Session on History of Mathematical Logic, II

2:15 PM - 3:45 PM
Organizer: John W. Dawson Jr., Pennsylvania State University, York

2:15 PM
Hilbert's consistency proofs. Preliminary report.
Wilfried Sieg, Carnegie Mellon University (930-01-267)

3:15 PM
The "Infinitary Cholera Bacillus": Cantor and the reception of infinitesimals, 1870-1910. Preliminary report.
Gregory H. Moore, McMaster University (930-01-1070)

AMS Special Session on Homotopy Theory, II

2:15 PM - 6:05 PM
Organizers: W. Stephen Wilson, Johns Hopkins University
Douglas C. Ravenel, University of Rochester

2:15 PM
Homotopy invariants of certain n-connective coverings.
Charles A. McGibbon, Wayne State University, and Joseph Roitberg*, Hunter College, Graduate Center (CUNY) (930-55-127)

3:15 PM
A construction producing cyclotomic extensions of E_n spectra. Preliminary report.
Roland Schwanzl, Rainer M. Vogt*, University of Osnabrück, and Friedhelm Waldhausen, University of Bielefeld (930-55-258)

3:45 PM
The Bousfield-Kan spectral sequence for periodic homology theories.
Martin Bendersky*, Hunter College, and Robert D. Thompson, Hunter College and The Graduate Center, CUNY (930-55-152)

4:15 PM
Γ1-periodic homotopy groups of compact simple Lie groups.
Donald M. Davis, Lehigh University (930-55-149)

4:45 PM
The rigidity theorems of Witten via equivariant elliptic cohomology.
Ioanid Rosu, M.I.T. (930-55-620)
AMS Special Session on Quantum Gravity and Low-Dimensional Topology, II
2:15 PM - 6:05 PM
Organizers: John C. Baez, University of California Riverside
Stephen F. Sawin, Fairfield University

2:15 PM
Homological perturbation theory. Preliminary report.
Mauricio Mata, The Pennsylvania State University (930-18-1004)

5:15 PM
Loop constraints: A habitat and their algebra.
Donald M. Marolf*, Syracuse University, and Jerzy Lewandowski, Instytut Fizyki Teoretycznej, Warsaw, Poland and Max-Planck-Institut fur Gravitationsphysik, Potsdam, Germany (930-83-601)

AMS Special Session on Recent Progress in the Theory of Operator Algebras and Their Applications, II
2:15 PM - 6:05 PM
Organizers: Randall Lee Crist, Creighton University
Roger Smith, Texas A&M University

2:15 PM
Derivations of non-selfadjoint operator algebras and hyper-reflexivity. Preliminary report.
Sarah H. Ferguson, Purdue University (930-46-722)

2:45 PM
Representations and primitive ideals in limit algebras. Preliminary report.
Timothy D. Hudson and Elias G. Katsoulis, East Carolina University (930-47-1073)

3:15 PM
Finite representability of operator spaces.
Edward G. Effros, UCLA, Marius Junge, Universitat Kiel, and Zhong-Jin Ruan*, University of Illinois (930-46-334)

3:45 PM
Isometries, shifts, Cuntz algebras and multiresolution wavelet analysis of scale N.
Ola Bratteli, University of Oslo, and Palle E.T. Jorgensen*, University of Iowa (930-46-27)

4:15 PM
Timur Oikhberg, Texas A&M University (930-47-709)

4:45 PM
Algebraic isomorphisms of triangular operator algebras. Preliminary report.
Allan P. Donsig*, University of Nebraska–Lincoln, Timothy D. Hudson and Elias G. Katsoulis, East Carolina University (930-47-474)

5:15 PM
Navigating-Pick interpolation for noncommutative analytic Toeplitz algebras.
Kenneth R. Davidson, University of Waterloo, and David R. Pitts*, University of Nebraska–Lincoln (930-47-526)

5:45 PM
Noncommutative interpolation and Poisson transforms.
Gelu F. Popescu, University of Texas at San Antonio (930-47-124)

AMS Special Session on Value Distribution Theory and its Related Topics, II
2:15 PM - 3:35 PM
Organizers: Ilpo Laine, University of Joensuu, Finland
Charles F. Osgood, National Security Agency
C. C. Yang, Hong Kong University of Science and Technology

2:15 PM
The approximation of delta-subharmonic functions and some applications.
David Drasin, Purdue University (930-30-728)

2:45 PM
Non-real zeros of $f''$ and the Wiman conjecture. Preliminary report.
Stephanie P. Edwards, University of Wisconsin – Madison (930-30-56)

3:15 PM
Mario Bonk and William Cherry*, TU-Berlin (930-30-36)
MAA Minicourse #10: Part A
2:15 PM - 4:15 PM
Polynomial algebra.
Organizers: David A. Cox, Amherst College
John B. Little, College of the Holy Cross
Donal B. O'Shea, Mount Holyoke College

MAA Minicourse #16: Part A
2:15 PM - 4:15 PM
The Fibonacci and Catalan numbers.
Organizer: Ralph P. Grimaldi, Rose-Hulman Institute of Technology

MAA Minicourse #7: Part A
2:15 PM - 4:15 PM
Mathematica laboratories in calculus instruction.
Organizers: Anita J. Salem, Rockhurst College
William H. Barker, Bowdoin College
John R. Michel, Marietta College

AMS Session on Number Theory, I
2:15 PM - 5:55 PM
2:15 PM Class fields and related Gauss sums.
(194) Stephen J. Carlson, UCSD (930-11-391)
2:30 PM The 2-class field towers of some quadratic number fields. Preliminary report.
(195) E. Benjamin, Unity College, F. Lemmermeyer, Heidelberg, Germany, and C. Snyder*, Univ. of Maine (930-11-323)
2:45 PM Characteristic p Galois Representations that are produced by Drinfeld.
(196) Nigel Boston, University of Illinois, and David T. Ose*, Lycoming College (930-11-553)
3:00 PM Symmetric spaces over finite fields. Preliminary report.
(197) Marla G. Martinez* and Audrey A. Terras, U.C.S.D. (930-11-954)
3:15 PM Three-class groups of quadratic fields and Selmer groups of rational three-isogenies. Preliminary report.
(198) Matthew E. DeLong, University of Michigan (930-11-1140)
3:30 PM Largest possible discriminant of a universal quaternary quadratic form.
(199) Azar N. Khosravani, University of Wisconsin-Oshkosh (930-11-1152)
3:45 PM On the orthogonal splitting of quadratic forms over global function fields.
(200) Larry J. Gerstein, University of California at Santa Barbara (930-11-1222)
4:00 PM Quadratic minima and modular forms.
(201) Barry Brent, University of Minnesota, Morris (930-11-494)
4:15 PM Explicit Chabauty.
(202) Joseph L. Wetherell, University of Southern California (930-11-1156)
4:30 PM 4-ranks of K2 of rings of integers in quadratic number fields. Preliminary report.
(203) Anthony M. Vazzana, University of Michigan (930-11-844)
4:45 PM Gauss's algorithms for binary quadratic forms.
(204) Preliminary report.
Michael Joseph, Universidad de Costa Rica (930-11-755)
5:00 PM Graphs over the ring of integers modulo 2^n.
(205) Michelle R. DeDeo, University of California - San Diego (930-11-91)
5:15 PM Counting points on certain CM elliptic curves modulo primes. Preliminary report.
(206) Wendy L. Miller, UCSD (930-11-340)
5:30 PM Selberg's trace formula for GL(2,p1)SL(2,q)/K.
(207) Preliminary report.
Audrey A. Terras, U.C.S.D. (930-11-960)
5:45 PM The measured Witt ring. Preliminary report.
(208) Douglas J. Limmer, Oregon State University (930-11-1201)

AMS Session on Approximations, Sequences, and Difference Equations
2:15 PM - 5:40 PM
(209) George A. Anastassiou, University of Memphis (930-41-155)
2:30 PM Statistical extensions of some classical Tauberian theorems.
(210) J. A. Fridy* and M. K. Khan, Kent State University, Kent, OH 44242 (930-40-1211)
2:45 PM Sensitivity of spline functions on triangulations to vertex perturbation. Preliminary report.
(211) David Assaf, IV, Vanderbilt University (930-41-506)
3:00 PM Wavelet transform and data compression.
(212) Preliminary report.
Zhenguang Gao* and Robert C. Sharpley, University of South Carolina (930-41-757)
3:15 PM Extensions and applications of positive wavelet expansions. Preliminary report.
(213) David K. Ruch and Patrick J. Van Fleet*, Sam Houston State University (930-41-826)
3:30 PM An example of a dissipative sequence which is not a finite union of weakly wandering sequences.
(214) Wojciech Kosek, University of South Dakota (930-28-74)
3:45 PM Stronger results of some commonly known tests for sequence convergence. Preliminary report.
(215) Thomas H. Jackson IV, Louisiana State University - Shreveport (930-28-604)
4:00 PM Back-type theorems for statistical convergence.
(216) Jeff Zeager, Kent State University, Kent, OH 44242 (930-40-1210)
4:15 PM Orbits of exponents.
(217) Saul I. Dronbins, San Diego State University (930-40-458)
4:30 PM Disconjugacy of a nth order linear difference equation. Preliminary report.
(218) Robert J. Krueger, Univ. of Nebraska-Lincoln (930-39-903)
4:45 PM Instability of nonnegative solutions for a class of semilinear elliptic boundary value problems.
(219) C. Maya and R. Shivaji*, Mississippi State University (930-35-738)
5:00 PM On difference equations and mathematical modes.
(220) Preliminary report.
Yixun Shi, Bloomsburg University (930-00-263)
5:15 PM A global asymptotic stability result on an extension of Pielou's discrete delay logistic model. Preliminary report.
(221) John H. Jaroma, Sacred Heart University (930-39-790)
Program of the Sessions – Baltimore, MD, Wednesday, January 7 (cont’d.)

5:30PM Global stability of a population model.
(222) Edward A. Grove*, Gerry Ladas, Candace M. Kent, Soudabeh Valicenti, University of Rhode Island, and Richard Levins, Harvard School of Public Health (930-39-535)

AMS Session on Group Theory
2:15PM – 6:10PM

2:15PM
(223) Squares of characters that are the sum of all irreducible characters. Preliminary report.
Stephen M. Gagola Jr.*, and Mark L. Lewis, Kent State University (930-20-803)

2:30PM
(224) On the generalized fire product of finitely generated nilpotent groups and the near Frattini subgroup.
Mohammad K. Azarian, University of Evansville (930-20-102)

2:45PM
(225) Supplementation in groups: The general case.
Luise-Charlotte Kappe*, SUNY at Binghamton, and Joseph Kirtland, Marist College (930-20-160)

3:00PM
(226) Supplementation in groups: The finite case.
Luise-Charlotte Kappe*, SUNY at Binghamton, and Joseph Kirtland*, Marist College (930-20-150)

3:15PM
(227) On generalized Hamiltonian groups.
Denise M. Rebold, SUNY-Binghamton (930-20-162)

3:30PM
(228) Generalizations of finite cyclic groups.
Gary L. Wallis, University of Southern Mississippi (930-20-347)

3:45PM
(229) Hypercentral Baer groups with weak chain conditions on normal subgroups. Preliminary report.
Vonn Walter, Allegheny College (930-20-446)

4:00PM
Michael J. J. Barry*, Allegheny College, and Michael B. Ward, Western Oregon University, Monmouth, OR (930-20-467)

4:15PM
(231) On the split metacyclic p-groups that are A-E.
Gary L. Peterson, James Madison University (930-20-541)

4:30PM
(232) Branching rules for two row partitions and applications to the inductive systems for symmetric groups. Preliminary report.
Jagat K. Sheth, University of Oregon (930-20-785)

4:45PM
(233) Finite groups that contain exactly N elements of order N.
Lenny K. Jones*, Shippensburg University, and Donald E. Spickler Jr, Morehead State University (930-20-1102)

5:00PM
(234) Simplified multiplication in the Burnside Ring.
John D. Lambros, California Polytechnic State University, San Luis Obispo (930-20-1219)

5:15PM
(235) Projectivities of free products II.
Charles S. Holmes, Miami University (930-20-1176)

5:30PM
(236) Graph groups are linear.
Tim Hsu*, University of Michigan, and Daniel T. Wise, Cornell University (930-20-751)

5:45PM
Darci L. Kracht, Kent State University (930-20-869)

6:00PM
(238) Group theoretical analysis of musical scales.
Paul F. Zweifel, Virginia Tech (930-00-59)

MAA Session on Rethinking Upper Level Core Mathematics Courses, I
2:15PM – 5:35PM

Organizer: Alan C. Tucker, SUNY at Stony Brook

2:15PM An alternative syllabus for abstract algebra.
(239) William P. Abrams, Longwood College (930-E1-1241)

2:35PM Conics and cubics.
(240) Robert A. Bix, University of Michigan-Flint (930-E1-898)

2:55PM Constructive abstract algebra. Preliminary report.
(241) Theodore S. Erickson, Westminster College (930-E1-1089)

3:15PM Try something new in abstract algebra.
(242) Richard M. Grassi*, University of Northern Colorado, Greeley, CO, and Tabitha Young Mingus, Morehead State University, Morehead, KY (930-E1-1240)

3:35PM Using a laboratory approach to teach an upper level mathematics course.
(243) Jerome W. Adler, SUNY at Binghamton, and Paul J. Sally, University of Chicago (930-E1-875)

4:20PM Real analysis: Lean, lively, and writing intensive?
(245) Preliminary report.
Preliminary report.

4:40PM Real and complex analysis: An amalgam for undergraduates. Preliminary report.
(246) Anant R. Godbole, Michigan Technological University (930-E1-557)

5:00PM Putting the analysis back in real analysis.
(247) Preliminary report.
Michael C. Reed, Duke University (930-E1-821)

5:20PM Laboratory experiences for a first semester real analysis course.
(248) Kirk E. Wellers*, Bethel College, Mishawaka, IN, and Joanne R. Snow, Saint Mary's College, Notre Dame, IN (930-E1-1047)

MAA Session on The World Wide Web in Mathematical Instruction, I
2:15PM – 5:55PM

Organizers: Earl D. Fife, Calvin College
Eugene A. Klotz
Lawrence S. Husch, University of Tennessee-Knoxville

2:15PM Dynamical systems on the Web.
(249) Robert L. Devaney, Boston University (930-L1-1096)

2:40PM An applet a day: Simple calculus demonstrations
(250) using Java.
Daniel C. Sloughter, Furman University (930-L1-818)

3:05PM Teaching mathematics using Java and the Web.
(251) Bruce McLean, Georgia Southern University (930-L1-969)

3:30PM The World Wide Web in discrete dynamical systems
(252) and calculus at West Point.
Mary Ann Connors, U.S. Military Academy (930-L1-780)

3:55PM MATours: Web-based calculus curriculum using others' Web pages.
(253) Larry Copes, Augsburg College (930-L1-721)

4:20PM Calculus I with the Web.
(254) Mark R. Woodard, Furman University (930-L1-853)

4:45PM The use of the Web in the teaching of freshman engineering mathematics. Preliminary report.
(255) Chris Rorres*, Loren N. Argabright and Robert C. Busby, Drexel University (930-L1-912)

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Baltimore, MD, Wednesday, January 7 - Program of the Sessions

5:10 PM  Interactive computer activities from the Mathwright Library. Preliminary report.
Dan Kalman, American University (930-L1-776)

Mohamed A. Khamsi*, Helmut Knaust and Nancy Marcus, The University of Texas at El Paso (930-L1-313)

Presentation on Mathematics Awareness Week

2:15 PM – 3:45 PM
Organizer: Ansuman Bagchi, Worcester Polytechnic Institute

MAA Invited Address

3:20 PM – 4:10 PM
(258) Some exceptional objects and their history.
John Stillwell, Monash University, Australia

AWM Panel Discussion

3:20 PM – 4:20 PM
Mathematicians and families.
Organizer: Sylvia Margaret Wiegand, University of Nebraska
Panelists: Deborah Tepper Haimo, University of California at San Diego
Rhonda J. Hughes, Bryn Mawr College
Craig L. Huneke, Purdue University
Stephen F. Kennedy, Carleton College
Suzanne M. Lenhart, University of Tennessee
Dawn A. Lott-Crumpler, New Jersey Institute of Technology

AWM Business Meeting

4:20 PM – 4:50 PM

MAA Minicourse #1: Part B

4:30 PM – 6:30 PM
Teaching a course in the history of mathematics.
Organizers: V. Frederick Rickey, Bowling Green State University
Victor J. Katz, University of the District of Columbia

MAA Minicourse #8: Part A

4:30 PM – 6:30 PM
Linear algebra using an interactive text.
Organizers: Eugene A. Herman, Grinnell College
Michael D. Pepe, Seattle Central Community College
Robert T. Moore, University of Washington
James R. King, University of Washington

AMS Committee on the Profession Panel Discussion

4:30 PM – 6:00 PM
Building connections to industry within graduate departments.
Moderator: Annalisa Crannell, Franklin & Marshall College
Panelists: L. Pamela Cook-Ioannidis, University of Delaware
Niels Nygaard, The University of Chicago
H. T. Banks, North Carolina State University
James G. Glimm, SUNY at Stony Brook
Robert E. Williamson, Claremont Graduate School

MAA Task Force on Graduate Students Panel Discussion

4:30 PM – 6:30 PM
Teaching at a college or university—advice about preparing for and securing such positions.
Organizers: James R. C. Leitzel, University of New Hampshire
Thomas W. Rishel, Cornell University
Panelists: John E. Meier, Lafayette College
Teresa Engel Moore, Ithaca College
Zsuzsanna M. Kadas, Saint Michael’s College
Richard J. Cleary, Saint Michael’s College

MAA Section Officers

4:30 PM – 6:30 PM

Reception for First-Time Participants

6:00 PM – 7:00 PM

Young Mathematicians Network Discussion

7:15 PM – 8:15 PM
Concerns of young mathematicians: A town meeting.
Moderator: Charles C. Yeomans, University of Kentucky
Panelists: Frank Arlinghaus, Youngstown State University
Leigh Lunsford, Alabama A&M University
Frank Sottile, University of Toronto

AMS Josiah Willard Gibbs Lecture

8:30 PM – 9:30 PM
M Theory.
Edward Witten, Institute For Advanced Study

AWM Reception

9:30 PM – 11:00 PM
Thursday, January 8

AMS-MAA-MER Special Session on Mathematics and Education Reform, III

8:00 AM - 11:50 AM

Organizers: William Henry Barker, Bowdoin College
Jerry L. Bona, University of Texas at Austin
Naomi Fisher, University of Illinois at Chicago
Harvey B. Keynes, University of Minnesota, Minneapolis
Kenneth C. Millett, University of California Santa Barbara

8:00 AM
What should we expect from the best and the brightest? A further look at TIMSS results.

8:30 AM
Bridging the Math Wars — Finding common ground upon which to build. Preliminary report.

9:00 AM
The Saxon Method of teaching mathematics.

9:30 AM
School mathematics through the years. Preliminary report.

10:00 AM
Education Reform

11:00 AM
Influencing mathematics education at the state level: A report from New Jersey. Preliminary report.

11:30 AM
Grades are out, standards are in, and the math looks tough: Implementing standards-based education and university admissions in Oregon. Preliminary report.

AMS-MAA Special Session on The Uses of History in the Teaching of Mathematics, I

8:00 AM - NOON

Organizers: Florence Fasanelli, Mathematical Association of America
V. Frederick Rickey, Bowling Green State University
Victor J. Katz, University of the District of Columbia

AMSI Special Session on Commutative Algebra and Algebraic Geometry, I

8:00 AM - 11:50 AM

Organizers: Melvin Hochster, University of Michigan, Ann Arbor
Craig L. Huneke, Purdue University

8:00 AM
Etaleness, normality and intersections. Preliminary report.

8:30 AM
On the acyclicity of Kustin-Ulrich complexes.

9:00 AM
Further cases when weak F-regularity localizes.

9:30 AM
Infinite free complexes with finite length homologies in characteristic p > 0.

8:05 AM
Great mathematics in Great Britain.

8:20 AM
Teaching classical mathematics from original sources in a senior seminar.

8:35 AM
Biographies of women mathematicians: History in a mathematics course.

8:50 AM
Newton’s Arithmetica Universalis. Preliminary report.

9:05 AM
History of mathematics as a problem-solving course. Preliminary report.

9:25 AM
Recurring patterns in the historical development of mathematical knowledge: Implications for pedagogy.

9:45 AM
A mathematics education course on teaching algebra from an historical perspective.

10:05 AM

10:25 AM
A historically-oriented course in rational thermodynamics.

10:45 AM
Presenting Kepler’s Second Law in Calculus 2 using Astronomia Nova.

11:05 AM
Two multimedia presentations incorporating historical background for pedagogical emphasis.

11:25 AM
Every course a history course.

11:45 AM

Great mathematics in Great Britain.

Teaching classical mathematics from original sources in a senior seminar.

Biographies of women mathematicians: History in a mathematics course.

Newton’s Arithmetica Universalis. Preliminary report.

History of mathematics as a problem-solving course. Preliminary report.

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A mathematics education course on teaching algebra from an historical perspective.


A historically-oriented course in rational thermodynamics.

Presenting Kepler’s Second Law in Calculus 2 using Astronomia Nova.

Two multimedia presentations incorporating historical background for pedagogical emphasis.

Every course a history course.

AMS Special Session on Comutable Mathematics and Its Applications, II

8:00 AM - 11:50 AM
Organizer: Valentina Harivanov, George Washington University

8:00 AM Degree spectra of relations on computable structures.
Richard A. Shore, Cornell University (930-03-318)

9:00 AM On intrinsically 1-recursive trees.
John Chisholm, Western Illinois University (930-03-882)

9:30 AM Towards a logic of discovery. Preliminary report.
V. Bárcenas, University of Latvia, and Carl H. Smith*, University of Maryland (930-03-1208)

10:00 AM Applications of computable mathematics in logical foundations of artificial intelligence.
Victor W. Marek*, University of Kentucky, and Jeffrey B. Remmel, University of California (930-03-862)

10:30 AM Some results in resource-bounded measure theory.
Steven M. Kautz, Randolph-Macon Woman's College (930-03-1151)

11:00 AM Recursion theory and fragments of arithmetic.
Marcia J. Groszek, Dartmouth College (930-03-1205)

11:30 AM On realizations of Scott Rank.
Gerald Sacks, Harvard University (930-03-1189)

AMS Special Session on Homotopy Theory, III

8:00 AM - 11:20 AM
Organizers: W. Stephen Wilson, Johns Hopkins University
Douglas C. Ravenel, University of Rochester

8:00 AM My time as Mike Boardman's student and our work on infinite loop spaces.
Rainer M. Vogt, University of Osnabrueck (930-55-235)

8:30 AM Calculations in the BP-cohomology of the classifying space of a finite group. Preliminary report.
Kevin P. Lee, University of Michigan (930-55-901)

9:00 AM The connective complex k-cohomology ring of elementary abelian groups.
Robert R. Bruner, Wayne State University (930-55-823)

9:30 AM The K-theory of p-compact homogeneous spaces.
Akimou Osse*, Université de Neuchâtel, and Alain Jeanneret, Bern University (930-55-819)

10:00 AM A calculation of the Morava K-theory of the Brown-Comenetz dual to \( L_{K(n)} \)
Michael J. Hopkins, Massachusetts Institute of Technology, and Hal Sadofsky*, University of Oregon (930-55-675)

AMS Special Session on Quantum Gravity and Low-Dimensional Topology, III

8:00 AM - 11:50 AM
Organizers: John C. Baez, University of California Riverside
Stephen F. Sawin, Fairfield University

8:00 AM Grist for a 4-D state-sum mill: Examples of monoidal bicategories. Preliminary report.
David N. Yetter, Kansas State University (930-18-530)

8:30 AM From loop quantum gravity to a sum over surfaces.
Carlo Rovelli, University of Pittsburgh (930-83-386)

9:00 AM Path integrals linking Chern-Simons and WZW partition functions.
Dana S. Fine, University of Massachusetts, Dartmouth (930-81-438)
AMS Special Session on Topology in Dynamical Systems, I

8:00 AM - 11:50 AM

Organizers: Kathleen T. Alligood, George Mason University
Judy Anita Kennedy, University of Delaware

8:00 AM
Recurrent critical points and typical limit sets of rational maps.
John C. Mayer*, University of Arizona at Tucson
Lex G. Oversteegen, University of Alabama at Birmingham (930-58-1223)

8:30 AM
Annulus diffeomorphisms with minimal pseudocircles. Preliminary report.
Mark H. Turpin, University of Hartford (930-58-1133)

9:00 AM
Concilium limit sets for circle diffeomorphisms.
Alec Norton, University of Texas at Austin (930-58-889)

9:30 AM
Concile bouquets and Brjuno numbers.
Robert L. Devaney*, Boston University, and Eileen Lee, Trinity College (930-58-658)

10:00 AM
Rotation vectors for surface diffeomorphisms.
John Franks, Northwestern University (930-58-661)

10:30 AM
The dynamics of surface homeomorphisms and of graph endomorphisms.
Andre S. de Carvalho, University of California at Berkeley (930-58-946)

11:00 AM
Entropy of homeomorphisms of continua. Preliminary report.
Marcy Barge, Montana State University (930-58-1130)

11:30 AM
Topological horseshoes.
James A. Yorke, Institute for Physical Sci. & Technology, University of Maryland (930-39-1044)

AMS Special Session on Value Distribution Theory and Its Related Topics, III

8:00 AM - 10:20 AM

Organizers: Ilpo Laine, University of Joensuu, Finland
Charles F. Osgood, National Security Agency
C. C. Yang, Hong Kong University of Science and Technology

8:00 AM
Unbounded domains of normality.
J. M. Anderson, University College London, and Aimo Hinkkanen*, University of Illinois (930-30-625)

8:30 AM
Distribution of values of subfunctions of the Schrödinger operator.
Alexander Kheyfits, Queensborough Community College/CUNY (930-31-810)

9:00 AM
On zero-free solutions of higher order linear differential equations. Preliminary report.
Jarkko Rieppo, University of Joensuu, Finland (930-34-631)

9:30 AM
Circular means of fine Green's functions and the longest arc relation.
Alexander Fryntula, Institute for Low Temperature, Kharkov, Ukraine, John F. Rossi*, Virginia Tech, and Allen Weissman, Purdue Univ. (930-30-51)

10:00 AM
Approximation of analytic functions.
Charles F. Osgood, NSA (930-30-113)

MAA Minicourse #14: Part A

8:00 AM - 10:00 AM

Knot theory and applications in science.
Organizer: Stefanos P. Giamas, The Illinois Institute of Art

MAA Minicourse #6: Part B

8:00 AM - 10:00 AM

Mathematical algorithms, models, and graphic representations using spreadsheets.
Organizers: Robert S. Smith, Miami University
Deane E. Arganbright, University of Papua New Guinea
Erich Neuwirth, University of Vienna

AMS Session on Ordinary Differential Equations

8:00 AM - 11:55 AM

8:00 AM
Eigenvalues for positive solutions of a nonlinear functional differential equation.
Bonita A. Lawrence*, University of South Carolina-Beaufort, and Clayton T. Brooks, Georgia Southwestern State University (930-31-1107)

8:15 AM
Positive solutions and nonlinear conjugate eigenvalue problems for functional differential equations.
Johnny Henderson, Auburn University, and William K. C. Yin*, LaGrande College (930-34-1076)

8:30 AM
Nonexistence of symmetric solutions to the Berman problem with injection. Preliminary report.
Chung-Ling Lu, Southern Illinois University at Edwardsville (930-34-324)

8:45 AM
A general model for linear differential-like equations.
Luis Verde-Star, Universidad Autonoma Metropolitana, Mexico City (930-34-460)

9:00 AM
Almost automorphic solutions of evolution equations.
Gaston N'Guerekata, Morgan State University (930-34-244)

9:15 AM
Some set theoretic maps in semi-dynamical systems.
Prem N. Bajaj, Wichita State University (930-34-504)

9:30 AM
The uniform bifurcation of traveling waves in the singularly perturbed Fitzhugh-Nagumo equation.
Daryl C. Bell, University of Nebraska-Lincoln (930-34-1134)
AMS Session on Complex Variables

8:00 AM - 10:25 AM

8:00 AM  Harmonic mappings on convex domains.
         (337) Preliminary report.
         Michael D. Galloy, University of Kentucky (930-30-273)

8:15 AM  Examples of harmonic mappings on punctured domains. Preliminary report.
         John W. Thompson, University of Kentucky (930-30-321)

8:30 AM  Subordination of plane harmonic functions.
         (349) Lisbeth E. Schaubroeck, University of North Carolina at Chapel Hill (930-30-534)

8:45 AM  The Operator DC4 on the Hardy and Bergman Spaces.
         Neil Portnoy, University of New Hampshire (930-30-522)

9:00 AM  Composition operators on Dirichlet-type spaces.
         (351) Preliminary report.
         Rita A. Hibschweiler, University of New Hampshire (930-30-662)

9:15 AM  On properties of the zeros of the Cesàro approximants to outer functions.
         (352) Roger W. Barnard, Kent Pearce and William Wheeler*, Texas Tech University (930-30-719)

9:30 AM  Convexity and ratios of successive zeros.
         (353) Faruk F. Abi-Khuzam, American University of Beirut (930-30-1225)

9:45 AM  Convexity preservation under the Hadamard product of functions f ∈ K1 with functions φ + φw.
         (354) Mary R. Goodloe, University of Kentucky (930-30-1050)

10:00 AM On the Muir-Ramanujan approximations to the arc length of an ellipse. Preliminary report.
         Roger W. Barnard*, Kent Pearce and Lawrence Schovanec, Texas Tech University (930-30-718)

         Melkana A. Brakalova*, The Hotchkiss School, and James A. Jenkins, Washington University (930-30-749)

AMS Session on Number Theory, II

8:00 AM - 11:40 AM

8:00 AM  On the occurrence of Fn in the Zeckendorf decomposition of n!.
         (357) Evelyn L. Hart* and Laura Sanchis, Colgate University (930-11-872)

8:15 AM  Sums of four kth powers. Preliminary report.
         (358) Joel M. Wisdom, University of Michigan (930-11-976)

8:30 AM  Almost all primes are very asymmetric. Preliminary report.
         (359) William Lindgren*, Slippery Rock University, and Carl Pomerance, University of Georgia (930-11-1014)

8:45 AM  An extension of Schur's Theorem. Preliminary report.
         (360) Lenny Jones and Michael D. Seyfried*, Shippensburg University (930-11-358)

9:00 AM  On the second and third largest prime divisors of an odd perfect number.
         (361) Douglas E. Iannucci, University of the Virgin Islands (930-11-106)

9:15 AM  Symmetric prime factors of Fermat numbers.
         (362) Preliminary report.
         Peter Fletcher* and Ezra Brown, Virginia Tech (930-11-436)

9:30 AM  Divisibility properties of numerators of sums of reciprocals. Preliminary report.
         (363) Scott H. Hochwald, University of North Florida (930-11-451)

9:45 AM  Density theorems for reciprocity equivalences. Preliminary report.
         (364) Thomas C. Palfrey, Xavier University of Louisiana (930-11-422)

10:00 AM  2-adic congruences of Norlund numbers.
         (365) Arnold Adelberg, Grinnell College (930-11-509)

10:15 AM  An explicit expression for large digit sums in base b, Expansions.
         (366) Curtis N. Cooper* and Robert E. Kennedy, Central Missouri State University (930-11-730)

10:30 AM  On the density of the Fibonacci number system Niven numbers.
         (367) Robert E. Kennedy* and Curtis N. Cooper, Central Missouri State University (930-11-731)

10:45 AM  Variations on Euclid's algorithm.
         (368) Geza Schay, University of Massachusetts at Boston (930-11-851)

11:00 AM  The distribution of generalized sum-of-digits functions in residue classes. Preliminary report.
         Abigail Holt, University of Illinois (930-11-1069)

         (370) John M. Holte, Gustavus Adolphus College (930-11-878)

11:30 AM  Connected and weakly connected dominating sets for complete grid graphs. Preliminary report.
         Jerrold W. Grossman, Oakland University, Rochester, MI 48309-4485 (930-05-499)
AMS Session on Topological Algebra

8:00 AM - 9:40 AM

8:00AM  Product of convergence groups. Preliminary report.  Jamuna P. Ambasht, Benedict College, Columbia, SC 29204 (930-54-1058)


8:30AM  $a$-adic topological groups and rings. Preliminary report.  Edwin P. Herman, St. Thomas (930-22-1220)


9:00AM  Right subgroups of compact semigroups.  Shing S. So* and Kathleen Roy, Central Missouri State University (930-22-624)

9:15AM  Divisors in a strict projective system.  Yue-Chan Phoebe Ho, Central Missouri State University (930-22-887)

9:30AM  Distal compactifications of group extensions.  Hugo D. Jungkhenn*, George Washington University, and Paul Milnes, University of Western Ontario (930-43-278)

MAA Session on Applied Calculus and Mathematics for Advanced Technical Careers, I

8:00 AM - 11:50 AM

Organizers: Janet P. Ray, Seattle Central Community College
Brian E. Smith, McGill University
Yajun Yang, State University of New York

8:00AM  Changing the paradigm—From both sides of the lecture.  Robert L. Kimball, Wake Technical Community College (930-A1-283)


8:45AM  What should students be learning in applied calculus?  Patti Frazer Lock, St. Lawrence University (930-A1-610)

9:00AM  Teaching a conceptual applied calculus course. Preliminary report.  William G. McCallum, University of Arizona (930-A1-1077)

9:15AM  Non-lethal military applications of calculus.  Howard L. Penn, United States Naval Academy (930-A1-684)

9:30AM  Enrolling in the Golden (Course) section: Integration of geometry study within design curricula Preliminary report.  Dorothy M. French* and Miles Grosbard, The Community College of Philadelphia (930-A1-489)

9:45AM  Support for mathematics by the NSF Advanced Technological Education Program.  Elizabeth J. Teles, National Science Foundation (930-A1-472)


10:30AM  Mathematics in cardiac magnetic resonance imaging. Preliminary report.  E. Clare Friedman, University of San Diego (930-A1-252)

10:45AM  Integrating curricula for mathematics and telecommunications - A team approach.  Susan H. Randolph* and Neil F. Jackson, Jackson State Community College (930-A1-655)

11:00AM  A precalculus initiative at an urban community college.  Joanne S. Darken, Community College of Philadelphia (930-A1-624)

11:15AM  Using technology to simulate real settings where students collaborate in teams to allocate and maximize fiscal resources.  Robert Carson, Hagerstown Junior College (930-A1-285)

MAA Poster Session

8:00 AM - 11:00 AM

The National Science Foundation’s Mathematics Across The Curriculum (MATC) projects.
Organizers: Frank R. Giordano, COMAP
  James H. Lightbourne III, National Science Foundation
  Elizabeth J. Teles, National Science Foundation

AMS Special Session on Applied Dynamics, Geometric Analysis, and Mechanics, II

8:30 AM - 11:50 AM

Organizer: Tudor Ratiu, University of California At Santa Cruz


9:30AM  Riemannian manifolds with systoles almost twice the diameters.  Liang K. Koh (930-53-24)

10:00AM  The multisymplectic geometry of field theory.  Steve Shkoller, Center for Nonlinear Studies (930-51-388)

10:30AM  On the transversal geometry of Poisson manifolds.  Roxana R. Costinescu, Western Oregon University (930-53-942)

11:00AM  An energy-momentum method for the stability of nonholonomic systems.  Dmitry V. Zenkov**, The Ohio State University, Anthony M. Bloch, University of Michigan, and Jerrold E. Marsden, California Institute of Technology (930-70-932)
AMS Colloquium Lectures: Lecture II
1:00 PM - 2:00 PM
(407) Invariant theory: old and new.
Gian-Carlo Rota, Massachusetts Institute of Technology (930-11-42)

AMS Invited Address
2:15 PM - 3:05 PM
(408) Why characteristic $p$ is better.
Melvin Hochster, University of Michigan, Ann Arbor
(930-16-04)

AMS-MAA-MER Special Session on Mathematics and Education Reform, IV
2:15 PM - 4:05 PM
Organizers: William Henry Barker, Bowdoin College
Jerry L. Bona, University of Texas at Austin
Naomi Fisher, University of Illinois at Chicago
Harvey B. Keynes, University of Minnesota, Minneapolis
Kenneth C. Millett, University of California Santa Barbara

AMS Special Session on Applied Dynamics, Geometric Analysis, and Mechanics, III
2:15 PM - 4:05 PM
Organizer: Tudor Ratiu, University of California At Santa Cruz

AMS Special Session on Computable Mathematics and Its Applications, III
2:15 PM - 4:05 PM
Organizer: Valentina Harizanov, George Washington University

AMS Invited Address
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AMS Special Session on Computable Mathematics and Its Applications, III
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Organizer: Valentina Harizanov, George Washington University

AMS Colloquium Lectures: Lecture II
1:00 PM - 2:00 PM
(407) Invariant theory: old and new.
Gian-Carlo Rota, Massachusetts Institute of Technology (930-11-42)
AMS Special Session on Homotopy Theory, IV
2:15 PM – 4:05 PM
Organizers: W. Stephen Wilson, Johns Hopkins University
Douglas C. Ravenel, University of Rochester

2:15 PM
A little remark concerning Hopkins’ chromatic splitting conjecture. Preliminary report.
Norihiko Minami, The University of Alabama (930-55-1180)

2:45 PM
Simplicial algebras through the looking glass of p-local homotopy theory. Preliminary report.
James M. Turner, College of the Holy Cross (930-55-40)

3:15 PM
Characterizations of spectra which satisfy the Brown-Gitter property.
Nicholas J. Kuhn*, University of Virginia, and David J. Hunter, North Central College (930-55-112)

AMS Special Session on Kleinian Groups and Hyperbolic Manifolds, III
2:15 PM – 4:05 PM
Organizer: James W. Anderson, University of Southampton

2:15 PM
Bending measured laminations for geometrically finite Kleinian groups. Preliminary report.
Francis Bonahon*, University of Southern California, and Jean-Pierre Otal, Ecole Normale Supérieure de Lyon (930-30-274)

2:45 PM
Quasigeodesic flows on hyperbolic 3-manifolds which fiber over the circle.
Diane Hoffoss, Colorado College (930-57-70)

3:15 PM
Essential surfaces in hyperbolic 3-manifolds. Preliminary report.

3:45 PM
Maps of the interval induced by linear fractional transformations mod one.
Andrew H. Haas, University of Connecticut (930-30-1185)

AMS Special Session on Nonlinear Inverse Problems: Mathematical Theory, Selected Applications, III
2:15 PM – 4:05 PM
Organizers: Heinz W. Engl, Johannes Kepler University
Thomas I. Seidman, University of Maryland, Baltimore County

2:15 PM
Newton methods in inverse obstacle scattering
Rainer Kress, Universität Göttingen (930-45-30)

3:15 PM
An accurate numerical algorithm for inverse problems of nonlinear parabolic PDEs.
Xingli Zhuang and Jianping Zhu*, Mississippi State University (930-65-732)

3:45 PM
The phase problem in inverse scattering.
Paul E. Sacks, Iowa State University (930-81-129)

AMS Special Session on Recent Progress in the Theory of Operator Algebras and Their Applications, III
2:15 PM – 4:05 PM
Organizers: Randall Lee Crist, Creighton University
Roger Smith, Texas A&M University

2:15 PM
On some decomposition properties of factors.
Liming Ge, MIT (930-49-331)

2:45 PM
Compact matrix sets and operator approximation properties.
Corran J. Webster, Texas A&M University (930-46-737)

3:15 PM
Frames, bases and group representations.
Deguang Han and David R. Larson*, Texas A&M University (930-47-1116)

3:45 PM
Separating vectors, cores, and affiliated operators.
Richard V. Kadison, University of Pennsylvania (930-46-333)

AMS Special Session on Value Distribution Theory and Its Related Topics, IV
2:15 PM – 4:05 PM
Organizers: Ilpo Laine, University of Joensuu, Finland
Charles F. Osgood, National Security Agency
C. C. Yang, Hong Kong University of Science and Technology

2:15 PM
Meromorphic functions with prescribed asymptotic behaviour and prescribed zeros and poles.
Andreas Sauer, Gerhard-Mercator-University Duisburg (930-30-793)

2:45 PM
Uniqueness theorems and hyperbolicity.
Bernard Shiffman, Johns Hopkins University (930-32-891)

3:15 PM
Value distribution for power series with gaps and slow growth. Preliminary report.
Linda R. Sons* and Zhuang J. Ye, NIU (930-30-191)

3:45 PM
Solutions of nonhomogeneous linear differential equations with exceptionally few zeros.
Gary G.undersen, Enid M. Steinbart* and Shupei Wang, University of New Orleans (930-34-49)

MAA Minicourse #10: Part B
2:15 PM – 4:10 PM
Polynomial algebra.
Organizers: David A. Cox, Amherst College
John B. Little, College of the Holy Cross
Donal B. O'Shea, Mount Holyoke College
### MAA Minicourse #15: Part A

2:15 PM - 4:10 PM

*Developing the ability in beginning college mathematics majors to write proofs.*

Organizers: Diane Resek, San Francisco State University
Daniel M. Fendel, San Francisco State University

### MAA Minicourse #16: Part B

2:15 PM - 4:10 PM

*The Fibonacci and Catalan numbers.*

Organizer: Ralph P. Grimaldi, Rose-Hulman Institute of Technology

### MAA Minicourse #9: Part A

2:15 PM - 4:10 PM

*Interactive multimedia modeling and differential equation solving.*

Organizers: Michael Moody, Harvey Mudd College
Robert L. Borrelli, Harvey Mudd College
Courtney S. Coleman, Harvey Mudd College
Beverly H. West, Cornell University

### AMS Session on Optimization, Optimal Control, and Coding

2:15 PM - 4:10 PM

2:15PM

AMS Session on Differential Geometry

2:15 PM - 3:55 PM

2:15PM

AMS Session on Topology, Dynamical Systems, and Semigroups

2:15 PM – 3:40 PM

2:15PM

AMS Session on The Uses of History in the Teaching of Mathematics, II

2:15 PM – 4:15 PM
Program of the Sessions - Baltimore, MD, Thursday, January 8 (cont’d.)

Mark P. Sand, Northwest Missouri State University (930-01-801)

2:30PM Four old problems revisited. Preliminary report.
Radoslav M. Dimitrić, University of California at Berkeley (930-01-478)

2:45PM Olivier and Abel on series convergence: An episode from early 19th century analysis.
Michael S. Goar, New Mexico State Univ. (930-01-981)

3:00PM A historical approach to the teaching of introductory analysis. Preliminary report.
Saul Stahl, University of Kansas (930-01-408)

3:20PM Historically based discovery exercises. Preliminary report.
Robert G. Stein, CSU San Bernardino (930-01-830)

3:40PM Volumes of solids of revolution: A historical approach.
Elyn K. Rykken*, Indiana University Northwest, and Jody M. Sorensen, Grand Valley State University (930-01-786)

4:00PM Barrow’s Geometrical Methods for Finding Tangents.
Andrew S. Leahy* and Nahyan A. G. Fancy, Knox College (930-01-663)

MAA Session on Teaching the Practice of Statistics at All Levels, I

2:15PM - 4:00PM
Organizers: Anne D. Sevin, Framingham State College
K. L. D. Gunawardena, University of Wisconsin-Oshkosh

2:15PM Statistics projects.
John D. McKenzie Jr., Babson College (930-D1-1065)

2:30PM Incorporating laboratory activities into introductory statistics.
Gina F. Reed, Gainesville College (930-D1-858)

2:45PM Teaching statistical analysis with spreadsheets.
Fred J. Rispoli, Dowling College (930-D1-359)

3:00PM Biostatistics laboratory. Preliminary report.
Ginger Holmes Rowell, Beloit College (930-D1-1124)

3:15PM Implementation of technology in the teaching of statistics.
Sue B. Schou, Idaho State University (930-D1-488)

3:30PM A dynamic graphics regression project. Preliminary report.
Andrew J. McDougall, Linda A. Tappin* and Robert A. Stellhorn, Montclair State University (930-D1-956)

3:50PM Appropriate technology for teaching introductory statistics.
K. L. D. Gunawardena, University of Wisconsin Oshkosh (930-D1-1099)

MAA Session on Rethinking Upper Level Core Mathematics Courses, II

2:15PM - 3:30PM
Organizer: Alan C. Tucker, SUNY at Stony Brook
2:15PM Actively learning topology.
Nancy Lineken Hagelgans, Ursinus College (930-E1-881)

2:35PM The transition to advanced mathematics.
(475) Preliminary report.
Alan L. Levine* and Benjamin C. Shanfelder, Franklin and Marshall College, Lancaster, PA (930-E1-703)

2:55PM A math major program for vocationally oriented students.
(476) Joseph D. Myers, U.S. Military Academy (930-E1-1000)

3:15PM Teaching geometry with CSP.
(477) James M. Parks, SUNY-Potsdam (930-E1-840)

MAA Session on Establishing and Maintaining Undergraduate Research Programs in Mathematics, I

2:15PM - 4:10PM
Organizers: Emelie Kenney, Sienna College
Joseph A. Gallian, University of Minnesota at Duluth

2:15PM REU at University of Tennessee - One-on-one style.
(478) Suzanne M. Lenhart, University of Tennessee (930-P1-316)

2:30PM Twenty-five years of mathematics REU programs at Indiana University.
(479) Daniel P. Maki, Indiana University (930-P1-820)

2:45PM The Rose-Hulman approach to undergraduate research—what works for us. Preliminary report.
S. Allen Broughton, Rose-Hulman Institute of Technology (930-P1-479)

3:00PM Introduction to mathematical research through summer programs. Preliminary report.
Magnhild Lien, CSU Northridge (930-P1-812)

3:15PM Designing small axiom systems.
(482) Anthony D. Berard Jr., King’s College (930-P1-208)

3:30PM A matrix analysis REU project at William and Mary. Preliminary report.
David J. Lutzer, College of William and Mary (930-P1-137)

3:45PM Undergraduate research in nonlinear differential equations.
Lisa D. Humphreys, Rhode Island College (930-P1-269)

4:00PM Mathematics/Engineering REU Site at the University of Kentucky: An interdisciplinary research experience for aspiring mathematical scientists.
Peter A. Perry, University of Kentucky (930-P1-859)

AMS Presentation

2:15PM - 3:15PM
Organizers: Ralph E. Youngen, AMS
Wendy A. Bucci, AMS

MAA Panel Discussion

2:15PM - 4:10PM
Case studies in curriculum reform.
Organizer: Kenneth Travers, University of Illinois, Urbana-Champaign
Panelists: Raymond L. Johnson, University of Maryland, College Park
Teri Jo Murphy, University of Oklahoma
Stephen B. Rodi, Austin Community College
Janet P. Ray, Seattle Central Community College
James H. Lightbourne III, National Science Foundation
Presenters: Omar Adawi, Parkland College
Carolyn R. Mahoney, California State University, San Marcos
Paul M. Weichsel, University of Illinois, Urbana-Champaign

ILI Projects Poster Session
2:15 PM - 4:10 PM
Organizer: Earl D. Fife, Calvin College

MAA Student Workshop
2:15 PM - 4:10 PM
Wheels on wheels.
Organizer: Thomas R. Berger, Colby College

SUMMA Workshop
2:15 PM - 4:10 PM
Organizer: William A. Hawkins Jr., Mathematical Association of America
Presenters: Celestino G. Mendez, Metropolitan State College of Denver
Vernise Steadman-Toler, University of the District of Columbia
Margaret Weiner, Marymount Manhattan College

JPBM Panel Discussion
2:15 PM - 3:45 PM
Writing mathematics books for the popular market.
Moderator: Donald J. Albers, MAA
Organizer: Keith J. Devlin, St. Mary's College of California
Panelists: K. C. Cole, Los Angeles Times
William W. Dunham, Muhlenberg College
Ivars Peterson, Science News

AMS Session on Operator Theory
2:30 PM - 3:55 PM
2:30PM Solving the linear operator Ly = h(x).
(486) L. Kirk Tolman, Brigham Young University
(930-47-125)
2:45PM Normal, J-selfadjoint operators on Krein spaces.
(487) Preliminary report.
John P. Daughtry, East Carolina University
(930-47-169)
3:00PM Operator valued typically real functions induced by a contraction.
(488) Il. B. Jung*, Kyungpook Univ Korea, and Yong C. Kim, Yeungnam Univ Korea (930-47-314)
3:15PM Self-maps of the unit disk inducing isometries on the Bergman space.
(489) William E. Hornor**, University of Southern Mississippi, and James E. Jamison, University of Memphis (930-47-695)
3:30PM Lattices of intermediate subfactors. Preliminary report.
(490) Zeph Landau, University of California, Berkeley
(930-47-1168)
3:45PM Commutants of certain composition operators.
(491) Preliminary report.
Tamara S. Worner, Purdue University (930-47-1196)

AMS Invited Address
3:20 PM - 4:10 PM
The idea of curvature for differential equations.
Robert L. Bryant, Duke University (930-53-52)

Joint Prize Session and Reception
4:25 PM - 7:00 PM

MAA Reception for Two-Year Colleges
5:45 PM - 7:00 PM

MAA Dramatic Presentation
6:30 PM - 7:15 PM
The Calculus War, Leibniz and Newton.
Panelists: H. W. Straley, Woodberry Forest School, VA
Charlene Straley
Chip Straley, Kaleidoscope Theatre Co., Richmond VA

Mathematicians and Education Reform Network Banquet
6:30 PM - 9:00 PM

MAA Presentation
7:00 PM - 9:00 PM
An evening of poetry.
Organizer: Alvin M. White, Harvey Mudd College

MAA Presentation
7:00 PM - 9:00 PM
Reunion for calculus reform workshop.
Organizer: Donald B. Small, U. S. Military Academy

Young Mathematicians Network-Project NExT Panel Discussion
7:00 PM - 8:30 PM
Professional development issues concerning young and future faculty.
Moderator: James R. C. Leitzel, University of New Hampshire

Friday, January 9
Joint Pi Mu Epsilon and MAA Student Chapter Advisors' Breakfast
7:00 AM - 8:00 AM

Joint Meetings Registration
7:30 AM - 4:00 PM
Program of the Sessions – Baltimore, MD, Friday, January 9 (cont’d.)

AMS-MAA Special Session on History of Mathematics, I
8:00 AM – 10:50 AM
Organizers: James J. Tattersall, Providence College
Karen H. Parshall, University of Virginia

8:00 AM
Shai Simonson, Stonehill College (930-01-372)

8:30 AM
Jacob M. Plotkin*, Michigan State University, and Marion Scheepers, Boise State University (930-01-432)

9:00 AM
George Berkeley’s mathematical, philosophical, and religious ideas: The intersections, 1732-1735.
Helena M. Pycior, University of Wisconsin-Milwaukee (930-01-566)

9:30 AM
Continuous nowhere differentiable functions. Preliminary report.
Peter Duren, University of Michigan (930-01-171)

10:00 AM
Women and mathematical education in classical India.
Kim Plofker, Brown University (930-01-214)

10:30 AM
The mathematical love letters of Barnes Wallis.
John G. Fauvel, The Open University, England (930-01-143)

AMS-MAA Special Session on Research in Undergraduate Mathematics Education, I
8:00 AM – 10:55 AM
Organizers: Michael A. McDonald, Occidental College
Karen J. Graham, University of New Hampshire

8:00 AM
Identifying the skills that are critical to success in precalculus.
Barry M. Cherkas* and Baranchik Alvin, Hunter College (CUNY) (930-00-471)

8:20 AM
The effect of computer algebra systems on developmental algebra courses.
Laurie B. Hopkins* and Amelia S. Kinard, Columbia College (930-98-296)

8:40 AM
A classification system for conceptual and procedural errors in calculus.
Mary K. Porter, Saint Mary’s College (930-98-955)

9:00 AM
Reform at West Point in year seven.
Rich West, U.S. Military Academy (930-98-348)

9:20 AM
A report on the impact of the calculus reform movement: A study conducted at the National Science Foundation.
Susan L. Garber, Worcester Polytechnic Institute (930-98-1018)

9:40 AM
The effects of writing assignments on second-semester calculus students’ understanding of the limit concept. Preliminary report.
Melanie A. Wahlberg, Western Michigan University (930-98-653)

10:00 AM
Knowing when you are right: Four students’ justifications of their solutions to a definite integral. Preliminary report.
King D. King*, San Diego State University, and Chris L. Rasmussen, Purdue University Calumet (930-98-688)

10:20 AM
Describing beginning calculus students’ understandings of variables, functions, and rates as a foundation for learning the derivative.
Susan F. Patstnojevsky, Alverno College (930-98-1167)

AMS Special Session on Commutative Algebra and Algebraic Geometry, II
8:00 AM – 10:50 AM
Organizers: Melvin Hochster, University of Michigan, Ann Arbor
Craig L. Huneke, Purdue University

8:00 AM
Algorithmic computation of local cohomology modules: An application of non-commutative Gröbner bases to commutative algebra.
Uli Walther, University of Minnesota (930-13-187)

8:30 AM
Symbolic Rees algebras over strongly F-regular rings.
Anurag K. Singh, University of Michigan (930-13-701)

9:00 AM
The plus closure in mixed characteristic. Preliminary report.
Raymond Heitmann, The University of Texas at Austin (930-13-877)

9:30 AM
A generalization of the Auslander-Buchsbaum formula. Preliminary report.
David A. Jorgensen, University of Texas (930-13-772)

10:00 AM
Test ideals in coordinate rings of Fermat curves.
Moira A. McDermott, Bowdoin College (930-13-746)

10:30 AM
Strong and weak F-regularity are equivalent in graded rings.
Gennady Lyubeznik, University of Minnesota, and Karen E. Smith*, MIT (930-13-334)

AMS Special Session on Difference Equations and Applications, I
8:00 AM – 10:50 AM
Organizers: Edward A. Grove, University of Rhode Island
Gerasimos Ladas, University of Rhode Island

8:00 AM
Extinction of several species in a discrete competitive system. Preliminary report.
John E. Franke* and David M. Chan, North Carolina State University (930-92-831)

8:30 AM
Discrete age-structured competitive systems with predation and patches. Preliminary report.
Abdul-Aziz Yakubu, Howard University (930-34-153)

9:00 AM
Dynamical behavior of a discrete, one-island, migration model with density-dependent selection. Preliminary report.
James P. Selgrade*, North Carolina State University, and James H. Roberts, USDA Forest Service (930-92-518)

9:30 AM
Jeffrey T. Hoag*, Providence College, Gerry Ladas, University of Rhode Island, and John E. Franke, North Carolina State University (930-39-1012)

10:00 AM
On the behavior of solutions of the difference equation $x_{n+1} = x_n^{1-x_n} - x_n$.
Edward A. Grove, Candace M. Kent* and Gerry Ladas, Univ. of Rhode Island (930-39-666)

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AMS Special Session on Inverse Problems and Signal Analysis, I

8:00 AM - 10:50 AM
Organizer: M. Zuhair Nashed, University of Delaware

8:00 AM
An overview of parabolic inverse problems.
John R. Cannon, University of Central Florida (930-35-294)

8:30 AM
Continuous dependence on modeling for ill-posed problems.
Karen A. Ames, UAH (930-35-748)

9:00 AM
The Gibbs (Wilbram) phenomenon—An update.
Abdul J. Jerri, Clarkson University (930-65-532)

9:30 AM
The discrete cosine transform.
Gilbert Strang, M.I.T. (930-42-330)

10:00 AM
The asymptotics of optimal (equivuiripple) filters.
Jianhong Shen* and Gilbert William Strang, MIT (930-41-1191)

10:30 AM
System identification using time-frequency analysis and synthesis.
Xiang-Gen Xia, University of Delaware (930-94-308)

AMS Special Session on Knot Theory and Quantum Topology, I

8:00 AM - 10:50 AM
Organizers: Doug Bullock, Boise State University
Mark E. Kidwell, U.S. Naval Academy
Jozef H. Przytycki, George Washington University
Yongwu Rong, George Washington University

8:00 AM
Multiple harmonic series and Kontsevich's invariant. Preliminary report.
Michael E. Hoffman, U.S. Naval Academy (930-16-29)

8:30 AM
Structures and diagrammatisms of four-dimensional topological lattice field theories. Preliminary report.
J. Scott Carter, University of South Alabama, Louis H. Kauffman, University of Illinois at Chicago, and Masahico Saito*, University of South Florida (930-57-295)

9:00 AM
A theorem about surface groups in surgered manifolds. Preliminary report.
Anneke Bart, University of California, Santa Barbara (930-57-612)

9:30 AM
John Rosson, Portland State University (930-57-928)

10:00 AM
Lie Group representations of knot complements. Preliminary report.
Brian S. Mangum*, Barnard College, Columbia University, and Patrick D. Shanahan, Loyola Marymount University (930-57-967)

10:30 AM
Cyclic Dehn surgery and the A-polynomial of a knot.
Patrick D. Shanahan, Loyola Marymount University (930-57-45)

AMS Special Session on Mathematical Methods in Paper Folding, I

8:00 AM - 10:50 AM
Organizers: Thomas C. Hull, University of Rhode Island
Robert J. Lang, Spectral Diode Laboratories, Inc.

8:00 AM
Mathematical models of paper folding - A survey.
Thomas C. Hull, Merrimack College (930-52-574)

8:30 AM
Folding and cutting paper.
Erik D. Demaine* and Martin L. Demaine, University of Waterloo (930-51-85)

9:00 AM
Folding regular polygons. Preliminary report.
Robert R. A. Geretschläger, Bundesrealgymnasium Keplerstrasse 1, Graz, Austria (930-51-139)

9:30 AM
Folding parabolic cylinders in three and higher dimensions.
Vincent J. Matsko, Quincy University (930-51-503)

10:00 AM
An algorithm for origami design.
Robert J. Lang, Pleasanton, CA (930-51-468)

10:30 AM
The complexity of flat origami.
Bern Marshall, Xerox PARC, and Hayes Barry*, PlaceWare, Inc. (930-05-1011)

AMS Special Session on Recent Developments on the Laplace Operator and Its Geometric Applications, I

8:00 AM - 10:50 AM
Organizers: Ying Shen, Dartmouth College
Shumhui Zhu, Dartmouth College

8:00 AM
Homoclinic harmonic maps from the Lorentz space
Chuu-Lian Terng*, Northeastern University, and Karen Uhlenbeck, The University of Texas at Austin (930-35-871)

8:30 AM
Kähler-Ricci solitons and periodic orbits. Preliminary report.
Hai-Dong Cao, Texas A&M University (930-53-674)

9:00 AM
Energy minimizing maps from Riemann surfaces.
Jingyi Chen, UBC/MIT (930-53-442)

9:30 AM
Minimal isometric immersions of spherical space forms into spheres.
Christine M. Escher, Oregon State University (930-53-215)

10:00 AM
Heat kernels of Lorentz cones.
Hongming Ding, St. Louis University (930-35-123)

10:30 AM
Mutually isospectral Riemann surfaces.
Robert Brooks, Technion - Israel Institute of Technology (Haifa), Ruth Gornet* and William H. Gustafson, Texas Tech University (930-53-1149)

AMS Special Session on Representation Theory and Noncommutative Harmonic Analysis: A Special Session Honoring the Memory of Harish- Chandra, I

8:00 AM - 10:50 AM
Organizer: Robert S. Doran, Texas Christian University

8:00 AM
Veeravalli S. Varadarajan, University of California at Los Angeles (930-22-133)

9:00 AM
Weighted orbital integrals and transfer on real groups. Preliminary report.
James G. Arthur, University of Toronto (930-22-439)
Program of the Sessions - Baltimore, MD, Friday, January 9 (cont’d.)

9:30 AM
Intertwining operators and small unitary representations. Preliminary report.
A. W. Knapp, SUNY Stony Brook (930-22-396)

AMS Special Session on Topology in Dynamical Systems, II

8:00 AM – 10:50 AM
Organizers: Kathleen T. Alligood, George Mason University
Judy Anita Kennedy, University of Delaware

8:00 AM
Conjugacies that preserve boundary orbits. Preliminary report.

8:30 AM
Chaos in the Lorenz equations with classical parameter values: A computer assisted proof.
Konstantin Mischaikow, Georgia Institute of Technology, Marian Mrozek, Universytet Jagiellonski, and Andrzej C. Szymczak, Georgia Institute of Technology (930-34-936)

9:00 AM
Non-symmetric Lorenz attractor from a homoclinic bifurcation.
Clark Robinson, Northwestern University (930-58-508)

9:30 AM
Homological properties of certain minimal sets. Preliminary report.
Kryystyna M. Kuperberg, Auburn University (930-58-783)

10:00 AM
New characterizations of (weakly) almost periodic functions in terms of the algebra of $\beta S_\mathbb{R}$.
Neil Hindman*, Howard University, and Dona Strauss, University of Hull (930-54-287)

10:30 AM
Directed organization [DO$_{+1}$] groups on toroidal manifolds, and folding dynamics of proteins by topological mechanics.
Okan Gurel*, IBM, and Demet Gurel, Touro College (930-54-1115)

MAA Minicourse #13: Part A

8:00 AM – 10:00 AM
Music and mathematics.
Organizer: Leon Harkleroad, Poughkeepsie, NY

MAA Minicourse #2: Part A

8:00 AM – 1:00 AM
Interdisciplinary lively application projects.
Organizers: Frank R. Giordano, COMAP
Marie M. Vanisko, Carroll College
Laurette B. Foster, Prairie View A

MAA Minicourse #8: Part B

8:00 AM – 10:00 AM
Linear algebra using an interactive text.
Organizers: Eugene A. Herman, Grinnell College
Michael D. Pepe, Seattle Central Community College

Robert T. Moore, University of Washington
James R. King, University of Washington

AMS Session on Algebraic Topology

8:00 AM – 10:40 AM
8:15 AM
A counterexample to a question on the integrality property of ‘virtual signature’. Preliminary report.
Ranj K. Roy, SUNY at Binghamton (930-55-66)

8:30 AM
Periodic points on tori and Pontryagin duality.
Peter N. Wong, Bates College (930-55-284)

8:45 AM
The topological fundamental group and the construction of fibrations which are nearly covering spaces.
Daniel K. Biss, Harvard University (930-55-487)

9:00 AM
Some completion problems in algebraic topology.
James A. Kosinski, University of Michigan (930-55-128)

9:15 AM
Homogeneous spaces, elliptic genera and loop groups. Preliminary report.
Scott J. Simmons, University of Kentucky (930-55-1013)

9:30 AM
Rational L.S. category of function spaces.
Samuel B. Smith, Saint Joseph’s University (930-55-79)

9:45 AM
A Minami-Weinstein formula for compact Lie groups.
John R. Martino*, Western Michigan University, and Stewart B. Priddy, Northwestern University (930-55-397)

10:00 AM
On the geometry of free loop space.
Palanivel Manoharan, Florida Gulf Coast University (930-58-243)

10:00 AM
A box product in unstable equivariant homotopy theory.
Michele Intermont, Mesa State College (930-55-1030)

10:30 AM
Residual amenability and the approximation of $L^1$-invariants.
Bryan F. Clair, Univ. Of Chicago (930-58-493)

AMS Session on Applied Dynamics, Geometric Analysis, and Mechanics

8:00 AM – 10:10 AM
8:00 AM
Filling wells of negative Ricci curvature.
Christine M. Guenther, University of Oregon (930-58-1118)

8:15 AM
Reproducing kernel Hilbert spaces and Robertson conjecture.
Subhabij Gholakhwadhu, Purdue University (930-47-978)

8:30 AM
Stabilizability issue for coupled wave system in parallel.
Mahmod Najafi, Kent State University (930-93-1066)

8:45 AM
The Dirichlet Problem for Dirac Spinors. Prescribing the surface tension of immersions. Preliminary report.
George I. Kamberov, Washington University (930-53-172)

9:00 AM
Modeling multi-rigid-body dynamics with contact and friction.
Mihai Anitescu, Argonne National Laboratory (930-70-605)

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NOTICES OF THE AMS
VOLUME 45, NUMBER 1
AMS Session on Lattices, Order, and Logic

8:00 AM - 9:55 AM

8:00 AM The lattice of convex partitions and the lattice of extendable partitions of a partially ordered set.
Scott R. Sykes, University of West Georgia (930-06-546)

8:15 AM P7-sublattices of a locally Noether lattice. Preliminary report.
Michael D. Deitelfsen, Slippery Rock University (930-06-897)

8:30 AM The whole completion of representable lattice ordered groups. Preliminary report.
Jason D. Holland and Gerard J. Buskes, University of Mississippi (930-06-905)

8:45 AM Orthosymmetric maps and almost k-rings. Preliminary report.
Gerard J. Buskes and Jason D. Holland, University of Mississippi (930-06-906)

9:00 AM Trapezoid order classification.
(576)

9:15 AM Diamond, a paradox logic.
(579)

9:30 AM Open-dense sigma-centered ultrafilters.
Michael Canjar, University of Detroit-Mercy (930-04-734)

9:45 AM Three player games and surreal numbers. Preliminary report.
Ryan C. Bissell-Siders, Princeton University (930-04-913)

AMS Session on Matrix Theory and Number Theory

8:00 AM - 10:40 AM

8:00 AM A geometric optimization method and its application in finance. Preliminary report.
Constantine E. Georgakis, DePaul University (930-15-725)

8:15 AM Linear functions represented by function tables. Preliminary report.
Kenneth E. Iverson, Iverson Software (930-98-96)

8:30 AM Remarks on positive-definite complex square matrices.
Bingwen Zhang, Jilin Electrical High Training School, and Xin Yi, Dalian Kai Tong Computer Co., Ltd. (930-15-141)

8:45 AM Closest matrices in the space of generalized doubly stochastic matrices. Preliminary report.
Raja N. Khoury, University of Houston (930-15-234)

9:00 AM Diagonalization and triangularization of matrices by similarity and consimilarity transformations.
Dipa Choudhury, Loyola College (930-15-240)

9:15 AM The determination of L-functions from just one value. Preliminary report.
Harold M. Stark, UCSD (930-11-957)

9:30 AM Effective bounds for a theorem of Belyi's.
Lily S. Khadijavi, University of California, Berkeley (930-11-975)

9:45 AM An ideal in Z. Preliminary report.
(589)

Patrick W. Beauleau, University of Southwestern Louisiana (930-11-1171)

10:00 AM A problem of continued fractions on Hausdorff dimension. Preliminary report.
Shoijenn Tseng, TamKang University, and Jyh-Ching Liang, Leem Institute of Technology (930-11-492)

10:15 AM Lattices without short characteristic vectors.
Mark Gaultier, University of California, Santa Barbara (930-11-837)

10:30 AM Linear automorphisms and relative negligibility.
Hamza Y. Ahmad, Univ. of UAE, Mowaffaq Hajaj, Yarmouk University, and Ming-Chang Kang, National Taiwan University (930-12-791)

MAA Session on Applied Calculus and Mathematics for Advanced Technical Careers, II

8:00 AM - 10:55 AM

Organizers: Janet P. Ray, Seattle Central Community College
Brian E. Smith, McGill University
Yajun Yang, State University of New York

8:00 AM SC ATE Center of Excellence—systemic change to address the demand for industry ready engineering technicians in South Carolina. Preliminary report.
Elizabeth T. Higgins, Greenville Technical College (930-A1-512)

8:30 AM Application-based, technology-supported, entry level mathematics curriculum.
Regina T. Shankland and Catherine E. Curtis, Mt. Hood Community College (930-A1-750)

8:45 AM Talking the tech talk.
David W. Cohen, Smith College (930-A1-286)

9:00 AM Beyond the crossroads in mathematics standards: A partnership to produce an introductory college algebra for a technical workforce. Preliminary report.

9:15 AM Mathematics requirements and assessment for workforce education.
Dean B. Becker III, Austin Community College (930-A1-1204)

9:30 AM Applied mathematics laboratories for precalculus.
Richard Goller and Gary Simundza, Wentworth Institute of Technology (930-A1-527)

9:45 AM Teams and writing in math for the technologies.

10:00 AM Northwest Center for Sustainable Resources (NCSR): Integrating mathematics into natural resources technical curriculum.

January 1998 Notices of the AMS 193
Program of the Sessions - Baltimore, MD, Friday, January 9 (cont’d.)


MAA Session on Chaotic Dynamics and Fractal Geometry, II

8:00AM - 10:55 AM

Organizers: Jon W. Scott, Montgomery College  Denny Gulick, University of Maryland, College Park

8:00AM  A freshman seminar on chaos and fractals: Some pedagogical problems and solutions.  James R. Hughes, Elizabethtown College (930-B1-758)

8:15AM  Quantifying chaos in dynamical systems with Lyapunov exponents.  Timothy J. Pennings, Hope College (930-B1-754)

8:30AM  Graphing fractals using a spreadsheet.  Donald C. York, University of Papua, New Guinea (930-B1-779)

8:45AM  Random Sierpinski triangles and interpolating functions.  Judith Palagallo, The University of Akron (930-B1-763)

9:00AM  A random fractal forest of statistically self-similar trees.  Anne M. Burns, C.W. Post Campus, Long Island University (930-B1-764)

9:20AM  Playful attractors from iterated function systems.  Clifford A. Reiter, Lafayette College (930-B1-765)

9:35AM  Fractal bifurcations of a discontinuous function.  Michael Frame, Union College (930-B1-766)

10:00AM  Viewing dynamical systems: Animations.  James A. Yorke, University of Maryland (930-B1-767)

10:30AM  Is the weather chaotic? An empirical approach.  C. R. Hall, Boston University, and J. A. Walsh, Oberlin College (930-B1-773)

10:45AM  Symbolic dynamics in an undergraduate dynamics course.  Marysia T. Weiss, Harold M. Hastings and Yihren Wu, Hofstra University (930-B1-778)

MAA Session on Mathematics For Preservice Elementary Teachers, II

8:00AM - 10:55 AM

Organizers: Albert D. Otto, Illinois State University  C. Patrick Collier, University of Wisconsin at Oshkosh  Judith L. Covington, Louisiana State University at Shreveport  William E. Haver, Virginia Commonwealth University

8:00AM  Strengthening the mathematics program for elementary education majors: Preliminary report.  Elizabeth D. Gray, Southeastern Louisiana University (930-N1-450)

8:20AM  I don’t know, but let me think. An approach to teaching geometry to pre-service teachers.  Jim Loats, Metropolitan State College of Denver, and Jodie D. Novak, University of Northern Colorado (930-N1-571)

8:40AM  Collaborative approaches to designing, describing and evaluating mathematics courses for elementary school teachers.  Rosamond Welchman*, Brooklyn College of CUNY, and Andy R. Magid**, University of Oklahoma (930-N1-289)

9:00AM  New mathematics requirements for elementary certification in Oklahoma: Challenges and responses.  William C. Coberly, University of Tulsa, and Andy R. Magid*, University of Oklahoma (930-N1-1039)

9:40AM  Setting priorities in courses for elementary teachers.  Patricia L. Jones, University of Southwestern Louisiana (930-N1-833)

10:00AM  Giving preservice teachers what they really need.  Robert B. Stein, CSU San Bernardino (930-N1-814)

10:20AM  Comprehensive reform of the mathematical preparation of preservice K-8 teachers: Project-based mathematics investigations with integrated educational field-based experiences.  David Dennis* and Blake Sally, University of Texas at El Paso (930-N1-379)

10:40AM  Undergraduate mathematics for elementary teachers (UMET).  Jean J. McGeeheee, University of Central Arkansas (930-N1-1192)

ASL Invited Addresses and Contributed Papers

8:00AM - 10:55 AM

MAA Panel Discussion

8:00AM - 9:20 AM

Increasing the participation of minorities in mathematics.

Organizer: Rafael Martinez-Planell, National Science Foundation and University of Puerto Rico at Mayaguez

Presenters: William A. Hawkins Jr., MAA-SUMMA  Robert E. Megginson, University of Michigan  Uri Treisman, University of Texas at Austin  Carlos Castillo Chavez, Cornell University  Lloyd E. Douglas, National Science Foundation

MAA Committee on Two-Year Colleges Panel Discussion

8:00AM - 9:20 AM

Successful articulation for innovative mathematics programs.

Organizer: Stephen B. Rodi, Austin Community College

Panelists: Gary L. Britton, University of Wisconsin, Washington County  Raymond J. Cannon Jr., Baylor University  Mona A. Fabricant, Queensborough College, CUNY  William E. Haver, Virginia Commonwealth University
AMS Colloquium Lectures: Lecture III

1:00 PM - 2:00 PM

1:00PM (624) Combinatorial snapshots.

Gian-Carlo Rota, Massachusetts Institute of Technology (930-05-43)

AMS-MAA Special Session on History of Mathematics, II

1:00 PM - 5:50 PM

Organizers: James J. Tattersall, Providence College
Karen H. Parshall, University of Virginia

1:00PM Leonard Eugene Dickson: One quote, one question—an inextricable link?

(625) Della D. Fenster, University of Richmond (930-01-491)

1:30PM The beginnings of general topology.

(626) Rebecca A. Adams, Southern California College (930-01-339)

2:00PM Three geometrical jewels of Al-Khali.

(627) John L. Berggreen*, Simon Fraser University, and

Glen Van Brummen, King's Univ. College (930-01-381)

2:30PM Divination in Madagascar: A case of

ethnomathematics. Preliminary report.

Marcia Ascher, Ithaca College (930-01-180)

3:00PM Fourier's analysis of inequalities (1831) and

Tarski's definable sets of real numbers (1931).

Hourya Sinaceur, Centre National de la Recherche Scientifique, Paris, France. (930-01-537)

3:30PM Mathematics and the modern state: The case of


Judith V. Grabiner, Pitzer College, Claremont, CA

(91711 (930-01-288)

4:00PM Mathematics and dialectical materialism.

(631) Charles E. Ford, Saint Louis University (930-01-38)

4:30PM Mathematics and the modern state: The case of

John L. Berggreen, Simon Fraser University (930-01-339)

(632) Marcia Ascher, Ithaca College (930-01-180)

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Judith V. Grabiner, Pitzer College, Claremont, CA

(91711 (930-01-288)

4:00PM Mathematics and dialectical materialism.
AMS Special Session on Difference Equations and Applications, II

Program of the Sessions – Baltimore, MD, Friday, January 9 (cont’d.)

2:30PM
Very ampleness and higher syzygies of Calabi-Yau threefolds.

Bangere P. Purnaprajna*, University of Missouri, and Francisco J. Gallego, Universidad Complutense de Madrid (930-14-253)

3:00PM
Grothendieck duality on formal schemes.

Joseph Lipman, Purdue University (930-14-782)

3:30PM
Weierstrass weights of fixed points of an involution.

Christopher W. Towse, Swarthmore College (930-14-707)

4:00PM
Differential operators on algebraic varieties and Nakai's conjecture.

William N. Traves, MIT and University of Toronto (930-13-619)

4:30PM
Characterization of Hilbert functions of standard algebras with Artinian coefficients.

Cristina Bacicafot and Scott R. Nollet, Dept. d'Algebra i Geometria, Universitat de Barcelona (930-13-407)

5:00PM
On the Jacobian ideal of a trilinear form.

Giandomenico Boffi, Universita' di Trieste, Winfried Bruns, University of Osnabrueck, and Anna Guerrieri*, Purdue University and Universita' di L'Aquila (930-13-577)

5:30PM
On the structure of path algebras.

Preliminary report.

Mordechai Katzman, CINVESTAV (930-13-1071)

AMS Special Session on Homotopy Theory, V

1:00 PM – 5:50 PM

Organizers: Edward A. Grove, University of Rhode Island

Gerasimos Ladas, University of Rhode Island

1:00PM
On the recursive sequence X(n+1)=A/X(n) + 1/X(n-2).

Stephen W. Schultz*, Providence College, Gerry Ladas, University of Rhode Island, and Richard DeVault, Northwestern State University (930-39-596)

1:30PM
A generalization of a two periodic difference equation.

Preliminary report.

Richard C. DeVault*, Northwestern State University, Gerry Ladas, University of Rhode Island, and Steven W. Schultz, Providence College (930-39-305)

2:00PM
Border collision bifurcations.

James A. Yorke, Institute for Physical Science & Technology, University of Maryland (930-39-349)

2:30PM
On some difference equations with eventually periodic solutions.

A. M. Amleh*, E. A. Grove, C. M. Kent and Gerry Ladas, University of Rhode Island (930-39-562)

3:00PM
Lyness' equation in the third quadrant.

Jeffrey J. Feuer*, Edward J. Janowski and Gerry Ladas, University of Rhode Island (930-39-222)

3:30PM
A preliminary report.

Edward J. Barbeau, University of Toronto (930-40-78)

4:00PM
Phase portraits for a class of difference equations.

Preliminary report.

Robert Hayden, Mountain View Institute, and Edward Thomas*, SUNY at Albany (930-39-94)

4:30PM
A survey of results and directions. First integrals for difference equations.

Leon M. Arriola, Western New Mexico University (930-39-859)

AMS Special Session on Inverse Problems and Signal Analysis, II

1:00 PM – 5:45 PM

Organizer: M. Zuhair Nashed, University of Delaware

1:00PM
Mellin analysis and exponential sampling theory.

Preliminary report.


1:30PM
Spline summability methods for the recovery of band limited functions from discrete data.

W. R. Madych, University of Connecticut (930-40-726)

2:00PM
Wavelet periodicity detection.

Preliminary report.

John J. Benedetto* and Goetz E. Pfander, University of Maryland (930-42-434)
AMS Special Session on Knot Theory and Quantum Topology, II

1:00 PM – 5:50 PM

Organizers: Doug Bullock, Boise State University
Mark E. Kidwell, U.S. Naval Academy
Jozef H. Przytycki, George Washington University
Yongwu Rong, George Washington University

1:00 PM
SL_2(\mathbb{R}) and 3-manifold invariants. Preliminary report.
Ruth Lawrence, University of Michigan (930-57-1128)

1:30 PM
Milnor and finite type invariants of plat-closures of pure braids.
Effie Kalfagianni, Rutgers University, New Brunswick, and Xiao-Song Lin*, University of California, Riverside (930-57-1138)

2:00 PM
Applications of the lantern identity.
Stavros Garoufalidis, Brandeis University (930-57-270)

2:30 PM
Finite type and quantum invariants of 3-manifolds. Preliminary report.
Thang T. Q. Le, SUNY Buffalo (930-57-640)

3:00 PM
Virtual knot theory. Preliminary report.
Louis H. Kauffman, University of Illinois at Chicago (930-57-83)

3:30 PM
Knot group symmetries and representation shifts. Preliminary report.
Daniel S. Silver* and Susan G. Williams, Univ. of South Alabama (930-57-944)

4:00 PM
A presentation of the mapping class groups.
Feng Luo, Rutgers University, New Brunswick, NJ 08903 (930-57-196)

4:30 PM
Topological quantum field theory and strong shift equivalence.
Patrick M. Gilmer, Louisiana State University (930-57-660)

5:00 PM
Topological quantum field theory and its applications.
Charles Frohman, University of Iowa, and Joanna Kania-Bartoszynska*, Boise State University (930-57-708)

5:30 PM
The embedding space of polygonal knots.
Calvo Jorge Alberto, UCSB (930-54-606)

AMS Special Session on Recent Developments on the Laplace Operator and Its Geometric Applications, II

1:00 PM – 5:50 PM

Organizers: Ying Shen, Dartmouth College
Shumhui Zhu, Dartmouth College

1:00 PM
Sarah J. Greenwald, University of Pennsylvania (930-53-396)

1:30 PM
New homogeneous Einstein metrics of negative Ricci curvature. Preliminary report.
Megan M. Kerr*, Wellesley College, and Carolyn S. Gordon, Dartmouth College (930-53-813)

2:00 PM
Constant mean curvature surfaces in Euclidean 3-space via graphical minimal surfaces in the 3-sphere. Preliminary report.
Robert B. Kusner, University of Massachusetts at Amherst (930-53-476)

2:30 PM
Function theory and generalized Liouville properties.

3:00 PM
Gauss maps of minimal surfaces with finite total curvature. Preliminary report.
Helen E. Moore, Bowdoin College (930-53-804)

3:30 PM
Applications of sub-Riemannian geometry to Riemannian geometry. Preliminary report.
Scott D. Pauls, University of Pennsylvania (930-53-1009)

4:00 PM
The scattering operator and deformations of Kleinian groups. Preliminary report.
Peter A. Perry, University of Kentucky (930-35-863)
AMS Special Session on Representation Theory and Noncommutative Harmonic Analysis: A Special Session Honoring the Memory of Harish-Chandra, II

1:00 PM – 4:20 PM
Organizer: Robert S. Doran, Texas Christian University

1:00PM: The influence of Harish-Chandra at M.I.T. in the 1960s. Preliminary report. 
Ronald L. Lipsman, Univ of MD, College Park (930-01-202)

1:30PM: Parabolic induction and unitary representations. 
David A. Vogan Jr., Massachusetts Institute of Technology (930-22-441)

2:00PM: Transfer between real forms and multiplicities. 
Nolan R. Wallach, University of California, San Diego (930-22-609)

Allen Moy, University of Michigan (930-22-342)

3:00PM: Bruhat filtrations and Whittaker vectors. 
Dragan Milicic, University of Utah (930-22-970)

3:30PM: A limit formula for transfer factors. Preliminary report. 
Diana F. Shelstad, Rutgers University (930-22-679)

4:00PM: Homogeneous partial differential complexes. 
Gregg J. Zuckerman, Yale University (930-22-1213)

AMS Special Session on Representations of Finite Groups, I

1:00 PM – 5:50 PM
Organizers: Jonathan L. Alperin, University of Chicago 
Jon F. Carlson, University of Georgia

1:00PM: The Hochschild cohomology ring of a group algebra, I: Multiplicative structures. 
Stephen F. Siegel*, Univ. of Massachusetts, and Sarah J. Witherspoon, University of Toronto (930-20-420)

1:30PM: The Hochschild cohomology ring of a group algebra, II: Connections with the quantum double. 
Stephen F. Siegel, University of Massachusetts, and Sarah J. Witherspoon*, University of Toronto (930-20-416)

2:00PM: Bounds for linear groups. Preliminary report. 
Michael J. Collins, University of Virginia (930-20-807)

2:30PM: The stable category of a group of p-rank two. Preliminary report. 
Wayne W. Wheeler, University of Georgia (930-20-822)

3:00PM: Lusztig functors in the special linear group over a finite field. 
Cedric Bonnafé, University of Chicago (930-20-463)

AMS Special Session on Topology in Dynamical Systems, III

1:00 PM – 5:50 PM
Organizers: Kathleen T. Alligood, George Mason University 
Judy Kennedy, University of Delaware

1:00PM: Inverse limit spaces of unimodal maps. Preliminary report. 
Karen M. Brucks, U-WI-Milwaukee (930-58-1094)
1:30PM Homoclinic tangencies in unimodal families with nonconstant topological entropy.

- (726) Steven M. Pederson, Georgia Tech (930-54-700)

2:00PM Closed curves in infinite affine iterated function systems. Preliminary report.

- (727) Irene Huerter, University of Florida, Gainesville, FL (930-28-346)

2:30PM Dynamics of quasi-continuous maps.


3:00PM Symbolic dynamics, knots and topological field theory.

- (729) Daniel S. Silver and Susan G. Williams*, University of South Alabama (930-58-952)

3:30PM One-dimensional Inelastic collapse.

- (730) Steve Kennedy*, Carleton College, Barry Cipra, Northfield, MN, Paolo Dini and Amy Kolan, St. Olaf College (930-58-849)

4:00PM Nonshadowability of nonhyperbolic systems.

- (731) Guo-Cheng Yuan, University of Maryland (930-58-1079)

4:30PM Exponents and denjoids.

- (732) Alex D. Clark, Auburn (930-58-361)

5:00PM Weakly mixing tiling flows arising from interval exchange transformations. Preliminary report.


5:30PM An ergodic theory link with abstract harmonic analysis. Preliminary report.

- (734) John R. Tucker, Board on Mathematical Sciences, National Research Council (930-46-60)

MAA Minicourse #12: Part A

1:00PM - 3:00PM

The use of hand-held numerical, graphical, and symbolic algebra devices in the teaching and learning of calculus.

Organizers: L. Carl Leinbach, Gettysburg College
Wade Ellis Jr., West Valley College
Bert K. Waits, The Ohio State University

MAA Minicourse #9: Part B

1:00PM - 3:00PM

Interactive multimedia modeling and differential equation solving.

Organizers: Michael Moody, Harvey Mudd College
Robert L. Borrelli, Harvey Mudd College
Courtney S. Coleman, Harvey Mudd College
Beverly H. West, Cornell University

AMS Session on Probability

1:00PM - 5:25PM

1:00PM An extension of the list of extreme value distributions. Preliminary report.

- (746) Boris I. Kunin, University of Alabama in Huntsville (930-60-309)

1:15PM Queuing systems with due dates in heavy traffic.

- (747) Bogdan D. Dytkinov*, Steven E. Shreve and John P. Lehoczky, Carnegie Mellon University (930-60-664)

1:30PM Racing random walkers. Preliminary report.

- (748) Thad Danke*, UNC-Wilmington, and Jeffrey L. Brown, University of North Carolina at Wilmington (930-60-717)

1:45PM Superposition of renewal-reward processes having stable interarrival times and stable rewards. Preliminary report.

- (749) Joshua Levy, Embry-Riddle Aeronautical University (930-60-652)

2:00PM Inequalities for means of first-passage times in percolation theory. Preliminary report.

- (750) John C. Wierman, Johns Hopkins University (930-60-159)

2:15PM Large deviation analysis of doubly-indexed stochastic processes with applications to the statistical mechanics of fluids.

- (751) Christopher L. Boucher*, Richard Ellis and Bruce Turkington, University of Massachusetts (930-60-1092)

2:30PM Microstructure functions for models of impenetrable nonaligned particles.

- (752) John A. Quintanilla, University of North Texas (930-60-681)
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<thead>
<tr>
<th>Time</th>
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<tr>
<td>2:45PM</td>
<td>Nearly optimal control for reflected wideband width processes with jumps.</td>
<td>Kandethody M. Ramachandran, University of South Florida (930-60-427)</td>
</tr>
<tr>
<td>3:00PM</td>
<td>Optimal filtering and prediction for classes of nonstationary processes.</td>
<td>Preliminary report.</td>
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<tr>
<td>3:30PM</td>
<td>Evolution equation of a stochastic semigroup with spatially non-smooth white noise drift</td>
<td>Preliminary report.</td>
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<td>Frederic G. Viens*, University of North Texas, and David Nualart,</td>
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<td>Universitat de Barcelona (930-60-615)</td>
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<tr>
<td>3:45PM</td>
<td>Random variable dilation equations and self-affine tilings.</td>
<td>Julie A. Belock, Lehigh University (930-60-747)</td>
</tr>
<tr>
<td>4:00PM</td>
<td>Critical values for a reversible nearest particle system on the homogeneous tree.</td>
<td>Amber Puha, University of California, Los Angeles (930-10-1051)</td>
</tr>
<tr>
<td>4:15PM</td>
<td>An example of a non-planar martingale crossterm dominated process.</td>
<td>Preliminary report.</td>
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<td>Michael L. Green, Baylor University (930-60-667)</td>
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<tr>
<td>4:30PM</td>
<td>Convergence and stability analysis of systems of parabolic partial differential equations</td>
<td>Mahmoud J. Anabtawi* and G. S. Ladde, University of Texas at Arlington (930-60-505)</td>
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<td></td>
<td>Markovian structural perturbations.</td>
<td>Preliminary report.</td>
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<td>Eliza Dargan Berry, North Carolina State University (930-16-848)</td>
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<tr>
<td>4:45PM</td>
<td>Strong approximations for Markovian service networks.</td>
<td>Avi Mandelbaum, Technion Institute, William A. Massey*, Bell Laboratories,</td>
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<td>networks.</td>
<td>and Marty Reiman, Bell Labs of Lucent Technologies (930-60-1035)</td>
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<tr>
<td>5:00PM</td>
<td>Integration by parts formulas involving analytic Feynman integrals.</td>
<td>Chull Park, Miami University (930-60-430)</td>
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<tr>
<td>5:15PM</td>
<td>Compositions of random Mobius transformations on the unit disk.</td>
<td>Satyajit Karmakar, Saint Paul's College (930-60-501)</td>
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</table>

**AMS Session on Rings, Groups, and Algebras**

1:00 PM - 6:10 PM

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<thead>
<tr>
<th>Time</th>
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<tbody>
<tr>
<td>1:00PM</td>
<td>Rings of polynomial functions.</td>
<td>Dennis Spellman, Philadelphia, PA, and William P. Wardlaw* U.S. Naval Academy (930-13-659)</td>
</tr>
<tr>
<td>1:15PM</td>
<td>Birational extensions of Noetherian unique factorization domains.</td>
<td>Aihua Li, Loyola University New Orleans (930-13-1193)</td>
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<tr>
<td>1:30PM</td>
<td>Divided rings.</td>
<td>Ayman Badawi, Birzeit University (930-13-199)</td>
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<tr>
<td>1:45PM</td>
<td>Krull-Schmidt theorem and a problem of Matlis.</td>
<td>Hua-Ping Yu, Emory and Henry College (930-16-25)</td>
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<tr>
<td>2:00PM</td>
<td>The existence and uniqueness of a graded torsion free covering of a graded k(x)-module (k a field).</td>
<td>Preliminary report.</td>
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<td>William T. Ashby, Ferrum College (930-13-743)</td>
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<tr>
<td>2:15PM</td>
<td>Lie Derivations in Prime Rings with Involutions.</td>
<td>Gordon A. Swain, Ashland University, and Philip S. Blau*, Boston University (930-16-607)</td>
</tr>
<tr>
<td>2:30PM</td>
<td>Positive semidefinite polynomials in ( \mathbb{R}[x,y] ) which are not a sum of squares in ( \mathbb{R}[x,y] ). Preliminary report.</td>
<td>David B. Leep and Colin Lee Starr*, University of Kentucky (930-12-177)</td>
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<tr>
<td>2:45PM</td>
<td>Commutativity of rings satisfying certain generalized polynomial identities.</td>
<td>Amir H. Yamini, Amirkabir University, Tehran-Iran (930-16-201)</td>
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<tr>
<td>3:00PM</td>
<td>Invariants of Brauer tree algebras.</td>
<td>Preliminary report.</td>
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<td>Michael J. Bardzell, Salisbury State University (930-16-645)</td>
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<td>3:15PM</td>
<td>Forms of Hopf Algebras and U(g)-Galois Extensions.</td>
<td>Preliminary report.</td>
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<td>Darren B. Parker, University of Wisconsin, Madison, WI (930-16-485)</td>
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<td>Jonathan S. Golan, University of Idaho (930-16-67)</td>
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<td>3:45PM</td>
<td>Involutions in a linearly compact ring.</td>
<td>Preliminary report.</td>
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<td>Eliza Dargan Berry, North Carolina State University (930-16-848)</td>
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<tr>
<td>4:00PM</td>
<td>Quantum groups, intertwiners and q-de Rham cocycles.</td>
<td>Preliminary report.</td>
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<td>Abdellah Sebab, CRM and CICMA, Montreal, Canada (930-16-762)</td>
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<td>Jennifer M. Hontz, North Carolina State Univ (930-00-800)</td>
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<td>4:45PM</td>
<td>Injective covers from injective covers.</td>
<td>Preliminary report.</td>
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<td>Christopher A. Aubuchon, University of Kentucky (930-18-759)</td>
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<td>5:00PM</td>
<td>The global dimension of a skew polynomial rings- preliminary report.</td>
<td>Preliminary report.</td>
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<td>Scott A. Woodward, University of California, Santa Barbara (930-18-985)</td>
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<td>5:15PM</td>
<td>Characterizing nilpotent Lie algebras by their multipliers.</td>
<td>Preliminary report.</td>
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<td>Peter G. Hardy, North Carolina State University (930-00-642)</td>
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<td>5:30PM</td>
<td>Uniserial modules and tensor product decompositions for group rings of p-groups.</td>
<td>Preliminary report.</td>
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<td>Philip Lloyd Osterlund, University of Minnesota (930-17-796)</td>
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<td>5:45PM</td>
<td>Units in integral group rings.</td>
<td>Joseph Buckley and Richard M. Low*, Western Michigan University (930-20-371)</td>
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<td>6:00PM</td>
<td>Ext groups between Weyl Modules for GL_n.</td>
<td>Preliminary report.</td>
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<td>Upendra B. Kulkarni, Brandeis University (930-20-986)</td>
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**MAA Session on Innovations in Teaching Linear Algebra, II**

1:00 PM - 3:50 PM

Organizers: David C. Lay, University of Maryland, College Park

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<thead>
<tr>
<th>Time</th>
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<tbody>
<tr>
<td>1:00PM</td>
<td>Teaching linear algebra with writing assignments.</td>
<td>Carl V. Lutzer, University of Kentucky (930-81-948)</td>
</tr>
</tbody>
</table>
1:20PM  Evaluating oral and written work in linear algebra. Preliminary report.  
Michael D. Galloy, University of Kentucky (930-F1-888)

1:40PM  Discovery learning and essay writing in linear algebra.  
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<tr>
<td>Discovery learning and essay writing in linear algebra</td>
<td>Carol Esther Collins, Drury College (930-F1-447)</td>
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<tr>
<td>2:00PM  Variety in teaching linear algebra. Preliminary report</td>
<td>Jim Hartman, The College of Wooster (930-F1-351)</td>
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<tr>
<td>2:20PM  Experience with the William and Mary REU Program.</td>
<td>Charles R. Johnson, The College of William and Mary (930-F1-1111)</td>
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<tr>
<td>2:40PM  The medium is the message: Reflections on instructor communication in linear algebra Preliminary report.</td>
<td>Mary T. Treanor, Valparaiso University (930-F1-1072)</td>
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<tr>
<td>3:00PM  Assignments that stimulate thinking and writing.</td>
<td>Jane M. Day, San Jose State University, San Jose, CA (930-F1-456)</td>
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<td>3:20PM  Writing to teach and learn linear algebra.</td>
<td>Luz M. DeAlba, Drake University (930-F1-1031)</td>
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<tr>
<td>3:40PM  Writing assignments that strengthen linear algebra concepts.</td>
<td>David C. Lay, University of Maryland (930-F1-927)</td>
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</table>

MAA Session on Using Real World Data in the Teaching and Learning of Mathematics, II

1:00 PM - 6:00 PM

Organizers: Florence S. Gordon, New York Institute of Technology  
Sheldon P. Gordon, Suffolk Community College  
Iris B. Fetta, Clemson University

1:00PM  Opening remarks.

1:05PM  Bridging the gap with real-world data. Preliminary report.  
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<tr>
<td>Alcohol in your body: An investigation using rational functions.</td>
<td>James T. Sandefur, Georgetown University (930-G1-559)</td>
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<tr>
<td>1:35PM  Using KWH data to electrify mathematical learning.</td>
<td>Jane T. Upshaw, University of South Carolina Beaufort (930-G1-629)</td>
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<td>1:50PM  Increasing understanding of elementary functions using US population data.</td>
<td>Mary E. Davis, DeKalb College (930-G1-947)</td>
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<td>2:05PM  CBL activities in intermediate algebra.</td>
<td>Darrell H. Abney, Maysville Community College, and Lillie F. Crowley, Lexington Community College (930-G1-1081)</td>
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<td>2:20PM  Regression models using real world data on a TI-83.</td>
<td>Raymond N. Greenwell, Hofstra University (930-G1-401)</td>
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<td>2:35PM  Mathematics and community service: Real problems that students care about. Preliminary report.</td>
<td>Rebekah Valdivia and Eric Grunzah, Augsburg College (930-G1-1163)</td>
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<td>2:50PM  Finding a precalculus model for the concentration of CO2 in the atmosphere.</td>
<td>Daniel J. Teague, NC School of Science and Mathematics (930-G1-1109)</td>
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3:05PM  A modeling exercise in calculus: How open-ended can we be?  
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<td>A mathematical investigation of the inter-relationship of malaria and sickle cell anemia.</td>
<td>Rosalie A. Dance, Georgetown University (930-G1-705)</td>
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<tr>
<td>3:20PM  A mathematical investigation of the inter-relationship of malaria and sickle cell anemia.</td>
<td>Rosalie A. Dance, Georgetown University (930-G1-705)</td>
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<td>3:25PM  Teaching the process of problem solving using student-generated projects.</td>
<td>Audrey Fredrick Borchardt and Bruce Pollack-Johnson, Villanova University (930-G1-567)</td>
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<td>3:50PM  Maple Picture Book as implemented in differential equations. Preliminary report.</td>
<td>Debra A. Coventry, Oklahoma State University (930-G1-507)</td>
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<td>4:05PM  Learning mathematics through completion of group projects of actual problems from industries.</td>
<td>Morteza Shafii-Mousavi and Paul Kochanowski, Indiana University, South Bend (930-G1-443)</td>
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<td>4:20PM  College algebra with environmental data.</td>
<td>Kay Gura, Ramapo College of New Jersey (930-G1-706)</td>
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<td>4:35PM  An interdisciplinary approach to functions.</td>
<td>Cathy Ann Godbois, Lancaster Campus Harrisburg Area Community College (930-G1-341)</td>
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<td>4:50PM  Using real-world data about gender in algebra courses.</td>
<td>Scott A. Smith, Columbia College (930-G1-1114)</td>
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5:05PM  A study of surfaces.  
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<tr>
<td>Perils of population predictions.</td>
<td>Duncan J. McVeigh, St. Lawrence University (930-G1-632)</td>
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<tr>
<td>5:35PM  Modeling with real data in elementary and intermediate algebra.</td>
<td>Elaine M. Hubbard, Kennesaw State University (930-G1-403)</td>
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<tr>
<td>5:50PM  Teaching with data from the calculator based laboratory.</td>
<td>Jon A. Beal, Oklahoma State University (930-G1-510)</td>
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</table>

MAA Session on Mathematics Across the Disciplines, I

1:00 PM - 3:40 PM

Organizer: Brian J. Winkel, United States Military Academy

1:00PM  Discrete math for data structures, a case study in interdisciplinary course planning. Preliminary report.  
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<td>Kenneth P. Bogart, Dartmouth College (930-K1-130)</td>
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<tr>
<td>1:15PM  Music and math.</td>
<td>Steve Gadbois, Rhodes College (930-K1-253)</td>
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<tr>
<td>1:30PM  Interdisciplinary design projects bridging mathematics and art.</td>
<td>Raymond F. Tennant, Eastern Kentucky University (930-K1-251)</td>
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<td>1:45PM  A tale of three numbers: An application of mathematics to the psychology of aesthetics.</td>
<td>Kathleen M. Shannan and James C. Clarke, Salisbury State University (930-K1-213)</td>
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<td>2:00PM  Post-calculus courses in mathematical finance.</td>
<td>Lester N. Coyle, Loyola College in Maryland (930-K1-186)</td>
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</table>
> (829)
Marise M. Chan, Nathan E. Dire* and Albert W. Schueller III, Whitman College (930-65-275)

2:30PM Extended Runge-Kutta Monte Carlo methods.
> (830)
Margaret Akata Dodson, Muhlenberg College (930-65-1002)

2:45PM Explorations on higher order convergence and Halley method.
> (831)
Carl M. Koreen, Monmouth University (930-65-1221)

3:00PM The Mountain Pass Algorithm: Description and applications. Preliminary report.
> (832)
Sharon H. Hill, Rowan University (930-65-100)

3:15PM Effectively speedable enumerable vector spaces have effectively speedable enumerable bases. Preliminary report.
> (833)
Lisa R. Galminas, Northwestern State University (930-03-949)

3:30PM A superconvergent collocation method for the radiosity equation.
> (834)
Sanda Micula, Western Oregon University (930-65-945)

3:45PM Approximation methodology for a Volterra integro-differential equation with application to curved beams. Preliminary report.
> (835)
Negash G. Medhin*, Clark Atlanta University, and M. Sambandham, Morehouse College (930-65-834)

4:00PM Particle modeling of gas bubbles in a liquid in 2-D. Preliminary report.
> (836)
Mark S. Korfle*, Montclair State University, and Donald Greenspan, University of Texas at Arlington (930-65-915)

> (837)
Valentin V. Sheplev and Natalia A. Bryshina*, Institute of Mineralogy and Petrology, Novosibirsk, Russia (930-92-233)

4:30PM Approximation of the singularities of a function of Vp class by means of its Fourier series.
> (838)
George Kvernadze*, Thomas Hagstrom, and Seenith Sivasundaram, Embry-Riddle Aeronautical University (930-65-148)

4:45PM Mathematical analysis of a volleyball match.
> (839)
Reza Noubary, Bloomsburg University, Bloomsburg, PA (930-00-993)

5:00PM Topological methods in pattern recognition: Colors and fibers.
> (840)
Monique L. Pavel, University of Paris, Paris, France (930-68-09)

5:15PM Terrain profiling using the wave number spectrum. Preliminary report.
> (841)
David A. Lamb, U.S. Army TACOM-TARDEC (930-70-680)

5:30PM Domains of mobility for a body moving among obstacles.
> (842)
Frederick A. Adkins, Indiana Univ.of PA (930-73-953)

5:45PM Asymptotic controllability implies feedback stabilization in terms of two measures.
> (843)
Seenith Sivasundaram, Embry-Riddle Aeronautical University (930-34-223)

MAA Invited Address

2:15PM - 3:05 PM

> (844)
Can we build a model of how and why teachers do what they do? And if so, why should we care?
Alan H. Schoenfeld, University of California, Berkeley
AMS Session on Combinatorics

2:15 PM - 6:10 PM

2:15PM  On the decomposability of orthogonal arrays.
   (845) Preliminary report.
   Wiebke S. Diestelkamp, University of Wisconsin-Milwaukee (930-05-616)

2:30PM  Linear independence of random binary vectors.
   (846) Preliminary report.
   Paul J. Wollan*, University of Chicago, and Daniel B. Tenny, Harvard University (930-05-634)

2:45PM  The longest k-match-free zone. Preliminary report.
   (847) Jessica M. Maia*, Massachusetts Institute of Technology, and Stawarz Marcin, Reed College (930-05-839)

3:00PM  Unreversed critical pairs in random permutations.
   (848) Preliminary report.
   Abigail Jager*, Calvin College, and Samantha Riesenfeld, Harvard University (930-05-633)

3:15PM  A probabilistic look at the Schur and van der Waerden numbers. Preliminary report.
   (849) Samantha J. Riesenfeld*, Harvard College, and Abby Jager, Calvin College (930-05-1045)

3:30PM  Rectangle-visibility layouts of unions and products of trees. Preliminary report.
   (850) Alice M. Dean*, Skidmore College, and Joan P. Hutchinson, Macalester College (930-05-997)

3:45PM  On the size of minimum super Arrovian domains.
   (851) Samit Dasgupta, Harvard University (930-05-621)

4:00PM  Uniformly optimally reliable graphs.
   (852) Daniel J. Gross and John T. Saccaman*, Seton Hall University (930-05-232)

   (853) Kurt M. Anstreicher, University of Iowa, Marcia Fampa, Federal University of Rio de Janeiro, Jon Lee and Joy Denise Williams*, University of Kentucky (930-05-146)

4:30PM  On path-sequential labellings of cycles.
   (854) Ron A. Fertig, Princeton University (930-05-788)

4:45PM  Palindromes in two dimensions. Preliminary report.
   (855) Marcin Stawarz*, Reed College, and Jessica M. Maia, MIT (930-05-1025)

5:00PM  A counterexample to a conjecture of Lee.
   (856) Preliminary report.
   Matthew W. Scobee, Unv. of Louisville (930-05-418)

5:15PM  Some new infinite families of eta function identities.
   (857) Verne E. Leininger*, The University of Akron, and Stephen C. Milne, The Ohio State University (930-05-744)

5:30PM  On the upper chromatic numbers of the reals.
   (858) Aaron F. Archer, Harvey Mudd College (930-05-400)

5:45PM  Sums of powers of integers. Preliminary report.
   (859) Carl A. Libis and Joseph Neugers, University of Alabama (930-05-399)

6:00PM  Factorizations of K_m,n into spanning trees.
   (860) Saad El Zanati and Charles L. Vanden Eynden*, Illinois State University (930-05-523)

NAM's Granville-Brown Session of Presentations by Recent Doctoral Recipients in the Mathematical Sciences

2:15 PM - 4:00 PM

Moderator:  James C. Turner Jr., Arizona State University

Presenters:  Errol Rowe, North Carolina A&T University

RMMC Board of Directors

2:15 PM - 4:15 PM

AMS Committee on Science Policy-MAA Science Policy Committee Invited Address

3:10 PM - 4:00 PM

(861) Title to be announced.
   Richard W. Riley, U. S. Secretary of Education

MAA Minicourse #11: Part A

3:15 PM - 5:15 PM

Elementary mathematical models: Order aplenty and a glimpse of chaos.
Organizers: Dan Kalman, American University
           Angela C. Hare, Messiah College

MAA Minicourse #7: Part B

3:15 PM - 5:15 PM

Mathematica laboratories in calculus instruction.
Organizers: Anita J. Salem, Rockhurst College
           William H. Barker, Bowdoin College
           John R. Michel, Marietta College

AMS Invited Address

3:20 PM - 4:10 PM

(862) Nonlinear wavelet image processing.
   Bradley Lucier, Purdue University, West Lafayette, Indiana

MAA Teaching Award Presentations

3:20 PM - 5:00 PM

(863) Title to be announced.
   Rhonda L. Hatcher, Texas Christian University

(864) Title to be announced.
   Rhonda J. Hughes, Bryn Mawr College

(865) Title to be announced.
   Colin C. Adams, Williams College

MAA CUPM Subcommittee on Research by Undergraduates Poster Session

4:00 PM - 7:00 PM

Mathematical research projects of undergraduate students.
Organizers: Judith A. Palagallo, University of Akron
           Arporna W. Higgins, University of Dayton

MAA Session on The World Wide Web in Mathematical Instruction, II

4:05 PM - 5:40 PM

Organizers: Earl D. Fife, Calvin College
Saturday, January 10

Joint Meetings Registration
7:30 AM - 2:00 PM

AMS-MAA Special Session on History of Mathematics, III
7:30 AM - 10:50 AM
Organizers: James J. Tattersall, Providence College
10:00AM Facilitating learning events through example
  generation.
  Randall P. Dahlberg, Crofton, MD, and David L. Housman*, Allegheny College (930-98-550)

10:20AM Pre-service elementary school teachers’ conceptions
  of least common multiple. Preliminary report.
  Anne Brown, Indiana University South Bend, Karen
  Thomas, University of Wisconsin-Platteville, and
  Georgia Toleas*, Purdue University Calumet (930-98-1056)

10:40AM Pre-service elementary school teachers’
  mathematical conceptions - some obstacles to
  schema construction. Preliminary report.
  Anne E. Brown*, Indiana University South Bend,
  Karen Thomas, University of Wisconsin-Platteville,
  and Georgia Toleas, Purdue University Calumet (930-98-573)

AMS Special Session on Commutative Algebra and
  Algebraic Geometry, IV

8:00AM - 10:50 AM
  Organizers: Melvin Hochster, University of
  Michigan, Ann Arbor
  Craig L. Huneke, Purdue University
  8:00AM A generalized Dedekind-Mertens lemma and its
    converse.
    Alberto Corso, Purdue University (930-13-999)
  8:30AM On small cofinite irreducibles.
    (890) I. E. Koh, Indiana University (930-13-1029)
  9:00AM The commutative algebra of exterior algebras.
    (891) Annetta Aramova, University of Sofia, Luchezar L.
    Avramov*, Purdue University, and Jurgen Herzog,
    University of Essen (930-13-860)
  9:30AM An asymptotic upper bound for certain Socle
    dimensions. Preliminary report.
    Carolyn A. Yackel, University of Michigan
    (930-13-378)
  10:00AM Gorenstein sets of points and the Gale Transform.
    (893) Preliminary report.
    David Eisenbud, MSRI/ UC Berkeley (930-13-1040)
  10:30AM Linear equivalence of topologies.
    (894) Irena Swanson, New Mexico State University
    (930-13-380)

AMS Special Session on Difference Equations and
  Applications, III

8:00AM - 10:50 AM
  Organizers: Edward A. Grove, University of Rhode
  Island
  Gerasimos Ladas, University of Rhode Island
  8:00AM Multiple positive solutions to a discrete boundary
    value problem. Preliminary report.
    Allan C. Peterson, Univ. of Nebraska-Lincoln
    (930-39-864)
  8:30AM Distributional analog of a sum form functional
    equation. Preliminary report.
    Elias Y. Deeba*, University of Houston-Downtown,
    Eusebio L. Koh, University of Regina, Shihhen S.
    Xie, University of Houston-Downtown, and
    Prasanna K. Sahoo, University of Louisville
    (930-39-93)
  9:00AM Positive solutions of boundary value problems for
    nth order nonlinear difference equations.
    Johnny Henderson* and Susan D. Lauer, Auburn
    University (930-39-533)
  9:30AM The Ibn-Ezra Transform.
    (898) Doron Zeilberger, Temple University (930-39-538)

10:00AM Polytopic Jacobi and Gauss-Seidel Iterations:
  convergence via convex M-matrices.
  Dragoslav D. Siljak* and Dušan M. Stipanović,
  Santa Clara University (930-65-392)

10:30AM Scaling laws for shadowing time.
  Tim D. Sauer, George Mason University
  (930-39-1085)

AMS Special Session on Homotopy Theory, VI

8:00 AM - 10:50 AM
  Organizers: W. Stephen Wilson, Johns Hopkins
  University
  Douglas C. Ravenel, University of Rochester
  Jean-Pierre Meyer, Johns Hopkins University
  8:00AM Some questions about Bousfield classes.
    (901) Mark Hovey, Wesleyan University, and John H.
    Palmieri*, University of Notre Dame (930-55-1075)
  8:30AM On rank two Kac-Moody groups. Preliminary report.
    (902) Nitya R. Kitchloo, Massachusetts Institute
    of Technology, (930-55-787)
  9:00AM On homotopy extensions of a finite p-group by a
    finite group. Preliminary report.
    Carlos Broto, Universitat Autonoma de Barcelona,
    and Ran Levi*, Northwestern University
    (930-55-1032)
  9:30AM Identification of infinite loop spaces arising from
    group theory.
    Kathryn Lesh Lesh, Univ of Toledo and MIT
    (930-55-556)
  10:00AM When projective does not imply flat.
    (905) L. Gaunce Lewis Jr., Syracuse University
    (930-55-545)
  10:30AM Chromatic Hesse squares, with an application to the
    cohomology of MO(8). Preliminary report.
    Matthew Ando, University of Virginia and Johns
    Hopkins University (visiting) (930-55-384)

AMS Special Session on Recent Developments on the
  Laplace Operator and Its Geometric Applications, III

8:00 AM - 9:50 AM
  Organizers: Ying Shen, Dartmouth College
  Shumhui Zhu, Dartmouth College
  8:00AM Harmonic functions on manifolds with nonnegative
    Ricci curvature and linear volume growth.
    Christina A. Sormani, Johns Hopkins (930-53-124)
  8:30AM Analysis and geometry on manifolds with integral
    Ricci curvature bounds.
    Peter Petersen, UCLA, and Guofang Wei*, UCB
    (930-53-362)
  9:00AM Weil-Petersson convexity of the energy functional
    and its applications.
    Sumio Yamada, MIT (930-58-714)
  9:30AM Eigenvalue spacings for some completely integrable
    systems.
    Steve Zelditch, Johns Hopkins University
    (930-81-328)

AMS Special Session on Representation Theory and
  Noncommutative Harmonic Analysis: A Special
  Session Honoring the Memory of Harish-Chandra, III

8:00 AM - 10:50 AM
  Organizer: Robert S. Doran, Texas Christian
  University
Program of the Sessions - Baltimore, MD, Saturday, January 10 (cont’d.)

8:00AM Orbital integrals of unipotent elements. Preliminary report.
   Dan M. Barbasch, Cornell University (930-22-618)
8:30AM Solving Seiberg Witten equations using representation theory. Preliminary report.
   Birgit E. Speh, Cornell University (930-22-879)
9:00AM Bessel functions on boundary orbits and analytic continuation of holomorphic discrete series. Preliminary report.
   Kenneth I. Gross*, University of Vermont, Ray A. Kunze, University of Georgia, Hongming Ding, St. Louis University, and Donald St. P. Richards, University of Virginia (930-22-974)
9:30AM Unitary representations of Lie groups with reflection symmetry.
   Palle E. T. Jorgensen*, University of Iowa, and Gestur Olafsson, Louisiana State University (930-22-332)
10:00AM K-theory for p-adic groups.
   Paul Baum, The Pennsylvania State University (930-19-282)
10:30AM Harish-Chandra homomorphisms for p-adic groups.
   Roger E. Howe, Yale University (930-22-322)

AMS Special Session on Representations of Finite Groups, II

8:00 AM – 10:50 AM

Organizers: Jonathan L. Alperin, University of Chicago
   Jon F. Carlson, University of Georgia

8:00AM On the decomposition matrix of a finite group of Lie type in the defining characteristic. Preliminary report.
   James E. Humphreys, University of Massachusetts at Amherst (930-20-189)
8:30AM On products of characters of the symmetric group. Preliminary report.
   Ernesto Vallejo, Instituto de Matematicas, UNAM (930-20-84)
9:00AM Phantom maps and purity over group algebras. Preliminary report.
   Gilles Ph. Gancadja, University of Georgia (930-20-424)
9:30AM Small cross characteristic representations for odd characteristic symplectic groups. Preliminary report.
   Robert M. Guralnick, University of Southern California, Kay Magaard*, Wayne State University, and Jan Saxl, Cambridge University (930-20-775)
10:00AM The norm map between the endomorphism algebras of Gelfand-Crav representations. Preliminary report.
   Julianne G. Rainbolt, Michigan State University (930-20-894)
   Bhama Srinivasan, Univ. of Illinois at Chicago (930-20-926)

AMS Special Session on Smooth Ergodic Theory and Related Areas, II

8:00 AM – 10:40 AM

Organizers: John Smillie, Cornell University
   John M. Franks, Northwestern University

8:00AM Pesin theory for actions of higher-rank Abelian groups. Preliminary report.
   Anatole Katok, Pennsylvania State University (930-58-1141)
9:00AM On the entropy and growth of expanding periodic points for one-dimensional maps.
   Anatole Katok and Alexander Mezhirov*, Pennsylvania State University (930-26-832)
9:30AM Smooth ergodic theory.
   Howard Weiss, The Pennsylvania State University (930-58-505)
10:00AM Lyapunov Spectrum For conformal smooth maps.
   Yakov B. Pesin, Penn State Univ. (930-58-535)

AMS Session on Functional Analysis

8:00 AM – 10:25 AM

8:00AM Fixed point theorems in logic programming.
   Mohamed A. Khamsi*, The University of Texas at El Paso, and Driss Misane, Mohamed V (930-46-311)
8:15AM On j-Convex preserving interpolation operators.
   Michael P. Prophet, Murray State University (930-46-387)
8:30AM Skew product graphs and coactions of discrete groups. Preliminary report.
   Steven P. Kaleszewski*, Dartmouth College, Iain Raeburn, University of Newcastle, and John Quigg, University of Arizona (930-46-1125)
8:45AM (sb)Operators on injective tensor product spaces. Preliminary report.
   Elizabeth M. Bator and Dawn R. Slavens*, University of North Texas (930-46-1003)
9:00AM Remarks on James’ distortion theorems.
   Patrick N. Dowling, Narcisse Randrianantoanina, Miami University, and Barry Turett*, Oakland University (930-46-1016)
9:15AM On the functional equation
   N. R. Nandakumar, Delaware State University (930-46-992)
9:30AM Holomorphic functions on an infinite dimensional group.
   Maria Gordina, Cornell University (930-46-965)
9:45AM Holomorphic idempotents in B*-algebras. Preliminary report.
   Tom M. Price, University of Kentucky (930-46-1169)
10:00AM Towards a generalized Euler’s constant.
   Leon C. Hardy, University of Central Florida (930-28-89)
10:15AM Partitions of real numbers. Preliminary report.
   Vandita Patel, University of Wisconsin-Oshkosh (930-26-1779)

AMS Session on Topology of Manifolds

8:00 AM – 9:40 AM

8:00AM Embeddings of essential tori in link complements.
   Valeriu Pinciu*, SUNY at Buffalo (930-55-933)
8:15AM An upper bound on edge numbers of 2-bridge knots and links.
   Cynthia L. McCabe, The University of Iowa (930-57-444)
8:30AM Noncompact finite-volume hyperbolic manifolds as submanifold complements.
   Dubravko Ivanšič, University of Oklahoma (930-57-1157)
8:45AM The appearance of Milnor linking numbers in Ohtsuki’s finite type invariants of integral homology spheres. Preliminary report.
   Daylene Zielinski, University of Iowa (930-57-1137)
9:00AM On the remaining (and original) case of H. Poincaré’s Conjecture. 
B. Craig Pringle, D.A., UNLV, Mathematics 
(930-57-333)

9:15AM Homogeneity of visual boundaries of some non-positively curved manifolds. Preliminary report. 
Hanspeter Fischer, University of Wisconsin-Milwaukee 
(930-57-382)

9:30AM Hyperbolic 5-manifolds that are nontrivial plane bundles over hyperbolic 3-manifolds. 
Igor Belegradek, University of Maryland, College Park 
(930-57-111)

MAA Session on Mathematics Across the Disciplines, II

8:00AM - 10:40AM
Organizer: Brian J. Winkel, United States Military Academy

8:00AM Integrating math modeling. 
Ronald M. Brzenk, Hartwick College 
(930-K-1-219)

8:15AM To beam or not to beam. Preliminary report. 
Charles G. Clark Jr. \( ^* \) and Joseph V. Muscarella, U. S. M. A. 
(930-K-1-810)

8:30AM A celestial marriage of mathematics and physics. 
Ethan J. Berkove, Richard J. Marchand \( ^* \), Wayne Jerzak, Frederick J. Gellert and Mark L. Sward, United States Military Academy 
(930-K-1-336)

8:45AM Vector analysis meets descriptive geometry in the college of architecture. 
Ruth Favro \( ^* \) and Patricia Wray, Lawrence Technological University 
(930-961)

9:00AM Resistance and basic electrical laws: An excellent source of data. 
Cathy Ann Godbois, Lancaster Campus Harrisburg Area Community College 
(930-K-1-179)

9:15AM How’s the weather up there? 
Steven M. Hetzler \( ^* \), Michael E. Folkoff and Donald C. Cathcart, Salisbury State University 
(930-K-1-564)

9:30AM Modeling lead dynamics in the human body: A lab for general education students. Preliminary report. 
Robert M. Tardiff \( ^* \), Salisbury State University, and Robert S. Cole, The Evergreen State College 
(930-K-1-205)

9:45AM Integrating vector calculus and electromagnetics in a first year curriculum. 
Kurt M. Bryan, Rose-Hulman Inst. of Tech. 
(930-K-1-237)

10:00AM Integrated Mathematics and Physical Science (IMPS): A new approach for first year students at Dartmouth College. 
Eric W. Hansen, Dartmouth College 
(930-K-1-656)

10:15AM An integrated pre-engineering curriculum. 
Phillip Zener \( ^* \) and Thomas Shumpert, Auburn University 
(930-K-1-539)

10:30AM Interdisciplinary workshop for mathematics, physics and technology. Preliminary report. 
Yuen Chinn, Arlene Kleinsteiner and Yajun Yang \( ^* \), SUNY-Farmingdale 
(930-K-1-690)

ASL Invited Addresses and Contributed Papers

8:00AM - 10:55AM

AMS-MAA Joint Panel Discussion

8:00AM - 9:20AM
New directions in information technology: Challenges and opportunities. 
Organizers: James H. Lightbourne III, National Science Foundation, Lee L. Zip, University of New Hampshire

AMS Session on Waves, Fluid Mechanics, and Scientific Applications

8:15AM - 10:25AM

8:15AM Variational principle for nonlinear Ross by waves and conservation laws. 
Lokenath Debnath, Univ of Central Florida 
(930-76-157)

8:30AM A class of exact solutions of steady plane MHD flow of a micropolar fluid. 
Indrasena Adluri, Wheeling Jesuit University 
(930-76-239)

8:45AM Drainage of a thin liquid film. 
Richard J. Braun \( ^* \), U of Delaware, Steven A. Snow and Udo C. Pernisz, Dow Corning Corp 
(930-76-1087)

9:00AM Proper-time classical electrodynamics. 
Tepper L. Gill, Institute For Advanced Study, and Woodford W. Zachary, Howard University, Wash., DC. 
(930-78-874)

9:15AM Analysis of viscoelastic deformations of the cochlear outer hair cell wall. 
J. Tilak Ratnanather \( ^* \), Alexander A. Spector, Aleksander S. Popel, Johns Hopkins University School of Medicine, and William E. Brownell, Baylor College of Medicine 
(930-92-1019)

9:30AM Modified boundary conditions in shell buckling. 
Preliminary report. 
Timothy J. McDavitt, Millersville University 
(930-73-165)

9:45AM The proper-time group in special relativity. 
Tepper L. Gill, Institute For Advanced Study, and Woodford W. Zachary \( ^* \), Howard University, Wash., DC. 
(930-83-868)

10:00AM Global stability in a mathematical model of a unilingual-bilingual populations interactions in two adjacent regions. 
A. S. Elkhader, Northern State University 
(930-92-367)

10:15AM Existence results for a class of abstract nonlocal Cauchy problems. 
Sergiu Aizicovici and Mark McKibben \( ^* \), Ohio University 
(930-34-520)

AWM Workshop

8:20AM - 5:10PM

8:20AM Opening remarks.

8:30AM Lower algebraic K-theory of Bianchi Groups. 
Kimberly Pearson, Valparaiso University 
(964)

9:00AM Counting moduli for some surfaces of general type. 
Caryn Werner, University of Michigan 
(965)

9:30AM Backlund transformations of hyperbolic Monge-Ampère systems. 
Jeanne Nielsen Clelland, Institute of Advanced Study 
(966)

10:00AM Closed geodesics on a pair of pants. 
Claire Barbian, Florida State University 
(967)

10:30AM Graduate Student Poster Session
NOON
10:55
5:20 PM

9:00AM-9:50AM
208 NOTICES OF AMS Committee on Education-MAA
8:30 AM - 2:00PM

Panelists: Kenneth A. Ross, University of Oregon
Roger E. Howe, Yale University

MAA Invited Address

9:00 AM - 9:50 AM

(984) Tilings, randomness, and undergraduate research. James Propp, Massachusetts Institute of Technology

NAM Panel Discussion

9:00 AM - 10:00 AM

A profile for an undergraduate in the department of mathematics at a minority institution for the 21st century.
Moderator: Leon C. Woodson, Morgan State University
Panelists: Genevieve M. Knight, Coppin State College
Stella Roberson Ashford, Southern University
William A. Hawkins Jr., University of the District of Columbia/MAA
Tasha Innis, University of Maryland, College Park

Book Sales and Exhibits

9:00 AM - NOON

NAM Business Meeting

10:00 AM - 10:55 AM

MAA Invited Address

10:05 AM - 10:55 AM

(985) New views of the idea of mathematical induction. Herbert S. Wilf, University of Pennsylvania, Philadelphia

MAA Business Meeting

11:10 AM - 11:40 AM

AMS Business Meeting

11:45 AM - 12:15 PM

NAM William W.S. Claytor Lecture

1:00 PM - 2:00 PM

(986) Lie's third theorem in infinite dimensions. Joshua Leslie, Howard University

AMS Special Session on Commutative Algebra and Algebraic Geometry, V

1:00 PM - 5:20 PM

Organizers: Melvin Hochster, University of Michigan, Ann Arbor
Craig L. Huneke, Purdue University

1:00 PM (987) Gorenstein singularities of finite Cohen-Macaulay type. Roger Wiegand, University of Nebraska
(930-13-683)

1:30 PM (988) Frobenius limits of finite length modules over complete intersections. Claudia Miller, University of Michigan
(930-13-1132)

2:00 PM (989) Some remarks on the relation type conjecture. Preliminary report.
Ian M. Aberbach, University of Missouri
(930-13-686)

2:30 PM (990) The almost complete intersection locus of icci ideals. Preliminary report.
Mark Johnson, University of Arkansas (930-13-544)
### AMS Special Session on Homotopy Theory, VII

**1:00 PM - 5:20 PM**

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### AMS Special Session on Difference Equations and Applications, IV

**1:00 PM - 5:20 PM**

**Organizers:** Edward A. Grove, University of Rhode Island  
Gerasimos Ladas, University of Rhode Island

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<td>Stacking sequences for generalized Pascal triangles.</td>
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<td>Some oscillation results for forced even order nonlinear difference equations.</td>
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### AMS Special Session on Inverse Problems and Signal Analysis, III

**1:00 PM - 4:20 PM**

**Organizer:** M. Zuhair Nashed, University of Delaware

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**AMS Special Session on Homotopy Theory, VII**

**Organizers:** W. Stephen Wilson, Johns Hopkins University  
Douglas C. Ravenel, University of Rochester  
Jean-Pierre G. Meyer, Johns Hopkins University

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**AMS Special Session on Difference Equations and Applications, IV**

**Organizers:** Edward A. Grove, University of Rhode Island  
Gerasimos Ladas, University of Rhode Island

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**Notes:**
- **AMS Special Session on Homotopy Theory, VII**
- **AMS Special Session on Difference Equations and Applications, IV**
- **AMS Special Session on Inverse Problems and Signal Analysis, III**
AMS Special Session on Knot Theory and Quantum Topology, III

1:00 PM - 5:50 PM

Organizers: Doug Bullock, Boise State University
Mark E. Kidwell, U.S. Naval Academy
Joel H. Przytycki, George Washington University
Yongwu Rong, George Washington University

1:00PM
A structure theorem for the Kauffman bracket skein module.
Walter F. LoFaro, University of Iowa (930-57-195)

1:30PM
An integral formula for the Tutte-Viro Invariant.
Charles D. Frohman*, The University of Iowa, and Joanna Kania-Bartoszynska, Boise State University (930-57-364)

2:00PM
A topological approach to character varieties and their quantizations.
Adam S. Sikora, University of Maryland at College Park (930-57-1134)

2:30PM
Kauffman–Radford–Hennings invariants of 3-manifolds associated with the centralized quantum group $\mathfrak{sl}_2(\mathbb{C})$. Preliminary report.
Kegin Liu, University of British Columbia (930-57-843)

3:00PM
Automorphisms of braid groups of surfaces.
Nikolai V. Ivanov, Michigan State University (930-57-745)

3:30PM
Invariants of embedded unframed topological graphs. Preliminary report.
David N. Yetter, Kansas State University (930-57-531)

4:00PM
Extending the Casson representation from pure braids to tangles, and some rational functions that generate Milnor invariants. Preliminary report.
Theodore B. Stanford, US Naval Academy (930-57-950)

4:30PM
A type 2 polynomial invariant of links derived from the Casson–Walker invariant.
Jeff Johannes*, Indiana University (930-57-1068)

5:00PM
The star-delta transformation in network reliability and knot theory. Preliminary report.
Lorenzo Traldi, Lafayette College (930-57-272)

AMS Special Session on Representation Theory and Noncommutative Harmonic Analysis: A Special Session Honoring the Memory of Harish-Chandra, IV

1:00 PM - 2:50 PM

Organizer: Robert S. Doran, Texas Christian University

1:00PM
Character theory. Preliminary report.
Jeffrey Adams*, University of Maryland (930-22-1217)

1:30PM
Discrete series characters as lifts from two-structure groups. Preliminary report.
Rebecca A. Herb, University of Maryland (930-22-374)

2:00PM
Linear cycle space and double fibration transforms. Preliminary report.
Joseph A. Wolf, University of California at Berkeley (930-22-344)

2:30PM
Germs of characters. Preliminary report.
Fiona Murnaghan, University of Toronto (930-22-326)

AMS Special Session on Representations of Finite Groups, III

1:00 PM - 5:20 PM

Organizers: Jonathan L. Alperin, University of Chicago
Jon F. Carlson, University of Georgia

1:00PM
Projective representations in cross characteristics for some classical groups.
Corneliu G. Hoffman, Univ. of Southern California (930-20-192)

1:30PM
Counting irreducible modules with formulas similar to Alperin’s weight conjecture-some examples. Preliminary report.
Harold E. Elliott, Northern Illinois University (930-20-904)

2:00PM
Alperin’s weight conjecture and the Brauer quotient for symmetric groups. Preliminary report.
Luis Valero-Elizondo, University of Minnesota (930-20-551)

2:30PM
Fitting heights of finite solvable groups with few irreducible character degrees. Preliminary report.
Jeffrey M. Riedl, University of Wisconsin, Madison (930-20-87)

3:00PM
Induction theorems on the center of the ring of generic matrices. Preliminary report.
Esther Beneish, Syracuse University (930-20-151)

3:30PM
Cross-characteristic character and fixed point space ratios.
David Gluck* and Kay Magaard, Wayne State University (930-20-216)

4:00PM
Determining group structure from sets of character degrees.
Mark L. Lewis, Kent State University (930-20-156)

4:30PM
Modular representations of symmetric and alternating groups. Preliminary report.
Ben Ford, Case Western Reserve University (930-20-685)

5:00PM
Stratifications and Mackey functors. Preliminary report.
Peter Webb, University of Minnesota (930-20-702)

AMS Special Session on Smooth Ergodic Theory and Related Areas, III

1:00 PM - 5:10 PM

Organizers: John Smillie, Cornell University
John M. Franks, Northwestern University

1:00PM
A new approach to the rigidity of real quadratic polynomials.
Mitsuhiro Shishikura, University of Tokyo and Johns Hopkins University (930-58-990)

2:00PM
Parabolic limits of renormalization.
Benjamin H. Hinkle, SUNY at Stony Brook (930-58-603)
2:30 PM Non-uniform hyperbolicity and universal bounds for S-unimodal maps.  
Duncan J. Sands*, SUNY Stony Brook, and Tomasz Nowicki, University of Warsaw (930-58-433)

3:00 PM Transversality principles in complex analytic dynamics.  
Adam L. Epstein, SUNY Stony Brook (930-30-668)

3:30 PM Rational maps with disconnected Julia set.  
Kevin M. Pilgrim*, Cornell University, and Lei Tan, Univ. of Warwick (930-58-597)

4:00 PM Renormalization in interval dynamics.  
Marco Martens, SUNY Stony Brook (930-58-1119)

4:30 PM Hausdorff dimension of the Feigenbaum Julia set.  
Mikhail Lyubich, SUNY at Stony Brook (930-58-529)

**MAA Minicourse #12: Part B**

1:00 PM - 3:00 PM
The use of hand-held numerical, graphical, and symbolic algebra devices in the teaching and learning of calculus.
Organizers: L. Carl Leinbach, Gettysburg College
Wade Ellis Jr., West Valley College
Bert K. Waits, The Ohio State University

**MAA Minicourse #13: Part B**

1:00 PM - 3:00 PM
Music and mathematics.
Organizer: Leon Harkleroad, Poughkeepsie, NY

**MAA Minicourse #15: Part B**

1:00 PM - 3:00 PM
Developing the ability in beginning college mathematics majors to write proofs.
Organizers: Diane Resek, San Francisco State University
Daniel M. Fendel, San Francisco State University

**AMS Session on Partial Differential Equations**

1:00 PM - 5:40 PM

1:00 PM Oscillatory and periodic solutions to a diffusion equation of neutral type.  
Joseph Wiener and William H. Heller*, Univ. of Texas-Pan American (930-35-136)

1:15 PM Propagation of singularities of semilinear hyperbolic equations with strongly singular initial data.  
Kirsten E. Travers, Duke University (930-58-194)

1:30 PM Weighted Caccioppoli-type estimate for solutions to the A-harmonic equation. Preliminary report.  
Shusen Ding, University of Minnesota (930-58-206)

1:45 PM Mountain pass solutions for a system of partial differential equations: An existence theorem with computational results.  
Lisa D. Humphreys, Rhode Island College (930-58-217)

2:00 PM The instability in conservation laws of mixed type.  
Mahmoud Affouf, Penn State University (930-35-304)

2:15 PM Complete blow-up for degenerate semilinear parabolic equations.  
C. Y. Chan and W. Y. Chan*, University of Southwestern Louisiana (930-35-354)

2:30 PM Nonlinear wave equations with blow-up solutions. Preliminary report.  
Kelly M. Fuller, Nazareth College (930-45-1043)

2:45 PM Ginzburg-Landau equations for a three-dimensional superconductor in a strong magnetic field. Preliminary report.  
Melvin G. Rojer, Purdue University (930-35-226)

3:00 PM Blow-up of solutions of semilinear Euler-Poisson-Darboux equations with nonlocal boundary conditions.  
C. Y. Chan and J. K. Zhu*, University of Southwestern Louisiana (930-35-453)

Joseph A. Iaia, Univ. of N. Texas (930-35-602)

3:30 PM Many solutions to a superlinear Dirichlet problem on a thin annulus.  
John M. Neuberger*, Northern Arizona University, Alfonso Castro, University of North Texas, and Jorge Cossio, Universidad de Nacional de Colombia (930-35-533)

3:45 PM Stable perturbations for clusters of potentially unstable eigenvalues for rectangular membranes.  
Joyce R. McLoughlin, Rensselaer Polytechnic Institute, and Arturo Portnoy*, University of Puerto Rico (930-35-525)

4:00 PM Spectral analysis on infinite Sierpinski gaskets.  
Alexander Teplyaev, Cornell University (930-35-963)

4:15 PM Boundary control for nonlinear Schrödinger equations.  
Joel P. Deljager, University of Minnesota (930-35-989)

4:30 PM A dynamic thermoviscoelastic contact problem with friction and wear.  
Kevin T. Andrews*, Oakland University, Anders Klarbring, Linköping Institute of Technology, Meir Shillor and Steve Wright, Oakland University (930-35-170)

4:45 PM Post-surgical passive response of local environment to primary tumor removal II: Heterogeneous model.  
Carryn Bellomo*, Old Dominion, and John A. Adam, ODU (930-35-802)

5:00 PM Analysis of nonlinear ion transport models.  
Rikki B. Wagstrom, University of Nebraska-Lincoln (930-35-1164)

Xueping Ru, Louisiana State University (930-35-1052)

Robert L. Pego, University of Maryland, and Henry A. Warchall*, University of North Texas (930-35-850)

**AMS Session on Graph Theory**

1:00 PM - 5:25 PM

1:00 PM A note on arc-transitive circulants.  
(1070) Margaret J. Morton, University of Auckland (930-05-760)

1:15 PM On exact n-step domination. Preliminary report.  
(1071) Lauren Klivoy Williams, Harvard University (930-05-1234)

1:30 PM Pebbling and Graham's conjecture.  
(1072) Stephen S. Wang, Harvard University, Cambridge, MA (930-05-977)

1:45 PM On edgemagic and strong edgemagic graphs.  
(1073) Ramon M. Figueroa-Centeno, Francisco A. Muntaner*, and Rikio Ichishima, Western Michigan University (930-05-657)

1:00 PM - 3:00 PM
Music and mathematics.
Organizer: Leon Harkleroad, Poughkeepsie, NY

1:00 PM - 3:00 PM
Developing the ability in beginning college mathematics majors to write proofs.
Organizers: Diane Resek, San Francisco State University
Daniel M. Fendel, San Francisco State University
AMS Session on Geometry

1:00 PM - 3:25 PM

1:00 PM

On questions by R. D. and Erdős about edge-magic graphs.

Esther Tesa, Drew University, and David Craft, Muskingum College (930-05-251)

1:15 PM


Timothy K. Polis and A. J. Radcliffe, University of Nebraska-Lincoln (930-05-1126)

1:30 PM

On matching extensions with prescribed and prescribed edge sets II.

Michael D. Plummer, Vanderbilt University, and Robert E. L. Aldred, University of Otago (930-05-884)

1:45 PM

Hamiltonian cycles in layered cubic planar graphs.

D. S. Franzblau, CUNY/College of Staten Island (930-05-676)

2:00 PM

On the n-dimensional Z-cube. Preliminary report.

Farrokh Saba, Univ. of Detroit Mercy, Rikio Ichishima, Keio University, and Dionysios Koutakis, Western Michigan Univ. (930-05-919)

2:15 PM


Heather Ames Lewis, Nazareth College (930-05-987)

2:30 PM

Random nearest neighbor graphs. Preliminary report.

Tara L. Bass, Pomona College (930-05-1005)

2:45 PM

The fractional chromatic gap of infinite graphs.

Gregory M. Levin, The Johns Hopkins University (930-05-1121)

AMS Session on Statistics and History

1:00 PM - 3:10 PM

1:00 PM

Concordance and Gini's measure of association.

Roger B. Nelsen, Lewis & Clark College (930-62-53)

1:15 PM

Limiting distribution of periodogram ordinates.

B. B. Bhattacharya, North Carolina State University, Raleigh, NC, and Gary Richardson, University of Central Florida, Orlando, FL (930-62-809)

1:30 PM

Adaptive estimation of the slope in the linear model.

Hans-Juergen Petersen, Loyola University Chicago (930-62-1158)

1:45 PM

Some criteria for the cumulant generating function of an exponential family.

Zhuihui Liu, Div. of Biostat., Univ. of Minnesota (930-62-1212)

2:00 PM

The number theorist Ramanujan, a tribute.

Bairuth F. Ambasth, Bank of Steel City, India, Jamuna P. Ambasth, Benedict College, Columbia, SC 29204, and Sanjay Tiwari, Jagiwan Road, Gaya, India (930-00-1061)

2:15 PM


Ben Fitzpatrick Jr., Auburn University (930-01-315)

2:30 PM

The role of women in mathematics education: A historic qualitative investigation.

Michael J. Bosse and Deborah A. Conley, Delaware State University (930-01-1060)

2:45 PM

An uncommon interpretation of Euclid's fifth postulate and the curvature of a space. Preliminary report.

Ilhan A. Izmirli, Strayer College (930-01-262)

3:00 PM

Identity: The uniqueness of the general structure.

Gun Won Lee, Seoul National University (930-03-90)

MAA Session on Mathematics and Sports

1:00 PM - 3:45 PM

1:00 PM

Organizer: Robert E. Lewand, Goucher College

1:05 PM

Introductory remarks by Robert Lewand.

1:10 PM

SABERMETRICS-Mathematics and baseball.

William P. Fox, USMA (930-C1-626)
  David A. Trautman, The Citadel (930-C1-166)
1:35 PM The SLOB in baseball: A mathematical model for judging offensive value.
  Helen E. Salzberg, Rhode Island College (930-C1-271)
1:50 PM Analysis of expansion draft methods for the Western Professional Hockey League.
  C. Bryan Dawson, Emporia State University (930-C1-473)
2:05 PM Defensive alignments in football and graph theory.
  Mark C. Ginn, Austin Peay State University (930-C1-815)
2:20 PM A mathematical approach to the long jump.
  Preliminary report.
  Martha L. Abell*, Lisa M. Norton, Georgia Southern University, and Stuart Davidson, Greensboro College (930-C1-242)
2:35 PM Modeling army football.
  William P. Fox, USMA (930-C1-628)
2:50 PM Mathematics and sport via a spreadsheet.
  Deane E. Arganbright, University of Papua New Guinea (930-C1-256)
3:05 PM Efficiently communicating the results of a tournament.
  Jeffrey L. Poet, University of Wyoming (930-C1-230)
3:20 PM Engineering the javelin for distance.
  Preliminary report.
  Joseph D. Myers* and Randolph J. Wagner, US Military Academy (930-C1-276)
  Deborah P. Levinson, The Colorado College (930-C1-163)
3:50 PM A new approach to introductory statistics.
  Preliminary report.
  Richard A. Nyman, Carleton College (930-C1-256)
4:05 PM Different examples for different samples.
  Preliminary report.
  John F. Putz, Alma College (930-D1-614)
4:20 PM Statistical and mathematical paradoxes in grading.
  Preliminary report.
  Jerry W. Bradford, College Misericordia (930-D1-742)
4:35 PM Using a portfolio in introductory statistics.
  Preliminary report.
  Deborah J. Bergstrand, Williams College (930-D1-193)
4:50 PM Using MAPLE to simulate observations of the first m out of n order statistics.
  Elliot A. Tanis, Hope College (930-D1-710)
5:05 PM Maximum entropy interpretation of common probability models. Preliminary report.
  Philip E. Luft, Salisbury State University (930-D1-348)
5:20 PM Applying linear regression in music.
  Preliminary report.
  John J. Schiller, Rhode Island College (930-D1-1172)
5:35 PM Statistical and mathematical paradoxes in grading.
  Preliminary report.
  Jerry W. Bradford, College Misericordia (930-D1-742)
5:50 PM Using a portfolio in introductory statistics.
  Preliminary report.
  Deborah J. Bergstrand, Williams College (930-D1-193)
6:05 PM Using a portfolio in introductory statistics.
  Preliminary report.
  Jerry W. Bradford, College Misericordia (930-D1-742)
6:20 PM Using a portfolio in introductory statistics.
  Preliminary report.
  Jerry W. Bradford, College Misericordia (930-D1-742)
6:35 PM Using a portfolio in introductory statistics.
  Preliminary report.
  Jerry W. Bradford, College Misericordia (930-D1-742)
6:50 PM Using a portfolio in introductory statistics.
  Preliminary report.
  Jerry W. Bradford, College Misericordia (930-D1-742)
7:05 PM Using a portfolio in introductory statistics.
  Preliminary report.
  Jerry W. Bradford, College Misericordia (930-D1-742)
7:20 PM Using a portfolio in introductory statistics.
  Preliminary report.
  Jerry W. Bradford, College Misericordia (930-D1-742)
7:35 PM Using a portfolio in introductory statistics.
  Preliminary report.
  Jerry W. Bradford, College Misericordia (930-D1-742)
7:50 PM Using a portfolio in introductory statistics.
  Preliminary report.
  Jerry W. Bradford, College Misericordia (930-D1-742)
8:05 PM Using a portfolio in introductory statistics.
  Preliminary report.
  Jerry W. Bradford, College Misericordia (930-D1-742)
8:20 PM Using a portfolio in introductory statistics.
  Preliminary report.
  Jerry W. Bradford, College Misericordia (930-D1-742)
8:35 PM Using a portfolio in introductory statistics.
  Preliminary report.
  Jerry W. Bradford, College Misericordia (930-D1-742)
8:50 PM Using a portfolio in introductory statistics.
  Preliminary report.
  Jerry W. Bradford, College Misericordia (930-D1-742)
9:05 PM Using a portfolio in introductory statistics.
  Preliminary report.
  Jerry W. Bradford, College Misericordia (930-D1-742)
9:20 PM Using a portfolio in introductory statistics.
  Preliminary report.
  Jerry W. Bradford, College Misericordia (930-D1-742)
9:35 PM Using a portfolio in introductory statistics.
  Preliminary report.
  Jerry W. Bradford, College Misericordia (930-D1-742)
Program of the Sessions – Baltimore, MD, Saturday, January 10 (cont’d.)

4:00PM Math research at the CMST Summer Camp.
   ► (1145) Mark Stamp*, Didon Pachner, National Security Agency; Matthew Lee, Massachusetts Institute of Technology, Jonathan Needlemann, Montgomery Blair High School; Alex Shaller, McDonough School, Michael Ferguson, Northfield Mt Herman High School; and Joseph Engel, Pikeville High School (930-P1-459)

ASL Invited Addresses and Contributed Papers

1:00 PM – 5:00 PM

MAA Panel Discussion

1:00 PM – 2:20 PM

Research methodology/ethics issues.
Organizer: Judith T. Sowder, San Diego State University

MAA Panel Discussion

1:00 PM – 2:20 PM

Environmental mathematics at work.
Organizer: B. A. Fusaro, Florida State University

MAA Session on Developmental Programs That Work

1:05 PM – 5:25 PM

Organizers: Catherine M. Murphy, Purdue University Calumet
           Eileen Polani, St. Peters College

1:00PM Introductory remarks.
   ► (1146) Jo F. Warner, Eastern Michigan University (930-J1-568)
   1:20PM Student beliefs, learning theories, and developmental mathematics: New challenges in preparing successful college students.
           Irene M. Duranczyk* and Joanne Caniglia, Eastern Michigan University (930-J1-1037)
   1:35PM An imagistic-based approach to developing meaning for algebraic expressions.
           Diana U. Gregg* and Erna Yackel, Purdue University Calumet (930-J1-1100)
   1:50PM Implementation of a developmental algebra curriculum project: An examination of the role of technology and its impact on the nature of knowledge acquisition.
           Mercedes A. McGown, William Rainey Harper College (930-J1-1182)

4:05PM Combining experiential/earning with the TI-92 in developmental algebra courses.
           Laurie B. Hopkins* and Amelina S. Kinard, Columbia College (930-J1-301)
   2:20PM The log divides formula: An example of content we should (and should not) be teaching in developmental mathematics courses. Preliminary report.
           Suzanne I. Doree, Augsburg College/Mpls, MN (930-J1-1120)
   2:35PM College mathematics instructions in transition.
           Teri J. Murphy, University of Oklahoma (930-J1-406)
   2:50PM Implementing a problem solving approach in arithmetic and pre-algebra for developmental students.
           Rose M. Dubec* and Diana Underwood, Purdue University Calumet (930-J1-740)

3:05PM Remedial algebra at the university level: How to deal with it.
           Arthur J. Currence, Univ. of SC Lancaster (930-J1-692)
   ► (1154) Tailoring the transition from developmental to college mathematics.
           Lisa S. Yooco, Georgia Southern University, Statesboro, Georgia (930-J1-1041)
   3:35PM Introduction to algebra for adult students: A developmental mathematics program that works.
           Katherine M. Safford, Saint Peter’s College (930-J1-1046)
   3:50PM The NKATE reform algebra project.
           (1157) Lillie F. Crowley*, Lexington Community College, and Darrell H. Abney, Maysville Community College (930-J1-1086)
   4:05PM Quantitative problem solving at Valparaiso University.
           Richard Alan Gillman, Valparaiso University (930-J1-1064)
   4:20PM Intensive calculus.
           (1159) James M. Henle, Smith College (930-J1-739)
   4:35PM A foundations course for underprepared students.
           (1160) Frances B. Lichtman, Alma College (930-J1-951)
   4:50PM A developmental program that works.
           (1161) Gabriella Wepner* and Kay Gura, Ramapo College of New Jersey (930-J1-694)
   5:05PM Cognitive development in an integrated mathematics & science program.
           Jerome S. Epstein, Brooklyn College, CUNY, Ed. Dept. (930-J1-1145)

AMS Invited Address

2:15 PM – 3:05 PM

(1163) Randomized algorithms.
           Prabhakar Raghavan, IBM Almaden Research Center, San Jose, CA

MAA Panel Discussion

2:35 PM – 3:55 PM

New models for the preparation of secondary school mathematics.
Organizers: Mary M. Lindquist, Columbia State University
          Joan Ferrini-Mundy, University of New Hampshire, Durham
          Philip Quarataro Jr., Southern University

MAA CRAFTY Panel Discussion

2:35 PM – 3:55 PM

Research in mathematics education: Its importance for undergraduate education.
Organizers: William H. Barker, Bowdoin College
           Herbert E. Kasube, Bradley University
           Susanna S. Epp, DePaul University
Panelists: Kathleen Held, Pennsylvania State University
          David M. Mathews, Southwestern Michigan College
          David O. Tall, University of Warwick

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AMS Session on Representation Theory and Noncommutative Harmonic Analysis

3:00 PM - 5:40 PM

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<tr>
<th>Time</th>
<th>Title</th>
<th>Speaker(s)</th>
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<tbody>
<tr>
<td>3:00PM</td>
<td>Hecke algebra isomorphisms for $p$-adic groups.</td>
<td>Daniel Goldstein, UCSD (930-22-1033)</td>
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<tr>
<td>3:15PM</td>
<td>Quantum groups, the unitary dual, and geometric quantization.</td>
<td>Tamba W. Sesay, African American Academy of Math, Science and Technology (930-43-69)</td>
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<tr>
<td>3:30PM</td>
<td>Prime ideals of the enveloping algebra $U(sl_3)$.</td>
<td>Stefan Catoiu, Temple University, Philadelphia (930-16-81)</td>
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<td>3:45PM</td>
<td>Simple Lie algebras of characteristic 5. Preliminary report.</td>
<td>Gaik M. Melikian, University of Wisconsin-Madison (930-17-86)</td>
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<td>4:00PM</td>
<td>A construction of supercuspidal representations.</td>
<td>Jeffrey D. Adler, University of Toronto (930-22-101)</td>
</tr>
<tr>
<td>4:15PM</td>
<td>Distinguished supercuspidal representations.</td>
<td>Jeffrey L. Hakim, American University (930-43-71)</td>
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<td>4:30PM</td>
<td>Convergence of the drunkard's walk on the sphere.</td>
<td>Francis Edward Su, Harvey Mudd College (930-43-613)</td>
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<tr>
<td>4:45PM</td>
<td>Unitary representations of $U(p,q)$.</td>
<td>Peter E. Trapa, Massachusetts Institute of Technology (930-22-116)</td>
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<tr>
<td>5:00PM</td>
<td>Invariant distributions and Bessel functions.</td>
<td>Moshe Baruch, Ohio State University (930-22-197)</td>
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<tr>
<td>5:15PM</td>
<td>Pompeiu sets in compact Heisenberg manifolds.</td>
<td>Robert R. Park*, Southern University, and Leonard Richardson, Louisiana State University (930-22-95)</td>
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<tr>
<td>5:30PM</td>
<td>Associated $U(n)$ bundles over the cone of positive definite symmetric matrices. Preliminary report.</td>
<td>George Rosensteel, Tulane University (930-81-1173)</td>
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</table>

MAA Minicourse #11: Part B

3:15 PM - 5:10 PM

Elementary mathematical models: Order aplenty and a glimpse of chaos.
Organizers: Dan Kalman, American University
Angela C. Hare, Messiah College

MAA Minicourse #2: Part B

3:15 PM - 5:15 PM

Interdisciplinary lively application projects.
Organizers: Frank R. Giordano, COMAP
Marie M. Vanisko, Carroll College
Laurette B. Foster, Prairie View A

MAA Committee on the Mathematical Education of Teachers Panel Discussion

4:10 PM - 5:30 PM

Accreditation of mathematics programs for the preparation of teachers.
Organizers: James D. Gates, National Council of Teachers of Mathematics
Mary M. Lindquist, Columbus State University
Panelists: Donna M. Gollnick, National Council for Accreditation of Teacher Education
Marilyn L. Hala, National Council for Teachers of Mathematics

C. Patrick Collier, University of Wisconsin, Oshkosh
Willie Mae W. Beamon, Norfolk State University

MAA Panel Discussion

4:10 PM - 5:30 PM

Authors, publishers, and contracts: Classical issues and modern problems.
Organizers: Susanna S. Epp, DePaul University
Gerald J. Porter, Pennsylvania State University
Presenter: Kay Murray, Authors Guild

AMS Banquet

7:30 PM - 10:00 PM

Robert J. Daverman
AMS Associate Secretary
Knoxville, Tennessee

Donovan H. Van Osdol
MAA Associate Secretary
Durham, New Hampshire
## Meetings and Conferences of the AMS

### Associate Secretaries of the AMS

Western Section: William A. Harris Jr., Department of Mathematics, University of Southern California, Los Angeles, CA 90089-1113; e-mail: wharris@math.usc.edu; telephone: 213-740-3794.

Central Section: Susan J. Friedlander, Department of Mathematics, University of Illinois at Chicago, 851 S. Morgan (MC 249), Chicago, IL 60607-7045; e-mail: susan@math.nwu.edu; telephone: 312-996-3041.

Eastern Section: Lesley M. Sibner, Department of Mathematics, Polytechnic University, Brooklyn, NY 11201-2990; e-mail: lsibner@magmas.poly.edu; telephone: 718-260-3505.

Southeastern Section: Robert J. Daverman, Department of Mathematics, University of Tennessee, Knoxville, TN 37996-1300; e-mail: daverman@novell.math.utk.edu; telephone: 423-974-6577.

The Meetings and Conferences section of the Notices gives information on all AMS meetings and conferences approved by press time for this issue. Please refer to the page numbers cited in the table of contents on this page for more detailed information on each event. Invited Speakers and Special Sessions are listed as soon as they are approved by the cognizant program committee; the codes listed are needed for electronic abstract submission. For some meetings the list may be incomplete. Up-to-date meeting and conference information is available on the World Wide Web at www.ams.org/meetings/.

### Meetings:

**1998**

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<tr>
<td>March 20-21</td>
<td>Louisville, Kentucky</td>
<td>153</td>
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### 2000

- **January 19-22**: Washington, DC
  - Annual Meeting

- **April 1-2**: Lowell, Massachusetts
  - Annual Meeting
- **April 7-9**: Notre Dame, Indiana

### 2001

- **January 10-13**: New Orleans, Louisiana
  - Annual Meeting
- **March 16-18**: Columbia, South Carolina
  - Annual Meeting
- **October 13-14**: Williamstown, MA
  - Annual Meeting

### Important Information Regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 183 in the January issue of the Notices for general information regarding participation in AMS meetings and conferences.

### Abstracts

Several options are available for speakers submitting abstracts, including an easy-to-use interactive Web form. No knowledge of TeX is necessary to submit an electronic form, although those who use plain TeX, AMS-TeX, LaTeX, or AMSTeX may submit abstracts with TeX coding. To see descriptions of the forms available, visit http://www.ams.org/abstracts/instructions.html or send mail to abs-submit@ams.org, typing help as the subject line, and descriptions and instructions on how to get the template of your choice will be e-mailed to you.

Completed abstracts should be sent to abs-submit@ams.org, typing submission as the subject line. Questions about abstracts may be sent to abs-info@ams.org.

Paper abstract forms may be sent to Abstracts Coordinator, AMS, P.O. Box 6887, Providence, RI 02940. Note that all abstract deadlines are strictly enforced. Close attention should be paid to specified deadlines in this issue. Unfortunately, late abstracts cannot be accommodated.

### Conferences:

**1998**

- January 5-6: AMS Short Course on Singular perturbation concepts for differential equations. See pp. 1262-1265 for details.

**Cosponsored Conference**:

The Beginner's Guide to Mathematica Version 3
Jerry Glynn and Theodore Gray

From the fundamentals of installing and running Mathematica on your computer, through to tips on how to get the most from the advanced programming features, the presentation maintains its concise and knowledgeable tone, providing indexes for both concepts and Mathematica function names.

1997 347 pp. 62202-6 Hardback $64.95
62734-6 Paperback $24.95

Dissections: Plane & Fancy
Plane and Fancy
Greg N. Frederickson

This book shows you many ingenious ways to solve geometric puzzle problems and the beautiful constructions you can create. The author explains solution methods carefully, assuming only a basic knowledge of high school geometry, then poses puzzles to solve.

1997 c.320 pp. 57197-9 Hardback $34.95

Approximation Theory and Optimization
Martin D. Buhmann and Arieh Iserles, Editors

This volume is derived from invited talks given at a meeting celebrating Michael Powell's sixtieth birthday and focuses on innovative work in optimization and approximation theory.

1997 c.250 pp. 58190-7 Hardback $49.95

Idempotency Analysis
J. Gunawardena, Editor

This volume includes a variety of contributions, a broad introduction to idempotency, written especially for the book, and a bibliography of the subject. It is the most up-to-date survey currently available of research in this developing area of mathematics; the articles cover both practical and more theoretical considerations, making it essential reading for all workers in the area.

1997 c.457 pp. 58424-X Hardback $80.00

Introduction to Geometric Probability
Daniel A. Klain and Gian-Carlo Rota

The theory of intrinsic volumes due to Hadwiger, McMullen, Santaló and others is presented, along with a complete and elementary proof of Hadwiger's characterization theorem of invariant measures in Euclidean n-space.

1997 c.169 pp. 59362-X Hardback $59.95
59654-8 Paperback $19.95

Probabilistic Modelling
Second Edition
I. Mitran

Professor Mitran has amplified the treatment of queues, reliability and applied probability. The text includes the necessary fundamentals in probability and stochastic processes, making the book ideal for students in computer science or operations research taking courses in modern system design.

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It will appeal to students who wish to learn modern mathematics, but have few prerequisites courses, and to high-school teachers who have a keen interest in mathematics, but seldom the time to pursue background technicalities. Even post-graduate mathematicians will enjoy being able to browse through a number of mathematical disciplines in one sitting. Highlights in this book include discussions of: Rationality, Elliptic Curves and Fermat’s Last Theorem, Fundamental Theorem of Algebra, Möbius Geometry, Hyperbolic Geometry and Riemann Surfaces, Platonic Solids, Topology of Surfaces, The Four Color Theorem and The Fourth Dimension. Over 150 computer generated images, accessible to readers via the World Wide Web, facilitate a further understanding of mathematical concepts and proofs. Additionally, the author includes recommended Web sites at the end of each section.

1998 / APP. 352 Pp. / 170 ILLUS. / HARDCOVER / $39.95
UNDERGRADUATE TEXTS IN MATHEMATICS

FRANCIS H. CLAIRVIE, Institut des Sciences, Université de Lyon I, Villeurbanne, France; YURI S. LEDYAEV, Steklov Mathematics Institute, Moscow, Russia; RONALD J. STEIN, Concordia University, Montreal, P.Q., Canada and PETER W. WOLKIEWICZ, Louisiana State University, Baton Rouge

NONSMOOTH ANALYSIS AND CONTROL THEORY

In the last decades the subject of nonsmooth analysis has grown rapidly due to the recognition that nondifferentiable phenomena are more widespread, and play a more important role, than had been thought. In recent years, it has come to play a role in functional analysis, optimization, optimal design, mechanics and plasticity, differential equations, control theory, and, increasingly, in analysis. This volume presents the essentials of the subject clearly and succinctly, together with some of its applications and a generous supply of interesting exercises. The book begins with an introductory chapter which gives the reader a sampling of what is to come while indicating at an early stage why the subject is of interest. The next three chapters constitute a course in nonsmooth analysis and identify a coherent and comprehensive approach to the subject leading to an efficient, natural, yet powerful body of theory. The last chapter, is a self-contained introduction to the theory of control of ordinary differential equations. The authors have incorporated in the text a number of new results which clarify the relationships between the different schools of thought in the subject.

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GRADUATE TEXTS IN MATHEMATICS, VOL. 178

GREGORY J. CHATIN, IBM Research Center, Thomas J. Watson Research Center, Yorktown Heights, NY

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Gregory Chaitin created the theory of algorithmic information as a teenager. In the three decades since, he's been the principal architect of the theory. This book stems from the author's course on algorithmic information theory, the limits of mathematical reasoning, and the epistemology of mathematics and physics. It discusses Einstein and Gödel's views on the nature of mathematics in the light of information theory, and sustains the thesis that mathematics is quasi-empirical. He uses LISP and Mathematica to explain his theory and advocates that experimental mathematics should be used more freely.

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INTRODUCTORY FUNCTIONAL ANALYSIS

With Applications to Boundary-Value Problems and Finite Elements

This book provides an introduction to functional analysis and treats in detail its application to boundary-value problems and finite elements. It is intended for use by senior undergraduate and graduate students in mathematics, the physical sciences and engineering, who may not have been exposed to the conventional prerequisites for a course in functional analysis, such as real analysis. Researchers wishing to learn the basic ideas of functional analysis would also find the text useful. The text is distinguished by the fact that abstract concepts are motivated and illustrated wherever possible. Readers of this book can expect to obtain a good grounding in those aspects of functional analysis which are most relevant to a proper understanding and appreciation of the mathematical aspects of boundary-value problems and the finite element method.

Contents: Linear Functional Analysis • Sets of Functions and Lebesgue Integration • Vector Spaces, Normed and Inner Product Spaces • Properties of Normed Spaces • Linear Operators • Orthogonal Bases and Fourier Series • Distributions and Sobolev Spaces • Elliptic Boundary-Value Problems • Variational Boundary-Value Problems • Approximate Methods of Solution • The Finite Element Method • Analysis of the Finite Element Method • References • Solutions to Exercises

1998 / 488 Pp. / 145 ILLUS. / $59.95 / HARDCOVER
ISBN 0-387-98502-0

APPLIED MATHEMATICAL SCIENCES, VOL. 101

YUAN SHIH CHOW, Columbia University, New York and HENRY TEICHER, Rutgers University, New Brunswick, NJ

PROBABILITY THEORY

Independence, Interchangeability, Martingales

This is a text comprising the major theorems of probability theory and the measure theoretical foundations of the subject. The main topics treated are independence, interchangeability, and martingales; particular emphasis is placed upon stopping times, both as tools in proving theorems and as objects of interest themselves. No prior knowledge of measure theory is assumed and a unique feature of the book is the combined presentation of measure and probability. However, it is easily adapted for graduate students familiar with measure theory. This edition includes a section dealing with U-statistics, additional theorems and examples, and simplified versions of some proofs.

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